# INDIANA

## DEPARTMENT

—OF—

# Geology and Natural Resources.

## SEVENTEENTH ANNUAL REPORT.

S. S. GORBY,

STATE GEOLOGIST.

1891.



TO THE GOVERNOR.

Geol.

INDIANAPOLIS: cl
WM. B. BURFORD, CONTRACTOR FOR STATE PRINTING AND BINDING.
1892

THE STATE OF INDIANA,
EXECUTIVE DEPARTMENT,
INDIANAPOLIS, Sept. 7, 1892.

Received by the Governor, examined and transmitted to the Secretary of State for publication, upon the order of the Board of Commissioners of Public Printing and Binding.

WILLIAM B. ROBERTS,
*Private Secretary.*

---

Filed in the office of the Secretary of State of the State of Indiana, September 7, 1892.

CLAUDE MATTHEWS,
*Secretary of State.*

3-27-33

# DEPARTMENT OF GEOLOGY AND NATURAL RESOURCES.

---

INDIANAPOLIS, IND., September 6.

TO HON. IRA J. CHASE, *Governor of Indiana:*

Herewith I submit the Seventeenth Report of the Department of Geology and Natural Resources. In the preparation of this volume I have been fortunate in securing the assistance of men who are known throughout the nation as experts in their various lines of work. The results of their labors, which appear in the body of this volume, will be fully appreciated by all those who are interested in the economic and scientific interests of our State.

By act of the General Assembly, in force in March, 1891, it became the duty of the State Geologist to appoint a State Inspector of Mines, a State Supervisor of Oils, and a State Supervisor of Natural Gas. In compliance with that act I appointed Thomas McQuade, of Clay County, Indiana, State Inspector of Mines; Nelson J. Hyde, of Marion County, Indiana, State Supervisor of Oils, and E. T. J. Jordan, of Shelby County, Indiana, State Supervisor of Natural Gas. These officers qualified according to law at once, and have since continued to discharge their duties in a wholly satisfactory manner. The report of each of these officers will be found included in this report to you, as provided by law.

While it has been the aim to make this report chiefly economic, there will be found in it, nevertheless, much matter of a purely scientific nature that will be of great value to the thousands of teachers and students of the State. The valuable article by Mr. S. A. Miller, with its accompanying twenty plates, describes and illustrates more than 150 species of fossils, found mainly in Indiana, that are wholly new to science.

The report is respectfully submitted.

S. S. GORBY,
*State Geologist.*

# ASSISTANTS TO THE STATE GEOLOGIST.

---

MAURICE THOMPSON,
*Geologist.*

A. C. BENEDICT,
*Geologist.*

CHAS. R. DRYER,
*Geologist and Chemist.*

MOSES N. ELROD,
*Geologist.*

S. A. MILLER,
*Palæontologist.*

O. P. HAY,
*Herpetologist.*

W. S. BLATCHLEY,
*Entomologist.*

E. BRADNER,
*Botanist.*

J. E. BEASLEY,
*Taxidermist.*

THOMAS McQUADE,
*Inspector of Mines.*

NELSON J. HYDE,
*Supervisor of Oils.*

E. T. J. JORDAN,
*Supervisor of Natural Gas.*

LILLIAN B. GORBY,
*Stenographer.*

# TABLE OF CONTENTS.

# INTRODUCTORY.

In preparing the Seventeenth Report of the Geology of Indiana for the press, the State Geologist has fortunately been able to secure the assistance of well-known specialists, who have aided in making this one of the most valuable reports, both for economic and scientific purposes, ever issued in the State. This volume exceeds the size originally intended, but circumstances that delayed the publication of the Sixteenth Report rendered it necessary to add somewhat to the size of this in order to secure the publication of material already prepared at considerable labor and expense, which, if publication was longer delayed, would lose much of its value.

The material for the Eighteenth Report is now nearly ready for the printer, and it will follow as soon as the funds become available for its publication. Like the present volume, it will be devoted mainly to matters of economic importance, but will contain many plates illustrating new species of fossils, with descriptions by Mr. S. A. Miller; besides valuable scientific papers by Prof. O. P. Hay and others.

## BUILDING STONE.

The report of ex-State Geologist Maurice Thompson and Mr. A. C. Benedict, upon the building stones of Indiana, has been prepared with great care. Mr. Thompson shows in his discussion of the value of the oolitic limestones of Indiana for building purposes, that, taking all things into consideration—durability, strength, texture, color, tractability in the hands of the artisan and cost of production, or cheapness—this stone is the equal of any, if not superior, to all others on the market. Its strength is sufficient to safely sustain a structure, properly designed and systematically constructed, one-half mile or more in height. Its texture is so unvarying that the strength of each block is evenly distributed through it. There are no alternating hard or soft spots in it. Its color, after weathering, is a uniform gray, pleasing and grateful to the eye, which gives to the more imposing structures a stately appearance that implies durability and strength. The facts referred to here are fully discussed in Mr. Thompson's paper.

In speaking of the merits of Indiana Stone it is not the design of the State Geologist nor any of his assistants to detract in the least from the value of the stone from any other section. It is intended solely to make public the value of the material afforded in Indiana. In this respect the State Geologist deplores the fact that in certain government publications, written in ignorance or through prejudice, statements are made concerning the oolitic limestones of this State, both of a scientific and statistical character, that are at absolute variance with the facts. Not only this, but the same publications have, through prejudice or ignorance, discriminated as unjustly against our valuable sandstones. It is to be regretted that it is necessary that public attention should be called to a matter of this kind in this way, and it is a matter of still farther regret that men employed to collect facts and make impartial statements of them should be led to undervalue the product of one locality or overestimate the product of another. The limestones and sandstones are all that the various chiefs of this department have ever claimed for them—durable, strong, even textured and tractable. The quarrymen of the State will be glad to submit samples for impartial and thorough tests at any time, knowing well the merits of the material they supply.

The statistical part of the report on building stone, etc., was prepared by Mr. A. C. Benedict, who, at the suggestion of the State Geologist, visited every quarry in the State and obtained all his data from the officers and proprietors direct. His statements, therefore, may be relied upon as being the most accurate that can be obtained, and they serve to show that the quarrying industry of the State has grown to gigantic proportions. More than 20,000,000 cubic feet of stone, for all purposes, were taken from the quarries of the State in 1890, and sold upon the market. Several millions of dollars are invested in this industry, giving employment to thousands of hands, who receive wages amounting to more than four millions of dollars annually. In addition to this, the employers derive reasonable profits upon their investments.

In this connection it is worthy of note that such a thing as a strike among the quarrymen of the State is unknown. The laborers get fair wages, they seem satisfied, and there is harmony and good feeling generally between employer and employe.

The valuable stones of Indiana consist of limestones and sandstones wholly. There are no granites, slates nor marbles in Indiana. There are, however, in some sections of the State crystalline limestones that are susceptible of a fine polish, and these rocks are sometimes called marble. Rocks of this character occur in the Devonian outcrops on Pipe Creek, in Miami County, at several points in Jefferson County, and also in the southern part of Fayette County, where Hon. J. N. Huston has recently opened an extensive quarry. The rock in Mr. Huston's quarry is a very dark limestone, which takes a good polish and makes a fine appearance when used for interior decorations. It is a strong, close-grained and durable stone, and well adapted to masonry.

The map accompanying this report shows the location of the principal quarrying industries of the State, and it is colored to indicate the kind of stone taken out and the geological formation where it occurs.

### THE DRIFT.

This vast mass of matter, sand, gravel, bowlders and clay, covers nearly the whole of the northern two-thirds of the State. The soils afforded by this great deposit are among the most fertile in the Union. For manufacturing purposes its clays are receiving much attention. For drain tiles and the manufacture of brick it is very valuable. In some localities excellent clay has been found for the manufacture of crockery-ware. Careful examinations will doubtless disclose vast deposits of clay in this region well adapted to the production of a variety of wares as yet not manufactured in the State.

In this connection it is proper to state that the State Geologist designs an exhaustive study of the clays of Indiana. In addition to the clays of the Drift area, the southern part of the State affords an abundance of clay of a finer grade. Citizens of all parts of the State are invited to send samples of clay to this office, with location of deposit and full description of the same. The clay should be sent in a four-ounce package, by mail, and it will be examined and analyzed and a full report concerning it will appear in the succeeding Geological Report of the State. Manufacturers of clay products everywhere are making inquiries for material suitable to the manufacture of their wares, and in this report it is hoped that the full resources of the State and in this particular may be made known.

### COUNTY REPORTS.

This volume contains reports on the Geology of Carroll, Steuben, Wabash and Whitley Counties. In his report on Steuben County, Professor Dryer has detailed the results of his studies of the drift deposits in that region clearly and minutely. The phenomena connected with the deposition of this great mass of material are the most complicated with which the Geologist has to contend. Dr. Dryer has studied this subject with great care, both stratigraphically and dynamically, and his excellent report upon Steuben County details with clearness many interesting facts connected with the morainic masses of Northern Indiana. There being no rock exposures in either of the two counties alloted to him, his work is necessarily confined to the study of morainic deposits.

The report on Carroll County, by Maurice Thompson, and that on Wabash County, by M. N. Elrod, M. D., and A. C. Benedict, deal largely with the phenomena connected with the disturbed strata along the Wabash River. To the student of Dynamic Geology these reports will be of peculiar interest, as phenomena are exhibited in both these counties at marked variance with the conditions disclosed throughout the southern part of the State. As the exposures of stone in this region are limited to the inconsiderable areas uncovered by the erosions of the streams, it is a difficult matter to make satisfactory observations, and the rocks exposed have to be examined with critical minuteness to enable one to arrive at satisfactory conclusions. Though the counties named are forty miles or more apart, both afford exposures of the Niagara limestones, and these are the rocks that exhibit such marked peculiarities of structure. Folds of the strata and cone-like projections are common in both counties, and all the facts connected with these peculiar structural features are presented in these reports with careful minuteness of detail. When the counties of Huntington, Blackford, and some others in that part of the State, in which limited exposures of stone occur, are surveyed, it is probable that additional facts will be obtained that will, in a measure, relieve the conclusions presented in these reports of some of their elements of uncertainty.

## STATE INSPECTOR OF MINES.

This officer was appointed by the State Geologist in March, 1891, and at once entered upon the discharge of his duties. His report shows a fairly prosperous condition of the coal mines of the State, and that adequate means are employed to protect the lives and sustain the health of the employes. Accompanying the report is a carefully prepared list of the mines operated in the State.

The law directing the State Geologist to appoint an Inspector of Mines also provided for an Assistant Inspector of Mines. For convenience, the State, as pertains to mines, was divided into two areas, called the Northern District and the Southern District respectively. The Southern District was assigned to the Assistant and the Northern District to the State Inspector. The report of the Southern District by the Assistant Inspector of Mines appears in connection with that of his Chief.

## STATE SUPERVISOR OF OILS.

This officer, in pursuance of law, was appointed by the State Geologist in March, 1891. His report for the year 1891 appears in this volume. The law provides for at least one Assistant Supervisor in each Congressional district, and these were all duly appointed and entered upon the discharge of their duties. But few complaints have reached this office concerning the evasion of law by manufacturers and dealers in petroleum, and these have been of a trivial character. The general inclination has been to comply with the laws concerning the inspection of oils, and, though a comparatively few packages have been rejected, they have been removed from the State without complaint. The officers charged with the inspection of oils have, without distinction, discharged all their duties faithfully and impartially.

Incidental to this there will be found in the volume a full report on the Oil Production of Indiana, by A. C. Benedict. Every portion of the field was visited in the spring of 1892, and he states fully all the facts attainable concerning the production of petroleum in Indiana at that time. While the field at this time is not as productive as the Ohio and Pennsylvania fields, it may yet be considered promising, inasmuch as quite a number of old operators in the more productive fields of the East are still prosecuting their work in this State, after having made sufficient tests of the Indiana field to determine its value.

The quality of oil yielded by the Indiana wells compares favorably with that produced in Ohio, and this industry may be considered one likely to prove of vast importance in a considerable portion of the State, and at least fairly profitable.

## STATE SUPERVISOR OF NATURAL GAS.

This officer was also appointed by the State Geologist in March, 1891, in pursuance to enactment by the General Assembly. He began the discharge of the duties of his office immediately after his appointment. His report for 1891 appears in this volume and is replete with important facts, valuable suggestions and wholesome recommendations. Aside from the cleanliness connected with its use and its convenience as a fuel, its intrinsic value for heat-producing should make gas an article to be used economically. It is now clearly understood that the immense area of gas-producing territory in Indiana is practically one reservoir, and, this being true, natural gas is the joint property of all the real estate owners in the gas area. It is the common property of all, from which any one may secure a supply who secures a right to drill a well. What right, then, has any one who perchance may own a well, or can get the right to use it, to recklessly waste, by needless consumption or otherwise, this substance of which he is only a joint owner? For a long period of time after the discovery of gas in Indiana the amount of gas daily consumed at the wells and absolutely wasted was in excess of 100,000,000 cubic feet; and it is not exaggerating to state that the amount of gas needlessly wasted in Indiana for the past six years was worth in cash $10,000 daily. The value of the gas thus wasted would amount at the present time to the enormous sum of $22,000,000, and if distributed pro rata among the inhabitants of the gas area would amount to $100 for each man, woman and child in that region. Who can apologize for this reckless extravagance? It is a matter of regret that, although it is not so great as formerly, there is still much extravagance connected with the consumption of gas over a large proportion of the field. Stringent laws should be enacted and rigidly enforced for the preservation of this valuable fuel, and to protect the individual rights of the joint owners.

### ENTOMOLOGIST'S REPORT.

The report of Prof. W. S. Blatchley on the Butterflies or Diurnal Lepidoptera of the State is the only complete work of this kind ever published concerning this class of insects in Indiana. Prof. Blatchley has prepared this paper after many years of collecting and study, and it will be found invaluable to the college student of Indiana. This subject has an economic side as well as purely scientific, for it is the larvæ of this class of insects that are so destructive of plants in the conservatory, the garden and the field. The author has fully described the habits of each species of this order occurring in Indiana.

### HERPETOLOGIST'S REPORT.

This valuable report by Prof. O. P Hay is complete, touching the reptiles and batrachians of Indiana. It is well that this subject was taken up in season, for individuals of some of the species are now very rare in this State, and it will be but a few years at most until some of these species will become wholly extinct. Prof. Hay has been a painstaking student in this field of science for many years, and he is credited with many new discoveries touching the habits and vagaries of structure of many of the species enumerated in his paper. This work by Prof. Hay completely exhausts the field so far as pertains to this department of natural history in Indiana. The illustrations accompanying his report were made especially for this volume under the immediate supervision of the author.

### PALEONTOLOGIST'S REPORT.

This volume, in Mr S. A. Miller's report, contains the largest original contribution to science in the way of new discoveries and descriptions of fossils ever published in the State. More than 150 new species of fossils are described and aptly illustrated in twenty finely executed plates. The specimens described are mainly from the collections of Mr. J. F. Hammell, of Madison; Mr. A. C. Benedict, of Indianapolis; that of the State Geologist's private collection, and from the Indiana State Museum. The rock formations of Indiana are very rich in organic remains, and it is by an accurate knowledge of these remains that the practical Geologist is able to identify the various divisions of rock formations, hence the importance of a thorough knowledge of all fossil forms existing in the rocks.

### THE MUSEUM.

The collection of specimens for the State Museum has been materially increased by the addition of the splendid collection secured from Drs. Frank and Warren Howard, of St. Paul, Ind., and by additions to the Natural History department made by Mr. J. E. Beasley, of Lebanon, Ind., besides minor collections. As soon as suitable cases can be secured for the Museum the process of further classification and arrangement of the specimens will proceed. As yet the new additions to the State collection have not been placed on exhibition for the lack of proper cases.

### THE OFFICE.

The work of the office, especially that pertaining to the correspondence, has materially increased within the last few years. The number of letters daily received at the office ranges from thirty to fifty. These all receive attention at the very earliest moment practicable, and all answers are dictated by the State Geologist, which entails a vast amount of work.

# A REPORT UPON THE VARIOUS STONES USED FOR BUILDING PURPOSES, AND FOUND IN INDIANA.

---

In submitting the following report I feel it necessary to state that throughout its preparation I have kept in view the practical rather than the technical aim. The object of such a report seemed to me to be, in the first place, the development of quarrying and kindred industries in the State. A strictly scientific geological report would require a minute detailed survey of the whole area considered, and a long and exhaustive study of the facts. The survey made by me, while it has been close and comprehensive, has been for the purpose mainly of describing and of comparing the practical value of stones suited to the various architectural and engineering demands of a great and growing population.

While I do not claim that the report is exhaustive, I feel sure that it will serve to call larger attention to the quarry wealth of our State.

While the aim of the Legislature in establishing a geological department of the State had in view the advancement of natural science, it also was intended that every mineral, in fact every physical resource of Indiana should be examined and reported upon with a view to commercial progress and the advancement of every desirable line of internal development. With this in mind I have made my examinations of the building stones of Indiana, and have chosen to make my report in terms that will render it perfectly comprehensible to the ordinary reader, and yet I have attempted to give all that is at present known on the geological as well as the commercial side of the subject.

The study of limestones and sandstones has been particularly careful, and upon these the report will be found much the fullest that has yet been made.

Architects, engineers, contractors, quarry owners, operatives and masons are constantly searching our State reports for information, and it is to give this information that I have labored. Some years of experience as a civil and mining engineer have enabled me to know about what should be given in a sketch of this kind, and I hope I have not failed to embody the main facts in an intelligible form.

Not only have I examined the principal outcroppings of building stones in this State, but, in order to bring all the useful facts of other men's discovery into my report, I have gone all over the State reports and have taken out such matter from them as seemed most useful for my purpose.

This report, then, may be safely taken and relied upon as embodying everything at present known upon the subjects treated, in so far as commercial building stone is concerned.

MAURICE THOMPSON.

# INDIANA BUILDING STONE.

BY MAURICE THOMPSON.

The value of building stone is not yet properly appreciated by the American people, especially in the Middle, Western and Southern States, where timber is still plentiful and comparatively cheap. In the older countries, throughout historic times, it has been different, and the consequence has been that American architecture compares very disadvantageously with that of Europe; indeed, architecture as an art, and building on a permanent plan, have never found just honor in the ambition of Americans. We have but few public or private buildings that for beauty or symmetry of design or for solidity and strength of construction can compare with the ancient or modern buildings of Europe. It can not be said that this is due wholly or in the larger part to our want of artistic instinct, or yet to poverty, for Americans have shown no lack of art in other directions, and certainly we have grown rich faster than any other people ever did.

It has been said that the monuments of architectural skill have ever been the index of civilization, and that the true standard of a people's character is evidenced by the buildings erected by that people for public or private purposes. Doubtless the extreme rapidity of our growth as a nation from a few poor and weak colonies along the Atlantic coast to a first-class power in political, military and financial significance, has of itself necessitated the neglect of many of what are called the ornamental acquirements; but, no matter how furious our rush after wealth, no matter how swiftly has swelled our tide of numerical increase, no matter how startling and brilliant have been our achievements in war, politics and finance, if we have failed to appreciate the durable part of art and have neglected setting in permanent form the peculiarities of our imagination, we have fallen short of just that which will tell to future ages in the most unmistakable language the true history of our national life.

For durability under all conditions there is no material for building purposes equal to stone. Bronze is too costly; iron oxidizes and is subject to great changes in volume under the exigencies of temperature; brick are too apt to crush under great weight and are unequal in strength, to say nothing of the objectionable amount of mortar that must be used in laying them; all kinds of concrete fail in one essential or another, and wood is the great generator of conflagration. Granite, limestone and sandstone are the three perfect materials for the architect and the artist. It is of these that all eternal monuments of man's genius must be built. The perfect statues of the Greeks were cut in limestone, and modern sculpture has used the same incomparable material. The pyramids, the temples, the cathedrals, the palaces, all are of stone, and the remarkable ruins of forgotten cities found in Egypt and in Asia have been left to us by Time, the great destroyer, because they were built of the only material that can not be destroyed by the ordinary chemistry of nature.

Building stone is extremely plentiful in nearly all of our States, and much of it is unsurpassed in beauty, workability and strength. No European granite really surpasses, even if it equals, that of our Eastern and Southern States, and our sandstones are of every variety of color, texture and quality. As for our limestone, it is unquestionably the best in the world.

It is a subject of interesting and instructive inquiry, and it may be of value here to take a swift glance at the causes that have operated to hinder Americans in coming to the general use of building stone in the construction of public and private edifices. Undoubtedly one of the chief objections commonly arising to the use of stone is the cost of procuring it. We are, and have been from the first, a widely scattered people; our cities and towns are far apart, and we have not been a nation of road builders, railroads excepted. Our common highways will compare unfavorably with the meanest in Europe. The transportation of stone requires solid and durable highways. On account of the weight of the material, this transportation is necessarily slow and its operations exceedingly laborious. Then, until recently, the cost of quarrying was great, even under most favorable conditions. When the stone had to be drilled by hand and blasted with powder, hoisted with rude derricks and loaded upon common wagons, to be drawn long distances by oxen or horses, it was indeed a vast undertaking to supply the material for an arched bridge or for a considerable church, to say nothing of larger structures. Still the very poorest of our modern appliances for handling stone have been probably far more efficient than were possessed by the ancients who built those marvels of architecture and hoisted to their places those stupendous blocks which would appear to us absolutely unmanageable with all our boasted improvements in machinery and knowledge of mechanics. Mere cost, then, has not been the sole cause of our neglect of stone. Hurry has, perhaps, fixed upon us the natural result of haste. We have been home-builders, content with any home that could be had quickly. So, in business life, any structure has been deemed sufficient if it would temporarily serve the purposes of business. Towns and cities have been erected as if by a species of magic, rising out of our prairies or in our forests like the trick pictures in a kaleidoscope. No sooner were these places built than they were thronged with an energetic, restless populace, bent upon trade and commerce. There has been given small thought to the distant future—everything has been constructed to meet a sudden present need. The burning of Chicago was no lesson for Seattle, nor has the recent destruction of the latter city been sufficient warning to other rapidly growing places. Haste to build and to reach the fruits of trade at the earliest moment, so as to forestall, in the greatest possible degree, that competition which gradually depresses business and shortens profits, has outweighed every consideration of permanency, and every thought connected with a long commercial perspective. But all this bustle and slipshod hurry, while it has, in a way, pushed forward a certain order of prosperity, has left us with few lasting improvements in the best sense of the phrase. Doubtless there has been, quite recently, the beginning of a change, and we shall soon feel the effect of a general impulse toward that permanency which has always been the best foundation of civilization. Stone structures are the indices of well-founded wealth, and as this wealth comes the structures must follow. Fire-proof cities and towns, noble piles of solid and enduring architecture and homes that shall become hereditary abiding places, are not incompatible with the republic in its highest and freest form. Indeed, the republic is the foster-mother of the true home and all that home should signify.

Geology is but a dry and useless science, fit only for the crooning of the hermit, specialist and the dusty-brained theorist, if it can not afford practical aid to the masses of the people. Of what use is all this study of the rocks if it be but to satisfy curiosity or to furnish links in idle theories? The highest aim of every science should be the permanent betterment of human life. Geology is not without this aim, and it has contributed and will continue to contribute to the store-house of practical human benefits by informing the people upon subjects that lie close to their material prosperity, while at the same time it has never, and it never must, let go the other strand of its usefulness which attaches to the purely scientific study of the Earth's contents. Pure science, in its last refinement, is pure common sense applied to the investigation of nature; if it is not this it is not worth having. With this view of the purposes and objects of geology, the following report upon the building stones found in Indiana has been made after a careful survey, and in the light of all the facts obtainable. To set this building stone before the world, as it should be set, with simple truth to the facts as they are, is the chief purpose of the report. In order to make it as nearly exhaustive as possible, it has been thought best to examine the different stones in their order, to-wit:

*First.* Granite and its kindred formations.

*Second.* Sandstone.

*Third.* Limestones in general.

*Fourth.* The Oolitic Limestone.

Before taking up this order, however, it will be necessary, especially in the interest of the reader not versed in geology and its cognate sciences, to give a concise description of the geological formations, so far as they are known, in Indiana.

So far as understanding the nature and position of the available building stones of the State is concerned, we need not consider any but outcropping rocks. In the geological sense, rock is a term used to designate any earthy or stone formation, and it includes clays, shales, chalks, sands and marls, as well as stones proper. Thus when we speak of a rock formation we do not necessarily mean that the formation is composed wholly or, perhaps, even in part, of solid stone. For instance, the Niagara rock of the Upper Silurian formation often is a soft, dirty shale, and the clays found in the Carboniferous formation are as much rock as the hardest limestone.

The stratified rocks outcropping in places in Indiana belong to one or another of three great geological ages: the Silurian, the Devonian or the Carboniferous.

The Silurian formation is divided into two easily distinguishable parts called, respectively, the Upper Silurian and the Lower Silurian. The Lower Silurian is the lowest and, therefore, the oldest formation outcropping in the State. Beginning with this as the base, a general section of Indiana's stratified rocks would show the following series:

Lower Silurian.

Upper Silurian.

Devonian.

Carboniferous.

Above the carboniferous rocks over a large part of their area lie the Drift and alluvial deposits.

What are known as the Hudson River limestones and shales compose the greater part of the outcropping Lower Silurian formation in this State, and these outcrop chiefly in the southeastern counties, and appear as far north as the vicinity of Richmond, in Wayne County, their greatest western exposure being on the Ohio River, in Clark County.

The Upper Silurian formation is chiefly Niagara shales and limestones, and for the purposes of their study we need consider only the limestones.

The Devonian rocks in this State are the Genesee black shales and the Corniferous limestone, the latter being the only stone worthy of the builder's notice, and is not of the best.

The Carboniferous formations are numerous and exceedingly interesting, as they include all our coal and all our best building stone.

The following section, beginning with the lowest group of rocks in the Carboniferous, and running up to and including the highest, will serve as a guide to the unlearned reader:

GENERAL SECTION OF THE CARBONIFEROUS ROCKS IN INDIANA.

Knobstone.
Keokuk.
St. Louis.
Chester.
Coal Measures.

Each of the above divisions is a group of varying stratified rocks with characteristic fossils and other peculiar features by which the geologist may easily distinguish it.

The sandstones, to be considered at the proper place, are mostly found in the Chester group and in the various divisions of the Coal Measures. The best limestones, for building purposes, are found in the St. Louis group, the "Oolitic" being the very best limestone ever yet discovered in America.

The only granite or other primary rock found in Indiana is in the form of bowlders, many of them very large, transported hither during the Drift period, by glacial forces, from Canada. It is, therefore, scarcely worth while to give much space to a discussion of this the most durable of all stones. Many of our magnificent bowlders, however, are worthy of being cut and set in our public buildings. Ofttimes they are of exceeding beauty, showing a grain and a coloring equal to the finest specimens of Scotch or New Hampshire stone. Where they are plentiful, cumbering (as they do in some places) the surface of the ground, they can be made available for foundations and for rustic monuments, for the curbing of wells, and for various ornamental purposes. By breaking them up they can be turned to excellent account for making rubble walls, and various forms of rough masonry, both picturesque and indestructible. As bases for the posts of iron fences, for the ornamental walls of fountains, even for building small rustic out-houses, there can be no more suitable material. Especially in prairie countries no bowlder of granite, greenstone or compact gneiss should ever be destroyed, but should be kept for use.

Before passing to the consideration of our sandstones and limestones in the order already indicated, it will be useful to examine the question of building-stones in general, so as to be able to distinguish between those that are most valuable and those suited only to certain purposes.

It has already been said that granite is the best of all building stones when once it has been cut and set; but it has many objectionable features, not the least of which are its hardness and its remoteness from a large part of our country. Very difficult to quarry and extremely hard and expensive to cut into shape, it must always be beyond the reach of the ordinary builder, who must look for material at once fire-proof, durable and comparatively inexpensive.

Brick, the commonest sort of artificial stone, have long served the purposes of architecture in lieu of natural stone, but, as has been noted, the amount of mortar necessary to laying them, the inequality of their strength and their inadequacy to withstand a very great crushing force, render them by no means perfect building material, especially where the structure into which they go is one of great weight. Moreover, after long years of exposure, most brick walls will show the effect of cold, heat, dampness, atmospheric forces and the results of unequal distribution of pressure. And even while the structure retains its general integrity, its beauty will be greatly marred by these and other causes incident to the imperfection of the materials. This has led to the adoption of stone facings for the fronts of many of our more pretentious city buildings. Indeed, more and more every year we are creeping on toward the "Stone age" of American architecture. Iron structures may prevail for a time, especially where very tall structures are desired, but nothing can ever set aside the final demand for a cheap and perfect building stone. Concretes have been tried and have utterly failed. In short, it would appear that nothing but the natural stone quarried from the rocks of the earth can be wholly relied upon for the best architectural results.

The qualities necessary to the best possible building stone are: Workability, durability and beauty. It must also be cheap.

*Workability* includes in its meaning accessibility, a ready yielding to quarrying operations, the absence of refractory qualities under the hammer and chisel, and a texture and grain that will hold decorative finish.

Stone that can not be quarried readily has the disadvantage of great cost to begin with. If the "raw material" is expensive, the finished product must be costly. On the other hand, if nature has so deposited her stores that the stone is easily taken from the quarry, still if the material is refractory in the final cutting and finishing, no matter what may be its other qualities, it can not be a very cheap material for the builder, as it will demand an over amount of expense and delay in preparation. Still less will it be desirable if it obstinately refuse to hold finish or decoration. Stone that comes from the quarry soft and yet somewhat tough, but hardening after a time, has the finest quality of workability. This renders it easy to quarry, very responsive to the tools of the cutter, and capable of taking easily and holding permanently the finish and decorative designs of the architect's specifications. It must be kept in mind, however, in examining stone, that if it comes from the quarry wet, and for that reason easily workable, it may again take up water after drying, which would be most objectionable; but if in the process of drying in the first place it pass through a chemical change which will render it ever afterward impervious to water, the quality is just what should be wished for in this regard. Usually an examination of the out-cropping surfaces of the stone in place will give a safe knowledge of its value as regards workability. Next after the character of the stone regard must be had touching the conditions of its deposit. Too much overlying matter, whether stone or earth, will usually make the quarry work very heavy and expensive. This overlying matter, technically called "stripping," is, as a rule, quite worthless, and must be entirely removed before the stone can be worked with steam channelers or other quarrying appliances, hence the necessity of a careful examination to determine its nature and extent in each case before opening a quarry.

*Durability*, as applied to building stone, includes every quality tending to make the material lasting and unchangeable after it is laid in a structure. These qualities are many and often seemingly conflicting in their nature. Hardness, elasticity, tensile strength, power to resist the greatest crushing force, imperviousness to water and invulnerability to the attacks of air and its corrosive and disintegrative burdens are some of the qualities, but not all. Evenness and homogeneity of composition, unity of substance, so to speak, and the power to resist extremes of heat and cold are quite as necessary. It will be seen at once that chemical analysis must be relied on to insure the best knowledge of some of these requirements. Some otherwise good and durable limestones will become corroded and discolored and have their integrity destroyed by the effect of sulphurous smoke from the burning of impure coals; others will be injuriously affected by the action of rain-water, and still others by the oxidizing power of the air. Some sandstones bear too much iron in their composition, others lack sufficient cohesion of the particles, whilst others yet are clayey or unequal in grain or texture. Every test of practical science should be given to stone before it is used in any building intended to be a permanent structure. As a rule, if the outcropping ledges are found to be infiltrated with water, which makes the outer surface constantly damp, the stone will not be good, for this would indicate that it would take up too much moisture in the wall. Still, it is often the case that an apparently over-hydrous stone will dry out permanently after it is quarried and cut. Many of the sandstones, notably the better qualities of conglomerate, are of this character, and so soft when first taken out that they may be cut to any rough shape with a common ax or hatchet, but hardening after a few days' exposure so that water will not affect them.

The elasticity of stone may be tested by sawing it into long, slender strips, say two inches square and three feet long, when, if it be quite perceptibly flexible, its elasticity is good. If such a bar be suspended so as to hang free by a string and is struck a light blow with a hammer, its evenness and solidity of fiber will be attested by a clear, sweet, metalic note, not unlike that of a fine bell, or that of a well-tempered steel bar. As a rule the best stone will break with a direct line of fracture; but it may be conchoidal or otherwise indirect and still be unobjectionable. Parallel lines of cleavage or of stratification are always favorable indications where other features are promising.

Resistance to crushing weight may be pretty safely inferred from solidity of texture and evenness of grain; but it is always necessary before a final acceptance to submit the material to the severest tests of an apparatus for that purpose. This will be described in the proper place.

In examining sandstone, with a view to building purposes, the outcropping, if there be any, should be carefully scanned with a view to discovering what effect long exposure to the atmosphere and the rigors of winter may have had upon it. If the stone has "weathered" badly this will be shown by one or another sign of disintegration or demolition, and a talus of fragments and sand will be found formed at or near the base of the outcropping cliff. Often the substance of the rock will show unmistakable evidence of inequalities of structural composition, such as horizontal cavities caused by the weathering out of seams or streaks that, on account of bearing too much iron, have oxidized and crumbled away. Such stone, if used in a building, would prove worthless and, therefore, dangerous. It is often the case, as I have observed during a long experience in civil engineering, that public bridges erected by counties are rendered unsafe by having their piers and abutments constructed of this kind of stone, and that, too, in places where most excellent material lay near at hand, and which a little knowledge of the nature of stone would have pointed out to the superintendent. Too frequently it happens that appearances of the most untrustworthy kind are relied upon where an ignorant person is set to do work which ought to be in charge of a skilled and well-informed engineer.

In judging of the probable durability of limestone, before subjecting it to any test of science, the same observations should be made as in the case of sandstone, with a view to ascertaining its weathering qualities. Any unequal discoloration of the face of the exposed ledge should be scrutinized carefully. Usually these are caused by the presence of iron in the composition of the rock. But limestones are much more injuriously affected by hidden faults of composition than are sandstones, and for this reason they demand a much more careful examination before any extensive quarries are opened. It is often the case that iron in limestone will do no more than discolor the outer surface on exposure to the action of air and rainwater; but even this is a serious defect when the stone is to be used in any structure wherein beauty is a chief object. For the rough masonry of ordinary bridges, and for the hidden foundations of buildings, a cheap and durable stone is what is most wanted, and in these discoloration is not a fatal fault.

*Beauty*, when applied to any building material, includes all the good qualities already enumerated with the added value of a pleasing color, or combination of colors, and a general effectiveness of appearance when the structure in which it is used has been completed. The variegated granites undoubtedly are the most beautiful of all building materials. Next to granite, the red and brown sandstones are most pleasing to the eye; but the white, gray and blue limestones are very effective, and they have the advantage over granite in that they work much more easily in ornamentation, while they take figures in relief with far more clearness of outline than do the sandstones as a rule. Architects have long since discovered the pleasing effects to be produced by using different kinds of stone in the same building, placing each where its particular qualities will best serve the general motive of the design.

As a rule, all else being equal, the stone which holds its native color best will be most beautiful in a building, and of the stones which change color, that will be most desirable which changes least and evenly. Some of the gray sandstones, however, change color unevenly and give a striking and ofttimes picturesque cloudiness to the surface, which adds to its effectiveness of color in a wall. The nearly white limestones that take on by exposure a dark cream-brown hue, if they do not contain too much magnesia, hold that tint very well and are quite beautiful. As a rule the presence of many large animal remains in a stone is objectionable on account of the tendency of such a composition to crumble; but where fossiliferous rock is durable it will usually be found very beautiful when cut, the organic remains bossing it over with variegations that greatly heighten its appearance. Stone which contains large fossils is not, however, the best for receiving raised ornamentations, such as figures in relief, no matter how durable and beautiful it may be, for the animal form will interfere with nicety of cutting and polish, as well as with the regularity of the figures. Fossils will usually be found harder than the matrix in which they are set, but this is not always the case, for quite often the form is that of a hollow cast or impress, filled in with material which crumbles easily. As a rule fossils, though very hard, are but loosely set in sandstone, and often they are very large and rough forms of plants, extremely silicious and refractory. Blocks containing these are to be avoided as probably worthless for building purposes, however valuable and interesting they may be from a scientific point of view.

Many very beautiful stones that are not durable when exposed to the weather are very valuable for the inside finishing of buildings, where they will last for ages, holding the finest tints of their coloring without perceptible change.

From what has been said above it will be seen that every owner of stone beds should, before going to the expense of opening quarries, have his rock-beds examined by an expert, whose report should show all the defects as well as all the good qualities of the material. Usually this can be done without any great outlay of labor or money, for the experienced geologist or engineer can quickly discover from the stone and its surroundings the nature of the deposit, and very simple chemical and mechanical tests will settle the question of strength and durability. There are beds of magnificent building stone lying undeveloped in many places, simply for the reason that the owners are not aware of the treasure they possess. In other places quarries are being industriously worked and the stone used in the erection of costly buildings, where in fact the material is wholly unfit for use on account of its lack of durability. I have examined many extensive structures whose stone was fast crumbling away. True, a few years will not show much decay, but in the long future the result will certainly be disastrous. The constant action of the atmosphere, the expansion and contraction consequent upon extremes of heat and cold, and the disintegrating effect of rain-water slowly but surely tell upon the integrity of the exposed parts.

## GRANITE AND OTHER BOWLDERS.

During the Drift period immense quantities of granite, gneiss, quartzite, greenstone and other igneous and metamorphic rocks were borne down by the glaciers from far northern areas and distributed over a large part of Indiana. The form in which the rocks are usually found is that of worn and polished bowlders, ranging in size from small pebbles to large masses weighing many tons. Many of these heavier bowlders are found lying on the surface or but slighlty buried in the clay of the drift, and could be utilized with very little trouble or expense. In some places vast fields of them appear in scattered or huddled groups, at others they are heaped in huge piles mixed with sand, gravel and clay. Much study has been given to these ice-worn wayfarers from the cold North, and much yet remains for science to do before the mystery of their situation shall be fully cleared up. Geologists are agreed in assigning to ice the power that brought them hither, but it is not yet established how the glaciers were formed or in just what way they acted. No mountain heights appear to have existed from which they could have crept down to our plains, as the glaciers are now doing among the Alpine regions of the world, nor is it easy to imagine the conditions that could have borne the almost incalculable mass of drift matter to its present resting place. Formulate any theory that we may, there is always some inexplicable obstacle to its final demonstration. To this problem many of the best equipped men of science have devoted years of the most patient and enlightened study and observation, and while the result of adequate solution has not yet been reached, discoveries have been made fixing beyond dispute the existence of a vast glacial period in the remote past, when, in some way or other, the action of immense masses of ice compelled the movement of all this drift matter in a generally southern direction from its original bed to the area now occupied by it. A rough calculation would show that in Indiana alone the granite of the drift mass would of itself, if drawn together, be sufficient to build a mountain of large dimensions. Indeed, in many places the bowlder clay is composed almost wholly of comminuted granite, gneiss and schist, the per cent. of calcareous matter being very small. At other points, however, lime is one of the chief substances of the clay.

The drift bowlders, as has already been said, are of greatly varying composition and quality. Almost every color is represented, from pure red, shading off into yellow and brown, to dark green, which runs through every lighter tint into a pale olive or a delicate celadon. The ordinary "pepper and salt" granite and the gray gneiss are very common. Many beautiful specimens of mica schist are found, especially in the northern areas of the drift. Immense bowlders of quartzite, white and almost translucent, lie here and there among their coarser fellows, looking like rough petrifactions of ancient ice fragments broken from the departed glaciers.

In Cass County, near Logansport; in Clinton County, a few miles south and west of Frankfort; in Tippecanoe County, near Lafayette; in Montgomery County, northeast of Crawfordsville, and at numerous other places in Indiana, vast "flocks and huddles" of these imperishable bowlders are lying exposed, ready-quarried for the hammer and chisel of the artist in stone. Many of these are as good as the best imported granite, and even more beautiful for monumental purposes, though they have, as yet, been very little used. It is not uncommon to find these polished fragments shot through with dykes of quartz and feldspar, and loaded with crystals of hornblende and pink mica. Occasionally clusters of regular quartz crystals appear in cavities of the stone shining like jewels in a rough but picturesque setting. Many of the bright yellowish particles, often seen in schistose rocks, have been brought to me by persons who were quite sure that they had found a bowlder of gold. The veins and dykes above mentioned usually run entirely through a bowlder, sometimes checkering the surface in a most odd and fantastic manner, the filling of the dykes being ordinarily of a different color from the rest of the stone. A close-grained, gray-blue granite bowlder, which I examined in Parke County, had dykes of pink quartz running in one direction, and at nearly right angles to these were others of a pearly white, beautifully spangled with crystals. The white veins were much more compact than were the pink ones, though both were very hard. When the stone is properly cut and polished, these irregular veins show in curious and beautiful contrast to the rest of the surface. If those who, year by year, are making our public cemeteries hideous with marble of ghastly white, and with unbearable, ugly artificial monuments of metal, would look about them they would find in the lovely granite bowlders of our fields the most enduring and far the most pleasing of all materials for marking, with taste and becoming dignity, the resting places of the dead. Any expert stonecutter can select, "upon sight," the most desirable specimens, and ofttimes the cost of removing a valuable bowlder to the place where it is to be worked will be much less than a moiety of the expense of transportation from the New England quarries. Very beautiful and strikingly picturesque monuments may be made of large bowlders by a very small amount of cutting, and their appearance in a cemetery is unique and striking, giving the effect of rugged strength and durability combined, with an attractiveness never found in the sleek and balanced shafts of the conventional monuments.

For the foundations of buildings, whose superstructure is to be of wood, nothing is better than rubble walls or pillars of bowlders; and even if the structure is to be of stone or brick, a very little cutting will serve to render these blocks of imperishable granite quite as valuable as the best product of the quarries. In some parts of our State the bowlders on many of the farms would furnish the material for a fence entirely around them, and it would, when once built, last forever. The time is probably not far off when our people will accept the lesson long since learned in older countries, and turn to best account all the available material at hand.

## INDIANA SANDSTONES.

Sandstones, of one form or another, appear in nearly all the formations of our State, but often they are wholly worthless for building purposes, being soft, shaley, or unequal in texture. Indeed, in many instances, they are but sandy seams or thin layers between the limestone or shale deposits.

In order to have an intelligent understanding of our great wealth of exceedingly beautiful and durable sandstone, it will be necessary to take a comprehensive glance over the subject from a geologic as well as an economic point of view. Most of the best building sandstones of Indiana are found in the Carboniferous or Sub-Carboniferous rocks; and, as these outcrop over a very large area, we have many varieties of this valuable material easily accessible to thoroughfares of transportation. As was said in the Fifteenth Report of this department: The Lower Coal Measures of Indiana are rich in sandstones perfectly adapted to building purposes, though at this time their value appears to be, in a large degree, overlooked, though the quarrying interest is gradually increasing. The

Conglomerate sandstone is a deposit pretty evenly and uniformly distributed throughout the base of the Coal Measures proper; and, wherever its grain is fine, it is usually a brown, buff, pinkish or gray massive sandstone, homogenous, non-cleaving, and exceedingly strong in all directions. It comes very soft from the quarry, which makes it remarkably easy to cut; afterward it dries quickly, takes on a lively glow, and holds its color perfectly. In the court-house walls of Rockville, in Parke County, may be seen some fine blocks of a pinkish colored sandstone, whose quality is equal to the best in the world. In the southwestern part of Montgomery County, near Williamsport, in Warren County, and in Fountain County, are inexhaustible quarries of this beautiful stone. Indeed, it may be looked for, and, as a rule, has been found in nearly every county in the State where the Lower Coal Measure rocks are outcropping. Along the line between the areas of the coal fields and the Sub-Carboniferous deposits the Conglomerate will usually be found forming the bluffs of the streams and the escarpments of the hills. It is not always a building stone, however, as in many places it takes the form of a coarse, pebbly, highly ferruginous mass, which weathers badly.

The best sandstones are composed of quartz particles of nearly uniform size, compactly cemented. They break ordinarily with a smooth (direct) fracture, in the direction of the force applied, and present a surface which, although beautifully even, has a finely cutting grit or "tooth" somewhat coarser than that of the fine grindstone grit. They are perfectly fire-proof and capable of withstanding all the changes of atmospheric temperature.

The resistance or crushing weight is very great in some of our sandstones—remarkably great, indeed, considering their softness when first quarried. Blocks hewn into any desired shape, as may be done readily with a common ax, will harden upon exposure to the air for a few days to such a degree that, upon being struck with a hammer, they will give forth a clear, metallic sound and emit sparks, like flint.

Professor Cox, formerly State Geologist of Indiana, made very extensive examinations of the Conglomerate sandstone, and in his report frequently called attention to its economic value. Professor Collett, also, has been enthusiastic in recommending it to builders. Geologically it is the equivalent of the "Millstone grit" of the older geologist, and it lies at the base of our Coal Measures, with rarely seams of coal below it. These seams, when found, however, are usually mere traces, never persistent for any great distance, and are shaley and without economic importance. In some places the Conglomerate comes directly in contact with the sandstone of the Chester group, and it is difficult to distinguish the dividing line. This is notably the case in the banks of Sugar Creek, in Montgomery County, where the shales and sandstones appear to run together in confused masses at some points, while at others the lines of separation are clearly traceable.

The general area of the Carboniferous and Sub-Carboniferous sandstones is contained in the following counties, in so far as the survey has developed it: Clay, Crawford, Dubois, Fountain, Greene, Parke, Putnam, Montgomery, Owen, Orange, Pike, Martin, Perry, Harrison and Warren, with a few outcroppings in Tippecanoe. Of course, sandstones are present in all the Coal Measure area, but often they are not visible, and are discoverable only by boring.

Although the quarrying of sandstone has not as yet come to be of that importance in Indiana which the value of the deposits demands, still it has been increasing yearly, and must soon take its place among our greatest industries. We shall not always go to far Northern and Eastern regions to import a material which lies at our feet ready for use. The best modern architects have long made use of sandstone similar to ours in the most costly and extensive structures of European cities. In due time we will imitate their example.

## GEOLOGY OF THE SANDSTONES OF INDIANA.

This is not the place for a technical treatise on the geology of our sandstones, but it is necessary, to a full understanding of the economic value of the material, that we shall sketch, in a way clear to the common understanding, the more important facts and conditions of the rock formations in which this excellent building stone is found.

Any person of ordinary intelligence, who has visited the shore of any sea or large lake, has observed that, as a rule, almost pure silicious sand is being constantly thrown out by the tides, currents or surf. Often this sand is formed into a compact floor or beach of beautiful evenness and solidity. Such a beach is a sandstone in embryo, so to speak, and if it were subjected to the pressure of hundreds or thousands of feet of superincumbent rock, it would, in the course of a long age of time, perhaps, become a firm, compact and durable building stone. The process of cementing together the silicious particles might be due partly to the action of heat, or of water creeping down into the mass from above and bearing with it the salts of iron, manganese or other mineral substances, or it might be due to chemical action generated by the presence of elements already in the sand. Not all has yet been discovered touching the operations of Nature's great underground laboratory, nor is it at all probable that all ever will be discovered; still we know enough of the secrets of chemical forces to understand, at least in a general way, the mighty effects they have wrought in building the solid rocks of the earth. The effect, for instance, of hot water upon the most obdurate substances of the rocks is disclosed by the geysers and warm springs of many countries. So the action of rain-water throughout long periods of time has been the cause of most wonderful results. The dissolution of one sort of rock has ended in the building of another and different deposit. Granite has been destroyed and its silicious constituents formed into sand, which in turn has become a sandstone; or the silicious and aluminous materials of a stone have been degraded into kaolin. Here the precipitation of pure silica has resulted in regular, translucent crystals of quartz; yonder some fortuitous conditions have deposited carbon in the form of most precious diamonds, while at other places the carbon is merely graphite. Under massive sandstones in many places we find beds of iron oxide leached, so to speak, from the body of the rock, while at other places in the same relation we see beds of pure flint deposited by a like action of rain-water. Limestones often present curious evidences of change or metamorphosis caused by the action of heat or by dissolution and rearrangement of their substances. The sandstones of Indiana, however, appear to have been deposited just as they are now found, mostly in heavy masses, by the action of sea currents, and often the ripple marks are still beautifully preserved in the surface of the rock.

The lowest sandstones of the Sub-Carboniferous age are found in the "Kinderhook group," which, in Indiana, is represented by the "Knobstone" formation, lying, as a rule, upon the Devonian black shale. Passing thence upward, we find beds of more or less massive sandstone in all the rocks to and including the Upper Coal Measures. In the Sub-Carboniferous rocks the best sandstones are in the Knobstone and Chester groups, the latter often closely resembling the Conglomerate in both stratification and substance. The fossils of the sandstones of Indiana are mostly of vegetable forms, some of them immense in size, though many are exceedingly slight and obscure. At some places the larger remains are heaped together, as if marking an old shore line where the waves had stranded floating drifts of plants and buried them under the incoming sand. Most of these are of the species of *Lepidodendron*, *Sigillaria*, *Calamites*, *Conifers*, of various kinds, and *Ferns*. Animal remains are scarce in the massive sandstones, though many species have been found.

In the Chester sandstones, of Indiana, I have observed the following:

*Lepidodendron forulatum*,
*Lepidodendron aculeatum*,
*Lepidodendron diplostegioïdes*,

and other species, probably, whose structure was too much obscured to be certainly made out. Usually, the *Calamites* are mere impressions or casts not clear in anything but the form, the markings being but vagely indicated. This is largely true of the *Cordaites* and many other forms.

In the sandstones of the Coal Measures the fossils are more abundant, but even there they are rarely well preserved. Some of the forms of *Sigillaria* and *Stigmaria*, and of the larger *Equiseta*, are fairly well kept in some of the non-ferruginous sandstones, where I have found *Colamites* whose joints and longitudinal markings were perfectly shown. The rule is, however, that neither animals nor plants are well preserved in our massive sandstones, and we must depend largely upon the contiguous limestone, shale or clay strata for identification of the rocks. Fossils often give place to cavities, and these, in turn, are frequently found filled with silicious, calcareous or earthy matter, or the combinations of substances deposited by water filtered through the rock, especially when the latter is porous like most of the coarser sandstones and coarser limestones. Beautiful crystal concretions are often thus formed, likewise nodules similar to geodes. In many places where large fossils have been destroyed by the action of water, the cavity will be found filled, or partly filled, with iron oxide, in one condition or another, mixed usually with fine sand or other silicious or calcareous sediment. Very rarely the impress of the fossil will be sufficient to identify it. I have found well preserved fossils where a cavity had formed around the body and had been filled with ferruginous matter which had taken the condition of a solid concretion inclosing it, but still firmly fixed in the rock. In other instances the fossil has been found lying loose in the cavity.

While it is generally true that in the sandstones of Indiana fossils are very scarce, this is not to be regretted by the prospector for building stone, however much the paleontologist may grumble, for the presence of fossils, especially if they be large, is an objectionable feature in quarry rock.

The following notes, showing the chief points in the State where sandstone out-crop, are taken from all the Indiana Reports up to date and here digested for the convenience of persons interested in the subject. I have thought that by thus condensing and sifting the matter scattered throughout the reports all the information relating to building stones could be so arranged as to be of immediate and permanent value to investigators of this important part of our State's material wealth. The notes represent the labors and discoveries of Professors Owen, Cox, Collett and Gorby, with the aid of their able assistants during many years. To these notes I have added my own researches which have been prosecuted all over most of the areas described.

In the twelfth report of the department of Geology and Natural History, Prof. Collett says: "The sandstones of Indiana occur in a broad belt from the Illinois line, in Warren County, south and southeast through the counties of Fountain, Vermillion, Montgomery, Parke, Putnam, Clay, Owen, Greene, Martin, Pike, Dubois, Orange, Perry, Crawford and Harrison, to the Ohio River. This is the conglomerate sand-rock, forming the base of the Coal Measures, and the same as the sandstones so famous in Scotch and English architecture; and, although irregular in color and physical characteristics to some extent, presents a great bed of building material, frost, fire, and water proof, and of practical value for permanence and solidity. In these beds, in Warren, Orange, Lawrence, Crawford, and Harrison Counties, are found extensive and valuable bands of grit stones, of great utility for grindstones, as well as quarries of the "Hindoostan" whetstones, so favorably known in all the markets of the civilized world.

"The sandstones of the Coal Measure proper, while not fully up to the above, are yet extensively used for foundations, piers and hammered masonry. In the Sub-Carboniferous formation, the sandstones of the Chester and Knobstone groups are well developed, easily accessible, and merit the local favor and reputation they sustain."

The Conglomerate, however, is often too coarse and porous for building purposes, and sometimes it is soft and clayey.

In Clay County the sand-rock, which forms the rim and base of the Coal measures, makes the best of fire-proof and weather-proof stone for foundations, piers, and hammered masonry.

This stone is of a bluish white color and is a hard, coarse-grained sandstone which presents a fine appearance in buildings. On South Otter Creek in quite a number of places, also in other parts of this county, there are a number of exposures of this valuable stone.

In Raccoon Valley, Parke County, in place of the seam of coal number three, there is a seam of sandstone forty feet deep. Although in this ravine there is but a ten or fifteen foot exposure, a short distance south it is exposed the full forty feet. This is a good building stone and can be quarried in convenient size and shape, and will dress well under the chisel.

There is a fine exposure of Carboniferous sandstone or mill-stone grit at Roseville.

There is also at Roseville, a large showing of the Conglomerate sandstone. This stone comes soft from the quarry, but hardens on exposure, thus making it a very desirable building stone. Some of this sandstone is of a beautiful pink-brown color; other specimens show a striking variegation of soft brown and gray tints. In Fountain County, there is an inexhaustible supply, almost, of superior quality of building sandstone. Great bluffs of this stone are at the narrows of Mill Creek, again on Clifty Creek, near the northern margin of Scott's Prairie, it out-crops, but it develops into high bluffs on the east fork of Coal Creek at Hillsboro. Again at Dry Run (sec. 33, town. 19, range 17), and at Stone Bluff (sec. 8, town. 20, range 8). Again after a disappearance of five miles it appears in Shawnee Creek near the junction of Little Shawnee and extends to the mouth of the creek.

The calciferous sandstone, which is exposed along the streams of Davis Township, will make a reliable building material. In sec. 33, town. 22, range 7, an out-crop of a coarse-grained light gray sandstone, apparently very good in quality, was observed. This stone is soft at the quarry, but is hardened by exposure; it has both a horizontal and a vertical line of cleavage, and splits readily into blocks of convenient size and shape for building purposes. It is especially adapted for heavy masonry, foundations, etc.

The high bluffs of Shawnee Creek in Shawnee Township offer an almost inexhaustible supply of a very fine quality of building stone.

The rock forming the lower strata of the conglomerate sandstone is a pure white, caused by it being composed of pure quartz grains, and is indestructible on exposure, though owing to these particles lying loosely cemented in the quarry, it is mostly rendered unfit for use when quarried by blasting; it would be far better quarried by the use of steel wedges. This stone embraces some six or seven strata of from two to three feet in thickness. This stone also, owing to its being so easily crushed when fresh from the quarry, would possibly make good glass.

The out-crop of conglomerate sandstone on Dry Run, in the extreme northern part of sec. 33, town. 20, range 8, also the out-crop at Stone Bluff, sec. 10, same town. and range, would make a durable building material. (Van Buren Township).

On the river face of Silver Island sandstone of good quality is found, though some of it has a blue tinge; this should not be used in exposed places. The lighter colored strata is a good reliable stone. Thus we see that in Fountain County there is a wealth of inexhaustible sandstone suitable for every purpose as a building stone, both in color and grain. We would call the especial attention of prospectors to these deposits.

In Warren County the sandstone which overlies the Sub-Carboniferous group is a massive, coarse-grained, ferruginous, micaceous, Conglomerate, admirably workable. Beginning in the northwestern portion of the county, this fine stone extends in a westerly direction with a slight dip to the west bank of Pine Creek, where the dip to the west and southwest suddenly drops at a rate of from twenty to thirty feet per mile. There are fine exposures of this stone along both sides of Pine Creek, on Kickapoo, at Williamsport and in the bluffs near the mouth of Redwood Creek. The stone of this county presents a most beautiful variety of colors; gray or brown on Redwood Creek; gray to yellow or straw color at Williamsport; white, gray, red, "bar stripe" and "bleeding-stone" on Pine Creek, and black, red or yellow near Milford. Most of this stone is soft in the quarry, but hardens on exposure, and will last for ages, making in every way a desirable building stone.

In Owen County the Conglomerate runs in a broad belt across the county from the northwest to the southeast corners. This stone is massive bedded, soft in the quarry, splits easily into blocks of any desirable size, dresses readily, hardens on exposure and is altogether a durable fire and waterproof building stone. In color it is a buff or brown.

There is no scarcity of good building stone in Greene County. The strata of this stone is from six to thirty-six inches thick. In color it is a brownish-gray or cream-color and is fine or moderately fine-grained, and can be split into blocks of any convenient size.

Vermillion County has no lack of building stone. There are some rather heavily bedded, slightly ferruginous sandstone in the hill between the mouth of Brouillet's Creek and Clinton. Along the little Vermillion, below White's Mill there is an exposure of fine building sandstone. This exposure is from four to nine feet in thickness, though some of the accompaning layers, while they appear solid in the quarry, are worthless on exposure.

Some of the stone in the beds of "Millstone grit" contain mica in such quantities as to make it appear as if it would make good furnace hearths.

There is a massive sandstone overlying the coal bed in the hills north of Washington, in Daviess County. This stone will probably make a good building stone for some purposes. It is, some of it, of a reddish-brown color, marked with spots of a deeper red; other parts of it are of a uniform chocolate color. Sandstone of excellent quality is also found in Martin County. This Conglomerate sandstone, where it is free from iron and pebbles, is an excellent and durable stone, which may be quarried in blocks of any convenient size with but little expense after the quarry is opened.

There is in Putnam County a light-gray, fine-grained sandstone, which is easily worked and is a durable and beautiful stone, but as to the quantity I am unable to state, since it has not been fully developed. It closely resembles the deposit in Parke County.

In Vigo County the sandstone which is found above and below the Coal Measures is of sufficient thickness and durability to make foundations, though it is not strictly a reliable stone. In the bluffs along Coal Creek, in Fayette Township, there is, however, a thin layer of good, durable sandstone. It is a bluish-gray, fine-grained stone, which rings when struck, and will present a fine appearance in a building.

The sandstone of Pike County spreads out in every direction from Pikesville. This stone furnishes the best of material for masonry. The outcrops show that the stone will withstand the air and moisture. It is a fire-stone, and will make good hearths for furnaces and ovens.

At Merom there is an outcrop of "Merom sandstone." This stone here seems to weather much better than it usually does. The stone-work in the Christian College on Merom Hill is made from stone quarried from the ledges north of town.

Perry County is indeed fortunate in the amount of its good building material, which may be so readily quarried and sent to market. The high bluff of sandstone along the Ohio River front, which reaches from Cannelton to Rock Island, is formed in a series of layers, two of which, averaging from twenty to forty feet in thickness, will furnish excellent building stone. Blocks of any thickness may be quarried from these layers. The upper layer of stone is much superior in quality to the lower, which is apt to have imperfections. The Catholic Church and other buildings at Cannelton were built from this stone. In color this stone is light brown; it is easily worked, being soft in the quarry but hardening on exposure. This stone has been used in a number of important places, and wherever used has given entire satisfaction.

In Lawrence County the sandstone in the eastern and western parts is only of fairly good quality. It is fire and weather-proof and will make excellent foundations and heavy masonry. This stone is in beds of from 50 to 120 feet in thickness.

In Knox County there are beds of red sandstone west of Wolf Hills and on the east of Pyramid Mound which is suitable for foundations and rough masonry; but in section 35, township 2, range 8, there is an unlimited quantity of good brown sandstone, suitable for hammered masonry. There is an abundance of sandstone suitable for building purposes in Brown County. This stone resembles the Waverly freestone of Ohio. In color it is buff or gray; it is easily quarried in blocks of convenient size, cuts readily into form for capitals, mouldings, etc. It is very durable and is fire-proof. Generally this stone is a sharp grit, is close-grained, homogeneous, and would make good grindstones or whetstones.

In the western and southwestern portions of Harrison County is found the Chester sandstone. The great beds which are exposed in the outcrop along the Blue River and the Ohio in Washington and Scott Townships contain stone which is excellent for foundations in exposed places. Though in some places in the outcrops huge masses fall down the cliffs, it is frost and weather-proof, the falling being due to the unstability of the underlying strata. There are extensive beds of sandstone in Crawford County which is an excellent stone for foundations and rough masonry.

The lower Chester sandstone in Orange County is in some places good quarry stone. The stone is a light tea-green in color. The upper strata make a good flagging stone, the lower make a good building stone. It is easily quarried and worked.

In Vanderburgh County sandstone is found in several parts of the county in layers of sufficient thickness to be quarried. It is well suited for foundations, etc.

From the northwest to the southeast corners of Owen County there is a belt of Conglomerate sandstone of from three to six miles in width. This stone is a heavy bedded or massive stone, which splits and dresses readily, being soft in the quarry but hardening on exposure; is a fire and water-proof stone of superior quality for fire-proof buildings, bridge abutments and foundations. In color it is a buff or brown, sometimes prettily variegated.

At Taylor Hill, in Bartholomew County, there is an outcrop of beautiful freestone which has an even, sharp angled fracture and splits well. This stone will make a superior water-proof building stone. Wall Ridge would furnish an abundance of good stone for building purposes.

About three or four miles southeast of Rensselaer, in Jasper County, section 33, township 29 north, range 6 west, there is a bed of coarse grit which is adapted to piers and heavy masonry.

In Morgan County nearly the whole county is underlaid with the Knob sandstone. The upper member of this formation is stratified clearly. In the highest member of this stone we find a bed of fine-grained sandstone from one to five feet in thickness. This stone is quite soft in the quarry, but when it loses its original softness it becomes quite hard and waterproof. The lower members of this stone are of a blue color, owing to the mixture of clay. Though in the quarry this stone is much more solid, yet it and all other members of this stone which show a blue color must be strictly avoided, as it is worthless when exposed. Occasionally small flecks of oxide of iron are observed in this stone, and may cause stains to appear when in a building. In quarrying this even the moderate blast will shatter the stone for a distance of fifteen or twenty feet, so as to practically ruin the stone. Outcrops of this stone appear on the southeast bank of the river from the mouth of Bluff Creek to Martinsville. In color the stone is generally gray, drab, or occasionally buff.

The sandstone outcropping along the banks of Stony Creek, in Hamilton County, is a most excellent stone for rough masonry. Over fifty years ago there was a quarry of this stone opened, and the exposure of all this time has not affected this stone in the least. This stone appears in the bed of White River above Strawtown, but owing to the difficulty of getting to it I was unable to test it. This same Pendleton sandstone appears at the falls of Fall Creek, in Madison County. This is very durable building rock, but is hard to quarry, as it is composed of quartz crystals, which make grit that soon turns the edges of the tools, and on the other hand these crystals are held together in such a loose way that blasting should not be attempted.

In Tippecanoe County there are but two exposures of Conglomerate sandstone. These two outcrops appear in deep hollows forming perpendicular walls forty feet high. These two exposures are about one mile apart. In quality and color these exposures are the same, both being fine-grained and firm, soft in the quarry, dressing into any desired shape. Both these exposures are near the Warren County line and are of the quality of the stone at Williamsport. These beds are too far away from transportation facilities to be quarried with profit at present.

The sandstones of Washington County are of good quality, but with such a wealth of the finest quality of limestone surrounding it, as is the case in this county, it can never have any great commercial value.

Montgomery County has in its western portion a magnificent display of massive heavy-bedded sandstone. The stone comes from the quarry soft and is easily shaped into blocks of any convenient size and shape. Some of the beds contain grits suitable for grindstones.

With the above notes to direct him any person interested in the quarrying of building stone will be able to find all the points where sandstone of good quality is likely to be found.

## THE LIMESTONES OF INDIANA.

We come now to consider by far the most valuable material for building purposes to be found in very large quantities in Indiana.

I have already stated that limestones are found in all the solid rock formations of the State, from the lowest outcrop of the Lower Silurian to the uppermost deposits of the Coal Measures.

From the nature of its formation limestone is less apt to have gross impurities in it than is the sandstone, though vast beds of clayey, silicious or ferruginous limestones are found everywhere so weakened by the presence of the matters indicated as to be worthless for building purposes.

Carbonate of lime is the substance of which the ideally perfect limestone should be formed; but this perfect purity is never found. In some specimens of our so-called oolitic limestone, however, the foreign substances amount to but about three per cent. of the whole!

Limestones bearing a considerable portion of the carbonate of magnesia have proved, in many instances, to be excellent building stones. They blacken, however, and are somewhat disintegrated superficially by exposure to the smoke of burning coal bearing sulphurous exhalations.

The finest form of limestone is marble, which may be of any color from pure white to a perfect black. Marble usually has a specific gravity of about 2.7 and its texture is more or less granular with a crystalline appearance on the edge of its fractures.

Next to marble in both beauty and susceptibility to perfect finish as regards application to architecture, comes the close-grained oolitic stone, so-called. I qualify the name "oolitic," because in fact there is no genuine oolitic limestone in our State. The appellation properly belongs to the oolite, a stone formed of minute balls or rolls of lime carbonate gathered about a small particle of a different substance. The oolite of Great Britain is found in a very different formation from that in which our celebrated limestone appears and its composition, although somewhat similar at a casual glance, is by no means the same. The name is good enough, nevertheless, and I see no objection to retaining it.

A careful examination of our oolitic limestone shows that, while it varies greatly in the nature and arrangement of its particles, its more striking characteristics are general and persistent. Shells, more or less minute

—scarcely discernible with the naked eye—and fragments of shells cemented by carbonate of lime, make up the entire mass. Indeed so meagre is the cementing substance that it is scarcely observable even with the aid of an ordinary pocket glass. This structure of the stone gives it the oolitic appearance, hence the name.

So far, very little attention has been given to studying the fossils brought to view by microscopic examination of this beautiful and durable limestone. My own work has been confined more particularly to an examination of the stratigraphic and structural conditions of the rock and to the economic aspects of the various outcrops of its deposit. It belongs geologically to the St. Louis division of the Sub-Carboniferous formation, and, as will appear when I come to speak of it more fully further on, it would seem to owe its most interesting peculiarities to the special conditions under which it was deposited.

The Devonian limestones of Indiana fit for building purposes are largely confined to the so-called Corniferous beds, though here again the name is misleading. Much of this stone is a friable, refractory sort of limestone, cherty and unequal in texture; but in many places it is workable and turns out a really admirable product of the quarry, especially for rough masonry.

The Upper Silurian formation, the Niagara limestone particularly, furnishes beautiful flag-stones, and a great deal of very hard and durable material for building. The Lower Silurian, too, affords excellent stone.

The limestones of the Coal Measures are not, as a rule, good for fine masonry, being crammed with fossils and often heavily loaded with iron. Moreover, they rarely persist over large areas, and are seldom so situated as to be worked to advantage even when they are of comparatively good quality.

It would be scarcely profitable to take the time and space necessary to a detailed description of the many hundreds of points in Indiana where limestone of more or less value for masonry is to be found. I have thought it best to confine myself to a study of the areas and outcrops which, so far as we now know, present the most certainly profitable materials.

The line of outcrop of any formation—the Lower or Upper Silurian, Devonian, Sub-Carboniferous or Coal Measures, for instance—is always the index which should guide us in our explorations. It is along this line of outcrop that we may easily discover the true nature of the deposit in any stratified formation, and thus determine the value of any particular part of it. In those counties where the Lower Silurian rocks put forth, we may easily learn the nature of the strata; and so of any other formation. Beginning, then, in the extreme southeastern corner of the State and working our way westward and northward, we shall find the outcrops of limestone in the following order:

1. Lower Silurian (Hudson River).

2. Upper Silurian (Niagara).
3. Devonian (Corniferous).
4. Sub-Carboniferous (chiefly the Oolitic).
5. Coal Measures (unclassified).

These formations come to the surface, one after the other, in the order mentioned, as we proceed.

I do not consider the Lower Silurian limestones of Indiana first-class building material for public buildings or for ornamental structures, but this must be taken as a general statement, to be modified wherever a special exception may arise. A great deal of good stone is quarried from this formation, and many more fine quarries will yet be opened with profit. Still, the large fact is that most of the limestone of our Hudson River rock is hard, refractory and unreliable for architectural purposes, save in foundations, rough walls, abutments, piers and the like, where it serves excellently. Dark gray, bluish and drab are the colors most common to this rock, though some of it has a creamy tinge. When it is good it cuts very well, hard as it is, and its appearance is beautiful.

The Upper Silurian presents in the Niagara limestone a large area of very valuable stone. No finer flag-stones can be found anywhere than are taken from this formation in many places. Excellent building stone for rough masonry appears wherever large areas of the Niagara are outcropping. A good deal of it is magnesian and may change color in weathering; not a little of it crumbles under the action of frost. Still, the well-informed quarry-master will be easily able to distinguish the reliable outcrops by the appearance of the exposed stone, which if good will retain its angles sharp and clear and show no discolorations. Wherever the Niagara is the surface rock good flag and rough building stone may be confidently looked for.

The Corniferous limestone of the Devonian formation is, as has been said, too often cherty and full of snarls and hollows to be relied upon, as a rule, for first-class material; but in many places intelligent examination will discover areas of thoroughly good stone for ordinary rough building purposes, and some of it is very beautiful indeed.

The foregoing three groups of limestone may be considered together in any general estimate of the building materials furnished by the rocks of our State, as they fall under much the same general description. They are not pure limestones as a rule, but often their impurities are not of a nature to destroy their value, merely restricting it and limiting the uses to which the material can be applied. Save in the foundations these stones should not be used in important buildings without the strictest tests to determine their qualities. Undoubtedly they are often found durable in the highest degree, but this excellence is not generally supplemented by other necessary qualities, to-wit, beauty of color, responsiveness to the cutter's tools, and tractability in quarrying.

It is when we reach the Sub-Carboniferous area that we discover the true wealth of Indiana's limestone. Here, indeed, the most wonderful and beautiful of the State's calcareous deposits lie almost uncovered and ready for the appliances of the quarry-master's trade. Its fame has already gone abroad over the world and the business of placing it upon the market is enlisting a large amount of capital, energy and skill. Year by year this industry is growing into importance second only to that of agriculture.

## THE OOLITIC LIMESTONE OF INDIANA.

The formation known as the St. Louis division or "group" of the Sub-Carboniferous deposits covers a large area in Indiana; but it is the surface rock of a much smaller space. Great interest has attached to it among collectors and students of paleontology owing to the numerous fossil beds it contains and to the variety and interest of the organic forms found therein. The St. Louis limestone is a general name given to the calcareous rocks of this division without reference to any particular quality of the deposit beyond the fact that it is limestone. No rock shows greater or more striking variations of composition and structure than this limestone. In one place it will be a "cavernous limestone," breaking up into crevices and caves, "sink-holes" and "pots;" at another place it will crop out in the form of a marly rotten stone full of fossils, while at still another place great vertical cliffs will prove it to be a solid, sharp-angled, durable building stone. All over its area, however, it shows a persistence of certain general features that render it not only interesting but easy to identify. Its fossils are so numerous and so well known that they are recognizable wherever seen.

The area in Indiana over which the St. Louis group certainly furnishes the surface rock may be roughly outlined thus:

Parts of Putnam County, Morgan, Owen, nearly all of Monroe and Lawrence, a large part of Orange and Washington, Floyd and Harrison. In Montgomery County there are a few outcrops. It may be looked for anywhere between the outcrops of the Conglomerate and Chester sandstones on the west, and the appearance of Keokuk and Knobstone formations on the east. In Montgomery County the Chester sandstones appear to lie directly over the St. Louis limestone, under which are found the crinoidal shales and limestones of the Keokuk. In Washington County, Professor Gorby, State Geologist, found a well-defined trace of the Burlington deposits, to which he called my attention during my own occupancy of the office. I have since had the pleasure of re-examining the ground and of tracing the discovery still further.

Along the line of the St. Louis outcrop from Putnamville southward to near the Ohio River is found the widely famous oolitic limestone. It lies in a narrow strip of country running somewhat diagonally from a northwesterly to a southeasterly direction, say from Greencastle in Putnam County to Salem in Washington County, a distance of about a hundred miles as the crow flies. The width of this strip varies, being from three to fifteen miles throughout its length. It lies on the eastern slope of the Wabash Valley until it enters Washington County, where the waters begin to flow directly into the Ohio. All the way along its western margin it is extremely difficult to trace the contact with superior formations and on the east the same difficulty attends any effort to outline exactly the contour of its area. The country is rolling and in many places quite abruptly broken. Outliers of superior strata crown the higher points and the weathering and tumbling down of great shelves which have been subsequently covered with residuary soil have rendered surface study very uncertain work. Along the bluffs that border the narrow valley of White River in the neighborhood of Gosport is an excellent region for studying some interesting features of the lower St. Louis rocks, and here the oolitic begins to show itself in perhaps its most instructive stage of progress from the compact and fine-grained gray and hard limestone of the northermost outcrops, to the creamy white, soft, even-grained, almost absolutely pure carbonate of lime which characterizes the outcrop farther south. All the way along the route of the L., N. A. & C. R. R. from Greencastle to Louisville this limestone frequently appears at the surface or protrudes in staunch cliffs from the hill-sides. The O. & M. and the I. & V. railroads cut this rich field across from east to west.

Every indication seems to be that the oolitic limestone has been deposited in deep sea water filling a basin whose shores are now marked by those lines where the rock is lightly, unevenly and irregularly bedded and formed of coarser and more loosely cemented materials than those of which the main body of the stone is composed. All along the most easterly fringe of the oolitic outcrop I have noted that this change from a fine and even grain to a coarse and loose structure is well marked wherever the rock has not been greatly weathered away or otherwise changed by extrinsic forces. In Lawrence County, as we pass eastward from the outcrops of most excellent quarry stone, we soon reach the straggling edge of the deposit, and find it taking on the coarser and looser structure. So it is in Washington County. These rough beds are much thinner, and bear every badge of being the approximate limit of an ancient shore line. Ripple marks and thin, broken strata of imperfect sandstone are the most reliable indicia of this fact. The fossils, too, are of larger species more likely to be preserved amid the debris washed up along the shallows of a shore line.

A careful examination of the oolitic limestone, under a glass, shows that it is oftentimes composed almost wholly of exceedingly minute shells (most of which appear to be nearly perfect), the mass held together by an imperceptible cement. This, however, is not true of all the stone. I have examined many admirably homogenous specimens from the best quarries, and found them largely composed of fine shell fragments and the perfect shells combined. There appears to be no marked difference in the quality of the stone on account of this variation in the structure, so long as the particles of which it is composed are small and of nearly uniform size throughout the substance of the specimen. From the neighborhood of Bedford, southward, the stone, wherever quarried, shows most of the excellent qualities of the Salem deposits of Washington County. Indeed, any of the quarries between Greencastle and New Albany will be found putting out material of the finest sort. It has been found satisfactory by the best architects of America for great public buildings all over the country. This, of itself, should be sufficient to urge the quarrying interests to the highest pitch of development.

## THE GEOLOGY OF THE OOLITIC BEDS.

It would be out of place, in this connection, to enter into any detailed, technical account of the geological conditions observable in the oolitic deposits. I purpose to present only such an outline as will enable the reader interested in the development of quarries to proceed intelligently to a study of this incomparably rich and valuable area.

The whole Sub-Carboniferous division presents a series of irregularly alternating strata, suggesting at once the periodic prevalence of deep and shallow sea waters over the face of the earth. As a rule the sandstones represent shallower seas than do the limestones, and wherever an old shore line is indicated the coarser and less compactly bedded sand rocks appear. Dirty shales, too, are often the silt deposited in the shallowing regions of receding seas. Rocks that contain deep sea organisms need not, however, be taken as altogether the deposits of deep waters. What processes have caused the destruction and precipitation of the millions of beings whose remains mark the substance of solid beds of stone must remain to us largely a matter of conjecture.

We can, however, apply certain general rules of natural philosophy in our attempts to reach general conclusions. It is well known that turbulent or violently agitated water will not deposit small objects held in suspension; but it is just as well known that still, or practically still, water will let fall even the finest particles whose specific gravity is greater than that of the water. The agitation of the seas by winds is superficial. Very deep seas are always comparatively still a short distance below the surface, even in the wildest storm, while the shallow seas are often violently stirred to their bottoms. This rule, then, may be taken as general: Shallow water will contain more matter taken up in suspension during boisterous weather than will deep water, and agitated water will deposit a coarser series of material than will still water; therefore, deep seas, being only superficially agitated, will continue to deposit all matter taken up in suspension, while the shallows will drop only the heaviest bodies. If this is true of seas now it was true of them in the days when the limestones of the oolitic region of Indiana were being deposited. Hence, I think that we may reasonably infer that the minute particles of calcareous matter composing this beautiful stone were dropped in place from the water of a deep and quiet part of the then existing sea. If this is true, and we find the stone shading off into a coarser and looser structure in certain directions, we may take it for granted that this condition indicates approach toward water shallower and, therefore, more easily agitated.

All the facts that I have been able to gather, by a good deal of patient investigation in the field, go to suggest that the oolitic limestone owes its fine and even grain, and its perfect cohesion of particles, to the special conditions under which it was deposited; and, in the main, these conditions were due to a deep, still sea, teeming with minute shell-bearing animal forms—a sea whose shores were lined with the deposits of still older seas of the Sub-Carboniferous age. It was from these more ancient rocks that the water took up in solution or suspension the carbonate of lime, which, when precipitated along with the animal remains, served as a cement to bind together those innumerable multitudes of minute shells which form the beautiful body of our far-famed building stone.

The well known fossil beds of the St. Louis rocks are usually found at places where the limestones are of coarse and loose texture, easily weathered down to a sort of marly residuum in which the organic forms are but lightly held.

The oolitic limestone, when found in massive beds, as in most of the quarries, is overlaid with a stratum of bluish or grayish blue limestone which does not weather well, and which, when exposed, rapidly falls to pieces under the action of rain and frost; hence, in many places the oolitic is found immediately under the residuary soil, formed by the degradation of this superior stratum.

The eastern and southern limits of the oolitic are often obscured by outliers of more recent formations, but wherever not thus hidden the rock will be found rapidly thinning out. Passing westward from the eastern margin the rock dips irregularly with the line of your progress, while it also thickens and assumes its characteristic evenness of grain and compactness of structure. Its western margin has not been located, owing to the fact that the rock soon dips far under the Coal Measures, and does not again come to the surface in Indiana. As to its northern limit none of the borings for gas passed through it anywhere north of Greencastle, in Putnam County. The St. Louis limestone of Montgomery County is the bluish stratum which overlies the oolitic, which is not here in place. The boring in Parke County did not disclose the presence of the oolitic deposits, though it cut the St. Louis rocks. The report from the wells sunk for gas and oil at Terre Haute, in Vigo County, shows that in passing through the Sub-Carboniferous strata the oolitic was not found. Indeed, all the facts point to an oblong basin or trough, for which I have proposed the name "Oolitic Basin of Indiana." In this basin lies the best building stone, granite aside, yet discovered in the world. The wealth that is to flow to the counties in which it occurs would appear fabulous were the true calculation made.

Geologically speaking, the oolitic limestone belongs to the lower division of the St. Louis group, to which has been given the name of "Warsaw Division" or group. It is in the upper member of this division, while the dark blue bituminous and often ferruginous limestone immediately overlying it belongs to the lower member of the upper division. Immediately under the oolitic is often found a dark blue crystalline limestone, usually a thin stratum, which, in turn, overlies a gray or whitish fossiliferous stratum, often of very loose texture, and crumbling to a "marl" on exposure to the air.

Toward the northern margin of the basin we find the oolitic passing by imperceptible degrees from its more characteristic composition of minute shells to a granular and even somewhat crystalline structure, though this latter extreme is by no means common anywhere within the area. Viewed at a little distance, its outcrops have the appearance of bold cliffs of heavy bedded gray sandstone, and the quarry blocks seen in transportation on the cars have this same granular appearance. One who wishes to study this stone in its various aspects of structure and deposit, will do well to visit, first, the quarries at Putnamville, Elletsville and Bedford; then he may go to Salem, in Washington County, where the stone takes on its extreme oolitic characteristics.

In the extensive quarries, near Salem, a complete and instructive section of almost the entire lower division of the St. Louis rocks may be seen at a glance, and in places the lower strata of the upper division are shown. The oolitic here is a massive, grayish white deposit, which, when cut through by the steam channelers, presents a bold, clean wall of almost marble beauty. I am far from saying that this stone is any better than that in many other oolitic quarries in the basin; but it certainly is the best exposure for study, from the geologist's point of view. From the dark bituminous stratum, or layer, which forms the lower member of the upper St. Louis, down to the singular blue crystalline layer underneath the oolitic proper, comparatively few fossils have been found, saving, of course, the minute shells that compose so large a part of the oolitic itself. This absence of characteristic fossils might lead to mistakes in identifying the rock where the structure could not be clearly made out. Fortunately, however, the many and extensive quarries scattered over almost the entire oolitic area have rendered such service in tracing the deposit as to leave all doubt behind.

My own careful survey of the oolitic field authorizes me to say, with perfect confidence, that nowhere in the United States, perhaps nowhere in the world, is there so large an area over which so thick, so persistent, and so admirable a building stone appears so near the surface, and so well suited to the operations of the quarryman.

## QUALITIES OF THE OOLITIC LIMESTONE.

Architects, builders and contractors will, of course, examine for themselves before adopting any material in buildings for which they are responsible. The writer of this paper has designed and superintended many considerable public works wherein stone was largely used, and can, therefore, speak with experience as his guide. But while the experienced architect, engineer or contractor must at the last depend upon his own tests, there is much to be saved by an acquaintance with the facts and observations of others in any particular field of inquiry of interest to the profession to which he is devoted. Hence it will be always apparent that the most successful men are those who gather information from every available source.

It is unfortunately true that geological reports often lack just the practical quality which would render them of greatest value to practical men. Mere "science" too often clothes itself in a cloak of technical reserve and bookish mustiness, instead of joining freely with the spirit of material progress. Still, it is but just to say that in many instances science has lent a strong hand to the world's practical workers, and geology, if heretofore a trifle behind in this, is gradually coming to the front.

Turning now from a survey of the oolitic field to a practical consideration of the qualities of this superb stone, as a building material, let us view it from the standpoint of the architect and civil engineer.

In a former report on this subject, when I had given it comparatively short study, I said that in cretaceous chalk, formed so largely of foramenifera, the mass is loosely deposited and feebly cemented, as a rule; but the oolitic limestone, though coming comparatively soft from the quarry, has a peculiar toughness and density, and withal a dryness, which render it a puzzle to every examiner. These features are due to the semi-concretionary nature of the structure, resulting from the coöperation of affinity and gravitation in the arrangement of the matter. The stone is granulated, rather than crystalline, in every particular, and yet, under the microscope, the grains show a nicety of correspondence—a perfect fitting, so to call it—which is the secret of resonance, elasticity, flexibility and non-cleavage. The following analysis is a fair average of the true oolitic limestone:

| | |
|---|---|
| Specific gravity . . . . . . . . . . . . . . . . . | 2.72 |
| Lime . . . . . . . . . . . . . . . . . . . . . . . | 53.55 per cent. |
| Carbonic acid . . . . . . . . . . . . . . . . . . . | 43.33 per cent. |
| Water . . . . . . . . . . . . . . . . . . . . . . | 56 per cent. |

to which must be added a trace of magnesia, iron, alumina, manganese, phosphoric acid, silica, and possibly a trace of another mineral not distinguishable, all in practically equal parts, and amounting altogether to 2.56 per cent. of the whole. I may remark that in the true oolitic the trace of iron is never observable, save by chemical analysis, it never in the slightest discolors the stone by oxidizing. The above analysis was of rock recently quarried.

Chemically speaking, then, the oolitic limestone is practically a pure carbonate of lime, the amount of foreign matter being often less than 4 per cent. of the whole. In other words, in the best specimens the carbonate of lime constitutes nearly 97 per cent. of the stone. It is flexible, elastic, resonant, uniform in its grain, equally strong in every direction, perfectly homogeneous in fact. These qualities give it the best possible power of resistance to strain or to crushing force. A bar of this stone may be bent very perceptibly, and when the force is removed it will spring back to its normal state with the promptness and energy of steel. Its tone, when struck, is a clear, musical bell-note, indicative of thorough metallic sympathy throughout the mass. This quality of perfect resonance, taken in connection with the fact that the stone cleaves nowhere save directly in a line with the cleaving force, gives the best evidence of an evenness of grain and a smoothly distributed cohesiveness of particles throughout the mass When first quarried it cuts like a sandstone, yielding readily to tools of all kinds. It is then soft, and yet tough enough to hold well the finest figures of carving. It comes from the quarry cut by the steam channelers into blocks, or quadrangular columns, six by ten feet, and a hundred feet long if desired. Its color at first is a pale brownish, which gradually lightens to a soft cream or grayish white.

Physically, the oolitic is in fact a calcareous sandstone composed in chief of small grains of carbonate of lime. It occurs in massive bodies, often sixty feet thick, without any lines of cleavage or parting, perfectly bedded, homogeneous throughout, a solid stone, in fact, from which a flawless block of any size, possibly manageable, may be cut. It takes up a very small amount of moisture, which is so distributed that no degree of heat or cold will work injury. When we consider to what awful and prolonged frigidity of temperature this rock was exposed during the glacial age, without in the least affecting its integrity, we may safely trust it in our buildings. Other limestones were cracked, shivered, crushed under the compressions and expansions of the arctic period, while this massive deposit was scarcely changed in any part of its great body.

Any architect or builder, any engineer or contractor, will say at once that, if this is a true description, the oolitic limestone is certainly a wonderful product of nature, and fitted, in the highest degree, for a cheap, beautiful and durable building stone. The best practical demonstration of its durability is given by its own angular cliff walls, which have stood exposed for hundreds of centuries, probably, without loosing the sharpness of their corners or the smallest inequalities of surface.

It has been subjected to every test by the most expert professional architects and builders, who have uniformly recommended it, and fortified their recommendations by using it in the building of some of the most important public works of recent years. State-houses, court-houses, churches, extensive business blocks, and stately private residences, have been constructed of it from New York to New Orleans, and from Chicago, Indianapolis and Louisville to all the smaller cities of our country east of the Rocky Mountains. This is a fact of value—it is one of the strongest possible invitations to an examination of our field—for certainly there can be no better judges of building stone than the architects whose business it is to plan and erect our most pretentious edifices.

The Capitol at Indianapolis is a structure of which any State should be proud. Its exterior walls show to excellent advantage the qualities of the oolitic stone. Although the building is not advantageously situated, as regards its site, yet its beauty is greatly heightened and the lines of its elevations are strengthened by the suggestion of solidity and permanence which the immense blocks of warm, gray stone enforce upon the observer. Were this superb edifice upon some considerable elevation, like that occupied by the State-house at Nashville, for instance, the remarkable suitability and beauty of its material would be demonstrated to even the casual glance.

Our Indiana oolitic limestone, though not the geological equivalent of the celebrated oolite of the British Island of Portland, resembles it in many particulars. It has the advantage of the Portland stone in coming softer from the quarry, and it is fully equal to it in other qualities. The famous Sir Christopher Wren chose the Portland oolite in building St. Paul's Cathedral. Time has proved that his choice was the very best that could possibly have been made.

In both England and America, in cities where large quantities of sulphurous coals are burnt, the oolitic limestone has withstood the sulphuric acid of the fumes without the slightest damage. Sir Christopher Wren thought that exposure to the weather for three years after quarrying was a sufficient test of the Portland oolite. We have a much better test than this, for blocks of our Indiana stone have been lying for twenty years, near some of our oolitic quarries, without showing the slighest change from exposure.

Careful experiments have proven that our oolitic limestone withstands a greater crushing force than any other fairly workable limestone, and at this point it comes next to granite. Indeed it has ample resistance for sustaining double the pressure that any building walls would subject it to under the severest conditions of modern architecture. Its flexibility is truly wonderful. A square rod (sawn from the stone) two inches to the side and five feet long, will bend with an even curve and spring like a bar of steel. Its elasticity is equally fine, and a suspended piece of it will ring like bell metal when tapped with a hammer.

No stone cuts more easily and beautifully. When green from the quarry it can be cut or broken in any direction by proper care, and it responds readily to the cutter's tools without chipping or refractory scaling. Thus dimension stone can be prepared at the quarries ready for shipment at the minimum cost, and with but a trifling waste of material.

A visit among the quarries will be found of interest and value to every person in the least connected with architecture, engineering or contracting, while to the practical quarryman it will open a new field. It will not be long till all the oolitic beds will be in the hands of those who will reap a golden harvest from their development. Already the quarrying interests of that region are swelling to enormous proportions, but the amount of unworked deposits is almost incalculable. Indeed the stone industry of Indiana is yet in its infancy, compared with what it is sure to be within the next few years.

Within the last five years the growth of practical interests in the oolitic deposits has more than doubled, and day by day the quarried stone is reaching new fields of demand, and yet the industry is really in its infancy. I should be called a mere boaster were I to make even a low estimate of what is sure to be its future development. Substitutes may be found for coal, for iron, for brick, for wood, but as the years go by the use of stone as a building material must continue to increase. No nation reaches its meridian of civilization until it enters the stone age of its architecture.

One of the chief points in favor of our oolitic deposit, is that it lies so near the surface over such a large area. Every quarryman knows that the most considerable item of expense in taxing out building stone is that incurred on account of removing overlying masses of earth or rock, an operation which is technically called stripping. Of course, the expense is still greater when the stone must be mined by means of shafts and the like. In very many places in Indiana the oolitic stone lies on the surface or is covered by only a slight deposit of soil or superior rock. This makes a minimum of cost to the quarryman in getting his product ready for delivery.

When we are calculating the future value of our building stone, the readiness and cheapness with which it may be put upon the market, is a most important item of the reckoning. In France, Germany and England the quarries are often extensive underground mines, whence the stone is brought at the maximum of labor and cost, and as compared with our own quarries show the wonderful advantages we shall have when we shall have reached the era of permanent building. Thousands upon thousands of acres of oolitic limestone lie just at the surface in nearly all the counties heretofore mentioned in this paper.

There is yet another feature of the oolitic rock that remains to be mentioned. It is massively, evenly and notably uniformly bedded. Its layers are rarely less than ten feet in thickness, often they are from twenty to sixty feet with scarcely a seam or variation of the grain. These layers are wonderfully persistent and even, like a smooth floor or table of the beautiful material. The elasticity and flexibility of the stone has made it proof against earthquake shocks, the action of intense extremes of heat and cold, and the pressure caused by any settling of the earth's crust—forces which have crushed the stones of other formations into fragmentory condition, as may be observed by the most casual student of our rocks.

A large part of the oolitic area is a decidedly rolling or broken country, the rock outcropping along the hillsides or in the jaws of shallow ravines and hollows. Often these ravines show that they have been formed by extensive sheer fissures through the rock, and one or the other, sometimes both, of the ragged jaws stand forth just as at first exposed, the sharp points and corners still unchanged. These walls, wherever the cliffs chance not to be subject to the drippings from overlying formations which may be ferruginous, show a clear, soft gray color, rarely tending to a bluish or brownish tint. It is often the case that a perishable stratum underlying the oolitic, has been destroyed by the action of water, thus causing the beautiful, even beds of this fine stone to fall, as so often happens with other limestones in the St. Louis formation. Owing to this accidental feature, the oolitic will be frequently found lying at a considerable angle of inclination against the side of a hill with a heavy talus or earth-slide overlying it. This has not seldom given rise to mistakes touching the true dip of the stone. If a local trend of this sort be followed a little way, the proper position of the rock in place will be found, and the dip will be usually very slight and westward.

Thus, in pursuance of the design suggested to me by the State Geologist, I have, as briefly as was consistent with a fair presentation of the subject, set forth the claims of our State in the matter of stone for building purposes. There remains, however, a consideration of the use of stone in the preparation of lime, cement and other artificial aids to building. This might well be the subject of a separate paper, but for many reasons it will be easier to consider the subject here, and to the student of our State's resources such a course will afford a more connected system of examination, as it will obviate the necessity of referring from one paper to the other in order to fully understand both. Moreover in many of our most extensive limestone quarries the manufacture of lime is profitably connected with the quarrying operations.

### INDIANA LIME.

The use of lime in building is so universal that no general explanation of its importance need be here made. In all structures of brick, or other artificial stone, it is the chief ingredient of the mortar in which the material is set, and its use for plastering the inner walls of houses, even those of wood, is well nigh universal. This large and constantly increasing demand for lime makes it one of the staple articles of commerce and one of the chief products of our limestone deposits, and adds to them a value which must increase as the years go by. The output of this necessary building material in Indiana is very large, and the quality second to none in the world.

As a rule limestone is best for burning into lime when it comes nearest being a pure carbonate, but before it is fit for use the lime thus produced must be mixed with sand in about the following proportions:

Taking thirty-five pounds of pure lime add three and a half cubic feet of clean sand and mix with one and a half cubic feet of water, the result will be three and a fourth cubic feet of lime-mortar. Two parts of sand to one of lime is a formula which gives very good results for ordinary purposes.

Mortar of this sort, however, will not stand the constant contact of water, and should be used in only those walls that are not exposed to such contact. Indeed it is a rule that mortar made of pure lime and sand will not set in water so as to become hard and durable. Hence the demand in all hydraulic operations for a mortar made of impure lime which in commerce is known as hydraulic lime or water lime, and which is the base of the best hydraulic cements.

Pure grades of lime, or those called pure, are burned out of limestones in which the carbonate of lime is the chief constituent. The product is nearly a pure white in color and has a soft, fine grain. When exposed to the air it rapidly absorbs water and falls into a fine, dust-like powder, known to chemists as hydrate of lime, and popularly called slacked or slack lime. In turn the hydrate of lime, after long exposure to air, absorbs carbonic acid and gradually forms itself into a mixture of single equivalents of hydrate and carbonate of lime.

The limestone of Indiana suitable to the manufacture of lime is found in so many places that it would be impossible to enumerate them. It might be said that wherever a good pure limestone is found there can lime be made.

The process of burning limestone to produce quick-lime (oxide of calcium) need not be here described. The elimination of the carbonic acid gas by means of heat is done by the use of kilns in which the stone is subjected to fire intensely hot. Stone freshly quarried calcines more readily than that which is less hydrous. It is economy, therefore, to quarry and break the stone no faster than it can go into the kiln.

The vast areas of excellent limestone in Indiana must attract the attention of lime manufacturers, and continue to be a source of increasing prosperity to the State. I have felt that this brief allusion to a subject so closely allied to that of building stone might be serviceable in attracting attention of capitalists to a most promising field.

### HYDRAULIC CEMENT.

It has been very long known that carbonate of lime containing a large admixture of clay would, when calcined, show little of the property of quick lime, known as slacking. In other words, if the lime product contained 25 to 35 per cent. of clayey impurity it was found that it would not heat in water, and would not slack well. The product was hard, but when ground fine and made into mortar by the admixture with it of water and sand, it would set speedily, and be impervious to water. If the clayey impurity go beyond 35 per cent. the rock, when burned, is spoiled for hydraulic purposes if not supplied with a sufficiency of lime after pulverization.

As a general proposition, it may be said that hydraulic cement must be composed of carbonate of lime and silica, carbonate of lime and silicate of alumina, or carbonate of lime and magnesia. It has been found by experiment that carbonate of lime, mixed with gelatinous silica, forms a good hydraulic cement. Furthermore, it is known that it spoils the hydraulic property of this lime if it be calcined at a heat greater than is barely necessary to eliminate the water from the clay and to expel a greater part of the carbonic acid from the carbonate of lime.

While neither of the ingredients of water lime will, by itself, set in water, it is easy to make a good hydraulic lime by calcining carbonate of lime and silicate of alumina together at a low heat.

After calcination, the silica in the lime is acted upon by acids, resulting in a gelatinous product called gelatinous silica. This is a good test of the hydraulic properties of a silicious limestone.

The presence of iron in the clayey limestone greatly adds to the hydraulic property of the product, for the larger the quantity of iron and alumina, up to a certain limit, the more readily will the substance take on the required stage necessary to a good cement. When the heat of the kiln is too intense vitrification takes place, while, if the temperature of burning is too low, the result will be that the silicates will not be rapidly formed, and the mortar will not harden without the assistance of water.

The best limestones for the production of hydraulic lime are those composed of carbonate of lime, silicate of alumina and iron, all evenly commingled. Some of our magnesian limestones will turn out an excellent quality of cement.

The difference between quick lime and lime suitable for hydraulic purposes, may, in short, be thus defined: Quick lime, when subjected to the action of water, rapidly falls to an impalpable white or grayish white powder, while hydraulic lime slacks slowly without any great generation of heat. Moreover, the hydrated silicates thus formed are not subject to the effect of water, but pass from a soluble to an insoluble condition.

Professor Gorby discovered large quantities of impure limestone in Washington County which he pronounced first-rate for the production of water lime.

This is a subject which will repay much further examination by the Geological Department of the State. The need of a well-equipped laboratory is keenly felt by the person called upon to do extensive scientific work for the State. There can be no doubt that a series of well-conducted chemical examinations extended over a series of years would do more than almost any other work to add new impetus to the material development of our great commonwealth. The cost of a laboratory and the conducting of it would be comparatively small and the outcome could not fail to be valuable.

## HIGHWAYS OF STONE.

In concluding this report I deem it proper to call attention to the subject of streets and country highways, which, as our State advances in wealth and physical improvement, must be built of stone in one form or another. Already we are taking steps in this direction. Many of our cities are laying down permanent pavements, and in not a few counties the highways are being built of gravel and broken stone, to the lasting comfort and welfare of the people. It has been said that the enlightenment and prosperity of a country may be read in its public roads. Certain it is that the value of real estate depends largely on the facilities for marketing its products, and good roads are the chief of these facilities. The graveled roads of Indiana and the limestone turnpikes of Kentucky are standing evidence of the effect of good highways on the development of a high state of agricultural prosperity.

It needs no labored essay to point out the inexhaustible supply of gravel and limestone in Indiana suited to use in making permanent roads. The whole Drift area has its beds of gravel, and wherever limestone is outcropping the "metal" for the superstructure of imperishable highways is at hand.

Public schools and public roads are the twins that need to be carefully nurtured by the State.

# THE QUARRYING INDUSTRY IN INDIANA.

From the tables and descriptions of quarries appended to this report, it will be seen that the amount of capital invested in taking out and working the building stone of Indiana is in the aggregate very large. Moreover the facts as tabulated show that the quarrying industry gives excellent returns in profits upon the money, skill and labor expended thereon.

It will well repay every person interested in this subject to give this part of our report a careful examination, as it constitutes a practical exemplification of what can be done on both a large and a small scale in the matter of developing the exhaustless treasures of our greatest material wealth.

So far, although much has been done, the quarrying business is in its early infancy in Indiana. As compared with the possibilities of what is actually in sight, the stone taken out is like a drop from the sea; it cannot be missed from the almost inconceivable extent of material from which it is drawn.

Of course the statistics here collected and arranged can not be called exhaustive, and there may be cases in which the figures are not exact, but the greatest pains have been taken to approach absolute truth as nearly as possible. In a few cases men were unwilling to give such details of their quarry workings as would render our report altogether satisfactory, yet as far as they go our statements may be relied upon as containing nothing but facts. We have rejected everything that could not be strictly authenticated.

It will be seen that along with our information touching the limestone industry of the State we have offered all that could be gathered in this connection with regard to the lime product, especially in cases where quarry-masters were interested in kilns. It is a matter of wonder that lime burning is not on a larger scale than it is now in this State. Nowhere in America can there be found stone better adapted, more plentiful or in a condition to be more easily and cheaply handled for this purpose. Fuel, too, is always at hand and as cheap as anywhere in the country.

By a glance at the map, after referring to these tables of quarry products, the reader will be better able to understand the location and area of the most important of our building stone deposits. The large body of the stone lies south of the center line of the State. The best limestone forms an irregular figure on the map's surface east of the Carboniferous outcrops and west of the Devonian; that is, it forms a large part of the southermost Sub-Carboniferous area, and is chiefly confined to the St. Louis deposits. The sandstones, which have not yet received the attention that is due them, are mostly contained in the Lower Coal Measures and in the upper Sub-Carboniferous rocks. They are of all shades of color between white and dark red; some specimens show curious and beautiful variations. The exceeding ease with which the sandstones can be quarried and their fireproof qualities are great recommendations of their value, but the fame of the oolitic limestone and the demand for it all over the United States have kept attention turned from the sandstones.

In collecting the facts contained in the various tables Professor Benedict has used every effort to obtain in each case a full statement from the quarry-master or his acting representative. It will be seen that some of the informants were very kind in furnishing all that was asked, while others either could not or would not disclose anything more than the most meager general statements of their affairs. Many persons are slow to appreciate the value of advertisement in business. The reports of this department are published for free circulation; they go into the hands of inquiring, investigating, progressive people all over the enlightened world, and it will be a great thing for the material wealth of Indiana when the citizens of our State learn that it is the best policy to help in every way to spread abroad in the world a knowledge of our mineral, agricultural and manufacturing wealth. There is a reciprocal law of compensation in the conduct of affairs based upon generous principles. The farmer may have no quarry rock on his lands, but if his neighbor own a quarry the value of the stone reflects its virtue upon the farm, because industry and increased varieties of production increase population and comsumption, and thereby add an increment to the value of farm and farm produce. In a word every citizen of Indiana profits by the thrift and prosperity of every other citizen. The more Indiana's inert wealth of mineral is advertised abroad the sooner will come that increase of capital and population upon which the progress of development depends. Diversified labor is the safety of labor in general. The more avenues we open to wealth the more active will become both labor and capital, each new source of industry adds energy to all the older ones.

Within the past ten years the advance in the development of Indiana stone quarries has been wonderful, especially in the oolitic region where lines of railway intersect the very best deposits of this incomparable limestone. Many miles of track and siding have been laid both by the railway companies and the owners of the quarries, so that most of the material is now cut by steam drills and channelers, hoisted by steam derricks and loaded directly on the cars by the most approved steam-driven machinery. Where a few years ago there were but the beginnings of a crude system of industry, there are many well-organized, thoroughly equipped and admirably managed companies carrying forward immense quarries and far-reaching commercial connections. Not a little of this valuable growth and welcome activity has been due to the researches and reports of this Department. It has been the constant practice of the chief and his assistants to keep before the minds of the scientific, the commercial and the manufacturing world all the discoverable facts in connection with all the undeveloped resources of the State, and among these building-stone has filled a large space. Never till now, however, has the Department been in condition to give anything like exhaustive study to this particular subject and to make a report covering so large a part of the facts most interesting and valuable to those who wish to investigate with a view to investment.

The amount of land now owned by individuals and companies engaged in quarrying, although large, is as nothing compared with the area still open to development. True, much of the best stone is situated at some distance from any railroad line, but to most of it switch lines or tramways could be easily laid, as has already been done in many cases. This will always pay where the quarrying is to be done on a large scale, and where the stone is found to be of the best quality, and so deposited as to be exceptionally easy to take out.

So widespread and excellent is the fame of Indiana stone that the danger of overproduction from the quarries is not an appreciable element in the consideration of the future production and profits of the building stone industry. The demand for bridge stone, rubble, paving stone, flagging, dimension stone for city and county buildings, and for general architectural uses, is increasing all over the country, and must go on increasing as wealth accumulates and building gradually becomes a question of permanent investment rather than the hasty shift of present and pressing need.

Already the eyes of alert capitalists, looking out for a safe and promising security for money, are turned upon these fine stone deposits of Indiana, and many large tracts have been bought as a matter of speculation, and are held by men who will neither develop the quarries nor permit others to do it. Still the area is so large, and the stone so plentiful, that it will be scarcely possible for any combination of capital to control it all. The people are beginning to appreciate the value of these lands, and as the knowledge of the business of quarrying and putting the stone on the market becomes more general, the industry will be urged to its fullest activity. This, so far from interfering with agriculture, will be a great stimulus to it. Wherever a mining or quarrying point is established, there will be a local center of consumption for farm products and a source from which money will be circulated freely. Many localities have already sprung into unprecedented prosperity on this account, especially in the oolitic region.

By reference to the lists it will be seen that, although not complete, they show that about two hundred firms, companies and individuals own quarries in the State, and many of them are operated on a very large scale. These, if evenly distributed, would give more than two successful quarries to each county in the State. Surely this is a most important item of our material prosperity, and when we remember that it is largely due to recent development it ought to be a matter of interest and pride to every citizen of Indiana.

The following tabulated statement will show some valuable facts:

| | |
|---|---|
| Amount of capital invested in quarries in Indiana | $4,294,943 |
| Number of engines in quarries | 129 |
| Number of laborers employed | 4,334 |
| Total amount of wages annually | $2,171,375.10 |
| Annual output of stone in cubic feet | 20,649,276 |
| Number of bushels of lime annually | 1,821,580 |
| Value of annual output | $3,312,446.70 |

It would be interesting, if it were possible, to give a statement showing the scope of the commerce in stone from Indiana, but we can only state that our best building stone now goes into almost every State east of the Rocky Mountains, and that costly and enduring monuments attest its superiority at the very gates of all the other most celebrated quarry fields. It is carried triumphantly beyond the marble regions of Tennessee and the granite of Georgia, over the limestone ledges of Alabama and into the central cities of Texas. Missouri calls for it, Chicago must have it and does have it every day in the year; Cincinnati, New Orleans, Philadelphia, New York, Atlanta, and hundreds of smaller cities and towns are using it freely in preference to any other stone. Its use is its advertisement, for wherever it is seen in a building its superiority is not to be overlooked or discredited.

The system of quarrying adopted in all the best quarries of Indiana includes the use of all the latest improvements in machinery. The old slop process of hand drilling and hand derricks has been discarded, as a rule, even in the smaller quarries, though there are exceptions. Steam has been applied to nearly all the operations of drilling or channeling, lifting and loading, as well as sawing and planing. Any one of the large quarries is well worth visiting by those who have a desire to know how the business of quarrying has progressed since the days of hand-drill and blasting powder, crow-bar and skid, hand-tackle and ox-team wagons. By the use of the steam channeler monoliths of any size are cut out, from cubes of four feet square to rectangular blocks sixty feet long by ten feet square in the cross-section. After these are taken out they are sawed to dimension by steam and carved into any desirable form. By examining the face of the stone exposed in the perpendicular walls of a quarry one may have the basis for making a rough estimate of the immense money value of all the building stone in Indiana. Often these walls show a thickness of from twenty to sixty feet of solid stone. Now, an acre is 43,560 square feet; make it 40 feet thick and you have 1,742,400 cubic feet to the acre. In many places the cost of quarrying is the minimum, as the stone shows at the surface of the ground, making the stripping very light and the lift short. The reports on the different quarries afford a safe basis for a good approximate calculation of the profits to be made in the quarrying business when carefully conducted. Of course the price of labor, skilled and unskilled, varies, and the nature of the stone, its situation, etc., must affect the first cost of production, but the price of the building stones of varies kinds has been always high enough to insure good returns upon intelligent effort. Indeed no property in Indiana is to-day more certainly profitable than the quarries, as a careful examination of the detailed statements of their workings will show.

A glance at any railroad map of the State makes it clear that facilities for transportation are exceptionally good throughout the entire area of the stone fields, and the number of car-loads annually shipped to all parts of the country is a guaranty that rates are sufficiently low to warrant the large and growing output of materials. In fact the demand for building-stone has been so steady and great that most of the quarries have been worked to the utmost of their capacity with orders constantly ahead throughout the year. The writer of this report has traveled extensively in the Western and Southern States recently, and everywhere he has seen the railroads carrying large consignments of Indiana stone, a fact which gives indisputable evidence of the demand.

In one regard the great activity and success of the stone industry has had a marked effect upon the character of public improvements in the State. The County Commissioners of the various counties in letting contracts for the bridges and culverts of our highways have taken advantage of the facilities for procuring indestructible stone for foundations, abutments and piers, and have stipulated that these should be built of nothing but the best Indiana stone. The court houses, jails, county asylums and other public buildings recently erected are mostly built in whole or in part of this material. The railroads have not been slow to avail themselves of the same advantage and have set all their bridges on permanent stone substructures. These are facts that should have their weight in every study of the economic value of our stone; they should give confidence to capital looking toward investment in the quarrying industry, and should enter largely into every calculation of the material wealth of the State. They supplement the deductions of scientific investigation with practical demonstration of economic values, and make clear to the ordinary mind what has long been known to the few enthusiastic pioneers in geological and statistical study. It has been said that the "proof of the pudding is in the eating," and the homely truth fits well into the process of proving which is now going on in the great building stone areas of Indiana. We are beginning to taste the flavor of ample success. Long ago this Department clearly pointed out this great field of industry, and used every means within its power to call public attention to it. We may now feel justly proud in congratulating ourselves upon a fair prospect of sharing the enjoyment of the prosperity of those who have profited by our advice.

It is not the quarry-masters alone, however, who have been directly benefited by the large demand for our building stones. The number of laboring men who have found employment at good wages in the quarries is quite large. Villages and towns have sprung up at many points and are flourishing little centers of life and traffic dependent largely upon the impetus given to business by the quarry interests.

We feel that it is important, at this time, to call especial attention to the sandstones of Indiana. The limestones have already, as has been shown, reached a popularity and a demand which forestall written recommendation in a large degree, but the sandstones have not been properly appreciated as yet. When we began, in this department, to call attention to the oolitic limestone, it was slow work, indeed, to make the public believe in our statements of its immense value. We hope that it will not be so difficult to convince intelligent capitalists of the equally important part that the sandstones are to take in the commerce of the future. Let us repeat here that nowhere in the world are there greater or better deposits of this fireproof and beautiful building material. The writer of this report has examined samples of sandstone from all the principal quarries of Great Britain and America, and has carefully compared them with the sandstones of Indiana, and is prepared to say that the latter are equal to the best in evenness of grain, solidity, cohesiveness, durability and beauty. It has a great advantage over all the limestones in the facility with which it may be quarried.

These sandstone beds, now so little worked, are waiting to enrich the men who first bring them largely into the market. Our words may not be heeded for years to come, as was the case when this department first began to point to our coal fields, or when we insisted upon the incomparable qualities of the oolitic limestone, but some day our words will be vindicated in this as they have been already amply proven true in the other instances. The tests of science may already be relied upon, and these tests have been fully applied to Indiana sandstones, demonstrating that they are as good as the very best in the world. This is the simplest statement of fact, as will be plain to any person having a knowledge of building stones, who will give the subject a practical examination.

Interested parties have raised groundless objections to the use of sandstone in buildings. It has been said that they are not durable; that they are subject to erosion; that they crumble under the action of frost; that they change color, and that they crush under great pressure. These statements are not true of any good sandstone. It is equally true of both bad limestone and bad sandstone. No architect of standing can afford to say that sandstone has not stood the severest tests of exposure and force for hundreds of years, or that it has not been proven the nearest perfectly fireproof of any easily workable stone yet discovered.

We invite the carefulest examination of the Indiana sandstone by architects, builders and quarrymen of experience, for we know that they are richly worth the fullest development. When once they come before the world in a way to show their true value, we shall see another great industry arise in our State. So sure is this Department of this that it is its purpose to keep the subject agitated in season and out of season until the end is reached. We can well afford to be laughed at for a time, if at last we can see the almost unimaginable material wealth of our State made the basis of a sound, enduring and happy industry, giving employment to thousands of men, competent support for their families, and well-earned riches to the intelligent and far-seeing investor. The sandstones of Indiana invite capital and promise it even larger returns than have yet been realized from the limestone quarries. It is the stone of the future for certain classes of architectural work and will always command a high price in the markets. The future may be well judged by the past. In the old countries of Europe, where stone buildings have been the rule for centuries, we find that the sandstone quarries have not been and are not now neglected. Indeed there are no more famous quarries in the world than those in the sandstones of England and Scotland. In Edinburgh and Glasgow some of the oldest and finest of modern buildings are built of this material. Many castles fashioned of it stand as monuments of its beauty and durability. The sandstones of Indiana are as good as the best of Scotland, and will one day take their place in buildings as beautiful and enduring as any church or cathedral of the old world.

As a matter of course the same judgment and caution must be exercised in selecting sandstones as in choosing other kinds of building stones. The oolitic limestone is not the average limestone of the country; it is exceptionally fine. The best sandstones are equally excellent when compared with the average materials. This may be said, however, in favor of the sandstone; it is more persistently good when found in favorable condition than the limestone, though its areas are smaller. We would not be understood as claiming more for the sandstone than for the limestone, but we do say that within its legitimate uses it is superior to any other stone.

It can not be applied to so many purposes, the demand for it will never, perhaps, be so general, but it will have a wide market and a certain one—a market with scarcely any successful competition within a very extended radius.

Most of our sandstone deposits, from the very nature of things, lie very near to the coal fields, thus insuring cheap fuel for engines. In fact, the quarrying of sandstone will, as a rule, be found much cheaper than in the case of most of the limestones. While the material is generally bedded massively, and has no distinct lines of cleavage, it is so soft and easily cut and split that expensive machinery is rarely necessary in the quarry. We have seen the fresh stone hewn out with an ax, as wood is hewn, and placed in foundations, chimneys, etc., where it would immediately harden to almost the refractory density and ringing resonance of flint. It will be readily seen that this quality is a very valuable one in connection with the first cost of production, as well as regarding its adaptability to many architectural uses.

The lists of quarries show that a number of companies and individuals have already begun the good work of developing the sandstone industry with most excellent results. It is to be hoped that now, with all the facts before the public, many others will see the promise of profitable enterprise in this field. What is now most needed is to get the stone itself before the public, as has already been done in the case of the oolitic limestone and the Silurian flagging stones. It avails little for men to spend their time and money quarrying stone if the great public knows nothing about the nature and value of the output. Unfortunately, the public will not take the statements made by careful and conscientious investigators. It must have occular demonstration, and this must be afforded by exhibition of the stone itself. There can be but one result when our sandstone is as well known as our oolitic limestone. It will be accepted at once as the best of its kind.

If the owners of sandstone deposits would risk a little labor and expense in taking out samples of the material and sending them to builders, architects, masons, dealers in monuments, engineers and geologists, the result would be surprising in a short time. This should be general amongst the owners of the prospective quarries, and should be kept up persistently until the public is fully informed of the valuable qualities of the stone, for it is as sure as that day follows night that active effort will follow the discovery of any paying field of industry. Convince men that they can make money by entering your sandstone fields, and you will not have to wait long to see active competition for possession of the best deposits and the most eligible sites for the drills, the channelers and the derricks.

It is a well-worn saying that the "Gods help those who help themselves," and it would be well if all the owners of our magnificent sandstone would profit by the suggestion.

The appended statistics show that the value of stone on the cars at the quarries varies from about eight dollars the car for rubble up to and considerably beyond two hundred dollars the car for cut stone. Averaging the car-load at two hundred cubic feet, this would make the maximum average for cut stone about one dollar the cubic foot for the best limestones, but by reference to the reports of companies this will be found too low for some of the quarries. The sandstones do not command so great a price, but they are so much cheaper to quarry that the profit is almost, if not quite, as large as on the limestone. Then it must be remembered that it is demand and supply that control prices. As yet the demand for Indiana sandstone is in its incipiency, and this prevents it from commanding the price which would be readily paid for it were the demand an active and general one, based on a full knowledge of its merits as a building stone.

In connection with the subject of building stone proper, it has been found convenient to collect much information touching the use of our various stones in lime-making, in glass-making, as flux in iron furnaces, and in road making. The reader will observe that although lime-burning has not been developed as an industry as it should be in Indiana, there are many firms and individuals doing a large business and producing a most excellent quality of lime. Indeed Indiana lime is classed very high in the markets of the country both for plaster work and for masonry and brick work.

Road-making has recently attracted much attention in the State, and many counties have wholly changed their system of highways from dirt to graveled or Macadam roads. This has created a large demand for broken stone in many counties where gravel could not be had, and has been the means of developing local quarries for the purpose of meeting this need. For railroad track ballast broken stone is the best possible material, and it is rapidly coming into use. It drains better than gravel, is less liable to wash and displacement, lasts indefinitely, relieves the road of the dust which in dry weather renders travel so disagreeable over gravel or dirt ballasted roads, and in the end is cheaper than any other material, all facts considered. Where there is a demand for broken stone for road building or ballasting, the quarry-master finds a ready market for all the chips and refuse stone of his quarries. The statistics show that a great deal of this kind of stone is already being shipped from nearly all the larger quarries of the State. Some one has said that the public highways of a country constitute the index of its prosperity and enlightenment. If this be true the influence exerted by the development of Indiana's stone fields has greatly aided in giving expression to a high state of civilization in our State.

Another important item reported from most of the quarries is flagstone, used so freely now in the paving of sidewalks in cities and towns.

A large part of this is produced from the Niagara limestone and the smooth, thin layers of the Devonian, though it is by no means confined to these. Wherever it can be found in hard, smooth sheets of the proper thickness, it is one of the most valuable products of the quarry, as it comes from the bed ready for use with little or no expense save the bare cost of taking it out.

As yet the marbles of Indiana have been little worked, but in time the deposits of this beautiful white and variegated limestone in the southern part of the State will be put to profitable use.

In concluding this report, it is but justice to say that as a rule the citizens interested in stone have been kind and cordial in giving aid and information toward the fullest collection of facts, and we hope that they may find a rich return in the stimulus which a report like this may give to their industry by attracting wide attention thereto. The fullest efficiency of this department can not be reached without this cordial cooperation of the people, and it has been the effort of the Chief and his assistants to seek in every way the freest communication with those who are most interested in the material prosperity of the several sections of which the Department's work has been carried on. We desire to make these reports full and reliable, so that a reference to them will be made with confidence and with profit. While we do not claim that everything has been told herein about the building stones of Indiana, it is believed that what has been said is true, and that a long step has been made in the right direction.

# QUARRIES IN INDIANA.

### JOSHUA STAPLES, ROCK RIDGE STATION,

PUTNAMVILLE POSTOFFICE, INDIANA.

| | |
|---|---|
| Amount of capital invested | $37,000 |
| Number of employes | 26 |
| Weekly pay-roll | $218.00 |
| Number of derricks | 6 |
| Number of engines | 3 |
| Two engines 12-horse power each, and one engine 35-horse power. | |
| Steam drills | 3 |
| Building stone, per month, number of cars | 25 |
| Cubic feet per car | 200 |
| Number of car-loads used for rip-rap | 320 |
| Value at quarry, per car | $8.25 |
| Rubble stone, number of cars | 180 |
| Value per car | $11.00 |
| Bridge stone, number of cars | 30 |
| Value per car | $25.00 |
| Flagging, number of cars | 15 |
| Value per car | $150.00 |
| Street crossings, number of cars | 7 |
| Value per car | $60.00 |
| Steps and sills, number of cars | 1 |
| Value per car | $210.00 |
| Besides a large amount of bridge stone. | |
| Acres controlled by firm | 123 |
| Acres in quarry | 3 |

### STEG HEIRS, GREENCASTLE JUNCTION, IND.

LIME BURNERS.

| | |
|---|---|
| Capacity of quarry, car-loads per week | 4 |

### I. N. PEEK, PUTNAMVILLE, IND.

| | |
|---|---|
| Product for 1890, number of cars | 30 |

### JAMES LEE, PUTNAMVILLE, IND.

| | |
|---|---|
| Product for 1890, number of cars | 52 |

## DAVID B. STEEG, GREENCASTLE JUNCTION, IND.

| | |
|---|---|
| Amount of capital invested | $12,000 |
| Number of employes | 6 |
| Weekly pay-roll | $76.00 |
| Derrick | 1 |
| Two horses and carts. | |
| Building stone, car-loads per month | 4 |
| Value per car | $8.00 |
| Cubic yards per car | 8 |
| St. Louis limestone, color blue, principal use for lime. | |
| Acres owned by firm | 15 |
| Acres in quarry | 2 |
| Amount of lime, car-loads, per month | 12 |
| Number of months kiln was run | 8 |
| Value per car-load | $50.00 |

This is a "hot" or quick-setting lime that answers well for masonry, but is too "hot" for plasterer's use.

## VIGO IRON CO., GREENCASTLE, IND.

| | |
|---|---|
| Number of employes | 6 |
| Monthly pay-roll | $215.00 |
| Cars per month | 41 |
| Cubic yards per car | 8 |
| Value per car | $8.25 |
| St. Louis limestone, color blue-gray, used for flux in blast furnace at Terre Haute: | |
| Acres in quarries | 4 |
| Acres leased from Mrs. McLain, and controlled by firm | 8 |

Thirty acres undeveloped land near Greencastle Junction, owned by Patrick O'Boyle.

## PATRICK ASH, GREENCASTLE, IND.

| | |
|---|---|
| Amount of capital invested | $500.00 |
| Number of employes | 5 |
| Weekly pay-roll | $45.00 |
| Average wages per day | $1.50 |
| Number car loads per year | 60 |
| Cubic yards per car | 8 |
| Value per car | $16.00 |
| Blue-gray St. Louis limestone, used for bridge work by the T. H. & I. R. R. | |
| Acres in quarry | 1¼ |

Stone from this quarry was used in the new buildings of the Depauw University.

## OOLITE QUARRY CO., SPENCER, IND.

| | |
|---|---|
| Amount of capital invested | $20,000 |
| Number of employes | 30 |
| Weekly pay-roll | $200.00 |

One engine, 40-horse power.
One channeler.
One steam bar drill.
One steam gadder.
One 30-ton derrick.

| | |
|---|---|
| Weekly amount of product in cubic feet | 6,300 |
| Cubic feet per car | 350 |
| Value per cubic foot | $0.35 |

Oolitic limestone, color blue-cream, used for architectural and bridge work.

| | |
|---|---|
| Acres controlled by firm | 116 |

Stone shipped to Indianapolis and Chicago.

## ROMONA OOLITIC STONE CO., ROMONA, IND.

| | |
|---|---|
| Amount of capital | $100,000 |
| Number of employes | 75 |
| Average daily wages | $1.65 |
| Number of engines | 3 |

Two engines 20-horse power each, and one engine 100-horse power.

| | |
|---|---|
| Channelers | 4 |
| Steam drills | 3 |
| Diamond saw | 1 |
| Header | 1 |
| Planers | 2 |
| Traveler | 1 |
| Steam derricks | 4 |
| Hand derrick | 1 |
| Daily capacity, cubic feet | 3,000 |
| Number cubic feet per car | 350 |
| Value per cubic foot | $0.15 |

Oolitic limestone (buff and blue), building stone.

| | |
|---|---|
| Acres controlled by firm | 70 |

There are several hundred acres undeveloped stone land in this vicinity, and the stone is of excellent quality.

## OWEN OOLITIC STONE CO., SPENCER, IND.

### QUARRIES AT ROMONA.

| | |
|---|---|
| Amount of capital | $7,000 |
| Number of employes | 25 |
| Average wages per day | $1.40 |

One engine 30-horse power.

| | |
|---|---|
| Channeler | 1 |
| Steam derrick | 1 |

Oolitic limestone, blue and gray.

| | |
|---|---|
| Acres controlled by firm | 10 |

Large number of acres undeveloped.

Company just commencing operations, having leased the Simpson & Archer quarry that had lain idle for several years.

## SPENCER LIME & RUBBLE QUARRY CO., SPENCER, IND.

| | |
|---|---|
| Amount of capital | $6,000 |
| Number of employes | 25 |
| Weekly pay-roll | $160.00 |
| Two derricks, and one crusher. | |
| Number of engines | 2 |
| One engine 10-horse power, and one 15-horse power. | |
| Amount of weekly product, cubic yards | 100 |
| Cubic yards rubble | 10 |
| Crushed stone, cubic yards | 18 |
| Rubble per car | $7.50 to $8.50 |
| Crushed stone, per cubic yard | $0.60 |
| Rubble stone, bluish-white used for foundations; crushed stone for street paving. | |
| Number of acres controlled by firm | 40 |

## OOLITIC QUARRY CO., SPENCER, IND.

| | |
|---|---|
| Amount of capital | $5,000 |
| Number of employes | 25 |
| Average wages per day | $1.45 |
| One engine 12-horse power. | |
| Channeler | 1 |
| Steam derrick | 1 |
| Number of car-loads per week | 18 |
| Cubic feet per car | 350 |
| Value per cubic foot | $0.25 |
| Oolitic limestone, buff color, quality good, building stone. | |
| Acres in quarry | 7 |
| Acres controlled by firm | 13 |

Land leased of E. R. Bladen, Spencer, Ind.

Samuel A. Steele, Romona, Ind., has 200 acres undeveloped stone land not for sale.

## NORTH BEDFORD STONE CO., BLOOMINGTON, IND.

### QUARRIES NEAR STINESVILLE, IND.

| | |
|---|---|
| Amount of capital | $150,000 |
| Number of employes | 20 |
| Average wages per day | $1.45 |
| One engine, 50-horse power. | |
| Channelers | 1 |
| Steam drill | 1 |
| Gang saws | 2 |
| Steam derricks | 2 |
| Number cars per week | 12 |
| Number cubic feet per car | 350 |
| Value per cubic foot | $0.30 |
| Value rongh stone, per cubic foot | 22 |

| | |
|---|---|
| Sawed stone, average per cubic foot | 55 |
| Oolitic limestone, buff and blue, building stone. | |
| Acres controlled by firm | 43 |
| Undeveloped stone land, Stinesville, Ind.: | |
| Enoch Morgan, number of acres | 80 |
| William Brown, number of acres | 80 |
| James Williams, number of acres | 100 |
| Dr. Osgood, res. Gosport, Ind., number of acres | 80 |
| John Mays, number of acres | 60 |
| Alonzo Batts, number of acres | 30 |

This land lies adjoining the North Bedford Stone Co.'s quarries, and is valued at $100 to $150 per acre.

The North Bedford Stone Co. commenced operation September, 1889. Ships its product to New York, Philadelphia and Chicago.

## BIG CREEK STONE CO.

### QUARRIES AT NORTH BEDFORD, NEAR STINESVILLE, IND.

| | |
|---|---|
| Amount of capital invested | $100,000 |
| Number of employes | 20 |
| Average daily wages | $1.50 |
| One engine, 60-horse power. | |
| Number channelers | 2 |
| Steam drills | 1 |
| Steam derricks | 1 |
| 150 car loads last year. Capacity cars per day | 4 |
| Number cubic feet per car | 300 |
| Value per cubic foot | $0.20 |
| Oolitic limestone, good buff and blue; building and bridge work. | |

## TERRE HAUTE STONE WORKS CO., STINESVILLE, IND.

| | |
|---|---|
| Amount of capital employed | $60,000 |
| Number of employes | 112 |
| Average daily wages | $2.00 |
| Number of engines | 4 |
| One engine 60-horse power, one 25-horse power, one 10-horse power, and one 30-horse power. | |
| Number of channelers | 2 |
| Seven gang saws. | |
| Number steam derricks | 6 |
| Number travelers | 2 |
| Number of car loads per year | 1,000 |
| Number cubic feet per car load | 350 |
| Value per cubic foot | $0.22½ |
| Company sells no rough stone, only sawed or worked material. | |
| Scabbled bases per foot | $0.35 |
| Oolitic limestone, buff building stone. | |
| Acres controlled by firm | 107 |

### PERRY BROS., ELLETTSVILLE, IND,

| | |
|---|---|
| Amount capital invested | $25,000 |
| Number of employes | 55 |
| Average wages per day | $1.35 |
| Number of engines | 2 |
| One engine 30-horse power, and one 20-horse power. | |
| Number of channelers | 1 |
| Number of travelers | 1 |
| Number of gang saws | 6 |
| Steam derricks | 3 |
| Number horse-power derricks | 2 |
| Number of cars for the year 1890 | 598 |
| Number cubic feet per car | 225 |
| Total sales for the year | $32,000 |
| Oolitic limestone, blue and buff; good building stone. | |
| Number of acres controlled by the firm | 160 |

Nearly all the country between Ellettsville and Stinesville abounds in fine exposures of undeveloped oolitic limestone.

### MATTHEWS BROS., ELLETTSVILLE, IND.

| | |
|---|---|
| Amount of capital invested | $30,000 |
| Number of employes | 70 |
| Average wages per day | $1.35 |
| Number of engines | 2 |
| One engine 30-horse power, and one 40-horse power. | |
| Number of channelers | 1 |
| Gang saws | 8 |
| Number steam derricks | 1 |
| Number horse power derricks | 4 |
| Number hand derricks | 1 |
| Number of cars per year | 600 |
| Number cubic feet per car | 250 |
| Estimated average value per cubic foot | $0.45 |
| Oolitic limestone, good quality; color, buff and blue. Used for building and monument work. | |
| Acres controlled by firm | 80 |

Stone sent to New York, Chicago, and as far northwest as Montana; as far south as New Orleans and Texas.

### MONROE COUNTY OOLITIC STONE CO., BLOOMINGTON, IND.

| | |
|---|---|
| Amount of capital | $100,000 |
| Amount paid in | $20,000 |
| Number of employes | 18 |
| Average daily wages | $1.50 |
| One engine, 25-horse power. | |
| Number channelers | 1 |
| Number of steam drills | 1 |
| Steam derrick | 1 |
| Number of cars per week | 12 |
| Number cubic feet per car | 225 |

| | |
|---|---|
| Value per cubic foot, buff | $0.22 |
| Value per cubic foot, blue | 55 |

Oolitic limestone, good buff and blue, building stone.

| | |
|---|---|
| Number of acres owned by firm | 80 |

Estimated amount of undeveloped stone land in the county, 100,000 acres.

## BEDFORD QUARRY CO., BLOOMINGTON, IND.

| | |
|---|---|
| Capital invested | $75,000 |
| Number of employes | 15 |
| Average daily wages | $1.50 |

One engine, 25-horse power.

| | |
|---|---|
| Number of channelers | 1 |
| Number steam drills | 1 |
| Number steam derricks | 1 |
| Number of cars per week | 10 |
| Number cubic feet per car | 225 |
| Value per cubic foot, buff | $0.22 |
| Value per cubic foot, blue | 35 |

Oolitic limestone; color, buff and blue. Good building stone.

| | |
|---|---|
| Number of acres owned by firm | 8 |

## BLOOMINGTON-BEDFORD STONE CO., CLEAR CREEK, P. O.

| | |
|---|---|
| Amount of capital | $100,000 |
| Number of employes | 15 |
| Average daily wages | $1.50 |

One engine, 25-horse power.

| | |
|---|---|
| Number of channelers | 1 |
| Number of steam drills | 1 |
| Number steam derricks | 1 |
| Number of cars per week | 6 |
| Number of cubic feet per car | 225 |
| Value per cubic foot, buff | $0.22 |
| Value per cubic foot, blue | 35 |
| Number of acres owned by firm | 40 |

## OOLITIC COMPANY OF INDIANA, BLOOMINGTON, IND.

| | |
|---|---|
| Amount of capital | $100,000 |
| Number of employes | 25 |
| Average daily wages | $1.50 |

One engine, 40-horse power.

| | |
|---|---|
| Number of channelers | 2 |
| Number of steam drills | 1 |
| Number of steam derricks | 1 |
| Number of cars per week | 18 |
| Number of cubic feet per car | 225 |
| Value per cubic foot, buff | $0.22 |
| Value per cubic foot, blue | 35 |

The quarry averages three-fourths blue.

Oolitic limestone, good building stone, color buff and blue.

| | |
|---|---|
| Number of acres controlled by company | 80 |

## BLOOMINGTON OOLITIC STONE CO., BLOOMINGTON, IND.

| | |
|---|---|
| Amount of capital | $20,000 |
| Number of employes | 20 |
| Average daily wages | $1.75 |
| One engine, 30-horse power. | |
| Number of channelers | 1 |
| Number steam drills | 1 |
| Number steam derricks | 1 |
| Number of cars per week | 5 |
| Number of cubic feet per car | 225 |
| Value per cubic foot, buff | $0.22 |
| Value per cubic foot, blue | 35 |
| Oolitic limestone, good building stone, color buff and blue—mainly blue. | |
| Number of acres controlled by firm | 9 |

Located within the city of Bloomington. Commenced operations May, 1890, and expects to double output this year.

## STINESVILLE AND BLOOMINGTON STONE CO., BLOOMINGTON, IND.

### QUARRIES AT STINESVILLE.

| | |
|---|---|
| Amount of capital | $50,000 |
| Number of employes | 50 |
| Average wages per day | $1.50 |
| Two engines, 20-horse power each. | |
| Number of channelers | 3 |
| Number steam drills | 2 |
| Number gang saws | 3 |
| Number steam derricks | 3 |
| Number carloads per week | 8 |
| Number cubic feet per car | 350 |
| Value per cubic foot | $0.23 |
| Oolitic limestone, good building stone, color buff. | |
| Number acres owned by firm | 73 |
| Chas. Frantman owns sixty acres undeveloped stone land. | |
| Jackson Wampler, number of acres | 80 |
| Samuel Harris, number of acres | 160 |
| This land is valued from $500 to $1,000 per acre. | |

## HALLOWELL STONE CO., BEDFORD, IND.

| | |
|---|---|
| Amount of capital | $100,000 |
| Number of employes | 100 |
| Average daily wages | $2.50 |
| This is caused by the large number of cutters the company employs. | |
| Number of engines | 3 |
| One engine, 65-horse power, and two 40-horse power each. | |
| Number of channelers | 4 |

| | |
|---|---|
| Number of steam drills | 2 |
| Number of travelers | 1 |
| Number of gang saws | 6 |
| Number of planers | 2 |
| Number of headers | 1 |
| Number of steam derricks | 6 |
| Number of hoisting machines | 2 |
| One steam pump and boiler, 16-horse power. | |
| Amount of output, number of cars per year | 1,000 |
| Number of cubic feet per car | 200 |
| Value per cubic foot, buff | $0.25 |
| Value per cubic foot, blue | 40 |
| Oolitic limestone, very good for building and monument work; color, buff and blue. | |
| Number of acres owned by firm | 40 |

The mill owned by the firm in the city covers five acres; it is located at the junction of the L., N. A. & C. and Narrow Gauge Railroads. This firm sawed a slab of stone nine feet long, twelve inches wide, and about one sixteenth of an inch thick. This shows the wonderful uniformity in texture of this stone.

### BEDFORD OOLITIC STONE CO., BEDFORD, IND.

| | |
|---|---|
| Amount of capital | $45,000 |
| Number of employes | 80 |
| Average daily wages | $1.60 |
| Number of engines | 2 |
| Of 30-horse power each. | |
| Number of channelers | 4 |
| Number of steam drills | 3 |
| Number steam derricks | 4 |
| Number of car-loads per week | 25 |
| Number cubic feet per car | 250 |
| Value per cubic foot | $0.22 |
| Oolitic limestone; good building stone; color, buff. | |
| Number of acres controlled by firm | 460 |
| Estimated amount of undeveloped land in the county, 10,000 acres. | |

### PERRY, MATTHEWS & BUSKIRK, BEDFORD, IND.

| | |
|---|---|
| Amount of capital | $70,000 |
| Number of employes | 50 |
| Average daily wages | $1.60 |
| One engine, 25-horse power. | |
| Number of channelers | 3 |
| Number of steam drills | 2 |
| Number of steam derricks | 2 |
| Number of cars per week | 30 |
| Number of cubic feet per car | 275 |
| Value per cubic foot | $0.22 |
| Oolitic limestone; good building stone; color buff. | |
| Number of acres owned by firm | 243 |

### HOOSIER STONE CO., BEDFORD, IND.

| | |
|---|---|
| Amount of capital | $75,000 |
| Number of employes | 150 |
| Average daily wages | $1.60 |
| Three engines, 30-horse power each. | |
| Number of channelers | 5 |
| Number of steam drills | 5 |
| Number of gang saws | 4 |
| Number of planers | 1 |
| Number of steam derricks | 6 |
| Three portable boilers, 10-horse power each, for drills. | |
| Annual output in car loads | 2,000 |
| Number of cubic feet per car | 250 |
| Value per cubic foot, blue | $0.35 |
| Value per cubic foot, buff | 20 |
| Oolitic limestone, used for building, color buff and blue. | |
| Number of acres controlled by firm | 175 |
| All stone land. | |
| Output will be greatly increased for 1891. | |

### PEERLESS STONE CO., BEDFORD, IND.

| | |
|---|---|
| Amount of capital invested | $100,000 |
| Number of employes | 45 |
| Average daily wages | $1.65 |
| One engine, 30-horse power. | |
| Number of channelers | 2 |
| Number of steam drills | 1 |
| Number of steam derricks | 2 |
| Number of car loads per year | 108 |
| Number of cubic feet per car | 275 |
| Value per cubic foot | $0.20 |
| Oolitic limestone, used for building, color buff. | |
| Number of acres owned by firm | 70 |
| All stone land. | |
| Commenced operations September, 1890. | |

### CHICAGO AND BEDFORD STONE CO., BEDFORD, IND.

| | |
|---|---|
| Amount of capital | $40,000 |
| Number of employes | 70 |
| Average daily wages | $1.65 |
| Number of channelers | 4 |
| One engine, 40-horse power. | |
| Number of steam drills | 3 |
| Number of steam derricks | 3 |
| Number of car loads per annum | 800 |
| Number of cubic feet per car | 225 |
| Value per cubic foot, buff | $0.20 |
| Value per cubic foot, blue | 40 |
| Three-fourths blue. | |
| Oolitic limestone, good quality; mainly used for building; small quantity bridge stone; color blue and buff. | |
| Number of acres controlled by firm | 80 |

## THE BEDFORD BLUE STONE CO., BEDFORD, IND.

| | |
|---|---|
| Amount of capital | $100,000 |
| Number of employes | 27 |
| Average weekly pay-roll | $270.00 |
| One engine, 25-horse power. | |
| Number of channelers | 1 |
| Number of steam drills | 2 |
| Number of steam derricks | 1 |
| Number of car loads per day | 3 |
| Number of cubic feet per car | 225 |
| Value per cubic foot, buff | $0.22 |
| Value per cubic foot, blue | 40 |
| Two-thirds buff. | |
| Oolitic limestone, color light buff to dark blue, used for carvings and for buildings. | |
| Number of acres controlled by firm, | 35 |
| Number of acres of undeveloped stone land owned by Jas. H. Williard | 256 |

## INDIANA STONE CO., BEDFORD, IND.

| | |
|---|---|
| Amount of capital | $50,000 |
| Number of employes | 45 |
| Average daily wages | $1.75 |
| Number of engines | 2 |
| One engine, 50-horse power, and one 30-horse power. | |
| Number of channelers | 2 |
| Number steam drills | 1 |
| Number of gang saws | 4 |
| Number of travelers | 1 |
| Number of steam derricks | 3 |
| Number of hand derricks | 1 |
| Annual product, cubic feet | 100,000 |
| Cubic feet per car | 225 |
| Average value of the output for the year, per cubic foot | $0.32 |
| Oolitic limestone, used for building, color buff. | |
| Number of acres controlled by firm | 415 |
| Company commenced operations in 1887. | |

## COSNER & NORTON STONE CO., BEDFORD, IND.

| | |
|---|---|
| Amount of capital | $25,000 |
| Number of employes | 20 |
| Average daily wages | $1.50 |
| One engine, 25-horse power. | |
| Number of channelers | 2 |
| Number of steam drills | 1 |
| Number of steam derricks | 1 |
| Number of car loads for nine months | 75 |
| Number of cubic feet per car | 225 |
| Value per cubic foot | $0.20 |
| Oolitic limestone, good building stone, color buff and blue. | |
| Number of acres controlled by firm | 20 |
| Quarried, one-half acre; remainder all good stone land. | |

## DARK HOLLOW QUARRY CO., BEDFORD, IND.

| | |
|---|---|
| Amount of capital | $300,000 |
| Number of employes | 135 |
| Average daily wages | $1.35 |
| Three engines, one 140-horse power, one 70, and one 20-horse power. | |
| Number of channelers | 3 |
| Number of steam drills | 3 |
| Number of gang saws | 4 |
| Number of planers | 2 |
| Number of headers | 1 |
| Number of travelers | 2 |
| One machine shop. | |
| Number of steam derricks | 4 |
| Three hand and one horse power derricks. | |
| Six steam pumps, four to six inch cylinders. | |
| Number of portable boilers | 1 |
| Number of stationary boilers | 3 |
| One boiler 80-horse power, one 60-horse, and one 40-horse power. | |
| Number of car-loads per year | 1,000 |
| Number of car-loads per day | 20 |
| Number of cubic feet per car | 225 |
| Value per cubic foot, buff | $0.20 |
| Oolitic limestone, used for bridge work; color, buff. | |
| Number of acres controlled by firm | 110 |
| All good stone land, about two and a half acres worked. | |

## BODENSCHATZ BEDFORD STONE CO., BEDFORD, IND.

| | |
|---|---|
| Amount of capital | $40,000 |
| Number of employes | 30 |
| Average wages per day | $1.65 |
| One engine, 60-horse power. | |
| Number of channelers | 2 |
| Number of steam drills | 1 |
| Number of gang saws | 2 |
| Number of steam derricks | 2 |
| One engine, 10-horse power, used for stripping. | |
| Product for last year, number of cubic feet | 12,000 |
| Number of cubic feet per car | 225 |
| Value per cubic foot, blue | $0.30 |
| Value per cubic foot, buff | 20 |
| Nearly all blue oolitic limestone, used for building. | |
| Number of acres controlled by firm | 95 |

## ACME BEDFORD STONE CO., BEDFORD, IND.

| | |
|---|---|
| Amount of capital | $25,000 |
| Number of employes | 18 |
| Average daily wages | $1.65 |
| One engine, 35-horse power. | |
| Number of channelers | 2 |
| Number of steam derricks | 1 |
| Number of car-loads per day | 4 |
| Number of cubic feet per car | 225 |
| Value per cubic foot, buff | $0.20 |
| Oolitic limestone, used for building; color, buff. | |
| Number of acres controlled by firm | 50 |

Leased of Geo. Dunn. Commenced operations November, 1889. This is the old Baalbeck quarry.

## BEDFORD STEAM STONE WORKS, BEDFORD, IND.

| | |
|---|---|
| Amount of capital | $10,000 |
| Number of employes | 20 |
| Average daily wages | $2.00 |
| Number of gang saws | 5 |
| One lathe. | |
| One engine, 45-horse power. | |
| Number of travelers | 1 |
| Number of steam pumps | 2 |
| One boiler, 6-horse power. | |
| Number of cars of stone per annum | 400 |
| Number of cubic feet per car | 250 |
| Value per cubic foot | $0.55 |

Oolitic limestone, used for building exclusively; color, buff and blue.

Mill located on the spurs of L., N. A. & C., and E. R. R. R.

Company commenced operations in 1887.

## TAN YARD STONE CO., BEDFORD, IND.

| | |
|---|---|
| Amount of capital | $150,000 |
| Number of employes | 50 |
| Average daily wages | $1.37 |
| Two steam hoists and derricks. | |
| One engine, 25-horse power. | |
| Number of steam channelers | 3 |
| Number of steam drills | 2 |
| One duplex pump, one steam jet. | |
| Number of car-loads per week | 36 |
| Number of cubic feet per car | 200 |
| Value per cubic foot | $0.25 |
| Building and bridge stone; color, buff and blue. | |
| Number of acres controlled by firm | 80 |
| Number of acres undeveloped stone land | 60 |

## THE BEDFORD STONE CO., BEDFORD, IND.

| | |
|---|---|
| Amount of capital | $150,000 |
| Number of employes | 50 |
| Average daily wages | $1.37 |
| Two steam hoists and derricks. | |
| One engine, 25-horse power. | |
| Number of steam channelers | 3 |
| Number of steam drills | 2 |
| One duplex pump, one steam jet. | |
| Number of car loads per week | 36 |
| Number of cubic feet per car | 200 |
| Value per cubic foot | $0.25 |
| Oolitic limestone, used for building and bridge stone, color buff and blue. | |
| Number of acres controlled by firm | 22 |
| Number of acres of undeveloped stone land | 5 |

## TAN YARD CREEK STONE CO., BEDFORD, IND.

| | |
|---|---|
| Amount of capital | |
| Number of employes | 25 |
| Average daily wages | $1.50 |
| One engine, 30-horse power. | |
| Number of channelers | 2 |
| Number of steam drills | 2 |
| Number of steam derricks | 1 |
| Number of cars per day | 3 |
| Number of cubic feet per car | 200 |
| Value per cubic foot | $0.20 |
| Oolitic limestone, color buff, good quality, used for bridge work. | |
| Number of acres controlled by firm | 10 |
| Commenced operations October, 1890. | |
| Number of acres of undeveloped stone land on the branch of the O. & M. R. R., owned by J. H. Willard | 100 |

## DAVID REED STONE CO., CHICAGO, ILL.

### QUARRIES AT SMITHVILLE, IND.

| | |
|---|---|
| Amount of capital | $125,000 |
| Number of employes | 125 |
| Average daily wages | $1.85 |
| Number of engines | 3 |
| One engine, 30-horse power, one 25, and one 75-horse power. | |
| Number of channelers | 5 |
| Number of steam drills | 3 |
| Number of gang saws | 7 |
| Number of planers | 3 |
| Number of travelers | 2 |

| | |
|---|---|
| Number of steam derricks | 4 |
| Number of steam pumps | 4 |
| Number of cubic feet per year | 240,000 |
| Number of cubic feet per car | 225 |
| Value per cubic foot | $0.30 |

Oolitic limestone, used for building, color buff and blue.

| | |
|---|---|
| Number of acres owned by firm | 100 |

This company commenced operations in 1880.

## OOLITIC QUARRY CO., OF INDIANA.

### CLEAR CREEK POSTOFFICE, MONROE COUNTY, INDIANA.

| | |
|---|---|
| Amount of capital | $100,000 |
| Number of employes | 22 |
| Average daily wages | $1.60 |

One engine, 35-horse power.

| | |
|---|---|
| Number of channelers | 2 |
| Number of steam drills | 1 |
| Number of steam derricks | 1 |
| Annual output cubic feet | 120,000 |
| Number of cubic feet per car | 225 |
| Value per cubic foot | $0.19 |

Oolitic limestone, used for building; color, buff and blue.

| | |
|---|---|
| Number of acres owned by firm | 80 |

## CLEVELAND STONE CO., CLEVELAND, O.

### OPERATED AT CLEAR CREEK, IND.

| | |
|---|---|
| Amount of capital | $40,000 |
| Number of employes | 40 |
| Average daily wages | $1.65 |
| Number of engines | 3 |

One engine, 40-horse power, and two 25-horse power.

| | |
|---|---|
| Number of channelers | 2 |
| Number of steam drills | 1 |
| Number of gang saws | 2 |
| Number of steam derricks | 3 |
| Annual output per car-loads | 300 |
| Cubic feet per car | 225 |
| Value per cubic foot | $0.35 |

Oolitic limestone, used for building; color, buff.

| | |
|---|---|
| Number of acres owned by firm | 29 |

## PROSPECTIVE QUARRIES. DARK HOLLOW OOLITIC STONE CO.

### QUARRIES AT DARK HOLLOW.

Machinery is ordered. Incorporators, D. V. Johnson, E. B. Thornton, J. B. Thornton.

## SALEM STONE AND LIME CO., SALEM, IND.

| | |
|---|---|
| Amount of capital | $250,000 |
| Number of employes | 165 |
| Average daily wages | $1.40 |
| Number of engines | 4 |
| Two engines, 30-horse power; one 80 and one 10-horse power. | |
| Number of channelers | 4 |
| Number of steam drills | 6 |
| Number of gang saws | 8 |
| Number of travelers | 2 |
| Number of steam derricks | 6 |
| One machine shop. | |
| One switch locomotive. | |
| Number of planers | 3 |
| Number of cars per year | 750 |
| Number of cubic feet per car | 300 |
| Average value of stone on cars, per cubic foot | $0.35 |
| Oolitic limestone; color, buff, blue and mottled; used for building and lime. | |
| Number of lime kilns | 5 |
| Two kilns 400 bushels per day, and three 200 bushels per day. | |
| Number of bushels of lime per year | 197,500 |
| Value per bushel on board car | $0.20 |
| Number of acres controlled by firm | 160 |

## J. L. CHILLAUX & BRO., ORANGEVILLE, IND.

| | |
|---|---|
| Amount of capital | $2,000 |
| Number of employes | 5 |
| Average daily wages | $1.25 |
| Annual product | $2,000 |
| Hindoostan stone; sandstone. | |
| One engine, 10-horse power. | |
| One rubber. | |
| Number of acres controlled by firm | 40 |

## T. N. BAXTON & SONS, PAOLI, IND.

### QUARRIES AT FRENCH LICK.

| | |
|---|---|
| Amount of capital | $10,000 |
| Number of employes | 12 |
| Work six months in the year. | |
| Average daily wages | $1.00 |
| Two rubbing plates, six feet in diameter. | |
| One engine 10-horse power. | |
| Annual product | $5,000 |
| Kaskaskia sandstone, color white and buff, used for whetstones. | |
| Number of acres controlled by firm | 1,000 |
| Principal market New York. | |

## W. F. OSBORN, PAOLI, IND.

WHETSTONE QUARRIES AT FRENCH LICK SPRINGS.

| | |
|---|---|
| Amount of capital | $2,500 |
| Number of employes | 20 |
| Average daily wages | $1.25 |
| Work seven months per year. | |
| Value of product | $5,000 |
| Kaskaskia Group, shoe rubber and Hindoostan whetstone. | |
| Number of acres owned by firm | 240 |
| Machinery, gang saws, rubbers, etc. | |
| Principal market, New York. | |
| Owners of undeveloped quarry land, French Lick: | |
| Wm. Able, number of acres (20 acres quarry land) | 80 |
| Brown More, number of acres | 40 |
| J. E. Buerk, West Baden, Ind., number of acres | 80 |
| W. F. Osborn, Paoli, Ind., number of acres | 400 |

## J. A. SPRINGER, ABYDELL, IND., ORANGE COUNTY.

| | |
|---|---|
| Amount of capital | $3,000 |
| Number of employes | 10 |
| Average daily wages | $1.25 |
| Number of car loads per week | 5 |
| Value per ton | $1.00 |
| Number of tons per car | 16 |
| Number of acres controlled by firm | 10 |
| St. Louis lithographic limestone, used by the Depauw glass works. | |
| Number of acres undeveloped stone land owned by J. A. Springer | 10 |
| Number of acres owned by W. T. Wells | 8 |
| Number of acres owned by Peter Pope | 6 |
| Number of acres owned by Moses F. Ham | 6 |

## TAYLOR & COFFMAN, PENDLETON, IND.

| | |
|---|---|
| Amount of capital | $10,000 |
| Number of employes | 12 |
| Average daily wages | $1.35 |
| Number of perch for 1890 | 9,500 |
| Value per perch | $1.50 |
| White sandstone, used for glassmaking and building. This is probably the Schoharie Grit of the New York Geologist. | |
| Number of acres controlled by firm | 8 |
| Number of acres undeveloped territory owned by Barber & Baird, Akron, O | 34 |
| Number of acres owned by Wm. K. Lukens, Pendleton, Ind | 40 |
| R. G Guptel, Pendleton, Ind., is opening a quarry. | |

## J. W. SANSBERY, ANDERSON, IND.

| | |
|---|---|
| Amount of capital | $6,000 |
| Number of employes | 12 |
| Average daily wages | $1.60 |
| One horse power derrick. | |
| Number of perch, 1890 | 7,000 |
| Value per perch | $1.60 |
| Niagara limestone; color, gray and blue; used for building. | |
| Number of acres controlled by firm | 25 |

## WM. CRIM, ANDERSON, IND.

| | |
|---|---|
| Amount of capital | $25,000 |
| Capital invested mainly in land. | |
| Number of employes | 8 |
| Average daily wages | $1.25 |
| Number of perch | 4,000 |
| Value per perch | $1.60 |
| Niagara limestone, used for building; color, gray and blue. | |
| Number of acres owned by firm | 46 |
| Number of acres of undeveloped stone land owned by Mr. McCulloch | 15 |
| Number of acres owned by Wm. Crim | 20 |

## L. C. NICOSON, ALEXANDRIA, IND.

| | |
|---|---|
| Amount of capital | $10,000 |
| Number of employes | 25 |
| Average daily wages | $1.40 |
| Number of engines | 1 |
| Size of engine, 40-horse power. | |
| Number of steam drills | 1 |
| One gas pump for pumping water. | |
| Number of steam derricks | 2 |
| Number of car-loads per annum | 1,000 |
| Number of cubic feet per car | 225 |
| Value per car | $12.00 |
| Niagara limestone, used for building, color buff and blue. | |
| Number of acres controlled by firm | 100 |
| Number of acres of undeveloped stone land owned by E. G. Vernon | 40 |
| E. G. Vernon is opening a quarry. | |

## BOOTH & FREE, ALEXANDRIA, IND.

| | |
|---|---|
| Amount of capital | $10,000 |
| Number of employes | 15 |
| Average daily wages | $1.40 |
| One engine, 20-horse power. | |
| Number of steam drills | 1 |
| Number of steam derricks | 1 |
| One 7-inch centrifugal pump, | |

| | |
|---|---|
| Number of car loads | 350 |
| Number of cubic feet per car load | 270 |
| Value per car load | $20.00 |
| Niagara limestone, used for building, color blue. | |
| Number of acres controlled by firm | 35 |
| Number of acres of undeveloped stone land owned by Mrs. Ennis | 10 |
| Number of acres owned by Wm. Carver | 40 |
| Number of acres owned by Peter Swin | 12 |

### D. R. McKENNEY & SON, MARION, IND.

| | |
|---|---|
| Amount of capital | $35,000 |
| Land is valued at $30,000. | |
| Number of employes | 40 |
| Average daily wages | $1.50 |
| One portable engine, 10-horse power. | |
| Number of perch of stone | 30,000 |
| Value per perch | $1.25 |
| Niagara limestone, used for building, color blue and gray. | |
| Number of acres owned by firm | 30 |
| Number of acres of undeveloped stone land owned by Phil. Matler | 30 |
| Number of acres owned by Dr. Williams | 15 |

### S. R. FRANKBONER, MARION, IND.

| | |
|---|---|
| Amount of capital | $1,000 |
| Number of employes | 3 |
| Average daily wages | $2.00 |
| (Piecework.) | |
| Number of perch | 2,400 |
| Value per perch | $1.25 |
| Niagara limestone, used for building, color gray and blue. | |
| Number of acres owned by firm | 4 |

### FRANK MAYO, MARION, IND.

| | |
|---|---|
| Amount of capital | $1,000 |
| Number of employes | 3 |
| Average daily wages | $1.50 |
| Number of perch | 300 |
| Value per perch | $1.25 |
| Hydraulic limestone, used for building, color buff. | |
| Number of acres controlled by firm | |

### MRS. KATE HARTER, EATON, IND.

| | |
|---|---|
| Amount of capital | $14,000 |
| Number of employes | 6 |
| Average daily wages | $1.30 |
| Number of perch | 1,200 |

| | |
|---|---|
| Value per perch | $0.80 |
| Niagara limestone, used for building, color buff and blue. | |
| Number of acres controlled by firm | 70 |
| Number of acres of undeveloped stone land owned by Brant, Carter & Co | 15 |
| Number of acres owned by Dr. Mitchel | 100 |

## YONTZ & MORRIS, EATON, IND.

| | |
|---|---|
| Amount of capital | $2,500 |
| Number of employes | 3 |
| Average daily wages | $1.25 |
| One pump run by horse power. | |
| Number of perch of stone | 2,000 |
| Value per perch | $1.10 |
| Niagara limestone, used for building, color buff and blue. | |
| Number of acres controlled by firm | 10 |
| Leased from William Bosman. | |

## W. D. B. COOK, MONTPELIER, IND.

| | |
|---|---|
| Amount of capital | $1,000 |
| Number of employes | 3 |
| Average daily wages | $1.35 |
| One portable engine, 10-horse power. | |
| One rotary pump. | |
| Number of perch | 900 |
| Value per perch | $0.75 |
| Niagara limestone, used for building, color buff and blue. | |
| Number of acres controlled by firm | 1½ |
| Leased from I. B. Spalding. | |

## WOOD & LEWIS, MONTPELIER, IND.

| | |
|---|---|
| Amount of capital | $3,500 |
| Number of employes | 6 |
| Average daily wages | $1.35 |
| One portable engine, 20-horse power. | |
| One centrifugal pump. | |
| Number of perch | 2,000 |
| Value per perch | $1.00 |
| Niagara limestone, used for building, color blue. | |
| Number of acres controlled by firm | 10 |
| Number of acres of undeveloped stone land owned by Joseph Range | 9 |
| Number of acres owned by James H. Markle | 60 |
| Number of acres owned by I. B. Spalding | 30 |
| Number of acres owned by Emanuel Lacey | 30 |
| Number of acres owned by Walker Monroe | 20 |
| Number of acres owned by Cal Shull | 10 |
| Number of acres owned by F. B. Miller | 40 |

## BALTES & PALMER, MONTPELIER, IND.

| | |
|---|---|
| Amount of capital | $18,500 |
| Number of employes | 20 |
| Average daily wages | $1.35 |
| Two engines, one 40 and one 12-horse power. | |
| One boiler, 60-horse power. | |
| Number of steam drills | 1 |
| Number of steam derricks | 1 |
| One centrifugal pump. | |
| Number of car loads per year | 600 |
| Number of cubic feet per car | 300 |
| Value per car | $12.00 |
| Niagara limestone, used for building, color blue. | |
| Number of acres controlled by firm | 28 |

## TWIBEL & SONS, MONTPELIER, IND.

| | |
|---|---|
| Amount of capital | $8,000 |
| Number of employes | 15 |
| Average daily wages | $1.35 |
| One engine, 25-horse power. | |
| Number of steam drills | 1 |
| Number of steam derricks | 1 |
| One centrifugal pump. | |
| Number of car loads per year | 300 |
| Value per car | $12.00 |
| Number of acres controlled by firm | 15 |
| Sold to Baltes & Palmer. | |

## J. W. FREEMAN, BLUFFTON, IND.

| | |
|---|---|
| Amount of capital | $7,000 |
| Number of employes | 16 |
| Average daily wages | $1.50 |
| One engine, 35-horse power. | |
| Number of steam drills | 1 |
| Number of rotary pumps | 1 |
| One Blake crusher. | |
| Number of perch | 4,000 |
| Value per perch | $1.00 |
| Niagara limestone, color gray; used for building. | |
| Number of acres controlled by firm | 12 |

## DECATUR STONE AND LIME CO., DECATUR, IND.

| | |
|---|---|
| Amount of capital | $8,000 |
| Number of employes | 10 |
| Average daily wages | $1.50 |
| One engine, 36-horse power. | |
| Number of steam drills | 1 |
| One steam and one hand derrick. | |

| | |
|---|---|
| Number of steam pumps | 1 |
| Number of gang-saws | 1 |
| Number of perch—long perch | 3,000 |
| Number of bushels of lime per year | 15,000 |
| Value per bushel | $0.17 |
| Value of stone per annum | $8,000 |

Limestone used for building and monument bases. Lime white.

| | |
|---|---|
| Number of acres controlled by firm | 3 |

## ROBINSON & GILLIG, DECATUR, IND.

| | |
|---|---|
| Amount of capital | $10,000 |
| Number of employes | 30 |
| Average daily wages | $1.50 |

One engine, 35-horse power.

| | |
|---|---|
| Number of steam drills | 1 |
| Number of Gates' crushers | 1 |
| Number of perch | 1,500 |
| Number of yards of stone | 3,500 |
| Value of stone per perch at quarry | $0.90 |
| Value of stone per yard at quarry | .85 |

Lower Helderberg group, dark dove-colored building stone.
Used for macadamizing.

| | |
|---|---|
| Number of acres controlled by firm | 30 |
| Number of acres of undeveloped stone land owned by Nimrod Dailey's heirs | 30 |
| Number of acres owned by Eli Zimmerman | 100 |

## SCHINDLER & SMITH, BUENA VISTA, IND. (P. O., LINN GROVE, IND.)

| | |
|---|---|
| Amount of capital | $2,000 |
| Number of employes | 8 |
| Average daily wages | $1.50 |

One engine, 10-horse power, portable.

| | |
|---|---|
| Number of perch | 2,000 |
| Value per perch | $0.80 |

Niagara limestone, used for building.

| | |
|---|---|
| Number of acres controlled by firm | 3 |

Leased from Mrs. Ensly.

## MESHBARGER & CO., BUENA VISTA, IND.

| | |
|---|---|
| Amount of capital | $2,000 |
| Number of employes | 8 |
| Average daily wages | |

One engine, 10-horse power, portable.

| | |
|---|---|
| Number of perch | 1,800 |
| Value per perch | $0.80 |

Niagara limestone, used for building, color blue.

| | |
|---|---|
| Number of acres controlled by firm | 4 |

### B. J. RICE, DECATUR, IND.

| | |
|---|---|
| Amount of capital | $2,500 |
| Number of employes | 12 |
| Average daily wages | $1.50 |
| One engine, 25-horse power. | |
| One crusher. | |
| Number of cubic yards per month | 4,000 |
| Used for roads and streets. | |
| Value per cubic yard | $0.85 |
| Number of acres controlled by firm | 5 |

### GUSMAN, CLINE & CO., MARKLE, IND.

| | |
|---|---|
| Amount of capital | $3,000 |
| Number of employes | 12 |
| Average daily wages | $1.75 |
| One engine, 10-horse power, portable. | |
| Number of steam drills | 1 |
| One horse power derrick. | |
| One centrifugal pump, 5x4½. | |
| Number of perch, 16½ feet per perch | 5,000 |
| Value per perch | $1.00 |
| Niagara limestone, good building stone, color blue. | |
| Number of acres controlled by firm | 4 |

### F. A. BRICKLEY, MARKLE, IND.

| | |
|---|---|
| Amount of capital | $1,250 |
| Number of employes | 8 |
| Average daily wages | $1.75 |
| One engine, 10-horse power, portable. | |
| One centrifugal pump, 4x3. | |
| Number of perch | 3,500 |
| Value per perch | $1.00 |
| Niagara limestone, used for building, color blue. | |
| Number of acres controlled by firm | 2 |

### J. W. ENGLISH, GREENSBURG, IND.

| | |
|---|---|
| Amount of capital | $2,500 |
| Number of employes | 35 |
| Average daily wages | $2.00 |
| One engine, 12-horse power. | |
| Number of steam drills | 2 |
| Number of derricks, one steam and three hand. | |
| Number of steam pumps | 1 |
| Number of car loads of stone per annum | 250 |
| Number of cubic feet per car | 225 |
| Value per car | $115.00 |
| All cut stone. | |
| Niagara limestone, used for building, color blue. | |

| | |
|---|---|
| Number of acres controlled by firm | 14 |
| Number of acres undeveloped stone land owned by— | |
| Charles Woodward | 12 |
| Thomas Kitchen | 7 |
| Pleasant Paugh | 4 |
| Elisha English | 5 |
| Cliff English | ½ |
| William Turner | 5 |
| Green Barnes | 10 |
| Mrs. Updyke | 10 |
| Harrison House | 10 |
| Everman Styers | 40 |

## LETT'S CORNER LIMESTONE CO., GREENSBURG, IND.

### QUARRIES AT LETT'S CORNER.

| | |
|---|---|
| Amount of capital | $4,000 |
| Number of employes | 35 |
| Average daily wages | $1.75 |
| One portable engine, 20-horse power. | |
| Number of steam drills | 2 |
| Number of derricks | 5 |
| Two are horse power and three hand power. | |
| Number of car loads per annum | 175 |
| Number of cubic feet per car | 200 |
| Value per car load | $75.00 |
| Niagara limestone, used for curb and gutter, color blue. | |
| Number of acres controlled by firm | 15 |
| There is good stone land in the vicinity. | |

## HOLLINSBEE STONE CO., GREENSBURG, IND.

### QUARRIES AT WESTPORT.

| | |
|---|---|
| Amount of capital | $20,000 |
| Number of employes | 67 |
| Average daily wages | $1.35 |
| One engine, 25-horse power. | |
| Number of channelers | 1 |
| Number of steam drills | 2 |
| One locomotive. | |
| Number of gang saws | 1 |
| Number of derricks | 7 |
| Four steam and three hand derricks. | |
| Number of car loads per annum | 750 |
| Number of cubic feet per car | 200 |
| Value per car | $26.30 |
| Limestone, used for curbing, bridges and paving. | |
| Number of acres controlled by firm | 50 |

## GREENSBURG LIMESTONE CO., GREENSBURG, IND.

Amount of capital . . . . . . . . . . . . . . . . . . . . . . . . . . $84,233
Number of employes . . . . . . . . . . . . . . . . . . . . . . . . . . 125
Average daily wages . . . . . . . . . . . . . . . . . . . . . . . . . . $2.25
One engine, 25-horse power.
Number of steam drills . . . . . . . . . . . . . . . . . . . . . . . . . 10
One of them is a capper.
Number of boilers . . . . . . . . . . . . . . . . . . . . . . . . . . 2
One boiler, 125-horse power, flue, and one 65-horse power, tubular.
One black crusher and engine, 35-horse power, and tubular boiler.
One upright boiler, 30-horse power.
One upright boiler, 20-horse power.
Number of steam pumps . . . . . . . . . . . . . . . . . . . . . . . . 1
Number of steam derricks . . . . . . . . . . . . . . . . . . . . . . . 4
Eight Buffalo horse-power and one hand-power derricks.
Number of car loads per annum . . . . . . . . . . . . . . . . . . . 1,566
Number of cubic feet per car . . . . . . . . . . . . . . . . . . . . 240
Value per car . . . . . . . . . . . . . . . . . . . . . . . . . . . $26.50
Total sales per annum . . . . . . . . . . . . . . . . . . . . . . . $41,386.00
Limestone, used for building and bridge work, color gray and blue.
Number of acres controlled by firm . . . . . . . . . . . . . . . . . 145¼
All stone land.

## THE FUESTON STONE CO., GREENSBURG, IND.

### QUARRIES AT WESTPORT, IND.

Amount of capital . . . . . . . . . . . . . . . . . . . . . . . . . . $2,000
Number of employes . . . . . . . . . . . . . . . . . . . . . . . . . . 30
Average daily wages . . . . . . . . . . . . . . . . . . . . . . . . . . $1.75
Number of hand derricks . . . . . . . . . . . . . . . . . . . . . . . 4
Number of car loads per annum . . . . . . . . . . . . . . . . . . . 150
Number of cubic feet per car . . . . . . . . . . . . . . . . . . . . 200
Value per car, all cut stone . . . . . . . . . . . . . . . . . . . . $115.00
Niagara limestone, used for curbing, guttering and flagging; color, blue.
Number of acres controlled by firm . . . . . . . . . . . . . . . . . 5
Leased from Aaron Boicourt.

## OWENS & STEVESON, WESTPORT, IND.

Amount of capital . . . . . . . . . . . . . . . . . . . . . . . . . . $225.00
Number of employes . . . . . . . . . . . . . . . . . . . . . . . . . . 9
Worked 75 days in 1890.
Wages paid . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . $852.00
Number of hand derricks . . . . . . . . . . . . . . . . . . . . . . . 2
Number of car loads . . . . . . . . . . . . . . . . . . . . . . . . . 12
Number of cubic feet per car load . . . . . . . . . . . . . . . . . . 200
Value per car . . . . . . . . . . . . . . . . . . . . . . . . . . . . $75.00
Niagara limestone, used for curbing and guttering; color, blue.

| | |
|---|---|
| Number of acres controlled by firm | 1 |
| Leased from Thos. Thomas. | |
| Number of acres of undeveloped stone land owned by | |
| Wm. Lawrence | 70 |
| Thos. Spencer | 60 |
| Craig & Forsythe | 160 |
| Jasper Patterson | 200 |

## W. F. BOBBINS, WESTPORT, IND.

### QUARRIES AT LETT'S CORNER.

| | |
|---|---|
| Amount of capital | $3,500 |
| Number of employes | 40 |
| Average daily wages | $1.75 |
| Number of boilers | 1 |
| Number of steam drills | 2 |
| Number of derricks | 3 |
| One horse power and two hand derricks. | |
| Number of cars per annum | 75 |
| Number of cubic feet per car | 200 |
| Value per car load | $90.00 |
| Limestone, used for flagging, curbing, footing, bridge and building, color blue. | |
| Number of acres controlled by firm | 7 |
| Leased from Allen Layton. | |

## BOICOURT & DOWDEN, WESTPORT, IND.

| | |
|---|---|
| Amount of capital | $1,000 |
| Number of employes | 10 |
| Average daily wages | $1.35 |
| Number of hand derricks | 3 |
| Number of car loads per annum | 200 |
| Number of cubic feet per car | 200 |
| Value per car load of cut stone | $70.00 |
| Value per car load of rough stone | $10.00 |
| Limestone, used for curbing, guttering and flagging, color blue. | |
| Number of acres controlled by firm | 3 |

## THOMAS BEMISH, WESTPORT, IND.

| | |
|---|---|
| Amount of capital | $300 |
| Average daily wages | $1.50 |
| Number of employes | 12 |
| Number of horse power derricks | 1 |
| Number of car loads for 1890 | 50 |
| Number of cubic feet per car | 250 |
| Estimated value of stone loaded on car | $70.00 |
| Niagara blue limestone. | |
| Number of acres owned by firm | 5 |

## JOHN L. SCANLAN, ST. PAUL, IND.

| | |
|---|---|
| Amount of capital | $30,000 |
| Number of employes | 75 |
| Average daily wages | $1.50 |
| Two engines, one 40-horse power and one 12-horse power. | |
| Number of channelers | 3 |
| Number of steam drills | 6 |
| Number of steam derricks | 5 |
| Number of horse power derricks | 1 |
| Number of hand power derricks | 1 |
| Number of car loads per annum— | |
| Flagging, 25 cars, value per car | $50.00 |
| Curbing, 50 cars, value per car | 70.00 |
| Rubble, 200 cars, value per car | 7.50 |
| Footing, 400 cars, value per car | 25.00 |
| Bridge, 375 cars, value per car | 18.00 |
| Macadam, 50 cars, value per car | 5.00 |
| Number of cubic feet per car | 200 |
| Limestone, color gray and blue. | |
| Number of acres controlled by firm | 150 |
| Forty acres good stone land. | |
| Number of acres undeveloped stone land owned by E. L. Floyd | 100 |

## HARPER & MUNS.

HARPER POSTOFFICE, DECATUR COUNTY, INDIANA.

| | |
|---|---|
| Amount of capital | $500 |
| Number of employes | 20 |
| Average daily wages | $1.50 |
| Two hand derricks. | |
| Number of car-loads per annum | 110 |
| Number of cubic feet per car | 200 |
| Value per car-load | $70.00 |
| Number of acres controlled by firm | 2 |
| Leased from John Boicourt. | |

## JOHN BOICOURT, HARPER POSTOFFICE, DECATUR COUNTY, IND.

QUARRIES AT SARDINIA CROSSING.

| | |
|---|---|
| Amount of capital | $500 |
| Number of employes | 10 |
| Average daily wages | $1.50 |
| Two hand derricks. | |
| Number of car-loads per annum | 25 |
| Number of cubic feet per car | 200 |
| Value per car-load | $70.00 |
| Niagara limestone, used for curbing and guttering; color, blue. | |
| Number of acres controlled by firm | 60 |
| Number of acres of undeveloped stone land owned by J. Q. Ellett | 80 |
| Jas. Meyers | 160 |
| Mrs. Dickson | 160 |

## WM. POOLE, NORTH VERNON, IND.

| | |
|---|---|
| Amount of capital | $200 |
| Number of employes | 5 |
| Average daily wages | $1.00 |
| Number of car-loads per annum | 4 |
| Number of cubic feet per car | 200 |
| Value per car-load | $50.00 |
| Devonian limestone, used for flagging and curbing; color, blue. | |
| Number of acres controlled by firm | 2 |

## HICKS & HOLMES, NORTH VERNON, IND.

| | |
|---|---|
| Amount of capital | $20,000 |
| Number of employes | 30 |
| Average daily wages | $1.75 |
| Work eight months per year. | |
| One engine, 16-horse power. | |
| Number of steam drills | 3 |
| One steam pump and boiler. | |
| Number of gang-saws | 1 |
| Number of horse-power derricks | 7 |
| Amount of product per year—number of cars | 400 |
| Number of cubic feet per car | 270 |
| Value per car | |
| Devonian limestone, color blue. | |
| Number of acres controlled by firm | 25 |

## HERMAN BROTHERS, VERNON, IND.

| | |
|---|---|
| Amount of capital | $5,000 |
| Number of employes | 7 |
| Average daily wages | $1.10 |
| Number of car loads per year | 400 |
| Number of cubic feet per car | 225 |
| Value per car | $8.50 |
| Rubble, macadam and bridge stone. | |
| Number of acres controlled by firm | 210 |
| One hundred and twenty acres stone land. | |

## CONNER & COVERT, NORTH VERNON, IND.

| | |
|---|---|
| Amount of capital | $600 |
| Number of employes | 3 |
| Average daily wages | $1.25 |
| Number of car loads per annum | 100 |
| Number of cubic feet per car | 250 |
| Value per car | $12.00 |
| Devonian limestone, color blue and gray. Rubble and macadam. | |
| Number of acres controlled by firm | 7 |

## BIG FOUR LIMESTONE CO., NEWPOINT, IND.

| | |
|---|---|
| Amount of capital | $35,000 |
| Number of employes | 125 |
| Average daily wages | $2.25 |

One engine, 40 horse-power; one portable engine, 10 horse-power, and one hoisting engine, 10 horse-power.

One locomotive.

| | |
|---|---|
| Number of steam drills | 6 |
| Number of steam derricks | 5 |
| Number of car loads per annum | 1,200 |
| Number of cubic feet per car | 225 |
| Value per car load | $50.00 |
| Total sales for last year | $60,000 |

Niagara limestone, used for rubble, curbing, guttering, bridge, flagging and jail stone; color, blue.

| | |
|---|---|
| Number of acres controlled by firm | 10 |

Leased from W. W. Hollinsbee.

Owned by same company:

| | |
|---|---|
| Quarry No. 2, number of acres | 80 |
| Number of acres of undeveloped stone land owned by Henry Topmiller, 10 acres good stone land. | 120 |
| Number of acres of undeveloped stone land owned by Oscar Barclay | 6 |
| Number of acres of John Gerwer's estate | 10 |

## EUREKA LIMESTONE CO., NEWPOINT, IND.

| | |
|---|---|
| Amount of capital | $7,000 |
| Number of employes | 40 |
| Average daily wages | $2.25 |

One portable engine, 10 horse-power.

| | |
|---|---|
| Number of steam drills | 2 |

Three horse-power and four hand-power derricks.

| | |
|---|---|
| Number of car loads per annum | 700 |
| Number of cubic feet per car | 225 |
| Value per car load | $50.00 |

Niagara limestone; color, blue and gray; used for flagging, curbing, guttering, footing, rubble, paving and rip rap.

| | |
|---|---|
| Number of acres controlled by firm | 14 |

One quarry leased on royalty from John F. Hollinsbee.

## COMAN & CO., NEWPOINT, IND.

| | |
|---|---|
| Amount of capital | $3,200 |
| Number of employes | 12 |
| Average daily wages | $1.50 |

One portable engine, 8-horse power.

| | |
|---|---|
| Number of steam drills | 1 |
| Number of horse power derricks | 2 |
| Number of car loads per year | 140 |
| Number of cubic feet per car | 225 |
| Value per car load | $30 |

Niagara limestone, used for rubble, footing and guttering, color blue and gray.

| | |
|---|---|
| Number of acres controlled by firm | 2 |

Leased from Susan Coman.

## ASHMAN & GLASGOW, OSGOOD, IND.

| | |
|---|---|
| Amount of capital | $20,000 |
| Number of employes | 75 |
| Average daily wages | $2.25 |
| Number of steam drills | 3 |
| Number of steam derricks | 2 |
| One traveler, 20-horse power. | |
| Number of steam pumps | 1 |
| One stationary boiler, 30-horse power. | |
| One Gates crusher and engine, 25-horse power. | |
| Number of car loads per annum | 700 |
| Number of cubic feet per car | 225 |
| Value per car load | $55.00 |

Niagara limestone, used for curbing, guttering, flagging and bridge stone, color blue and gray.

| | |
|---|---|
| Number of acres controlled by firm | ——— |
| Number of acres of undeveloped stone land owned by W. D. and T. Wilson | 30 |
| Number of acres owned by Mr. Levi | 10 |

## PETER WAGNER, OSGOOD, IND.

| | |
|---|---|
| Amount of capital | $10,000 |
| Number of employes | 25 |
| Average daily wages | $2.00 |
| One steam engine, 8-horse power. | |
| Number of steam drills | 1 |
| Number of hand derricks | 4 |
| Number of car loads per year | 100 |
| Number of cubic feet per car | 225 |
| Value per car | $70.00 |

Niagara limestone, used for curbing and guttering, color blue.

| | |
|---|---|
| Number of acres controlled by firm | 126 |
| Number of acres of undeveloped stone land owned by Thomas Jones | 48 |
| Number of acres owned by I. Levi | 7 |
| Number of acres owned by W. D. Wilson | 15 |

## J. T. BEACH, HOLTON, IND.

| | |
|---|---|
| Amount of capital | $335 |
| Number of employes | 12 |
| Average daily wages | $1.50 |
| Number of hand derricks | 1 |
| Number of car loads per annum | 250 |
| Number of cubic feet per car | 225 |
| Value per car load | $50 |

Niagara limestone, used for guttering, flagging, etc., color gray.

| | |
|---|---|
| Number of acres controlled by firm | 4 |

Leased from Phoebe J. Murdock.

## SQUIRE COX, HOLTON, IND.

| | |
|---|---|
| Amount of capital | $13,000 |
| Number of employes | 50 |
| Average daily wages | $1.75 |
| Number of steam drills | 1 |
| Number of hand derricks | 2 |
| One boiler, 15 horse power. | |
| Number of car-loads per annum | 850 |
| Number of cubic feet per car | 225 |
| Value per car-load | $50.00 |
| Niagara limestone, used for curbing, guttering, etc.; color, gray. | |
| Number of acres controlled by firm | 16 |
| Number of acres of undeveloped stone land owned by Clifford Overturf | 80 |
| Number of acres owned by Samuel Overturf | 80 |
| Number of acres owned by Henry Overturf | 160 |

## SECREST & CO., LAUREL, IND.

| | |
|---|---|
| Amount of capital | $15,000 |
| Number of employes | 85 |
| Work nine months per year. | |
| Average daily wages | $1.45 |
| Six derricks, four horse power, and two hand power. | |
| Number of car-loads per year | 800 |
| Number of cubic feet per car | 200 |
| Value per car-load | $44.00 |
| Niagara limestone, used for curbing, flagging, etc.; color, buff and blue. | |
| Number of acres controlled by firm | 400 |
| Available stone land, 20 acres. | |

## W. D. ADAMS, LAUREL, IND.

| | |
|---|---|
| Amount of capital | $500 |
| Number of employes | 3 |
| Average daily wages | $1.50 |
| Number of car-loads per annum | 5 |
| Number of cubic feet per car | 200 |
| Value per car | $70.00 |
| Niagara limestone, used for flagging; color, buff and blue. | |
| Number of acres controlled by firm | 12 |
| Number of acres of undeveloped stone land owned by Mrs. Fannie Derbyshire | 4 |
| Number of acres owned by Jas. Derbyshire | 8 |
| Number of acres owned by Harrison Crowe | 20 |

### JACOB SENIOUR, LAUREL, IND.

| | |
|---|---|
| Amount of capital | $1,000 |
| Number of employes | 5 |
| Average daily wages | $1.50 |
| Number of car-loads per annum | 75 |
| Number of cubic feet per car | 200 |
| Value per car-load | $60.00 |

Niagara limestone, used for flagging; color, buff and blue.

| | |
|---|---|
| Number of acres controlled by firm | 5 |

### FRANK DICE, LAUREL, IND.

| | |
|---|---|
| Amount of capital | $1,000 |
| Number of employes | 3 |
| Average daily wages | $1.75 |
| Number of car-loads per annum | 60 |
| Number of cubic feet per car-load | 200 |
| Value per car-load | $30.00 |

Niagara limestone, used for flagging and building; color, buff and blue.

| | |
|---|---|
| Number of acres controlled by firm | 6 |

### WILLIAM BLUE, LAUREL, IND.

| | |
|---|---|
| Amount of capital | $1,200 |
| Number of employes | 3 |
| Average daily wages | $1.50 |
| Number of car loads per year | 40 |
| Number of cubic feet per car | 200 |
| Value per car load | $60.00 |
| Number of acres controlled by firm | 10 |

### W. T. BALL, LONGWOOD, IND.

| | |
|---|---|
| Amount of capital | $8,000 |
| Number of employes | 10 |
| Average daily wages | $1.25 |

One derrick.

| | |
|---|---|
| Number of car loads per annum | 100 |
| Value per car load | $25.00 |

Limestone, used for foundations, crossings and flagging.

| | |
|---|---|
| Number of acres controlled by firm | 30 |

### A. W. CLOUD, LAUREL, IND.

| | |
|---|---|
| Amount of capital | $3,000 |
| Number of employes | 15 |
| Average daily wages | $1.40 |
| Number of car loads of stone for 1890 | 160 |
| Estimated value loaded on cars | $40.00 |
| Number of acres controlled by firm | 106 |

## JOSEPH WORSHAM, LONGWOOD, IND.

| | |
|---|---|
| Amount of capital | $1,000 |
| Number of employes | 3 |
| Average daily wages | $1.25 |
| Number of perch | 250 |
| Value per perch | $1.00 |
| Number of acres controlled by firm | 5 |

## BECK, PURVIANCE & BECK, HUNTINGTON, IND.

| | |
|---|---|
| Amount of capital | $50,000 |
| Number of employes | 50 |
| Average daily wages | $1.35 |
| One engine and hoist, 40-horse power. | |
| Number of steam drills | 2 |
| One steam and one centrifugal pump. | |
| Number of bushels of lime per annum | 280,000 |
| Value per bushel | $0.11 |
| Number of acres controlled by firm | 125 |
| Number of perpetual kilns | 6 |

## HUNTINGTON WHITE LIME CO., HUNTINGTON, IND.

| | |
|---|---|
| Amount of capital | $70,000 |
| Number of employes | 60 |
| Average daily wages | $1.35 |
| Two engines, one 40-horse power, and one 12-horse power. | |
| Number of boilers | 2 |
| Number of steam drills | 2 |
| One steam and one centrifugal pump. | |
| Number of bushels of lime per annum | 420,000 |
| Value per bushel | $0.11 |
| Number of acres controlled by firm | 200 |
| Number of perpetual kilns | 8 |

## BALTES & MARTINS, HUNTINGTON, IND.

| | |
|---|---|
| Amount of capital | $75,000 |
| Number of employes | 75 |
| Average daily wages | $1.35 |
| Three engines, one 25 horse-power and two 20 horse-power. | |
| Number of steam drills | 2 |
| One steam and one centrifugal pump. | |
| Number of bushels of lime per annum | 525,000 |
| Value per bushel | $0.11 |
| Number of acres controlled by firm | 395 |
| Number of perpetual kilns | 10 |

## CASPER NOLLIS, HUNTINGTON, IND.

| | |
|---|---|
| Amount of capital | $1,500 |
| Number of employes | 4 |
| Average daily wages | $1.35 |
| One portable engine, 10 horse-power. | |
| Number of steam drills | 1 |
| One centrifugal pump. | |
| Number of perch | 2,500 |
| Value per perch | $0.60 |
| Niagara limestone, used for building; color, blue. | |
| Number of acres controlled by firm | 3 |

## FRANK LISMAN, HUNTINGTON, IND.

| | |
|---|---|
| Amount of capital | $5,000 |
| Number of employes | 10 |
| Average daily wages | $1.35 |
| Two engines, 10 horse-power each. | |
| Number of steam drills | 1 |
| Number of perch | 6,000 |
| Value per perch | $0.60 |
| Niagara limestone, used for building; color, blue. | |
| Number of acres controlled by firm | 20 |
| Leased from Dr. Furgeson. | |

## BRIDGES & SONS, WABASH, IND.

| | |
|---|---|
| Amount of capital | $10,000 |
| Number of employes | 10 |
| Average daily wages | $1.50 |
| Number of perch | 5,000 |
| Value per perch | $0.83 |
| Niagara limestone, used for building; color, blue and gray. | |
| Number of acres controlled by firm | 10 |
| Five acres stone land. | |
| Number of acres of undeveloped stone land owned by Mr. Safford | 12 |
| Number of acres owned by Smith heirs | 12 |

## W. H. BENT, SOUTH WABASH, IND.

| | |
|---|---|
| Amount of capital | $10,000 |
| Number of employes | 8 |
| Average daily wages | $1.50 |
| Number of perch | 4,000 |
| Value per perch | $0.50 |
| Niagara limestone, used for flagging and crossing; color, buff. | |
| Number of acres controlled by firm | 13 |

## JACOB S. LAMBERT, SOUTH WABASH, IND.

| | |
|---|---|
| Amount of capital | $500 |
| Number of employes | 10 |
| Average daily wages | $1.50 |
| Number of perch | 6,000 |
| Value per perch | $5.00 |
| Value per foot | 20 |
| Limestone, used for flagging and street crossings. | |
| Number of acres controlled by firm | 3 |

## A. C. LAMBERT, SOUTH WABASH, IND.

| | |
|---|---|
| Amount of capital | $2,000 |
| Number of employes | 15 |
| Average daily wages | $1.50 |
| Number of car loads per annum | 500 |
| Number of cubic feet per car load | 275 |
| Value per car load | $30.00 |
| Niagara limestone, used for building, color buff and blue. | |
| Number of acres controlled by firm | 15 |
| Number of acres undeveloped stone land owned by Joseph Daugherty | 25 |
| Number of acres owned by Smith heirs | 4 |
| Number of acres owned by Daniel Hutching | 116 |
| Number of acres owned by William Unger | 80 |
| Number of acres owned by Isaac Unger | 80 |
| Number of acres owned by William Pierson | 40 |
| Number of acres owned by William P. Stocker | 40 |
| Number of acres owned by U. M. Engleman | 40 |

## PHILIP DAVIS, SOUTH WABASH, IND.

| | |
|---|---|
| Amount of capital | $500 |
| Number of employes | 3 |
| Average daily wages | $1.50 |
| Number of perch | 200 |
| Value per perch | $0.75 |
| Niagara limestone, used for building, color blue. | |
| Number of acres controlled by firm | 60 |

## PHILIP HIPSKIND, WABASH, IND.

| | |
|---|---|
| Amount of capital | $10,000 |
| Number of employes | 14 |
| Average daily wages | $1.50 |
| One portable engine, 12-horse power. | |
| One steam pump. | |
| Number of yards per annum | 2,000 |
| Number of perch of stone per annum | 2,000 |
| Number of square feet flagging | 7,000 |
| Value per square yard | $0.85 |
| Value per perch, 16½ feet | 65 |
| Value per foot for flagging | 15 |
| Niagara limestone, used for macadam, building and flagging, color gray. | |
| Number of acres controlled by firm | 25 |
| Twenty acres leased from T. F. Payne. | |

## WILLIAM MOELERING, WABASH, IND.

| | |
|---|---|
| Amount of capital | $10,000 |
| Number of employes | 50 |
| Average daily wages | $1.75 |
| Number of car loads per annum | 800 |
| Number of cubic feet per car load | 275 |
| Value per car load | $12.00 |
| Niagara limestone, used for building. | |
| Number of acres controlled by firm | 35 |

## SMITH BROS., WABASH, IND.

| | |
|---|---|
| Amount of capital | $3,000 |
| Number of employes | 18 |
| Average daily wages | $1.50 |
| Number of perch | 6,000 |
| Value per perch | $0.75 |
| Niagara limestone, used for building, color blue and gray. | |
| Number of acres controlled by firm | 1 |

## C. H. BROWNELL, PERU, IND.

| | |
|---|---|
| Amount of capital | $3,000 |
| Number of employes | 8 |
| Average daily wages | $1.25 |
| One engine, 10-horse power. | |
| Number of steam pumps | 1 |
| Number of perch | 3,000 |
| Value per perch | $1.25 |
| Niagara limestone, used for building; color, blue. | |
| Number of acres controlled by firm | 6 |

## DAVID LONG, PERU, IND.

| | |
|---|---|
| Amount of capital | $1,000 |
| Number of employes | 3 |
| Average daily wages | $1.25 |
| Number of perch, per month | 300 |
| Value per perch | $1,25 |
| Number of acres coutrolled by firm | 4 |

## CHAS. TRIPPIER, PERU, IND.

| | |
|---|---|
| Amount of capital | $500 |
| Number of employes | 2 |
| Average daily wages | $1.25 |
| Number of bushels of lime per annum | 1,000 |
| Value per bushel | $0.20 |
| Number of acres controlled by firm | 2 |

### DAVID McRAE, PERU, IND.

| | |
|---|---|
| Amount of capital | $1,000 |
| Number of employes | 2 |
| Average daily wages | $1.25 |
| Number of perch | 1,000 |
| Value per perch | $1.25 |
| Number of acres controlled by firm | 2 |

### A. B. KEEPORT, LOGANSPORT, IND.

| | |
|---|---|
| Amount of capital | $10,000 |
| Number of employes | 15 |
| Average daily wages | $1.35 |
| One engine, 10-horse power. | |
| Number of steam drills | 1 |
| Number of bushels of lime per annum | 100,000 |
| Value per bushel | $0.11 |
| Devonian limestone; color, blue. | |
| Number of acres controlled by firm | 30 |

### AUGUST GLEITZ, LOGANSPORT, IND.

| | |
|---|---|
| Amount of capital | $10,000 |
| Number of employes | 12 |
| Average daily wages | $2.50 |
| This includes teams and teamsters. | |
| Two hand power derricks. | |
| Number of perch, 16½ feet | 10,000 |
| Value per perch | $1.00 |
| Devonian limestone, used for rubble; color, gray. | |
| Number of acres controlled by firm | 9 |
| Number of acres of undeveloped stone land owned by Hamburg heirs | 15 |
| Number of acres owned by Andrew Young | 10 |
| Number of acres owned by Dr. Fitch | 20 |
| Number of acres owned by G. M. Fitch | 10 |

### HEADY & WOOLF, LOGANSPORT, IND.

| | |
|---|---|
| Amount of capital | $5,000 |
| Number of employes | 6 |
| Average daily wages | $2.00 |
| Number of perch | 5,000 |
| Value per perch | $1.00 |
| Devonian limestone, used for rubble; color, gray. | |
| Number of acres controlled by firm | 3 |
| Leased from E. M. Talbot. | |

## JOHN BARNES, LOGANSPORT, IND.

| | |
|---|---|
| Amount of capital | $1,000 |
| Number of employes | 4 |
| Average daily wages | $1.50 |
| Number of perch | 2,500 |
| Value per perch | $1.00 |
| Devonian limestone, used for rubble; color, gray. | |
| Number of acres controlled by firm | 1 |

## T. C. BARNES, LOGANSPORT, IND.

| | |
|---|---|
| Amount of capital | $500 |
| Number of employes | 5 |
| Average daily wages | $1.75 |
| Number of perch | 2,000 |
| Value per perch | $1.00 |
| Devonian limestone, used for rubble; color, gray. | |
| Number of acres controlled by firm | 4 |
| Leased from E. M. Talbott. | |

## LUX & LUX, LOGANSPORT, IND.

| | |
|---|---|
| Amount of capital | $10,000 |
| Number of employes | 6 |
| Average daily wages | $1.50 |
| Number of perch | 3,000 |
| Value per perch | $0.75 |
| Devonian limestone, used for building; color, gray and blue. | |
| Number of acres controlled by firm | 26 |

## GEO. W. DEFENBAUGH, KOKOMO, IND.

| | |
|---|---|
| Amount of capital, principally land | $20,000 |
| Number of employes | 10 |
| Average daily wages | $1.25 |
| One engine, 5 horse-power. | |
| Number of steam pumps | 2 |
| Number of perch | 2,000 |
| Number of yards of macadam | 3,000 |
| Value per perch | $1.35 |
| Value per yard macadam | .45 |
| Water line, used for building and macadam; color, dove. | |
| Number of acres controlled by firm | 20 |
| Number of acres of undeveloped stone land owned by Geo. W. Hocker, | 1 |

## HOCKER & DALMAN, KOKOMO, IND.

| | |
|---|---|
| Amount of capital | $5,000 |
| Number of employes | 8 |
| Average daily wages | $1.25 |
| One engine, 10 horse-power. | |
| Number of steam pumps | 1 |
| Number of perch | 3,000 |
| Value per perch | $1.35 |
| Number of acres controlled by firm | 25 |

## McGLEN & CO., KOKOMO, IND.

| | |
|---|---|
| Amount of capital | $4,000 |
| Number of employes | 14 |
| Average daily wages | $1.75 |
| One engine, 10-horse power. | |
| Number of steam pumps | 1 |
| Number of perch | 5,000 |
| Number of yards of macadam | 3,000 |
| Value per perch | $1.10 |
| Value per yard, macadam | .90 |
| Water lime, used for building and macadam. | |
| Number of acres controlled by firm | 10 |

## STEWART & BROTHERS, KOKOMO, IND.

| | |
|---|---|
| Amount of capital | $5,000 |
| Number of employes | 100 |
| Average daily wages | $1.50 |
| One engine, 15-horse power. | |
| Number of steam pumps | 1 |
| Number of perch | 6,000 |
| Number of yards of macadam | 28,000 |
| Value per perch | $1.25 |
| Value per yard macadam | .80 |
| Water lime, dove color. | |
| Number of acres controlled by firm | 8 |

## JOLLISANT & SWEENEY, GEORGETOWN, IND.

| | |
|---|---|
| Amount of capital | $1,000 |
| Number of employes | 12 |
| Average daily wages | $1.40 |
| One hand derrick. | |
| Number of car loads of stone per annum | 300 |
| Number of cubic feet per car load | 225 |
| Value per car load | $30.00 |
| Oolitic limestone, used for paving and macadam. | |
| Number of acres controlled by firm | 4 |

Leased from Jefferson Keithly. Quarries at Crandall were not worked last year; now owned by the Indiana Improvement Co., that expects to work them extensively this year.

This is Oolitic stone, of buff color, and good quality.

## CORYDON STONE CO., CORYDON, IND.

| | |
|---|---|
| Amount of capital | $75,000 |
| Number of employes | 40 |
| Average daily wages | $1.40 |
| Number of engines | 2 |
| One engine 50-horse power, and one 30-horse power. | |
| Number of steam drills | 2 |
| Number of channelers | 3 |
| Number of gang-saws | 4 |
| Number of steam derricks | 4 |
| Number of horse-power derricks | 1 |
| Number of ejectors | 4 |
| One rubbing bed. | |
| Number of car loads of stone per annum | 200 |
| Number of cubic feet per car load | 200 |
| Value per car | $100 |
| Oolitic and St. Louis limestone; the former buff, and the latter a beautiful blue, that makes fine table tops, door and window sills and caps, and trimmings of all kinds. | |
| Number of acres controlled by firm | 80 |

## INDIANA CONTRACT CO., MILLTOWN, IND.

OFFICE AT EVANSVILLE, IND.

| | |
|---|---|
| Amount of capital | $20,000 |
| Number of employes | 100 |
| Average daily wages | $1.50 |
| Number of engines | 2 |
| One engine 100-horse power and one 25-horse power. | |
| Number of crushers | 1 |
| Number of elevators | 2 |
| Number of carriers | 1 |
| Number of car loads of stone per annum | 2,000 |
| Number of cubic feet per car | 350 |
| Value per car load | $11.00 |
| St. Louis limestone, used for macadam, color drab. | |
| Number of acres controlled by firm | 42 |

## J. B. SPEED & CO., MILLTOWN, IND.

| | |
|---|---|
| Amount of capital | $20,000 |
| Number of employes | 14 |
| Average daily wages | $1.40 |
| Number of engines | 2 |
| One engine 16-horse power and one 10-horse power. | |
| Number of bushels of lime per annum | 100,000 |
| Value per bushel | $0.12½ |
| St. Louis limestone, color drab. | |
| Number of acres controlled by firm | 24 |

### MRS. GARROW, MARENGO, IND.

| | |
|---|---|
| Amount of capital | $2,000 |
| Number of employes | 15 |
| Average daily wages | $1.25 |
| One engine, 35-horse power. | |
| Number of crushers | 1 |
| One set of burrs. | |
| Number of bushels of lime | 8,000 |
| Number of car loads of stone, pulverized for glass making | 150 |
| Number of car loads of macadam | 100 |
| Number of cubic feet per car | 250 |
| Value per car, pulverized | $40.00 |
| Value per car load, macadam | 12.00 |
| St. Louis limestone, color gray. | |
| Number of acres controlled by firm | 2½ |

### DR. BUEST, ST. ANTHONY, IND.

RESIDENCE, NEW ALBANY, IND.

| | |
|---|---|
| Amount of capital | $5,000 |
| Number of steam drills | 1 |
| One-horse power derrick. | |
| Lower Coal Measure sandstone, color brown, used for building. | |
| Number of acres controlled by firm | 200 |
| Not worked for two years. | |
| The above facts were gathered from a visit to the quarry. | |

### WINDSTANLY & BREYFOGLE, ST. ANTHONY, IND.

| | |
|---|---|
| Lower Coal Measure sandstone, color brown, used for building. | |
| Number of acres controlled by firm | 200 |
| Not worked in 1890. | |

### JACOB ECKERT, JASPER, IND.

| | |
|---|---|
| Amount of capital | $2,000 |
| Number of employes | 5 |
| Average daily wages | $1.50 |
| One hand derrick. | |
| Number of cubic yards per annum | 300 |
| Value per yard | $3.50 |
| Carboniferous sandstone, color blue and white. | |
| Number of acres controlled by firm | 37 |

## VAN SCHRODER, JASPER, IND.

| | |
|---|---|
| Amount of capital | $1,500 |
| Number of employes | 2 |
| Average daily wages | $1.50 |
| One derrick. | |
| Number of cubic yards per annum | 200 |
| Value per cubic yard | $3.50 |
| Carboniferous sandstone, color white, good quality. | |
| Number of acres controlled by firm | 2 |
| Leased from Buelline Bros. | |

## EIEGENMANN & HALLENBACH, CANNELTON, IND.

| | |
|---|---|
| Amount of capital | $2,000 |
| Number of employes | 50 |
| Average daily wages | $2.25 |
| One derrick boat and engine, 25 horse-power. | |
| Three hand derricks. | |
| Number of cubic yards per annum | 1,535 |
| Value per cubic yard | $2.50 |
| Lower carboniferous sandstone; color, buff. | |
| Territory leased from American Cannel Coal Co. and N. Vaughn. | |

## FRANK PAULINE, CANNELTON, IND.

| | |
|---|---|
| Amount of capital | $200 |
| Number of employes | 8 |
| Average daily wages | $1.35 |
| Three hand derricks. | |
| Number of cubic yards per annum | 300 |
| Value per cubic yard | $2.50 |
| Lower carboniferous sandstone, used for bridge and foundation work; color, buff. | |
| Number of acres controlled by firm | 4 |

## CLEARWATER BROS., CANNELTON, IND.

| | |
|---|---|
| Amount of capital | $200 |
| Number of employes | |
| Average daily wages | $1.35 |
| Two horse-power derricks. | |
| Number of cubic yards per annum | 443 |
| Value per cubic yard | $2.50 |
| Lower carboniferous sandstone, good, used for bridge and lock work; color, buff. | |
| Number of acres controlled by firm | 2 |
| Leased from N. Vaughn. | |

## W. S. DOUGLAS, FOUNTAIN, IND.

| | |
|---|---|
| Amount of capital | $300 |
| Number of employes | 3 |
| Average daily wages | $1.25 |
| Number of car loads per annum | 30 |
| Number of cubic feet per car | 180 |
| Value per car | $20.00 |
| Lower carboniferous sandstone, used for building; color, buff and blue. | |
| Number of acres controlled by firm | 2 |
| Leased from H. J. Reed. | |
| Number of acres of undeveloped stone land owned by L. B. Brooks | 10 |
| Number of acres owned by W. C. B. Sewall | 4 |

## THE ILLINOIS & INDIANA STONE CO., SILVERWOOD, IND.

| | |
|---|---|
| Amount of capital | $250,000 |
| Number of employes | 60 |
| Average daily wages | $1.50 |
| Two engines, 40 horse-power each. | |
| Number of channelers | 4 |
| Two bar and two Waddell. | |
| Number of gang saws | 3 |
| One double gang, 16 feet long. | |
| Number of steam pumps | 2 |
| Number car loads per annum | 750 |
| Number of cubic feet per car | 275 |
| Value per car | $75.00 |
| Carboniferous sandstone; color, gray; used for building. | |
| Number of acres controlled by firm | 25 |
| Number of acres undeveloped stone land, owned by Jacob Oldshoe | 40 |
| Number of acres owned by Robert Oldshoe | 40 |
| Number of acres owned by Samuel Milligan | 40 |
| All limestone. | |
| Number of acres undeveloped stone land, owned by William Jarvis, Guion, Ind. | 30 |
| Sandstone. | |

## JAMES SCHEE, POTTSVILLE, IND.

| | |
|---|---|
| Amount of capital | $1,500 |
| Number of employes | 12 |
| Average daily wages | $1.25 |
| Number of car-loads per annum | 400 |
| Number of cubic feet per car | 180 |
| Value per car | $12.50 |
| Carboniferous sandstone; color, gray; used for rip-rap. | |
| Number of acres controlled by firm | 4 |

## PARK COUNTY BROWN STONE CO., MANSFIELD, IND.

| | |
|---|---|
| Amount of capital | $150,000 |
| Number of employes | 20 |
| Average daily wages | $1.50 |
| One engine, 30-horse power. | |
| Number of channelers | 2 |
| Number of derricks | 3 |
| One steam, one horse, and one hand power. | |
| Number of car-loads per annum | 150 |
| Number of cubic feet per car | 275 |
| Value per car | $200.00 |
| Carboniferous sandstone; color, brown; used for building. | |
| Number of acres controlled by firm | 200 |
| Number of acres undeveloped stone land owned by J. R. Johnson | 40 |
| Number of acres owned by Mrs. Zopher Coleman | 20 |

## E. & T. H. R. R. FARMERSBURG, IND.

| | |
|---|---|
| Amount of capital | |
| Number of employes | 12 |
| Average daily wages | $1.50 |
| Number of derricks | 3 |
| One horse and two hand power. | |
| Number of car-loads per annum | 60 |
| Number of cubic feet per car | 225 |
| Value per car | $70.00 |
| Coal measure limestone; color, gray; used for bridge work. | |
| Number of acres controlled by firm | 2 |
| Leased from Mr. Cally, Sullivan, Ind. | |
| Number of acres undeveloped stone land owned by William Baldridge | 150 |
| Number of acres owned by William Johns | 40 |
| Number of acres owned by Willis Bennefield | 30 |

## McKAIN BROS. & CO., DELPHI, IND.

| | |
|---|---|
| Amount of capital | $10,000 |
| Number of employes | 20 |
| Average daily wages | $1.25 |
| One engine, 12-horse power. | |
| Number of steam drills | 1 |
| Number of steam pumps | 1 |
| Number of bushels of lime per annum | 80,000 |
| Value per bushel | $0.12 |
| Niagara limestone; color, buff. | |
| Number of acres controlled by firm | 21 |

### DELPHI LIME CO., DELPHI, IND.

| | |
|---|---|
| Amount of capital | $20,000 |
| Number of employes | 25 |
| Average daily wages | $1.25 |
| One engine, 12-horse power. | |
| Number of steam drills | 1 |
| Number of bushels of lime per annum | 110,000 |
| Value per bushel | $0.12 |
| Niagara limestone; color, gray. | |
| Number of acres controlled by firm | 20 |
| Number of acres undeveloped stone land owned by L. B. Sims | 40 |
| Number of acres owned by McKain heirs | 50 |
| Number of acres owned by Sarah Mitchel | 40 |
| Number of acres owned by William Bradshaw | 20 |

### A. T. BOWEN & CO., DELPHI, IND.

| | |
|---|---|
| Amount of capital | $10,000 |
| Number of employes | 5 |
| Average daily wages | $1.50 |
| Number of perch | 1,000 |
| Value per perch | $0.75 |
| Devonian limestone, color buff, used for building. | |
| Number of acres controlled by firm | 20 |

### BARNHART BROS., ATTICA STONE QUARRY, ATTICA, IND.

| | |
|---|---|
| Amount of capital | $40,000 |
| Number of employes | 35 |
| Average daily wages | $1.75 |
| Number of engines, 14-horse power each | 2 |
| Number of derricks, three steam and four hand | 7 |
| Number of car loads per annum | 1,200 |
| Number of cubic feet per car | 190 |
| Value per car | $18.00 |
| Sandstone, color buff, used for bridge and rubble. | |
| Number of acres controlled by firm | 40 |

### C. & G. P. HARLEY, DELPHI, IND.

| | |
|---|---|
| Amount of capital | $5,200 |
| Number of employes | 12 |
| Average daily wages | $1.25 |
| Number of bushels of lime per annum | 40,000 |
| Value per bushel | $0.12 |
| Niagara limestone. | |
| Number of acres controlled by firm | 40 |
| Capacity of kilns, per annum | 100,000 |

## JACOB SMITH, ATTICA, IND.

| | |
|---|---|
| Amount of capital | $500 |
| Number of employes | 4 |
| Average daily wages | $1.50 |
| Number of car loads per annum | 20 |
| Number of cubic feet per car | 180 |
| Value per car | $18.00 |
| Sandstone, color white, used for bridge work. | |
| Number of acres controlled by firm | 4 |
| Leased from Robert Milligan. | |

## HENRY HERRICK, WILLIAMSPORT, IND.

| | |
|---|---|
| Amount of capital | $1,500 |
| Number of employes | 12 |
| Average daily wages | $1.25 |
| Number of hand derricks | 4 |
| Number of car loads per annum | 180 |
| Number of cubic feet per car | 180 |
| Value per car | $18.00 |
| Sandstone, color buff, used for building. | |
| Number of acres controlled by firm | 4 |
| Leased from Gregory heirs. | |
| Number of acres undeveloped stone land owned by Gregory heirs | 20 |
| Number of acres owned by Henry Herrick | 25 |

## J. L. STUMP, WILLIAMSPORT, IND.

| | |
|---|---|
| Amount of capital | $1,500 |
| Number of employes | 20 |
| Average daily wages | $1.25 |
| Number of hand derricks | 2 |
| Number of hand pumps | 8 |
| Number of car loads of stone per annum | 40 |
| Number of cubic feet per car | 200 |
| Lower carboniferous sandstone, color buff; used for bridge abutments and piers. | |
| Number of acres controlled by firm | 4 |
| Leased from James McCabe. | |

## J. L. STUMP, WILLIAMSPORT, IND.

| | |
|---|---|
| Amount of capital | $400 |
| Number of employes | 8 |
| Average daily wages | $1.25 |
| Number of hand derricks | 2 |
| Number of car loads per annum | 17 |
| Number of cubic feet per car | 200 |
| Value per car | $21.00 |
| Lower carboniferous sandstone, color buff; used for bridge work. | |
| Number of acres controlled by firm | 10 |
| Leased from Isaac D. High. | |

### J. L. STUMP, WILLIAMSPORT, IND.

| | |
|---|---|
| Amount of capital | $600 |
| Number of employes | 15 |
| Average daily wages | $1.25 |
| Number of hand derricks | 2 |
| Number of car loads per annum | 18 |
| Number of cubic feet per car | 200 |
| Value per car | $21.00 |

Lower carboniferous sandstone, color buff; used for bridge work.

| | |
|---|---|
| Number of acres controlled by firm | 20 |

Leased from Woods & Boner.

### JACOB PFEIFER, WILLIAMSPORT, IND.

| | |
|---|---|
| Amount of capital | $500 |
| Number of employes | 10 |
| Average daily wages | $1.50 |

One horse and one hand power derrick.

| | |
|---|---|
| Number of car loads per annum | 120 |
| Number of cubic feet per car | 180 |
| Value per car | $18.00 |

Lower carboniferous sandstone, color buff; used for bridge work.

| | |
|---|---|
| Number of acres controlled by firm | 10 |

### ANTON ELLGEN, WILLIAMSPORT, IND.

| | |
|---|---|
| Amount of capital | $1,500 |
| Number of employes | 8 |
| Average daily wages | $1.50 |

One horse power.

| | |
|---|---|
| Number of derricks—one horse and two hand powers | 3 |
| Number of car loads per annum | 200 |
| Number of cubic feet per car | 180 |
| Value per car | $18.00 |

Lower carboniferous sandstone; color, buff; used for rubble and bridge work.

| | |
|---|---|
| Number of acres controlled by firm | 8 |

Leased from Gregory heirs.

### HARRISON & LANGDON, RIVERSIDE, IND.

| | |
|---|---|
| Amount of capital | $5,000 |
| Number of employes | 15 |
| Average daily wages | $1.50 |
| Number of hand derricks | 2 |
| Number of car loads per annum | 100 |
| Number of cubic feet per car | 200 |
| Value per car | $20.00 |

Lower carboniferous sandstone; color, buff and blue; used for rubble and bridge work.

| | |
|---|---|
| Number of acres controlled by firm | 6 |

## GUYER & BURCHBY, RIVERSIDE, IND.

| | |
|---|---|
| Amount of capital | $10,000 |
| Number of employes | 20 |
| Average daily wages | $1.75 |
| One engine, 10 horse-power. | |
| Number of steam drills | 8 |
| Number of channelers | 4 |
| Number of hand derricks | 4 |
| Number of car loads per annum | 600 |
| Number of cubic feet per car | 180 |
| Value per car | $50.00 |
| Lower carboniferous sandstone; color, buff and blue; cut stone, bridge and rubble work. | |
| Number of acres controlled by firm | 60 |

## GODDARD & CO., INDIANAPOLIS, IND.

| | |
|---|---|
| Amount of capital | $15,000 |
| Number of employes | 20 |
| Average daily wages | $2.75 |
| Number of engines | 1 |
| 30 horse-power. | |
| Number of steam gang saws | 4 |
| Number of derricks | 5 |
| Four hand and one steam derrick. | |
| Number of car loads of stone per annum | 100 |
| Number of cubic feet per car | 225 |
| Value per cubic foot | $1.40 |
| Niagara and oolitic limestone, mainly the latter. | |

## ITTENBACH & CO., INDIANAPOLIS, IND.

| | |
|---|---|
| Amount of capital | $40,000 |
| Number of employes | 30 |
| Average daily wages | $2.75 |
| Number of engines | 1 |
| 25 horse-power. | |
| Number of gang saws | 6 |
| Number of planers | 1 |
| Number of hand derricks | 1 |
| Number of travelers | 1 |
| Number of car loads per annum | 125 |
| Number of cubic feet per car | 225 |
| Value per cubic foot | $1.30 |

# REPORT UPON THE GEOLOGY OF STEUBEN COUNTY.

BY CHARLES R. DRYER.

Steuben County, situated in the extreme northeast corner of the State, is bounded on the north by Michigan, on the east by Michigan and Ohio, on the south by Dekalb County, Indiana, and on the west by Lagrange County. It is nearly twenty-one miles long east and west, sixteen miles wide from north to south, and comprises about 330 square miles. It includes the whole or a part of townships 36 and 38, in ranges 12 and 15, those in the northern and eastern tiers being fractional. For convenience the civil names will be used to designate the Congressional townships, as follows:

| | *R.* 12. | *R.* 13. | *R.* 14. | *R.* 15. |
|---|---|---|---|---|
| Township No. 38, | Millgrove, | Jamestown, | Fremont, | Clear Lake, |
| Township No. 37, | Jackson, | Pleasant, | Scott, | York, |
| Township No. 36. | Salem. | Steuben. | Otsego. | Richland. |

The first settlers in the county came to Jackson Prairie in 1831, and the county was organized in 1837, with Angola, a little south of its center as the county seat. But one railroad enters its limits, the Fort Wayne branch of the Lake Shore & Michigan Southern crossing from south to northeast. An extension of the Canada Southern was graded several years ago, along the southern border, and then abandoned.

Physically, Steuben County is wholly occupied by the moraines of the Erie, Maumee and Saginaw glaciers, two of which are clearly distinguishable, crossing it from south southwest to north northeast; consequently the bed-rock is covered with a very heavy mantle of drift, which is probably as thick as anywhere in the State, at least 300 feet, and possibly, in some places, twice that thickness. These moraines are not at all modest or obscure, but display their massive proportions and strong features in a manner unmistakable to the most hasty observer. A remarkable collection of domed hills and irregular valleys, each usually occupied by a lake, gives to the surface a picturesque diversity unparalleled in Indiana. The lakes constitute, both for the traveler and the scientific observer, the most attractive and interesting feature of the region. Their great variety in size, shape and character render this region one of the best in the country for the study of morainic lakes, while their beauty and facilities for aquatic recreation render it delightful alike to the permanent resident and to the transient visitor. The area to be described comprises five natural divisions:

1. The Fish Creek Valley.
2. The Salamonie or Third Erie Moraine.
3. The Valley of Upper Pigeon River.
4. The Mississinewa or Fourth Erie Moraine.
5. The Region of Saginaw Drift.

### THE WABASH-ABOIT OR SECOND ERIE MORAINE.*

This moraine touches the southeast corner of the county, and covers four or five sections of Richland Township.

*The Fish Creek Valley* comprises a portion of the townships of Richland and York. It is a level depression, about one mile wide, through which the stream meanders in a direction a few degrees west of south, from the southeast corner of York to the southeast corner of Otsego, where it is joined by the outlet of Fish Lake, and, turning abruptly to the southeast, cuts through the Wabash-Aboit Moraine to the St. Joseph of the Maumee. This valley forms a part of the interval between the second and third Erie Moraines, and is continuous with the more strongly marked interval occupied in Dekalb County by Cedar Creek.

*The Salamonie or Third Erie Moraine*† is a ridge of drift of extremely variable character, which extends from Mercer County, Ohio, along the right bank of the Salamonie River through the counties of Jay, Wells and Huntington, crossing the Wabash-Erie channel near Huntington City, and passes thence through the counties of Huntington, Whitley, Allen, Noble, Dekalb and Steuben to the northeast corner of the State. In Steuben County it comprises a belt about four miles wide, stretching from Clear Lake to Fish Lake and occupying the townships of Clear Lake and York, nearly the whole of Otsego, and portions of Fremont, Scott and Richland. This is by far the most strongly marked portion of the whole moraine. It is a belt of massive, rounded and dome-shaped hills, with moderate slopes, the valleys between being narrow and with no extensive marshes. Small kettle holes and large crystalline bowlders are numerous. The soil is chiefly bowlder clay, with occasional sand hills. The strongest features appear along the west shores of Fish Lake, where precipitous gravelly knobs, narrow ravines and innumerable dry kettle holes of all sizes monopolize the surface of the country. The whole topography probably lies within a vertical range of two hundred feet. A considerable tract around Cedar Lake is comparatively smooth and

* This moraine is fully described in the 16th Report of the State Geologist, page 119.

† Described in the Sixteenth Report of the State Geologist, p. 113.

covered with deposits of sand nearly worthless for agriculture. The greater part of this region presents one of the most beautifully diversified landscapes to be found in the State. At the same time the soil is the best quality of drift clay and the slopes are not too steep for agreeable farming. Magnificent forests of beech and maple timber still abound. It is strongly contrasted with the rest of the county by the absence of marshes and small lakes.

*The Valley of Upper Pigeon River* and its continuation in the sandy plain of western Otsego and eastern Steuben Townships constitute the interval between the third and fourth Erie Moraines. It is a very flat tract of country, three to four miles wide, in surprising contrast to the rugged hills on either side. It occupies the townships of Fremont and Scott and portions of Pleasant, Otsego and Steuben. This interval lies very near the crest of the Saginaw-Erie Moraine system, and has been largely filled up with overwash from both sides. It has been drained through transverse gaps in the range on the west, presently to be described, but at present has only one outlet. Pigeon Creek heads in Cedar Lake, sections 22 and 23 Fremont, once a large body of water, now buried under a muck meadow, and meanders southward to section 8, Otsego, where it turns westward and reaches the outlet gap at Pleasant Lake. It drains in its course several small marshy lakes in Scott Township, one buried or extinct in sections 2, 3, 10 and 11, one in sections 15 and 16, and Pigeon Lake, in section 20, also Johnson's Lake, in section 16, Otsego, and numerous tamarack swamps. The depressions are all shallow and mostly occupied by tamarack or other marshes of the "platter"-type. These are distinguished from the "kettles" and "bowls" characteristic of a moraine by their inconsiderable depth and indefinite margins. An extensive deposit of sand extends from Fremont village southeast three miles to the banks of the creek. In the eastern part of Steuben Township the valley becomes less distinguishable and merges into the relatively elevated plateau which forms the crest of the system in northern Dekalb. The Fort Wayne branch of the Lake Shore & Michigan Southern Railroad passes along the western edge of this valley and affords the following elevations:

| | |
|---|---|
| Pleasant Lake | 975 |
| Angola | 1,052 |
| Fremont | 1,055 |
| State Line (Ray) | 1,073 |

The same phenomenon of an elevated level interval along the western side of the morainic crest occurs also in western Whitley County.

*The Mississinewa or Fourth Erie Moraine* extends along the right bank of the Mississinewa River, through the counties of Jay, Delaware, Blackford, Grant and Wabash, crosses the Wabash River near La Gro, and extends thence through the counties of Wabash, Whitley, Noble and

Steuben. Like its neighbor on the east, it attains its highest elevation in Steuben County, where it occupies the greater part of the townships of Jamestown, Pleasant, Steuben and Salem, and a part of Jackson and Millgrove. It consists of an irregular range of knobs and hills, broken by transverse gaps into several groups, and interspersed with a great number of equally irregular lakes, among which are included the largest (with one possible exception) in the State. The southern section of this region lies in Salem Township, the southwestern part of Steuben and the southern half of Jackson. It is bounded on the north by the valley of Pigeon River, and on the south by that of Turkey Creek, both of which are depressed at least 100 feet below the general level. It consists of an elevated plateau comparatively level toward the south, but largely covered with massive hills of clay in the central portion, and of gravel with numerous bowlders toward the west line of the county.

The middle section in the townships of Pleasant and Jackson lies between the valley of Pigeon River and the basin of Centre, Crooked and Gage Lakes with their connecting streams. It is a region of knobs, gravel ridges, sand dunes, and medium sized lakes thrown together in extreme confusion. Its features are all on a moderate scale, but their variety and irregularity defy description. This portion of the moraine is bounded on the west by a valley of unique and interesting character, which seems to have been originally continuous from Hogback Lake to Gage Lake. It was probably once a large drainage channel through which the waters of the Pigeon River valley flowed to Crooked Creek, or *vice versa*.

Northeast of Hogback Lake the valley opens broadly to include Silver Lake and extensive bottom lands surrounding it, and sends an arm to the north occupied by Bass and Howard Lakes. Between the north end of Howard and the south end of Cheesebro and Grass Lakes, in section 24, Jackson, a gravel ridge a few rods wide and thirty feet high crosses the valley like an irregular railroad embankment or "fill." From this ridge the narrow valley of Grass Lake, 150 feet deep, extends northward a mile and a half, although the lake itself now consists only of a pool at the north end. On the north line of section 13, another gravel ridge is thrown across the valley, on the north side of which lies another small lake. A third and a fourth ridge, more massive than the others, with a third small lake between, separates Grass Lake from Gage Lake. Grass and the other two have no visible outlet. That the lakes of this chain occupy one continuous valley is obvious to any one who examines the region carefully, and that they are fragments of a once continuous body of water is equally plain. The original lake or stream has been dammed by subsequent intrusions of gravel and sand. This valley is an important feature in the topography, because it marks distinctly the dividing line between the Erie and the Saginaw drift. The difference between the general *facies* of the country on opposite sides of it is easy to see, but difficult to describe. On the east the hills and dunes of the fourth Erie moraine are piled in indescribable confusion. The country on the west has about the same general elevation, and is distinctly morainic in character, but is very much smoothed out. The slopes, whether gentle or steep, are broad and plateau-like, their evenness being broken only by an occasional small kettle-hole. The difference may be compared to that between the plump, rounded and dimpled face of a child and the prominent features, harsh outlines and wrinkled skin of an old man.

North of Angola a level, sandy plain two miles wide is continuous on the east with the valley of Pigeon Creek, and on the west with the basins of Crooked and James Lakes. This plain and its western prolongation through Crooked and Gage Lakes, forms the southwestern boundary of the northern section of the fourth moraine. On the northwest this section gradually smoothes out in western Jamestown and eastern Millgrove, but on the north it is very abruptly bounded by a deep gorge which extends from section 30, Fremont, westward to the north end of James Lake. This is the culminating point of the moraine, both in massiveness, grandeur and absolute elevation. It is a roughly trapeziform mass of sand, gravel and bowlders about twenty miles in perimeter, piled up at the highest possible angles, and in the wildest possible confusion, its numerous peaks attaining an elevation of about 200 feet above the surrounding valleys. Near its northeastern angle the station of the United States Lake Survey, in section 31 Fremont, has an elevation of 1,141.5 feet above tide, and a higher point in section 1, Pleasant, attains an elevation little, if any, below that of the highest land in Indiana. In the midst of this elevated mass, the valley of James Lake, extends from the southern angle to the northern, cutting it into two nearly equal triangles. The descent to the lake, as well as upon the outer sides of the highland, is generally very abrupt.

The two ranges of hills just described are known to be Erie drift, because their connection with the moraines of the Erie system, south of the Wabash River, can be traced. The exact boundary line between Erie and Saginaw drift can be traced only in favorable localities like the Grass Lake Valley. For the most part no definite boundary exists, because the material from both sources was, to some extent, mingled together, both during the original deposit from melting ice, and still more by the wash of escaping waters. Probably that part of Salem northwest of Mud Creek and the southern half of Jackson owe the greater part of their soil to the Saginaw glacier, but the confusion is there too great for differentiation.

*The Region of Saginaw Drift* includes Millgrove and the north half of Jackson, the character of this region differs decidedly from that of the rest of Steuben County. The surface is almost uniformly level, or gently rolling, broken only by a few bowldery knolls. The soil is a rich, sandy loam. Jackson Prairie, in sections 3, 4, 5, 8, 9 and 10, Jackson, comprises about three square miles of as beautiful rolling prairie land as ever lay under the sun. The remainder of the region was originally covered with "oak openings," grown up to bushes over which a wagon could be driven anywhere. The land was broken up with large plows, drawn by several yoke of oxen, and its agricultural character is still strongly contrasted with that of the heavy timbered lands. The soil is not so poor as the sand and gravel hills, nor so inexhaustible as clay or black land. It is quickly responsive to good treatment, which at first meant gypsum and clover. It will not bear deep plowing or abuse of any kind. It requires more careful and intelligent farming than the heavier and deeper soils, and crops of corn and wheat grow less rank, but, with proper management, more uniformly good returns can be obtained.

### DRAINAGE.

Athough the relief of Steuben County is extremely diversified, its area thus falls into a few well marked natural divisions. The drainage, always intimately dependent upon the relief, of course conforms to it here, as upon every other portion of the earth's surface. Yet, the influence of conditions which no longer exist, but were dominant thousands of years ago, is so strong as to compel the streams apparently to violate the fundamental principles of hydrography, to behave in a manner largely independent of the topography, and to take courses surprisingly different from those which the prominent features of the region would lead one to expect. Two considerable ranges of hills cross the county in a southwest and northeast direction, yet the principal streams flow at right angles to these ranges toward the northwest. The higher range, the principal axis of the region, is scarcely a water-shed at all, and exerts but an insignificant influence upon the drainage. The large streams flow directly across it, through ample gaps, and do not appear to turn one foot to either side on account of it. Many of the smaller streams treat the lower range with equal indifference, so that the great water-shed in Steuben County, between the Michigan basin and the Erie basin, lies not upon the crest of a ridge, but along the border of a nearly level valley.

Again, the county may be nearly equally divided into two drainage areas—the southeastern, in which the principal streams flow parallel with the moraines toward the southwest, and the northwestern, in which they flow at right angles to the moraines toward the northwest. The L. S. & M. S. R. R. marks almost exactly the dividing line between these areas. In the first the streams occupy channels of their own making and of comparatively recent origin. In the second the streams and lakes occupy channels which were lines of drainage during the glacial period, and once served to carry much greater volumes of water than at present. Here the valleys and streams are older than the hills, and have been open water-ways since a period before the great masses of sand, gravel and clay were piled up on either side of them. The most important of these water-gaps is the Pigeon-Fish Valley, which cuts through the entire morainic system from the St. Joseph of the Maumee to the St. Joseph of Lake Michigan. Its course across the moraines is thirty miles long, its average width about one mile, and its depression below the surface on either side varies within the limits of 150 feet. From a point midway of its length, in section 24, Steuben, it slopes gently both ways, carrying the waters of Fish Creek and its tributary lakes southeastward, and the waters of Pigeon River and its lakes northwestward. Into this valley Upper Fish Creek falls in Northeastern Dekalb County, and Upper Pigeon Creek, in section 14, Steuben, the latter stream rises in Cedar Lake, Fremont Township, near the northern border of the State, flows in a southerly direction twelve miles, and then turns westward; the result is that only the area of Steuben County occupied by the third morains is drained toward Lake Erie. In the southwestern corner of the county the valley of Turkey Creek and its connected lakes extends from Hudson, parallel with the Pigeon River valley, which it joins in Lagrange County. The third transverse valley opens from Pigeon Lake, section 29, Scott, through the basin of Centre, Crooked and Gage Lakes, connected by Concord Creek, to the Crooked Creek valley in section 22, Millgrove. The fourth valley, already partially described, begins south of Fremont village and extends westward to James Lake, where it joins a north and south depression occupied by the basins of George and James Lakes, and their connecting streams. This in turn opens into another valley which lies in the normal transverse direction and contains Jimerson Lake and its outlet, Crooked Creek, which pursues a course generally parallel and in close proximity to Pigeon River. This is still an important drainage channel, a rather swift stream, twenty or thirty feet wide and four or five feet deep; but its former superior dimensions are shown by the width of the bordering marsh, in many places half a mile.

### THE LAKES.

No thorough and extensive examination of the lakes of Northern Indiana has ever been made. In 1875 Dr. G. M. Levette, of the Indiana Geological Survey, and Cable Cook, of Salem, Mass., made a hasty reconnoissance of certain lakes in Fulton, Laporte, Kosciusko, Noble, Lagrange and Steuben counties,* and determined to some extent their

*Seventh Report of the State Geologist, 1875, p. 469.

depth and temperature. In the summer of 1889, the writer made as careful a survey of the lakes of Steuben County as circumstances would permit, in which he tried to determine their origin, form of basin, character of bottom and shores, quality of water, sources of supply and the various agents which tend to their destruction, and to construct from these materials their life history in the past and the future. No more favorable region could have been chosen for the work. Within the area of Steuben County there are more than one hundred lakes which have names upon the map, an average of one to every three square miles. Probably no similar area possesses such a variety of lakes, or so many of the largest and finest of their kind, more than thirty of them exceeding half a mile in diameter. They are all intra-morainic lakes, lying within the mass of the moraine, and owing their origin to the irregular deposits of drift. The lake basins are the counterparts of the hills and knobs among which they lie, and may be regarded as huge kettle-holes with clay bottoms.

Along the northern border of the county are a few lakes which lie partly in Branch County, Michigan, and are drained through a channel parallel with Crooked Creek into the St. Joseph, near Three Rivers. Among these are the Walter's Lake, section 18, Fremont; Hog Lake, section 17, Jamestown, and Lake Pleasant, section 18, Jamestown, and 13 and 14 Millgrove. The latter is a mile and a half long by half a mile in width, with low and sandy shores. The northwestern half is less than ten feet deep, and most of the remainder is less than twenty feet deep. The deepest sounding was forty-two feet near the center of the southeastern half. Vegetation is scanty, as is usual in lakes with sand bottom, and confined to a few species of *potamogeton* and *scirpus*.

*The Crooked Creek Chain* of lakes begins with Lake George, the greatest part of which is in sections 14 and 15 Jamestown, and the rest in Michigan. It is slightly irregular in outline, about one mile in its longest diameters, with low bowldery shores, and clear, clean water. The northwest arm was not sounded, but is apparently shallow. The main body of water was found to have nearly a uniform depth of from 50 to 60 feet, sinking to 80 feet a little south of the center, the depth being far in excess of what might be expected from the character of the shore. This lake is famous for its eels, an accumulation of which amounting to 200 pounds once stopped the mill wheel at Jamestown. About twelve years ago Crooked Lake was planted with these fish, which have now become very abundant in all the connected waters, single specimens sometimes attaining a length of seven feet and a weight of ten pounds.

From the southwestern extremity of Lake George, Crooked Creek flows southward through a broad and beautiful valley, studded with clear pools of a few acres extent, one mile to the north basin of James Lake. Into this basin also enters from the east the outlet of the deep transverse gorge, which bounds the northern section of the fourth moraine. This valley contains Marsh and the twin Otter Lakes, in sections 25, 26 and 27, Jamestown, the latter about one mile long, the former half as long. The whole valley for three miles east of James Lake was evidently once a continuous and open body of water. It is now a marsh in which the present lakes remain as pools. In the very heart of the hills, sections 35 and 36, Jamestown, lies the Failing group of lakes, originally a single body of water one mile and a quarter in length, now reduced by drainage to a chain of six:

Failing's Lake, 29 acres, 55 feet deep.*
Medsker Lake, 20 acres.
McClew Lake, 10 acres.
Hollis Lake, 8 acres.
Wooldridge Lake, 8 acres.
Whistler Lake, 12 acres.

The Failing chain presents in miniature all the characteristic features of a mountain lake. The highest peaks of the moraine look down upon it, and its shores rise very abruptly on all sides to a height of 200 feet or more. The basin opens out northward into the valley of Marsh and Otter Lakes.

*James Lake*, the largest in the county and equaled in size by but one other in the State (Turkey Lake, Kosciusko County), is a very irregular body of water, has a total length of five miles and an average width of half a mile. It lies in section 10, 3 and 4, Pleasant, and 33, 28, 27 and 21, Jamestown. It consists of five distinct basins, separated by narrow and shallow straits or by bars. The southern and largest basin is one mile by a mile and a quarter, with very irregular shores and bottom. The shores are abrupt, and upon the east side rise to a height of one to two hundred feet. Bold promontories, sequestered coves and precipitous bluffs give it an almost Alpine character. Three small islands stud its surface, and the water between varies from thirty to sixty-five feet in depth. Through a narrow strait on the west side, with a small island in its middle, the second basin is entered. This is more regular in outline, with a length of one mile and a maximum width of half a mile. The east shore is still very high and steep, and only a few rods from it sixty feet of water can be found. The greatest depth found was eighty feet. Northward it narrows to a strait, with only two feet of water over the bar, which opens into the third basin, which in shape, size and depth closely resembles the second basin.

Eagle Island, a high peak rising abruptly from the water, is a conspicuous landmark on the north shore. A few rods from its west side the deepest sounding in the lake was made, 87 feet. The island is now joined

*For these data I am indebted to Mr. Charles Young, whose farm borders upon the lakes.

to the mainland on the north by an extensive bog, but a narrow passage on the east side admits to the fourth basin, the longer axis of which extends northeast and southwest, and is continuous on the east with the valley of Otter and Marsh Lakes. Its depth varies from thirty to fifty-five feet. Deer Island, similar to Eagle, but smaller, a bog on the west of it, and a long bar, separate the fourth from the fifth and northernmost basin, which is larger than the fourth and of about the same depth. These two basins together are sometimes called Snow Lake.

James Lake has a head at both ends, and Crooked Creek flows out of it about midway of its length on the west side of the second basin. A navigable channel of less than half a mile leads to Jimerson Lake, the open water of which lies in the form of a St. Andrew cross, and from its center a beautiful view is obtained into the four arms, each about half a mile long. The depth varies from thirty to fifty-four feet. From the northwest extremity a narrow neck or finger reaches out a mile or more to Nevada Mills. The group of lakes including James and its companions furnish about ten miles of boating, every rod of which is rendered delightful by repeated surprises and a changing variety of picturesque scenes which rival on a smaller scale Lake George, the gem of the Adirondacks, and the famous Thousand Islands of the St. Lawrence. The region around it might be fitly characterized as the Alps of Indiana, and although Alpine only in miniature, is worthy to attract more attention than it has yet received. It needs only to be better known to become a favorite resort for many who now travel hundreds of miles in search of the beautiful and the picturesque.

A second chain of lakes belonging to the drainage system of Crooked Creek lies parallel with James and Jimerson on the south, and only about one mile distant. Its largest member is Crooked Lake, the best example of the bottle or gourd-shaped lakes. The main body lies in sections 8, 9, 16 and 17, Pleasant, and is nearly two miles long by one mile in breadth. This is nearly divided midway into two by a long point projecting from the north side. The eastern basin is shallow, scarcely deeper than thirty feet, but presents along its east shore a broad sandy beach, very popular with bathers. Vegetation is comparatively scanty. Various filiform species of *potamogeton* form a thin line off-shore, and some areas are thickly grown with *chara* and tangled masses of filamentous green *confervæ*. These plants seem to be covered with an organic slime, and the water is full of gray particles partly organic, partly a deposit of lime, which is very heavy upon the bottom, forming greenish-brown crusts especially thick upon fragments of mussel shells. From the west end a rather wide neck, nearly choked with vegetation, extends to the northwest two miles. Loon Lake, in sections 20 and 21, and Centre Lake, in section 22, Pleasant, are tributary to Crooked Lake. They are shallow bodies of water, originally 200 and 300 acres in extent, but their areas have been largely reduced by ditching, the latter having been nearly all converted into meadow land and tamarack swamp.

The outlet of Crooked Lake, called Concord Creek, a clear and rapid stream, empties into Gage Lake, section 2, Jackson, and 35 Millgrove. This is a compact body of water, one mile by three-quarters of a mile in diameter, surrounded by high bluffs of sand and gravel. It is clear and clean, without marsh or vegetation except a few rushes (*scirpus*), and has a very uniform depth of over fifty feet. A line northwest and southeast through its long axis gave soundings of nearly seventy feet. It is the finest specimen in the county of a lake with a single deep and symmetrical basin, and presents especial attractions for the pleasure-seeker and the fisherman. The country east and south of Gage Lake is hilly with large kettle holes in every field; on the west more level and threaded with marshy channels, holding occasional pools of clear water. Among these the various fragments which occupy a once continuous glacial drainage channel, and are now known collectively as Grass Lake, have already been described.

Tamarack Lake, sections 22, 23, 26 and 27 Millgrove, is all that remains of a lake formerly much more extensive. It now covers about forty acres and is surrounded by marsh and tamarack swamp. Twenty-five years ago it was twenty-five feet deep, but has been lowered by drainage and filled with sediment and vegetation until there are few places over ten feet deep. Its complete extinction is an event of the near future. Tamarack Lake is scarcely separated from the ancient channel of Crooked Creek, and in fact once formed an expansion or side inlet of it. In late glacial times this was the point where two large rivers met, one from the James Lake system and one from the Crooked Lake system.

Lime Lake, near the northwestern corner of the county, section 18, Millgrove, deserves special notice. It is a symmetrical oval of ten acres. The water looks like milk on account of reflection from the bottom, which is covered with a deposit of marl, said to be ten or fifteen feet thick, and formerly burned for lime. It has a nearly uniform depth of twenty feet, with a maximum of twenty-eight. A small species of *chara* is the only vegetation, and even that is scanty. Analysis of this "marl" shows it to contain:

| | |
|---|---|
| Calcium carbonate | 86.00 |
| Magnesium carbonate | 9.42 |
| Iron carbonate | 1.16 |
| Silica | 1.08 |
| Organic matter | 2.32 |
| | 99.98 |

Recognizable organic remains are very scarce and the deposit seems to be almost entirely a chemical precipitate from solution in the water.

*The Lakes of the Pigeon River Chain* are strung along the course of that stream for twenty-five miles, and are more numerous than those drained by Crooked Creek, but they do not include any lakes of the first class in size. At the head of the stream, in sections 22 and 23, Fremont, stands Cedar Lake, represented upon the map as more than a mile across. In fact, at the present time there is no lake there; most of the water has been drawn off by artificial drainage, and the remainder is now covered by a quaking and probably floating bog meadow, with a few open lagoons. This lake can scarcely be said to be either living or extinct, but rather buried alive. The water which drains from this bog has the amber color of clear coffee, a peculiarity which it preserves throughout the course of the stream. It drains numerous swamps and small lakes in Fremont, Scott and Otsego townships, and in section 9, Steuben, empties into Long Lake in the great transverse Pigeon-Fish gap. Analysis of the water of Pigeon Creek shows it to contain twenty-eight grains of solid matter to the gallon, seven grains of which is organic. Before reaching Long Lake Pigeon Creek receives the waters of a stream from Fox Lake, which lies in the body of the middle section of the fourth moraine, section 34, Pleasant. This is a little gem, three-quarters of a mile by half a mile in diameter, with high abrupt shores and a very uniform depth of more than forty feet. The deepest sounding was sixty feet. The water is clear and cold, with clean shores and no marsh, except at one point near the west end. This lake is a reduced copy of Gage Lake, which it resembles in all its characteristic features. It has been recently stocked with fish, in 1887 with three thousand Mackinac trout, and again in 1889 with three thousand Mackinac trout and thirty-five hundred California trout,* for the growth and multiplication of which the waters of this lake seem to be peculiarly favorable.

Pleasant Lake, section 15, Steuben, differs widely in character from its companions in the Pigeon River chain. It is not more than half a mile long by one-quarter wide, but has a symmetrical kidney-shaped basin of unusual depth. The water is thirty feet deep quite near the shore, all around, and through the middle from forty to fifty feet. There is no marsh, and the water is clear.

The village of Pleasant Lake extends around two sides of it, and the well-kept grounds give the place a somewhat artificial air like that of a lake in a park. A few rods to the west, but at a considerable lower level, lies Long Lake, sections 15 and 16, Pleasant, a pointed ellipse, like a willow leaf, one mile in length, and having a depth which varies between twenty-five and forty feet. It is nearly surrounded by marsh, and the water is of the rich amber color characteristic of Pigeon Creek, which enters the lake at a point west of the middle, on the north side, and flows

*For this information I am indebted to Prof. L. D. Creel, of Angola; also for valuable assistance in the examination of Crooked and Fox lakes.

out at the western extremity. On leaving this lake the stream deserves to be called a river. The open water is fifteen to twenty feet wide and four feet deep, with a scarcely perceptible current, bordered by a marsh impassible to boat or foot. It winds through a jungle of cattail (*typha*), wild rice (*zizania*), swamp loosestrife (*decodon*), willow and other shrubs as impenetrable as those of Central Africa. Nothing is visible but the brown water full of *chara*, duckweed (*lemna*), milfoil (*myriophyllum*), bladderwort (*utricularia*), and pond lilies (*nuphar and nymphaea*) beneath, the wall of flags and trees on either side, and the sky overhead. It is a place to look for a tiger to spring out or an alligator to rise, but nothing is seen more exciting than a mud-turtle, whose efforts to climb down into the tangle are very amusing.

Golden Lake, in section 5, 6 and 8, Steuben, is a counterpart of Long Lake, except that its outline is more irregular. Its depth is exactly the same.

A half-mile farther down stream, in section 36, Jackson, is Hogback Lake, which in shape and size bears a close resemblance to Jimerson Lake, being four lobed. This lake takes its name from a precipitous ridge of coarse gravel and bowlders, seventy or eighty feet high and about forty rods long, which stands upon its northeastern shore. It is known as "the hogback," and constitutes a small but typical kame. Owing to the high wind and scarcity of good boats on two different visits, no soundings were made. A short distance to the northeast, in sections 29, 30, 31 and 32, Pleasant, Silver Lake lies like a coin or plate dropped down among the hills. It is an oval, one mile by half a mile, and over a portion of its area, the water seen from a distance glitters with the white luster of burnished silver. This is due to the fact that an irregular patch of several acres has a depth of only one foot, and the marl on the bottom gives the water its milky color. The water all around this area has a depth of from twenty to thirty feet. It has recently been lowered three feet by drainage, and the northeast half is filled with rushes (*scirpus*). The remainder is very free from vegetation, to which the character of the bottom seems unfavorable. The marl of Silver Lake contains numerous fragments of the shells of the fresh-water mussel, yet analysis shows that it does not differ materially in composition from that of Lime Lake.

| | |
|---|---|
| Calcium carbonate | 84.00 |
| Magnesium carbonate | 6.46 |
| Ferrous carbonate | 1.34 |
| Silica and silicates | 4.52 |
| Organic matter | 3.68 |
| Total | 100.00 |

Bass and Howard, small lakes in section 25, Jackson, also tributary to Hogback Lake, have been previously mentioned. Below Hogback Lake, the valley of Pigeon River continues to be nearly a mile in width, but is less marshy. It contains but one more lake worthy of description in the county. Otter Lake, section 20 and 29, Jackson, is a typical lake of another class. It is a pear or gourd-shaped body of water one mile long north and south. Around the lower end the land is low and marshy, but the upper half is a symmetrical, boat-shaped basin between high hills. The shore descends uniformly at the rate of one foot in three to a depth of twenty-eight to thirty-three feet. The bottom is covered with a tenacious black mud-like paint or thick India ink. Its composition proves to be:

| | |
|---|---|
| Lime and magnesium salts | 41.00 |
| Silicates (clay) | 29.50 |
| Organic matter | 29.50 |
| Total | 100.00 |

This mixture forms a soil of exceeding fertility and a rich growth of vegetation surrounds the lake in the depths above fifteen feet. The various plants having capillary leaves in dense whorls around a single stem are especially abundant, so that the water seems filled with scared cat's-tails eight or ten feet long, among them milfoil (*myriophyllum*) *bidens, Beckii*, and bladderwort, *utricularia vulgaris* were found in blossom (August 15).

The lakes of the Turkey Creek chain, Little Turkey, section 35, Limekiln, section 28, and Big Turkey, sections 7 and 18, Salem, were not personally examined. Both valley and lakes resemble in all essential features those of Pigeon Creek. Big Turkey Lake, lying partly in Lagrange County, has a total length of two and one-half miles and a maximum width of half a mile. It is divided midway into two basins, the depth of the upper being forty-five to fifty feet, that of the lower twenty-five to seventy-five feet.*

*The Lakes of the Third Moraine*, which empty into the St. Joseph of the Maumee, remain to be described. They are few in number, but among the most interesting in the county.

Fish Lake, in sections 21, 27, 28 and 33, Otsego, has a length of nearly two miles, a breadth of one mile, and a very irregular outline. Its elevation was found by U. S. Engineer Stansberry, in 1827, to be 887 feet above tide. Its area, according to the report of Col. J. M. Wilson, U. S. A., is 740 acres, the largest lake in the St. Joseph basin. Its basin is only a larger depression in the surface of a country which is made up entirely of conical and dome-shaped drift hills, with corresponding depressions between. Here the kettle holes are in every field and of every size and shape, the lake basin being but a broad and irregular kettle hole.

* These depths are reported by Henry Wright, who is very familiar with the lake.

Numerous soundings show that the bottom is very uneven and occupied by several depressions of varying size, shape and depth. It contains two large islands and one very small one. Its character is partly due to the fact that it was raised about fifty years ago by a dam on the outlet at its southeastern extremity. The small basin just above this, called the mill-pond, is shallow and nearly covered with a most luxuriant growth of *nymphœa odorata.* It opens into the main body of the lake through a channel thirty feet deep between the mainland on the east and a large island on the west. A short distance north of this is a high wooded point, a typical drift hill, which once formed an island, but is now connected with the west shore by a growth of peat. The channel between the islands is thirty-five feet deep. Northwest of the high island or peninsula is a large and nearly land locked basin, called Muskrat Bay. North of the bay a point is extended by several acres of peat nearly to the third island, which, although the area above water is minute in size, proves to be the southern extremity of a long bar. The space between the shore and this bar was known to the Indians as "the slaughter pen," on account of the facilities it afforded for entrapping and killing deer. The open water between these islands and the east shore, from one-quarter to one-half a mile in width, varies in depth from two to sixty feet, probably averaging forty feet. The north half of the lake is an unbroken expanse of water with an average depth of forty or fifty feet, the maximum found being sixty-eight feet. The northwestern extremity of the lake is bordered by a growth of peat which rises abruptly from the water with a clean edge two feet high. From the eastern side of this basin a long funnel-shaped arm, known as "the Devil's Neck," extends half a mile to the southeast. The eastern shore of the lake is everywhere high, abrupt and free from peat and aquatic vegetation, although the water is in many places no more than from two to ten feet deep several rods from shore. A single patch about three feet in diameter has formed upon the most exposed point of the shore line, but seems to be washed away as fast as formed. A high point on the northeast side is known as "Cold Springs," from the fact that several copious streams of water, strongly impregnated with iron, there issue from the face of the bluff. One of these has formed a mass of peat 75 feet wide and 100 feet long upon the steeply-sloping face of the bluff. The peat seems to slide slowly downward to the shore, where the waves break off large pieces like ice-bergs. This may be regarded as a peat glacier.

Careful examination of the masses of peat and vegetable growth around the shores of this lake was made with the view of determining, as far as possible, the conditions and rate of growth. One most striking feature is the fact that the encroachments made by vegetation are confined to the west shore, although the conditions, as far as shallowness of water is concerned, are equally favorable along a considerable extent of the east shore.

On the west side the area of the lake has been diminished by many acres of peat, while on the east side, which presents no discernable difference in character, one square yard is the sum total of peat to be found. Possibly this may be accounted for by the fact that the water is usually much rougher along the east side, and peat-producing plants require still water.

In the bays of the west shore the outer zone of vegetation begins at a depth of ten feet with a band of *chara*, *potamogeton* and *Vallisneria spiralis*, the latter peculiar to this lake. At a depth of five feet *nymphaea* flourishes, *nuphar* being scarce. At a depth of three feet *scirpus*, *polygonum* and *typha* form a floating margin too thick to push a boat through. Above water level, on the solid mass of peat, a great variety of plants flourish, among which, besides grasses, small sedges and ferns, *Lycopsis europoeus*, *Pilea pumila*, *Potentilla fruticosa*, *Epilobium coloratum* and *palustre*, *Sagittaria variabilis*, *Rudbeckia hirta*, *Impatiens pulva*, covered with tangled orange skeins of *Cuscuta gronovii*, *Galium asprellum*, *Campanula apariuoides*, *Pycnanthemum*, *Liatris spicata*, *Lobelia cardinalis*, *Asclepias incarnata* and *Scutellaria galericulata*, are conspicuous in August. In many places the strictly aquatic plants are absent, and the peat bed rises with a clean cut edge two feet above the water.

The large area of Fish Lake, furnishing a broad expanse of water visible at one sweep of the eye, its irregular outline and prominent islands, its bold shores and encircling hills, and the beauty and profusion of its aquatic vegetation, form a combination of characters which render this lake one of the most interesting and attractive in the State. The village of Hamilton, at its south end, is clean and quiet, and furnishes such accommodations to the summer visitor as can not fail to make his stay enjoyable.

The Fish Lake basin opens southward into the great Pigeon-Fish transverse valley, a half mile up which, toward the west, lies Ball's Lake, in section 32, Otsego. It is one mile long and seventy rods wide, surrounded by steep wooded bluffs fifty feet high. Its basin is a symmetrical boat-shaped depression sixty-five feet deep,* and in regularity of outline and depth of valley, can scarcely be equaled. Both Fish Lake and Ball's Lake are now owned by the Fort Wayne Water Power Company, which, by the construction of proper dams and other means of regulating the flow of the water into and through the St. Joseph River, designs to use these lakes as reservoirs for the supply of the city of Fort Wayne, forty miles distant. If desirable, a cut through the low divide would turn the waters of Pigeon Creek or Pleasant Lake, or both, into Fish Creek and the St. Joseph. No better source of water supply can be found within an available distance from Fort Wayne.

*Reported by Eugene Swift, grandson of Gideon Ball, who once owned, surveyed and sounded it.

In the extreme northeastern corner of Indiana lies Clear Lake, in sections 19 and 20, Clear Lake Township. It is an irregular body of water, having a maximum length east and west of nearly two miles, and a breadth of over one mile. The shores are rather low. Along the east end a sand beach four rods wide lies between the water and the foot of a bluff twenty-five feet high. A broad shelf of shallow water extends nearly all around the lake, outside of which the depth increases rapidly. Its level has been lowered slightly by ditching, which accounts for the present sand beach; but the broad shelf of still wider water seems to indicate that the level of the lake now stands higher than at some more or less remote period. This conjecture is further supported by the fact that the lake consists of three very distinct basins, two of which would become separate lakes if the water level should fall ten feet. The south basin is regular in outline, one mile and a quarter in length by half a mile wide, and of great depth. It is separated from the basin on the north by a wide bar over which the depth is uniformly six feet; yet within ten rods of the bar a depth of ninety feet can be found. A descent of thirty to forty feet in five rods was found in several places, and the average slope of the basin outside the shelf is not far from one foot in two, or at an angle of over twenty degrees. The line of maximum depth near the centre of the basin varies from 70 to 101 feet, the latter being the deepest sounding made in the county, and one which can be equaled in very few lakes of the State.

The north basin has a more irregular bottom and a less average depth, but descends in some places to 80 feet, and one sounding of 90 feet was made a short distance from the island. The shelf around its north and east shores is very wide and furnishes excellent facilities for bathing. The western basin is much smaller than either of the others, with which it is connected by a strait and from which it is separated by points, and a small, high island which stands in the mouth of the strait. The basin itself is surprisingly deep in proportion to its size, the soundings varying from 54 to 77 feet. The northwest shore of the lake is bordered by an extensive peat meadow, containing spring mounds and small elevated islands. The soil around Clear Lake is largely composed of deep and barren sand, which appears also in the bottom of the shallow parts of the lake. It is very hard to drive a stake into the sand beach along the east shore, and on the bar a stake is easily pushed in, but pulled out with difficulty. Notwithstanding the shelf of shallow water, the shores are for the most part clean, and aquatic vegetation is everywhere very scanty. *Scirpus validus* is the most conspicuous species, thinly covering the bars. *Nymphaea-nuphar* and *Pontederia* occur only in small isolated patches. *Potamageton* and *Chara* occur, but are scarce. The water is very clear, black over the deeps, and said to be very cold in some places at the bottom. Over these areas ice seldom forms, and they probably indicate the position of copious sub-lacustrine springs. Clear Lake empties northward, through a small stream, which by a circuitous course through Michigan and Ohio, empties into the St. Joseph of the Maumee. East of Clear Lake lies a group of these small lakes, one tributary to Clear, the others emptying eastward by a different channel. The largest of these, Long Lake, lies partly in Ohio. Two large hotels on the north side of Clear Lake, accessible from Ray Station on the L. S. & M. S. R. R., furnish accommodations for visitors, and the place is destined to become a favorite pleasure resort for sportsmen, and all who seek clean, safe and ample bathing, boating and fishing grounds.

Having thus described with considerable minuteness the natnral features of the most important lakes in the county, it remains to sum up and classify the facts observed, and to draw from them such conclusions as seem to be warranted. Of all the varied features now presented upon the face of the earth there are probably none whose essential characteristics are obvious, whose life histories are more easy to read than those of the drift lakes. They are all geologically young, and the main events of the period which gave them birth have left a record so voluminous and unmistakable that the marvel is that its significance was not earlier recognized. It was only necessary that the interest and attention of geologists should be directed to glacial phenomena to discover such a wealth of material for study as was perhaps never before presented to any body of scientific investigators. But the mine had to wait until the seventh decade of the nineteenth century before the slowly opening eyes and awakening scientific interest of the human race found therein an almost inexhaustible field of discovery. The results of the last twenty years of work have been rich beyond all expectations, and to-day the glacialist is able to write the history of events which occurred thousands of years ago with as much certitude and detail as the historian of human affairs can claim for the events as many hundred years past. "The track of a glacier," says Prof. Newberry, "is as plain and unmistakable as the track of a bear or a man." In the region south of the great lakes the enormous masses of drift, largely composed of the debris scooped out from the great lake basins, tell plainly the story of the advance and retreat of the last North American ice-sheet. The disposal of this debris in crescentic or horseshoe-shaped ridges reveals the fact that the ice-sheet advanced much as an army advances into the enemy's country, not with a long unbroken front, but in separate but contiguous columns. The basins of the great lakes furnished the highways by which the solid columns of ice invaded the territory of the United States, and also determined largely the mass, force and direction with which those columns pushed forward. The one which occupied the bed of Lake Erie was broad, massive and strong, and, overcoming all obstacles, occupied the greater part of Indiana. The Lake Michigan column was also deep and heavy, but it seems to have found the territory already occupied by the Erie ice, and to have been deflected westward, so that it got possession of only the northwest corner of Indiana. Between these two a much lighter column advanced from Saginaw Bay across Michigan, and in spite of being hemmed in by its more powerful neighbors on either side, succeeded in penetrating Indiana as far south as Fulton County. Where the outer edges of these ice-lobes came together was the battle ground of the glaciers, and there the drift is piled highest and in the most irregular forms. It may be supposed that the narrow belt of sand between them was the scene of repeated advances and retreats, and was alternately occupied by ice belonging first to one lobe and then to another, hence the material deposited along such a belt was plowed up, overridden, tumbled about, and finally left in the wildest confusion. Such a belt or drift forms the *Saginaw-Erie interlobate moraine*, which in Indiana stretches across the counties of Steuben, Lagrange, Noble, Whitley and Kosciusko. Thus are the peculiarities of topography and soil in that region accounted for.

Among the materials composing this moraine, clay largely predominates, usually mixed with a liberal supply of gravel, and not unfrequently containing fifty per cent. of ground limestone. Over and under the clay are immense beds, sheets and ridges of sand and gravel, and scattered over and through the whole with little partiality a variety of bowlders as thick as plums in a pudding. The presence of elevations implies the existence of corresponding depressions, and the lake basins are the complements and counterparts of the hills. Deep and symmetrical hollows in the midst of a comparatively level country, of which the basins of Pleasant Lake and Clear Lake present striking examples, are accounted for by supposing that a large mass of ice became detached from the main body and was left partially imbedded in the drift, its final disappearance by melting left the hole now occupied by the waters of the lake. This theory is sustained by observations made upon existing glaciers. The great morainic belt which stretches across the country from Cape Cod to Dakota presents everywhere the same essential features, differing only in size and prominence. To this rule moranic lakes form an exception. The massive moraines of New York are almost devoid of lakes, in Ohio there are very few, while the map of Northern Indiana and Southern Michigan is thickly peppered with them. Throughout the whole extent of the morainic belt the peculiar symmetrical or irregular hollows between the hills exist; east of Indiana they are dry kettle holes, here nearly every one is filled with water to the brim. This phenomenon can be due to no other cause than a difference in morainic materials. In one case the bottoms of the basins are gravel through which the water drains away as through a sieve; in the other case the basins are lined or underlaid with clay and hold water like a cistern. Given a surface of country studded with innumerable water-tight basins which rapidly fill until they overflow at the lowest point, in many cases several basins finally coalescing into one large body of water, and the lakes of Northern Indiana are the inevitable result. Such has been their origin; but from the day of their birth their progress has been toward remote but certain extinction. During the period of glacial retreat, torrents of water from the melting ice poured through the valleys, carrying with them loads of mud and sand, which in some places are still visible upon the face of the country. Thus the intermorainic intervals were filled, but to what extent it is now impossible to determine. In the case of the valley of Upper Pigeon Creek, this filling seems to have progressed far enough to raise its surface to the level of the lateral transverse gaps through the moraines on either side, and the lake basins which may have once existed there were nearly all obliterated. During this period the principal drainage lines were established and the great transverse valleys of Crooked Creek, Pigeon Creek, Fish Creek and Turkey Creek were opened. Other channels which once existed have been partially filled, and now only detached fragments remain. The greatest of these now traceable extends from Hogback and Silver Lakes through Grass Lake to Lake Gage. Other fragments, like the "necks" of Crooked and Jimerson Lakes, testify to the important changes which evasion and wash have accomplished. It seems obvious that in this manner all the lakes must have suffered a considerable diminution of their original depth. As soon as the surface of the country became covered with forest, general evasion and removal of material was greatly diminished, and at the present time the results of these processes are practically nothing. The streams which now empty into the lakes are few and small, and the quantity of mud or sand thus brought down is very trifling. In fact they are great springs fed chiefly by inflow at the bottom, and the subterranean waters are so strongly charged with lime and iron salts that the accumulation of marl is doing more to fill up the basins than surface evasion. Aquatic plants are, as a rule, incrusted with lime, and mussel-shells and other objects upon the bottom form muclei for similar deposits which soon render their original form scarcely recognizable. These phenomena are especially noticeable in Lime, Silver, James, Crooked and Clear Lakes.

Another very efficient agent tending toward the extinction of these lakes is man himself. In the case of small and shallow lakes, artificial drainage has often resulted in their complete destruction, while the areas of large shallow ones have been reduced one-half or more. In general, the extent of encroachment, actual or possible, upon a lake by human agency, may be said to be a function of its depth.

A third agency, more effective than all others for the obliteration of morainic lakes, is the growth of aquatic vegetation. The character and extent of this growth depends somewhat upon the depth of the lake and the slope of the shores, but chiefly upon the nature of the bottom. In this respect lakes may be divided into three classes: *lime lakes*, *sand lakes* and *peat lakes*. Of the first class, Lime and Silver lakes are typical examples; of the second class, Gage and Clear lakes. In all these vegetation is very scanty, apparently for no other reason than that their bottom and shores do not afford a soil sufficiently fertile to support an abundant growth.

A large majority of the Steuben lakes belong to the third class, and were characterized by the black, tenacious mud which constitutes their beds, and by the luxuriant growth of plants wherever the requisite shallowness and stillness of water permit. Of these, Otter Lake (Jackson Township) and Fish Lake are typical specimens. These are literally being filled with air, the great bulk of the solid material which composes the plants being absorbed from the gaseous ocean above and consigned to the watery depths below. This process is undoubtedly slow if measured by the years of man's life; perhaps the peat bed extends into the lake only a few feet in a century, but measured by the periods of geologic time, these lakes were born but yesterday and will disappear to-morrow. The present dominant race of men may pass away and leave these lakes still lying like bright jewels among the hills; but every one is nevertheless doomed to final extinction. The peat lakes will disappear first in the order of their size and shallowness; the lime lakes next, and the sand lakes last of all. In consideration of its size, depth and barren bottom, it seems safe to predict for Clear Lake a permanence and length of life not to be surpassed by any of its companions. As long as the lakes remain they will continue to contribute to the service and delight of man, feeding his eye with their beauty, and affording means for that relaxation and healthful pleasure which the conditions of life every year more imperatively demand. The time may come when the lakes of Steuben County will be the most valuable and profitable possession of her citizens, who will then seek and devise means for preserving instead of destroying them. Between the Great Lakes and the Ohio there is no more beautiful tract of country than Steuben County. At present comparatively few of the citizens of Indiana are aware of its attractions; but it can not long remain unknown and unvisited. Among its hills and lakes thousands of the coming generation will find their summer homes.

The great variety of soil and situation in the county implies a flora very rich in species, an influence which the most cursory examination will confirm. Fortunately the county numbers among its citizens a botanist whose powers of observation and devotion to his work are worthy of his opportunities. Mr. Elbert Bradner, of Angola, contributes to this report a list of the plants of Steuben County, the result of several years assiduous collecting. As the work of an amateur wholly without the assistance of professional botanists, it is worthy to rank with the best that has yet been done in the State.

# A PARTIAL CATALOGUE OF THE FLORA OF STEUBEN COUNTY.

ANGOLA, IND., October 1, 1890.

*Hon. S. S. Gorby, State Geologist of Indiana:*

SIR—I take pleasure in presenting the accompanying Catalogue of the Flora of Steuben County. In the analysis and identification of many plants I have received much valuable assistance from Dr. Charles R. Dryer, of Fort Wayne, to whom I express my most sincere thanks.

Very truly,

E. BRADNER.

### REMARKS.

The following catalogue, although incomplete, contains nearly all of the Phenogams. The *Cyperaceæ*, *Gramineæ* and the aquatic plants have received the least attention, and are therefore the most incomplete. A few Cryptogams have been recorded. The order and nomenclature of Gray's Manual of Botany, Revised Edition, have been carefully followed. For the benefit of the general reader the common names of many of the plants have been given. In this I have principally consulted Gray, introducing, however, a few local names. I have recorded 100 orders, 366 genera and 729 species. Of these 34 genera and 91 species belong to the Order *Compositæ;* 25 genera and 47 species to *Gramineæ;* 19 genera and 36 species to *Leguminosæ;* 16 genera and 21 species to *Labiatæ;* 12 genera and 22 species to *Ranunculaceæ;* 11 genera and 33 species to *Rosaceæ;* 9 genera and 16 species to *Orchidaceæ;* 7 genera and 32 species to *Cyperaceæ.* There are 19 species of *Carix;* 17 of *Polygonum;* 13 of *Aster*, and 11 of *Solidago.* Many others might be enumerated, but they will be found in the Catalogue. The above are the most numerous. I would call attention to a peculiar form of *Staphylea trifolia.* The leaves are a bright green, lanceolate and very finely serrate. The pods are much smaller and less inflated. In fact the whole habit differs from the usual form and is found growing near it, a fact which clearly proves that the difference is not due to situation. I would also call attention to a form of *Sambucus Canadensis.* It has a very robust growth, the leaf-stems are red, the petals are curled or inflexed. It blooms later than the usual form, and is found growing with it.

## CATALOGUE.

### RANUNCULACEÆ.

*Clematis virginiana*, L. Virgin's Bower.
*Anemone parviflora*, Michx.
*A. cylindrica*, Gray. Long-fruited Anemone.
*A. virginiana*, L.
*A. nemorosa*, L. Wind flower. Wood Anemone.
*Hepatica acutiloba*, D. C. Liver Leaf.
*Anemonella thalictroides*, Spach. Rue Anemone.
*Thalictrum dioicum*, L. Early Meadow Rue.
*T. polygamum*, Muhl. Tall Meadow Rue.
*Ranunculus aquatilis*, L., var. *trichophyllus*, Gray. White Water Crowfoot.
*R. multifidus*, Pursh. Yellow Water Crowfoot.
*R. sceleratus*, L. Cursed Crowfoot.
*R. recurvatus*, Poir. Hooked Crowfoot.
*R. fascicularis*, Muhl. Early Crowfoot.
*R. repens*, L.
*R. Pennsylvanicus*, L. f. Bristly Crowfoot.
*Caltha palustris*, L. Marsh Marigold.
*Coptis trifolia*, Salisb. Three-leaved Goldthread.
*Aquilegia Canadensis*, L. Wild Columbine.
*Delphinium consolida*, L. Field Larkspur. Roadsides. Escaped from cultivation.
*Actaea alba*, Bigel. White Baneberry. Cohosh.
*Hydrastis Canadensis*, L. Golden Seal. Yellow Puccoon.

### MAGNOLIACEÆ.

*Liriodendron tulipifera*, L. Tulip-tree. Whitewood.

### ANONACEÆ.

*Asimina triloba*, Dunal. Common Pawpaw.

### MANISPERMACEÆ.

*Menispermum Canadense*, L. Moonseed.

### BERBERIDACEÆ.

*Caulophyllum thalictroides*, Michx. Blue Cohosh. Pappoose Root.
*Podophyllum peltatum*, L. May Apple. Mandrake.

### NYMPHÆACEÆ.

*Brasenia peltata*, Pursh. Water Shield.

*Nymphæa odorata*, Ait. Sweet-scented White Water Lily. Water Nymph.

*Nymphæa advena*, Ait. f. Yellow Pond Lily. Spatter-dock.

### SARRACENIACEÆ.

*Sarracenia purpurea*, L. Side-Saddle Flower. Pitcher Plant. Huntsman's Cup.

### PAPAVERACEÆ.

*Sanguinaria Canadensis*, L. Blood-root.

*Stylophorum diphyllum*, Nutt. Celandine Poppy.

*Chelidonium majus*, L. Celandine. Waste grounds near dwellings. Adv. from Europe.

### FUMARIACEÆ.

*Adlumia cirrhosa*, Raf. Climbing Fumitory.

*Dicentra cucullaria*, D. C. Dutchman's Breeches.

*D. Canadensis*, D. C. Squirrel Corn.

### CRUCIFERÆ.

*Dentaria diphylla*, L. Toothwort.

*D. laciniata*, Muhl. Pepper-root.

*Cardamine rhomboidea*, D. C. Spring Cress.

*C. hirsuta*, L. Small Bitter Cress.

*Arabis Canadensis*, L. Sickle-pod.

*A. perfoliata*, Lam. Flower Mustard.

*A. lyrata*, L.

*Nasturtium officinale*, R. Br. True Water Cress. Brooks and ditches; escaped from cultivation.

*N. palustre*, D. C. Marsh Cress.

*N. palustre*, var. *hispidum*, D. C.

*Brassica Sinapistrum*, Boiss. The English Charlock. Adv. from Europe.

*B. alba*. White Mustard. Adv. from Europe.

*B. nigra*, Roch. Black Mustard. Fields and waste grounds. Adv. from Europe.

*Capsella Bursa-pastoris*, Moench. Shepherd's Purse.

*Lepidium Virginicum*, L. Wild Peppergrass.

### CISTACEÆ.

*Lechea major*, Michx. Pinweed.

*L. minor*, L.

VIOLACEÆ.

*Viola pedata*, L. Bird-foot Violet.
*V. cucullata*, Gray. Common Blue Violet.
*V. sagittata*, Ait. Arrow-leaved Violet.
*V. blanda*, Willd. Sweet White Violet.
*V. pubescens*, Ait. Downy Yellow Violet.
*V. Canadensis*, L. Canada Violet.
*V. striata*, Ait. Pale Violet.
*V. rostrata*, Pursh. Long-spurred Violet.

CARYOPHYLLACEÆ.

*Saponaria officinalis*, L. Soapwort. Bouncing Bet. Roadsides. Adv. from Europe.
*Silene stellata*, Ait. Starry Campion.
*S. noctiflora*, L. Night-flowering Catchfly. In wheat fields and cultivated grounds.
*Lychnis Githago*, Lam. Corn Cockle. In wheat fields. Adv. from Europe.
*Stellaria media*, Smith. Common Chickweed. Nat. from Europe.
*S. pubera*, Michx. Great Chickweed.
*S. longifolia*, Muhl. Long-leaved Stitchwort.
*Cerastium viscosum*, L. Mouse-ear Chickweed. Nat. from Europe.
*C. nutans*, Raf.

PORTULACACEÆ.

*Portulaca oleracea*, L. Common Purslane. Nat. from Europe.
*Claytonia Caroliniana*, Michx. Spring Beauty.

ELATINACEÆ.

*Elatine Americana*, Arn. Waterwort.

HYPERICACEÆ.

*Hypericum prolificum*, L. Shrubby St. Johnswort.
*H. perforatum*, L. Common St. Johnswort. Nat. from Europe.
*H. maculatum*, Walt.
*H. Canadense*, L.
*Elodes campanulata*, Pursh. Marsh St. Johnswort.

MALVACEÆ.

*Malva rotundifolia*, L. Common Mallow. Nat. from Europe.
*M. sylvestris*, L. High Mallow. Waysides and waste places. Adv. from Europe.

*M. Moschata*, L. Musk Mallow. Escaped from gardens to waysides. Adv. from Europe.

*Sida Napæa*, Cab.

*Abuliton Avicennæ*, Gaertn. Velvet Leaf. Waste places. Adv. from India.

*Hibiscus Trionum*, L. Bladder Ketmia. Flower-of-an-Hour. Escaped from gardens.

TILIACEÆ.

*Tilia Americana*, L. Linden. Basswood.

GERANIACEÆ.

*Geranium maculatum*, L. Wild Cranesbill.

*Oxalis corniculata*, L., var., *stricta*, Sav. Yellow Woodsorrel.

*Impatiens pallida*, Nutt. Pale Touch-Me-Not.

*I. fulva*, Nutt. Spotted Touch-Me-Not.

RUTACEÆ.

*Zanthoxylum Americanum*, Mill. Northern Prickly Ash. Toothache-tree.

ILICINEÆ.

*Ilex vesticillata*, Gray. Black Alder. Winterberry.

*Nemopanthes fascicularis*, Raf. Mountain Holly.

CELASTRACEÆ.

*Celastrus scandens*, L. Wax-work. Climbing Bitter-Sweet. Staff-tree.

*Euonymus atropurpureus*, Jacq. Burning Bush. Waahoo.

*E. Americanus*, L., var. *obovatus*, Torr and Gray. Strawberry Bush.

RHAMNACEÆ.

*Ceanothus Americanus*, L. New Jersey Tea. Wild Snowball. Red Root.

VITACEÆ.

*Vitis æstivalis*, Michx. Summer Grape.

*V. cordifolia*, Michx. Frost or Chicken Grape.

*Ampelopsis quinquefolia*, Michx. Virginia Creeper. American Ivy.

SAPINDACEÆ.

*Æsculus glabra*, Willd. Fetid or Ohio Buckeye.

*Acer saccharinum*, Wang. Sugar or Rock Maple.

*A. rubrum*, L. Red or Swamp Maple.

*Negundo aceroides*, Moench. Ash leaved Maple. Box Elder.

**Staphylea trifolia*, L. American Bladder Nut.

* See remarks.

ANACARDIACEÆ.

*Rhus typhina*, L. Staghorn Sumach.
*Rhus glabra*, L. Smooth Sumach.
*R. copallina*, L. Dwarf Sumach.
*R. venenata*, D. C. Poison Sumach. Swamp Dogwood.
*R. Toxicodendron*, L. Poison Ivy. Poison Oak.

POLYGALACEÆ.

*Polygala Senega*, L. Seneca Snakeroot.
*P. sanguinea*, L.
*P. cruciata*, L.
*P. verticillata*, L.

LEGUMINOSÆ.

*Baptisia tinctoria*, R. Br. Wild Indigo.
*B. leucophæa*, Nutt.
*Lupinus perennis*, L., var. *occidentalis*, Watson. Wild Lupine.
*Trifolium arvense*, L. Rabbit-foot or Stone Clover. Nat. from Europe.
*T. pratense*, L. Red Clover. Adv. from Europe.
*T. repens*, L. White Clover.
*T. hybridum*, L. Alsike Clover. Nat. from Europe.
*T. procumbens*, L. Low Hop Clover. Nat. from Europe.
*Melilotus officinalis*, Willd. Yellow Melilot. Adv. from Europe.
*M. Alba*, Lam. White Melilot. Sweet Clover. Adv. from Europe.
*Medicago sativa*, L. Lucerne. Alfalfa. Adv. from Europe.
*M. lupulina*, L. Black Medick. Nonesuch. Waste places. Adv. from Europe.
*Amorpha canescens*, Nutt. Lead Plant.
*Tephrosia Virginiana*, Pers. Goat's Rue.
*Robinia Pseudacacia*, L. Common Locust or False Acacia. Naturalized.
*Desmodium nudiflorum*, D. C.
*D. acuminatum*, D. C.
*D. rotundifolium*, D. C.
*D. canescens*, D. C.
*D. cuspidatum*, Torr. & Gray.
*D. paniculatum*, D. C.
*D. sessilifolium*, Torr. & Gray.
*Lespedeza violacea*, Pers. Bush Clover.
*L. polystachya*, Michx.
*L. capitata*, Michx.
*Vicia Cracca*, L. Vetch.
*V. Caroliniana*, Walt.

*Lathyrus palustris*, L.
*L. orchrolencus*, Hook.
*Apios tuberosa*, Moench. Groundnut. Wild Bean.
*Phaseolus perennis*, Walt. Wild Bean.
*Amphicarpœa Monoica*, Nutt. Hog Peanut.
*Cercis Canadensis*, L. Red Bud. Judas Tree.
*Cassia Marilandica*, L. Wild Senna.
*Gymnocladus Canadensis*, Lam. Kentucky Coffee Tree.
*Gleditschia triacanthos*, L. Three-thorned Acacia or Honey Locust.

ROSACEÆ.

*Prunus Americana*, Marshall. Wild Yellow or Red Plum.
*P. Virginiana*, L. Choke Cherry.
*P. serotina*, Ehrh. Wild Black Cherry.
*Spirœa salicifolia*, L. Common Meadow Sweet.
*S. tomentosa*, L. Hardhack. Steeple Bush.
*Rubus triflorus*, Richardson. Dwarf Raspberry.
*R. strigosus*, Michx. Wild Red Raspberry.
*R. occidentalis*, L. Black Raspberry. Thimbleberry.
*R. villosus*, Ait. Common or High Blackberry.
*R. Canadensis*, L. Low Blackberry. Dewberry.
*R. hispidus*, L. Running Swamp Blackberry.
*Geum album*, Gmelin.
*G. Virginianum*, L.
*G. strictum*, Ait.
*Fragaria Virginiana*, Mill. Strawberry.
*Potentilla arguta*, Pursh.
*P. Norvegica*, L.
*P. argentea*, L. Silvery Cinque-foil.
*P. palustris*, Scop. Marsh Five-Finger.
*P. fruticosa*, L. Shrubby Cinque-foil.
*Argimonia parviflora*, Ait. Small-flowered Agrimony
*Rosa setigera*, Michx. Climbing or Prairie Rose.
*R. Carolina*, L. Swamp Rose.
*R. lucida*, Ehrh. Dwarf Wild Rose.
*Rosa rubiginosa*, L. Sweetbrier. Eglantine. Nat. from Europe.
*Pyrus coronaria*, L. American Crab Apple.
*P. arbutifolia*, L. f., var. *melanocarpa*, Hook. Chokeberry.
*Cratœgus coccinea*, L. Scarlet-fruited Thorn.
*C. coccinea*, L., var. *mollis*, Torr. & Gray.
*C. tomentosa*, L. Blackthorn.
*C. punctata*, Jacq.
*Amelanchier Canadensis*, Torr. & Gray. Shad Bush. Serviceberry. Juneberry.
*A. Canadensis*, var. *rotundifolia*, Torr. & Gray.

### SAXIFRAGACEÆ.

*Saxifraga Pennsylvanica*, L. Swamp Saxifrage.
*Mitella diphylla*, L. Mitrewort. Bishop's Cap.
*Heuchera Americana*, L, Common Alum Root.
*Parnassia Caroliniana*, Michx. Grass of Parnassus.
*Ribes Cynosbati*, L. Prickly Gooseberry.
*R. oxyacanthoides*, L.
*R. floridum*, L'Her. Wild Black Currant.

### CRASSULACEÆ.

*Penthorum sedoides*, L. Ditch Stone Crop.
*Sedum Telephium*, L. Garden Orpine or Live Forever. Adv. from Europe.

### DROSERACEÆ.

*Drosera rotundifolia*, L. Round-leaved Sundew.

### HAMAMELIDEAÆ.

*Hamamelis Virginiana*, L. Witch Hazel.

### HALORAGEÆ.

*Myriophyllum spicatum*, L. Water Milfiol.
*M. verticillatum*, L.
*M. heterohyllum*, Michx.

### LYTHRACEÆ.

*Lythrum alatum*, Pursh. Loosestrife.
*Decodon verticillatus*, Ell. Swamp Loosestrife.

### ONAGRACEÆ.

*Ludwigia alternifolia*, L. Seed Box.
*L. polycarpa*, Short & Peter.
*L. palustris*, L. Water Purslane.
*Epilobium angustifolium*, L. Great Willow Herb. Fire Weed. This is the *Bee Plant* or *Spider Flower* of the seed catalogues.
*E. strictum*, Muhl.
*E. coloratum*, Muhl.
*E. palustre*, L.
*Ænothera biennis*, L. Common Evening Primrose.
*Circæa Lutetiana*, L. Enchanter's Nightshade.
*Circæa alpina*, L.

### FICOIDEÆ.

*Mollugo verticillata*, L. Carpet Weed,

### UMBELLIFERÆ.

*Daucus Carota*, L. Carrot. Escaped from cultivation.
*Angelica atropurpurea*, L.
*Heracleum lanatum*, Michx. Cow Parsnip.
*Pastinaca sativa*, L. Parsnip. Adv. from Europe.
*Cryptotænia Canadensis*, D. C. Honewort.
*Sium cicutæfolium*, Gmelin. Water Parsnip.
*Zizia aurea*, Koch. Golden Alexanders.
*Z. cordata*, D. C.
*Carum carui*, L. Caraway. Nat. from Europe.
*Cicuta maculata*, L. Spotted Cowbane. Musquash Root. Beaver Poison.
*C. bulbifera*, L.
*Osmorrhiza brevistylis*, D. C. Hairy Sweet Cicely.
*O. longistylis*, D. C. Sweet Cicely.
*Erigenia bulbosa*, Nutt. Harbinger of Spring.
*Hydrocotyle umbellata*, L. Water Pennywort.
*Eryngium yaccæfolium*, Michx. Rattlesnake Master. Buttonsnake Root.
*Sanicula Marylandica*, L. Sanicle. Black Snake Root.

### ARALIACEÆ.

*Aralia racemosa*, L. Spikenard.
*A. nudicaulis*, L. Wild Sarsaparilla.
*A. quinquefolia*, Decsne. & Plauch. Ginseng.
*A. trifolia*, Descne. & Plauch. Dwarf Ginseng. Ground-nut.

### CORNACEÆ.

*Cornus florida*, L. Flowering Dogwood.
*C. sericea*, L. Silky Cornel. Kinnikinnik.
*C. stolonifera*, Michx. Red-osier Dogwood.
*C. paniculata*, L'Her. Panicled Cornel.
*C. alternifolia*, L. f.
*Nyssa sylvatica*, Marsh. Tupelo. Pepperidge. Black or Sour Gum.

### CAPRIFOLIACEÆ.

* *Sambucus Canadensis*, L. Common Elder.
*S. racemosa*, L. Red-berried Elder.
*Viburnum Opulus*, L. Cranberry Tree.
*V. acerifolium*, L. Dockmackie. Arrow-wood.
*V. pubescens*, Pursh.
*V. nudum*, L.

* See remarks.

*V. Lentago*, L. Sweet Viburnum, Sheep-berry.

*V. prunifolium*, L. Black Haw.

*Triosteum perfoliatum*, L. Fever-wort. Horse-Gentian. Tinker's-weed. Wild Coffee.

*T. angustifolium*, L.

*Symphoricarpus racemosus*, Michx. Snowberry. Wax-berry. Escaped from cultivation.

*Lonicera hirsuta*, Eaton. Hairy Honeysuckle. Woodbine.

*Diervilla trifida*, Moench. Bush-Honeysuckle.

RUBIACEÆ.

*Cephalanthus occidentalis*, L. Button Bush.

*Mitchella repens*, L. Partridge-berry. Squaw-berry. Saddle-berry. One-berry.

*Galium pilosum*, Ait.

*G. circæzans*, Michx. Wild Liquorice.

*G. latifolium*, Michx.

*G. trifidum*, L. Small Bedstraw.

*G. triflorum*, Michx. Sweet-scented Bedstraw.

*G. asprellum*, Michx. Rough Bedstraw.

DIPSACEÆ.

*Dipsacus sylvestris*, Mill. Wild Teasel. Roadsides. Nat. from Europe.

COMPOSITÆ.

*Veronia fasciculata*, Michx. Iron-weed.

*Eupatorium purpureum*, L. Joe-Pye Weed. Trumpet-weed. Queen-of-the-meadow.

*E. serotinum*, Michx.

*E. perfoliatum*, L. Thoroughwort. Boneset.

*Liatris scariosa*, Willd. Gay Feather.

*L. spicata*, Willd. Button Snakeroot.

*Solidago cæsia*, L. Golden-rod.

*S. latifolia*, L.

*S. stricta*, Ait.

*S. speciosa*, Nutt.

*S. patula*, Muhl.

*S. rugosa*, Mill.

*S. serotina*, Ait., var. *gigantea*, Gray.

*S. nemoralis*, Ait.

*S. rigida*, L.

*S. lanceolata*, L.

*S. Canadensis*, L.

*Aster macrophyllus*, L.
*A. Novæ Angliæ*, L. New England Aster.
*A. cordifolius*, L.
*A. sagittifolius*, Willd.
*A. lævis*, L.
*A. amethystinus*, Nutt.
*A. diffusus*, Ait.
*A. Tradescanti*, L.
*A. paniculatus*, Lam.
*A. salicifolius*, Ait.
*A. puniceus*, L.
*A. unbellatus*, Mill.
*A. tenuifolius*, L.
*Erigeron Canadensis*, L. Horse-weed. Butter-weed. Mare's Tail.
*E. annuus*, Pers. Daisy Fleabane. Sweet Scabious.
*E. bellidifolius*, Muhl. Robin's Plantain.
*E. Philadelphicus*, L. Common Fleabane.
*Antennaria plantaginifolia*, Hook. Plantain-leaved Everlasting. Mouse Ear. E.
*Gnaphalium polycephalum*, Michx. Common Everlasting.
*G. decurrens*, Ives. Everlasting.
*G. uliginosum*, L. Low Cudweed.
*Inula Helenium*, L. Elecampane. Roadsides. Nat. from Europe.
*Silphium terebinthinaceum*, L. Prairie Dock.
*Ambrosia trifida*, L. Great Rag-weed. Horse-weed.
*A. artemisiæfolia*, L. Roman Wormwood. Hog-weed. Bitter-weed. Rag-weed.
*Xanthium strumarium*, L. Cockle-burr. Clot-burr. Road-sides and Waste places. Nat. from Eu. (?) or Ind. (?)
*Rudbeckia hirta*, L. Cone-flower. Individuals with *tubular* petals occasionally occur.
*Lepachys pinnata*, Torr & Gray.
*Helianthus annuus*, L. Common Sunflower. Fields and waste places, escaped from cultivation.
*H. laetiflorus*, Pers.
*H. occidentalis*, Riddell.
*H. tomentosus*, Michx.
*H. giganteus*, L.
*H. divaricatus*, L.
*H. tuberosus*, L. Jerusalem Artichoke. Escaped from cultivation.
*Coreopsis lanceolata*, L.
*C. auriculata*, Linn.
*C. tripteris*, L. Tall Coreopsis.
*C. trichosperma*, Michx. Tickseed. Sunflower.

*C. aristosa*, Michx.

*Bidens frondosa*, L. Common Beggar-ticks. Stick-tight

*B. connata*, Muhl. Swamp Beggar-ticks.

*B. cernua*, L. Smaller Burr-Marigold.

*B. Beckii*, Torr. Water Marigold.

*Anthemis Cotula*, D. C. May-weed. Dog Fennel. Common about dwellings and along road sides. Nat. from Europe.

*Achillea Millefolium*, L. Common Yarrow or Milfoil. The variety with rose-colored flowers occasionally occurs.

*Tanacetum vulgare*, L. Common Tansy. Road sides. Escaped from gardens. Nat. from Europe.

*Artemisia Absinthium*, L. Wormwood. Road-sides. Escaped from gardens. Adv. from Europe.

*Senecio aureus*, L. Golden Ragwort. Squaw-weed. Life-Root.

*Cacalia atriplicifolia*, L. Pale Indian Plantain.

*Erechthites hieracifolia*, Raf. Fireweed.

*Arctium Lappa*, L. Burdock. Nat. from Europe.

*Cnicus lanceolatus*, Hoffm. Common Thistle. Nat. from Europe.

*C. altissimus*, Willd.

*C. altissimus*, Willd., var. *discolor*, Gray.

*C. muticus*, Pursh. Swamp Thistle.

*C. arvensis*, Hoffm. Canada Thistle. Nat. from Europe.

*Centaurea Cyanus*, L. Bachelor's Button. Bluebottle. Escaped from cultivation. Adv. from Europe.

*Krigia amplexicaulis*, Nutt.

*Cichorium Intybus*, L. Succory or Chicory. Road-sides and wastes places. Nat. from Europe.

*Hieracium Canadense*, Michx. Hawkweed.

*H. scabrum*, Michx.

*H. Gronovii*, L.

*H. longipilum*, Torr.

*Pernanthes racemosa*, Michx.

*P. aspera*, Michx.

*P. alba*, L. White Lettuce. Rattlesnake root.

*P. serpentaria*, Pursh. Lion's-foot. Gall-of-the-earth.

*P. altissima*, L.

*Taraxacum officinale*, Weber. Common Dandelion.

*Lactuca Canadensis*, L. Wild Lettuce.

*L. leucophæa*, Gray.

*Sonchus oleraceus*, L. Common Sow Thistle. Waste places. Nat. from Europe.

*Sonchus asper*, Vill. Spring-leaved Sow Thistle.

### LOBELIACEÆ.

*Lobelia cardinalis*, L. Cardinal-flower.
*L. syphilitica*, L. Great Lobelia. I have seen one white specimen.
*L. Kalmii*, L.
*L. inflata*, L. Indian Tobacco.

### CAMPANULACEÆ.

*Campanula rotundifolia*, L. Harebell.
*C. aparinoides*, Pursh. Marsh Bellflower.
*C. Americana*, L. Tall Bellflower.

### ERICACEÆ.

*Gaylussacia resinosa*, Torr. & Gray. Black Huckleberry.
*Vaccinium Canadense*, Kalm.
*V. corymbosum*, L. Common High or Swamp Blueberry.
*V. Macrocarpon*, Ait. Large or American Cranberry.
*Gaultheria procumbens*, L. Aromatic or Creeping Wintergreen. Tea-berry. Checkerberry.
*Andromeda polifolia*, L.
*Cassandra calyculata*, Don. Leather-Leaf.
*Chimaphila umbellata*, Nutt. Prince's Pine. Pipsissewa. I have seen but one specimen.
*Pyrola secunda*, L.
*Pyrola rotundifolia*, L. Wintergreen.
*Monotropa uniflora*, L. Indian Pipe. Corpse Plant.

### PRIMULACEÆ.

*Steironema ciliatum*, Raf.
*S. lanceolatum*, Gray.
*S. longifolium*, Gray.
*Lysimachia quadrifolia*, Gray.
*L. stricta*, Ait.
*L. thyrsiflora*, L. Tufted Loosestrife.
*Samolus Valerandi*, L.

### OLEACEÆ.

*Fraxinus Americana*, L. White Ash.
*F. quadrangulata*, Michx. Blue Ash.
*F. sambucifolia*, Lam. Black Ash.

### APOCYNACEÆ.

*Apocynum androsæmifolium*, L. Spreading Dogbane.
*A. cannabinum*, L. Indian Hemp.

### ASCLEPIADACEÆ.

*Asclepias tuberosa*, L. Butterfly-weed. Pleurisy-root.
*A. incarnata*, Swamp Milkweed.
*A. Cornuti*, Decaisne. Common Milkweed or Silkweed.
*A. phytolaccoides*, Pursh. Poke Milkweed.
*Acerates viridiflora*, Ell.

### GENTIANACEÆ.

*Gentiana crinita*, Frœl. Fringed Gentian.
*G. quinqueflora*, Lam.
*G. Andrewsii*, Griseb. Closed Gentian.
*G. alba*, Muhl.
*Frasera Carolinensis*, Walt. American Columbo.
*Menyanthes trifoliata*, L. Buckbean.

### POLEMONIACEÆ.

*Phlox pilosa*, L.

### HYDROPHYLLACEÆ.

*Hydrophyllum Virginicum*, L. Water-leaf.
*H. appendiculatum*, Michx.

### BORRAGINACEÆ.

*Cynoglossum officinale*, L. Common Hound's Tongue. Nat. from Europe.
*C. Virginicum*, L. Wild Comfrey.
*Echinospermum Virginicum*, Lehm. Beggar's Lice.
*E. Lappula*, Lehm. Nat. from Europe.
*Lithospermum arvense*, L. Corn Gromwell. Wheat-thief. Redroot. A great pest in wheat-fields. Nat. from Europe.
*L. hirtum*, Lehm.
*L. angustifolium*, Michx.

### CONVOLVULACEÆ. (?)

*Convolvulus sepium*, L. Hedge Bindweed.
*C. sepium*, L., var. *repens*, Gray. Often as double as a rose.
*Cuscuta Gronovii*, Willd. Dodder.

SOLANACEÆ.

*Solanum Dulcamara*, L. Bittersweet. Flowers often *white*. Nat. from Europe.

*S. nigrum*, L. Common Black Nightshade.

*Physalis pubescens*, L. Ground Cherry.

*P. viscosa*, L.

*Lycium vulgare*, Dunal. Matrimony vine. Escaped from cultivation. Adv. from Europe.

*Datura Stramonium*, L. Jamestown weed. Jimson weed. Thorn Apple. Adv. from Asia.

SCROPHULARIACEÆ.

*Verbascum Thapus*, L. Common Mullein. Nat. from Europe.

*V. Blattaria*, L. Moth Mullein. Nat. from Europe.

*Linaria vulgaris*, Mill. Ramsted. Butter and Eggs. Nat. from Europe.

*Scrophularia nodosa*, L., var. *Marilandica*, Gray.

*Collinsia verna*, Nutt.

*Chelone glabra*, L. Turtle-head. Snake-head.

*Pentstemon pubescens*, Solander. Beard-tongue.

*Mimulus ringens*, L. Monkey-flower.

*Gratiola Virginiana*, L. Hedge-Hyssop.

*Ilysanthes riparia*, Raf. False Pimpernel.

*Veronica Virginica*, L. Culver's-root. Culver's Physic.

*V. Anagallis*, L. Water Speedwell.

*V. scutellata*, L. Marsh Speedwell.

*V. officinalis*, L. Common Speedwell.

*V. arvensis*, L. Corn Speedwell. Nat. from Europe.

*Gerardia pedicularia*, L.

*G. grandiflora*, Benth.

*G. flava*, L. Downy False Foxglove.

*G. quercifolia*, Pursh.

*G. purpurea*, L. Purple Gerardia.

*G. tenuifolia*, Vahl. Slender Gerardia.

*Castilleia coccinea*, Spreng. Scarlet Painted-Cup.

*Pedicularis Canadensis*, L. Common Lousewort. Wood Betony.

*P. lanceolata*, Michx.

*Melampyrum Americanum*, Michx. Cow-Wheat.

OROBANCHACEÆ.

*Epiphegus Virginiana*, Bart. Beech-drops. Cancer-root.

*Conopholis Americana*, Wallroth. Squaw-root. Cancer-root.

LENTIBULARIACEÆ.

*Utricularia vulgaris*, L. Greater Bladderwort.
*U. subulata*, L.

VERBENACEÆ.

*Verbena urticæfolia*, L. White Vervain.
*V. hastata*, L. Blue Vervain.
*V. stricata*, Vent. Hoary Vervain.
*Phryma Leptostachya*, L. Lopseed.

LABIATÆ.

*Teucrium Canadense*, L. American Germander. Wood Sage.
*Collinsonia Canadensis*, L. Rich-weed. Stone-root.
*Mentha viridis*, L. Spearmint.
*M. piperita*, L. Peppermint.
*M. Canadensis*, L. Wild Mint.
*Lycopus rubellus*, Moench. Water Horehound.
*Pycnanthemum lanceolatum*, Pursh. Basil.
*P. muticum*, Pers., var. *pilosum*, Gray.
*Hedeoma pulegioides*, Pursh. American Pennyroyal.
*Monarda fistulosa*, L. Wild Bergamot.
*Blephilia-hirsuta*, Benth.
*Lophanthus nepetoides*, Benth.
*Nepeta cataria*, L. Capnip. Nat. from Europe.
*N. Glechoma*, Benth. Ground Ivy. Gill-over-the-ground. Nat. from Europe.
*Scutellaria lateriflora*, L. Mad-dog Skullcap.
*S. galericulata*, L.
*Prunella vulgaris*, L. Self-heal. Heal-all.
*Marrubium vulgare*, L. Horehound. Escaped from cultivation into clearings, along roadsides, etc. Nat. from Europe.
*Leonurus Cardiaca*, L. Mother-wort. Waste places, around dwellings. Nat. from Europe.
*Lamium purpureum*, L. Nat. from Europe.
*Stachys aspera*, Michx., var. glabra, Gray.

PLANTAGINACEÆ.

*Plantago major*, L. Common Plantain.
*P. lanceolata*, L. Ribgrass. Ripplegrass. English Plantain. Buckhorn. A noxious weed. Nat. from Europe.

### AMARANTHACEÆ.

*Amaranthus hypochondriacus*, L. Escaped from gardens. Adv. from Trop. Amer.

*A. paniculatus*, L. Adv. from Trop. Amer.

*A. retroflexus*, L. Adv. from Trop. Amer.

*A. albus*, L. Tumble Weed.

### CHENOPODIACEÆ.

*Chenopodium album*, L. Lamb's Quarters. Pig-weed. Nat. from Europe.

*C. urbicum*, L. Nat. from Europe.

*C. hybridum*, L. Maple-leaved Goosefoot.

*C. capitatum*, Watson. Strawberry Blight.

*C. Botrys*, L. Jerusalem Oak. Feather Geranium. Nat. from Europe.

*C. ambrosioides*, L., var. *anthelminticum*, Gray. Wormseed. Nat. from Trop Amer.

*Atriplex patulum*, L., var. *littorale*, Gray.

### PHYTOLACCACEÆ.

*Phytolacca decandra*, L. Poke. Scoke. Garget. Pigeon Berry.

### POLYGONACEÆ.

*Rumex Britannica*, L. Great Water-Dock.

*R. crispus*, L. Curled Dock.

*R. obtusifolius*, L. Bitter Dock.

*R. Acetosella*, L. Field or Sheep Sorrel. Horse Sorrel. Nat. from Europe.

*Polygonum aviculare*, L. Knotgrass. Door-weed.

*P. erectum*, L.

*P. lapathifolium*, L., var. *incarnatum*, Watson.

*P. Pennsylvanicum*, L.

*P. amphibium*, L.

*P. Muhlenbergii*, Watson.

*P. Hartwrightii*, Gray.

*P. orientale*, L. Prince's Feather. Escaped from gardens. Adv. from India.

*P. Persicaria*, L. Lady's Thumb. Nat. from Europe.

*P. Hydropiper*, L. Common Smartweed or Water-Pepper.

*P. hydropiperoides*, Michx. Wild Water-Pepper.

*P. acre*, H. B. K. Water Smartweed.

*P. Virginianum*, L.

*P. arifolium*, L. Halbert-leaved Tear-Thumb.
*Polygonum sagittatum*, L. Arrow-leaved Tear-Thumb.
*P. Convolvulus*, L. Black Bindweed.
*P. dumetorum*, L., var. *scandens*, Gray. Climing False Buckwheat.

ARISTOLOCHIACEÆ.

*Asarum Canadense*, L. Wild Ginger. Canada Snakeroot. Colt's Foot.
*Aristolochia Serpentaria*, L. Virginia Snakeroot.

PIPERACEÆ.

*Saururus cernuus*, L. Lizard's Tail.

LAURACEÆ.

*Sassafras officinale*, Nees.
*Lindera Benzoin*, Blüme. Spice-bush. Spicewood. Benjamin-bush.
*Dirca palustris*, L. Leatherwood. Moose-wood.

SANTALACEÆ.

*Comandra umbellata*, Nutt.

EUPHORBIACEÆ.

*Euphorbia maculata*, L. Spurge.
*E. Preslii*, Guss.
*E. corollata*, L. Large Flowering Spurge. Milkweed.
*E. Esula*, L. Garden Pine. Escaped from cultivation. Adv. from Europe.
*Acalypha Virginica*, L. Three-seeded Murcury.

URTICACEÆ.

*Ulmus fulva*, Michx. Slippery or Red Elm.
*U. Americana*, L. American or White Elm.
*U. racemosa*, Thomas. Cork or Rock Elm. Hickory Elm.
*Celtis occidentalis*, L. Sugarberry. Hackberry.
*Cannabis sativa*, L. Hemp. Waste places. Adv. from Europe.
*Humulus Lupulus*, L. Common Hop.
*Morus rubra*, L. Red Mulberry.
*Urtica gracilis*, Ait. Nettle.
*Laportea Canadensis*, Grandichand. Wood-Nettle.
*Pilea pumila*, Gray. Richweed. Clearweed. Glass-Nettle.
*Bœhmeria cylindrica*, Willd. False Nettle.

PLATANACEÆ.

*Platanus occidentalis*, L. Sycamore. Buttonwood.

### JUGLANDACEÆ.

*Juglans cinerea*, L. Butternut. White Walnut.

*J. nigra*, L. Black Walnut.

*Carya alba*, Nutt. White Hickory. Shell-bark. Shag-bark. Hickory.

*C. sulcata*, Nutt. Big Shell-bark. King-nut.

*C. porcina*, Nutt. Pignut. Broom Hickory.

*C. amara*, Nutt. Bitternut. Swamp Hickory.

### CUPULIFERÆ.

*Bentula lenta*, L. Cherry Birch. Sweet or Black Birch.

*B. pumila*, L. Low or Dwarf Birch.

*Corylus Americana*, Walt. Wild Hazel-nut.

*Ostrya Virginica*, Willd. American Hop-Hornbeam. Lever-wood. Iron-wood.

*Carpinus Caroliniana*, Walter. American Hornbeam. Blue or Water Beech.

*Quercus alba*, L. White Oak.

*Q. Macrocarpa*, Michx. Bur Oak. Over-cup or Mossy-cup Oak.

*Q. bicolor*, Willd. Swamp White Oak.

*Q. Muhlenbergii*, Engelm. Yellow Oak. Chestnut Oak. Sweet Oak.

*Q. rubra*, L. Red Oak.

*Q. coccinea*, Wang., var. *tinctoria*, Gray. Quercitron, Yellow-barked Black Oak.

*Q. palustris*, Du Roi. Swamp Spanish Oak. Pin Oak.

*Q. imbricaria*, Michx. Laurel Oak. Shingle Oak.

*Fagus ferruginea*, Ait. American Beech.

### SALICACEÆ.

*Salix nigra*, Marsh. Black Willow.

*S. nigra*, Marsh., var. *falcata*, Torr.

*S. lucida*, Muhl. Shining Willow.

*S. alba*, L. White Willow. Adv. from Europe.

*S. longifolia*, Muhl. Long-leaved Willow.

*S. rostrata*, Richardson.

*S. discolor*, Muhl. Glaucous Willow.

*S. discolor*, Muhl., var. *eriocaphala*, Anders.

*S. humilis*, Marsh. Prairie Willow.

*S. sericea*, Marsh. Silky Willow.

*S. candida*, Willd. Sage Willow. Hoary Willow.

*S. cordata*, Muhl., var. *angustata*, Anders.

*Populus alba*, L. White Poplar. Abele. Adv. from Europe.
*P. tremuloides*, Michx. American Aspen.
*P. grandidentata*, Michx. Large-toothed Aspen.
*P. balsamifera*, L. Balsam Poplar. Tacamahac.
*P. monilifera*, Ait. Cotton-wood. Necklace Poplar.

CONIFERÆ.

*Laix Americana*, Michx. American or Black Larch. Tamarack. Hackmatack.
*Juniperus communis*, L. Common Juniper.
*J. Virginiana*, L. Red Cedar.

HYDROCHARIDACEÆ.

*Elodea Canadensis*, Michx. Water-weed. Ditch Moss.
*Vallisneria spiralis*, L. Tape-grass. Ell-grass.

ORCHIDACEÆ.

*Aplectrum hiemale*, Nutt. Putty-root. Adam-and-Eve.
*Corallorhiza odontorhiza*, Nutt. Coral-root.
*C. multiflora*, Nutt.
*Spiranthes præcox*, Watson. Ladies Tresses.
*Goodyera repens*, R. Br. Rattlesnake Plantain.
*Calopogon pulchellus*, R. Br. Grass Pink.
*Pogonia ophioglossoides*, Nutt.
*P. pendula*, Lindl. Three-Birds.
*Orchis spectabilis*, L. Showy Orchis.
*Habenaria ciliaris*, R. Br. Yellow Fringed Orchis.
*H. virescens*, Spreng.
*H. leucophæe*, Gray. White Prairie Orchis.
*H. psycodes*, Gray. Purple Fringed Orchis.
*Cypripedium candidum*, Muhl. Small White Lady's Slipper.
*C. pubescens*, Willd. Larger Yellow Lady's Slipper.
*C. spectabile*, Swartz. Showy Lady's Slipper.

IRIDACEÆ.

*Iris versicolor*, L. Larger Blue Flag.
*Sisyrinchium angustifolium*, Mill. Blue-eyed Grass.

AMARYLLIDACEÆ.

*Hypoxis erecta*, L. Yellow Star Grass.

DIOSCOREACEÆ.

*Dioscorea villosa*, L. Wild Yam-root.

LILIACEÆ.

*Smilax herbacea*, L. Carrion-Flower.
*S. rotundifolia*, L. Common Greenbrier. Horse-brier.
*Allium tricoccum*, Ait. Wild Leek.
*A. cernuum*, Roth. Wild Onion.
*Yucca filamentosa*, L. Adam's Needle. Eve's Thread. Streets. Escaped from gardens.
*Polygonatum biflorum*, Ell. Smaller Solomon's Seal.
*P. giganteum*, Dietrich. Great Solomon's Seal.
*Smilacina racemosa*, Desf. False Spikenard. False Solomon's Seal.
*Maianthemum Canadense*, Desf. Two-leaved Solomon's Seal.
*Uvularia perfoliata*, L. Bellwort.
*Erythronium Americanum*, Ker. Dog's tooth Violet. Adder's-tongue.
*E. albidum*, Nutt. White Dog's-tooth Violet.
*Lilium superbum*, L. Turk's Cap Lily.
*L. Canadense*, L. Wild Yellow Lily.
*Medeola Virginiana*, L. Indian Cucumber-root.
*Trillium sessile*, L. Spotted Wake Robin.
*T. recurvatum*, Beck.
*T. erectum*, L. Purple Trillium Birth-root.
*T. grandiflorum*, Salisb.
*T. cernuum*, L. Nodding Trillium. Monstrosities are frequent in the Trilliums, such as four leaves, petals changed to leaves, etc.
*Tofieldia glutinosa*, Willd. (?) False Asphodel.

PONTEDERIACEÆ.

*Pontederia cordata*, L. Pickerel-weed.

COMMELINACEÆ.

*Tradescantia Virginica*, L. Spider-wort.

JUNCACEÆ.

*Juncus effusus*, L. Common or Soft Rush.
*J. tenuis*, Willd.
*J. Canadensis*, J. Gay.
*Luzula campestris*, DC. Wood Rush.

TYPHACEÆ.

*Typha latifolia*, L. Common Cat-tail.
*T. angustifolia*, L.
*Sparganium eurycarpum*, Engelm. Burr-reed.

### ARACEÆ.

*Arisæma triphyllum*, Torr. Indian Turnip.
*A. Dracontium*, Schoot. Green Dragon. Dragon root.
*Peltandra undulata*, Raf. Arrow Arum.
*Symplocarpus fœtidus*, Salisb. Skunk Cabbage.
*Acorus Calamus*, L. Sweet Flag.

### LEMNACEÆ.

*Spirodela polyrrhiza*, Schleid.
*Lemna trisulca*, L. Duckweed. Duck's-meat.
*Wolffia Columbiana*, Karsten.

### ALISMACEÆ.

*Alisma Plantago*, L. Water-Plantain.
*Sagittaria variabilis*, *Engelm.* Arrow-head.
*S. variabilis*, Engelm., var. *obtusa.*
*S. variabilis*, Engelm., var. (?) *gracilis.*

### NAIADACEÆ.

*Potamogeton natans*, L. Pondweed.
*P. Pennsylvanicus*, Cham.
*P. heterophyllus*, Schreb.
*P. lucens*, L.
*P. zosteræfolius*, Schum.
*P. Robbinsii*, Oakes.

### ERIOCAULEÆ.

*Eriocaulon septangulare*, Withering. Badly named, as the scape frequently has eight striæ.

### CYPERACEÆ.

*Cyperus diandrus*, Torr.
*C. Erythrorhizos*, Muhl.
*C. strigosus*, L.
*Dulichium spathaceum*, Pers.
*Eleocharis quadrangulata*, R. Br. Spike Rush.
*E. ovata*, R. Br.
*E. acicularis*, R. Br.
*Scirpus pungens*, Vahl. Bulrush. Clubrush.
*S. lacustris*, L. Great Bulrush.
*Eriophorum cyperinum*, L. Wool-grass.
*E. vaginatum*, L. Cotton-grass.
*E. gracile*, Koch.

*Rhynchospora alba*, Wahl. Beak-Rush.
*Carex lurida*, Wahl. Sedge.
*C. hystricina*, Muhl.
*C. Pseudo-Cyperus*, L., var. *Americana*, Hochst.
*C. riparia*, W. Curtis.
*C. prasina*, Wahl.
*C. crinita*, Lam.
*C. arctata*, Boott.
*C. debilis*, Michx., var. *Rudgei*, Bailey.
*C. Davisii*, Schwein. & Torr.
*C. laxiflora*, Lam.
*C. platyphylla*, Carey.
*C. plantaginea*, Lam.
*C. pedunculata*, Muhl.
*C. Pennsylvanica*, Lam.
*C. pubescens*, Muhl.
*C. sparganioides*, Muhl.
*C. exilis*, Dewey.
*C. schinata*, Murray, var. *microstachys*, Boeckl.
*C. scoparia*, Schkuhr.

GRAMINEÆ.

*Spartina cynosuroides*, Willd. Fresh-water Cord-Grass.
*Panicum sanguinale*, L. Crab or Finger-Grass. Nat. from Europe.
*P. capillare*, L. Old-witch Grass. Tickle-Grass.
*P. agrostoides*, Muhl.
*P. latifolium*, L.
*P. clandestinum*, L.
*P. dichotomum*, L.
*P. Crus-galli*, L. Cock-spur Grass. Barnyard Grass. Nat. from Europe.
*Setaria glauca*, Beauv. Foxtail. Pigeon-Grass. Adv. from Europe.
*S. viridis*, Beauv. Green Foxtail. Bottle-Grass. Adv. from Europe.
*S. Italica*, Kunth. Hungarian or Bengal Grass. Adv. from Europe
*Leersia Virginica*, Willd. White Grass.
*L. oryzoides*, Swartz. Rice Cut-grass.
*Zizania aquatica*, L. Indian Rice. Water Oats.
*Z. miliacea*, Michx.
*Androphogon Aurcatus*, Muhl. Forked Spike.
*A. scoparius*, Michx. Beard Grass.
*Phalaris Canariensis*, L. Canary-Grass. Waste grounds. Adv. from Europe.
*Muhlenbergia, glomerata*, Trin.

*Phleum pratense*, L. Timothy. Herd's-Grass. Nat. from Europe.
*Alopecurus geniculatus*, L., var. *aristulatus*, Torr.
*Agrostis alba*, L. Fiorin or White Bent-Grass.
*A. alba*, L., var. *valgaris*, Thurb. Red Top. Nat. from Europe.
*Cinna pendula*, Trin. Wood Reed-Grass.
*Calamagrastis Canadensis*, Beauv. Blue-Joint.
*Deschampsia cæspitosa*, Beauv.
*Bouteloua racemosa*, Lag. Musquite-Grass.
*Eleusine Indica*, Gærtn. Dog's Tail or Wire Grass. Nat. from Ind. (?)
*Phragmites communis*; Trinn. Reed.
*Eragrostis reptans*, Nees.
*E. minor*, Host. Nat. from Europe.
*E. pilosa*, Beauv. Nat. from Europe.
*Dactylis glomerata*, L. Orchard Grass. Nat. from Europe.
*Poa annua*, L. Low Spear-Grass. Nat. from Europe.
*P. compressa*, L. Wire-Grass. English Blue-Grass. Nat. from Europe.
*P. serotina*, Echart. False Red-top. Fowl Meadow-Grass.
*P. pratensis*, L. June Grass. Spear Grass. Kentucky Blue-Grass.
*P. debilis*, Torr.
*Glyceria Canadensis*, Trin. Rattlesnake-Grass.
*G. nervata*, Trin. Fowl Meadow-Grass.
*G. fluitans*, R. Br.
*Bromus secalinus*, L. Cheat. Chess. Adv. from Europe.
*B. ciliatus*, L.
*Agropyrum repens*, Beauv. Couch, Quich, or Quock-Grass.
*Elymus Virginicus*, L. Wild Rye.
*E. Canadensis*, L.
*Asprella Hystrix*, Willd. Hedgehog-Grass. Bottle-brush Grass.

EQUISETACEÆ.

*Equisetum arvense*, L. Common Horsetail.
*Equisetum hyemale*, L. Scouring Rush. Shave-Grass.

FILICES.

*Polypodium valgare*, L. Polypody.
*Adiantum pedatum*, L. Maidenhair Fern.
*Pteris aquilina*, L. Common Brake.
*Asplemium ebenum*, Ait. Ebony Spleenwort.
*Aspidium acrostichoides*, Swartz. Acrostic, Shield, or Christmas Fern.
*Dicksonia pilosiuscula*, Willd.
*Osmunda regalis*, L. Flowering Fern.
*O. cinnamomea*, L. Cinnamon Fern.

### OPHIOGLOSSACEÆ.

*Botrychium ternatum*, Swartz., var. *lunarioides*, Moonwort.
*B. Virginianum*, Swartz.

### LYCOPODIACEÆ.

*Lycopodium lucidulum*, Michx. Club Moss.
*L. inundatum*, L.

### MARCHANTIACEÆ.

*Marchantia polymorpha*, L. Liverwort.
*Conocephalus conicus.*, Dumont.

# REPORT UPON THE GEOLOGY OF WHITLEY COUNTY.

BY CHARLES R. DRYER, M. D.

Whitley County is bounded on the north by Noble, on the east by Allen, on the south by Huntington and on the west by Wabash and Kosciusko. Originally included in Allen County, it was organized independently in 1838, and named after Col. William Whitley, of Kentucky, who was killed at the battle of the Thames. At first it included townships 30, 31 and 32 north, in ranges 8, 9 and 10 east of 2d P. M., but a few years afterward, for some undiscoverable reason, sections 25 to 36, township 33, range 8, were taken from Noble County to form Etna Township, Whitley County. The county now comprises 228 square miles, and on account of the addition of Etna and a jog of a mile and a half between townships 31 and 32, it forms a slightly irregular square. The civil townships are made up as follows:

| | *Township.* | *Range.* | *Sections.* |
|---|---|---|---|
| **Smith** | 32 | 10 | 1–36 |
| **Union** | 31 | 10 | 1–36 |
| **Jefferson** | 30 | 10 | 1–36 |
| **Washington** | 30 | 9 | 1–36 |
| **Columbia** | 31 | 9 | 1–36 |
| **Thorn Creek** | 32 | 9 | 1–36 |
| **Etna** | 33 | 8 | 25–36 |
| **Troy** | 32 | 8 | 1–24 |
| **Richland** | 32 | 8 | 25–36 |
| | 31 | 8 | 1–24 |
| **Cleveland** | 31 | 8 | 25–36 |
| | 30 | 8 | 1–36 |

Columbia City, the county seat, is situated in section 11. Columbia, Churubusco, section 13, Smith; Larwill, section 32, Richland; South Whitley, sections 3 and 4, township 30, range 8 (Cleveland) and Coesse, sections 21 and 22, Union, are important villages. The county is crossed by three railroads, the Pittsburgh, Fort Wayne & Chicago, passing through Coesse, Columbia City and Larwill, the Detroit division of the Wabash, passing through Churubusco, Columbia City and South Whitley, and the New York, Chicago & St. Louis, extending east and west near the line between townships 30 and 31, and crossing the Wabash at South Whitley.

The Indian history of Whitley County is very interesting, the territory having been occupied by the Eel River Miamis, of which the most important town, next to Kekionga or Fort Wayne, was the Turtle village in the northeast corner of Union Township. Leek's village, near the site of Columbia City, and the Raccoon village, at the southeast corner of the county, the head of navigation on the Little Wabash River and the beginning of the portage to the Maumee, were also places of importance to the Indians and early white settlers. The Wabash and Erie Canal touched the southeast corner of the county.

Whitley County is entirely occupied by the great *Saginaw-Erie interlobate moraine,* two members of which are distinguishable within its limits, the outer or third and fourth Erie moraines.* The crest of this morainic system, forming the water-shed between the Tippecanoe and Eel Rivers, passes through Troy and Thorn Creek Townships, thus leaving the greater part of the county upon the Erie side. The borings at Columbia City and Larwill passed through 220 feet of drift, and its thickness can not be much less than that anywhere in the county, except near the southeast corner where it touches the Wabash-Erie channel.† Perhaps nowhere else within equal limits does the surface of the drift present aspects so strongly marked and contrasted in character; yet nowhere else in the State is it more difficult to differentiate and correlate the various members of the morainic system. There are at least five distinct topographical types which agree only in strong features, limited area, and confused arrangement. These will first be described, and afterward an attempt will be made to arrange them in accordance with the general plan of the morainic system of Northeastern Indiana.

In the townships of Jefferson and Washington, and the southern third of Union, the surface is best described by the word *flat.*

It forms a part of the great level plain of east central Indiana. While the slopes are sufficient for drainage, they are usually imperceptible to the eye, and can be determined only by the general course of the streams. The surface resembles that of a sheet of paper which has been wet and dried, the depressions and elevations having very slight relief and no definite boundaries. The concavities are perceptible only because the water stands in them like puddles on a flat tin roof. The only relief from unbroken monotony is afforded by the channels of the streams which have been eroded to a considerable depth, and which grow deeper as the stream descends toward its mouth. The marshes are like a platter having only an insignificant depth and no definite margins. The soil is a stiff clay, containing very few bowlders, and requires understanding to realize its

*See Report upon the Geology of Steuben County, in this volume.
† See 16th Report of the State Geologist, p. 113.

full fertility. It is a part of that enormous mass of fine mud which, as the ice melted, settled quietly to the bottom of the glacier, and is known as *ground moraine*. From this region several streams flow east and south toward the Wabash-Erie channel. Indian Creek and Big Indian Creek flow in parallel courses eastward to join the Aboit, just above its mouth, in Allen County. Where they enter the Aboit Valley they are bordered by bluffs forty to fifty feet high. Along the southern border are the head-waters of Calf Creek and Clear Creek, which flow south, through Huntington County, to the Little Wabash. Out of the marshes of northern Jefferson and Washington, Sugar Creek and Stony Creek wind sluggishly westward to join the Eel river. The whole region seems characterized chiefly by its want of character. A slight but perceptible ridge along the east tier of sections, in Washington, forms the water-shed between the Indian and Calf creeks on the east, and Clear Creek and the tributaries of Eel River on the west. In summing up the results of the survey, this ridge will be found to possess more importance than its appearance seems to warrant.

In passing westward into the southern part of Cleveland Township a marked change is discernable. Here the surface is no longer flat, but *corrugated* with gently sloping ridges which are elevated above the general level and extend northeast and southwest. These ridges grow successively higher to a summit two to four miles east of the county line, whence they fall away more rapidly to the Eel River Valley, in Wabash County. Hurricane Creek, and other small streams, cut across them almost at right angles, and flow westward through deep channels. These ridges are also pitted with frequent kettle holes.

At the west line of the county the sandy and gently undulating valley of Eel River is encountered, here about one mile wide, the slopes on either side being gradual and without bluffs. In the four or five miles of its course, east of South Whitley, the river flows at the bottom of a much deeper and narrower valley. The hills upon either side rise to a greater height and have more abrupt slopes. In section 1, township 30, range 8, two very curious depressions extend back from the river into the hills. One is narrow and over half a mile long, the other smaller, but separated from the first by a narrow ridge like a canal tow-path. They are now occupied by swamps, but were originally lakes exactly similar to some of those in the northern part of the county. They are the southernmost specimens of morainic or kettle-hole lakes to be found upon the Erie side of the Saginaw-Erie system. The ridges of Cleveland Township form a part of the Mississinewa or fourth Erie moraine, through which Eel River, following the example of so many other streams in this region, here cuts transversely.*

---

*See Sixteenth Report of the State Geologist, pp. 123-4; also, Report on the Geology of Steuben County in this volume.

In the northwest half of Columbia and the east half of Richland townships the fourth moraine assumes a character which words are powerless to picture. The country is entirely occupied by deep irregular, elongated valleys, with narrow, sharp, winding ridges between, all in inextricable, indescribable and almost unmappable confusion. In a somewhat extensive study of the great morainic belts of North America, both by personal observation and from numerous published reports, the writer has never seen or found described anything closely resembling this area. It covers in all scarcely more than forty square miles, and the greatest differences of level probably do not exceed one hundred feet; yet this little patch seems to be unique. The roads through it are very crooked in order to avoid the marshes; yet in whatever direction one travels it is nothing but a succession of steep descents and ascents. The ridges are composed of rather barren clay and the valleys occupied by marshes and tamarack swamps. The relief might be imitated by taking a block of plastic clay and gouging it with some blunt instrument in the most irregular manner possible, somewhat as the ancient Babalonians did their bricks. It is one of nature's cuneiform inscriptions, and as difficult of interpretation as those of the Euphrates Valley. This type of topography may be called *chasmed.* It is now impossible to imagine with any definiteness of detail the process by which this little bit of the face of the earth was put into its present shape. Another strange peculiarity is that a country which so abounds in depressions is almost devoid of lakes.

Black's Lake, section 27, and Wilson's Lake, section 35, township 32, range 8, lie upon the northwestern border of this region. The former covers about forty acres, is nearly free from vegetation, and evidently shallow. An unusually high and precipitous ridge separates the two. From these lakes Spring Creek flows southward through the chasms to Eel River.

West of the middle of Richland Township the country smoothes out decidedly retaining similar features in a much milder form, and may be called *gently sloping*. This comparatively smooth interval extends westward to and beyond the county line, and to the north occupies the greater part of Troy and Etna Townships. Although the contrast between the precipitous chasms on the east and the gentle undulations on the west is very strong, it is impossible to draw more than an approximate boundary line. The village of Larwill is situated upon this boundary, which extends thence southward and toward the northeast, passing between Loon and Crooked Lakes. On the west side of the interval, in Kosciusko County, the surface becomes again tumbled and broken, assuming the usual characters of a moraine. This type of topography, which may be fitly designated as *crumpled*, touches Whitley County near Robinson's Lake, section 18, Troy. This lake, with an area of about one hundred and fifty acres, has an average depth of thirty feet, and a maximum of fifty-two feet near the southwest end. It is drained northwestward into the Tippecanoe. Etna Township and the northern part of Troy have the appearance of an elevated tableland, a smooth plain, not level, but slightly inclined to the west. Ridges and gorges are wholly absent. It is a country of long, gentle slopes and wide vistas, from which woods beyond fields may be seen stretching away to a horizon dim in the distance. It is remarkable that this comparatively level interval should be found upon the very crest of the Saginaw-Erie interlobate moraine,* the slopes on either side being much more rough and irregular. Like the valley of Upper Pigeon Creek in Steuben County, and a portion of Northwestern Dekalb County, it looks as though it once might have been a wide and deep valley, subsequently filled by overwash from either side.

This impression is made stronger by the fact that in both cases the interval is found to contain extensive sand streams. The one described as lying south of Fremont, Steuben County,† is matched by the deposits of sand south and west of Loon Lake. sections 1 and 2, Troy.

In Whitley County the interval contains several lakes. Cedar Lake, sections 10 and 11, Troy, originally of about 150 acres, has been lowered ten feet by a ditch, and has a sand beach nearly all around it, in some places ten rods wide. The deepest place found was forty-five feet. Goose Lake, in section 12, resembles Cedar, but is only about half as large. In this region also is Loon Lake, one of the largest in the county. It occupies parts of sections 36, Etna, 1, Troy, and 6, Thorn Creek, and about one-half of its area is comprised in Noble County. It is broadly bottle-shaped, with a short neck to the north, one mile and a quarter long by half a mile wide. The shores are low but clean, without marsh except at the north and south ends. The water is so clear that the bottom can be distinctly seen at depths of thirty or forty feet. Between the south shore and a small island depths of thirty-five and forty feet were found. From the island a gravel bar covered with small bowlders extends westward. The main body of the lake has a depth varying but little from seventy feet. One sounding northwest of the island reached the very unusual figure of one hundred and two feet, thus placing Loon Lake among the list of the deepest lakes in the State.

Tributary to Loon Lake are Old Lake and New Lake, each of about eighty acres, the latter interesting from the fact that within a year it had been drained and diminished to one-half its size. The wide beach of sand and shells was almost bare of vegetation, but the little *lobelia Kalmii* was rapidly taking possession, with only *Lysiwachia ciliata* and

*See 16th report of the State Geologist, p. 99, where for Saginaw *Lake* read *lobe*, and p. 100, where for Erie *Lake* read *lobe*.

†See Report upon the Geology of Steuben County in this volume.

*Cassia Marilandica* for competitors. The country around these lakes is moderately uneven, but its irregularity is not at all comparable with that of the regions on the east and west of it. The lake basins are great depressions in a surface otherwise comparatively smooth.

The remainder of Whitley County, including the townships of Thorn Creek and Smith, and the portions of Columbia and Union present the usual features of crumpled moraine topography in moderate strength and great variety. It is divided diagonally from northeast to southwest by the valley of Blue River, which here serves to separate the third and fourth Erie moraines. The latter contains a group of lakes which for beauty and general attractiveness may challenge comparison with any of their Indiana rivals. Shriner's and Cedar, in sections 2, 11 and 12, Thorn Creek, are as pretty a pair of twin lakes as one can wish to see. They occupy two narrow parallel valleys, separated by a ridge scarcely a quarter of a mile wide. Shriner's, the smaller and prettier of the two, is a mile and a quarter long by a quarter of a mile wide. Its level was lowered several feet about forty years ago by a ditch cut through the ridge between it and Round Lake. The beach thus left dry is several rods wide and covered with grass. The present shores are remarkably clean, bordered by only a thin belt of sedges and rushes. Outside of that the water deepens rapidly, and varies from forty-five feet to over seventy at the upper end. The water is very clear and furnishes excellent fishing grounds. Moderately high bluffs on either side, covered to a large extent with open forest of magnificent beeches, maples and lindens, form a fit setting for this charming picture.

Cedar Lake is much like Shriner's, but more irregular. The lower fourth is separated from the main body by narrows and an island. Its level was raised by a dam at the same time that Shriner's was lowered, and the shallow space thus gained is entirely occupied by aquatic vegetation, chiefly *Nuphar*. These two lakes furnish an illustration of the law that lowering a lake leaves clean shores and raising it results in the formation of a marshy border. The depth of Cedar Lake varies from forty-five to seventy-nine feet in the center of the upper basin. Round Lake, 160 acres, lies at the same level as Cedar, with which it is connected by a strait, scarcely navigable on account of vegetation. Its axis is at right angles with that of Cedar, and its depth from thirty-five to sixty feet. These lakes are drained through Thorn Creek into Blue River.

Separated from the west end of Cedar by a divide a quarter of a mile across and twenty-five or thirty feet high is Crooked Lake, which empties westward into the Tippecanoe River. Its axis continues the general direction of Shriner's and Cedar, southeast and northwest, but it is nearly as large as the other two and much more irregular in outline and bottom. The upper basin is small and partially separated from the central by a narrow gravel ridge. The central basin is half a mile in diameter, and near its center was found the deepest sounding ever made by the writer in an Indiana lake, 107 feet. The approach of night prevented its complete examination, and the lower end, which extends into Noble County, was not visited. The shores are clean and gravelly and the hills on either side probably form the highest ground in Whitley County. The group of lakes comprising Shriner's, Round, Cedar and Crooked furnish five or six miles of boating and offer attractions for the camper, sportsman, fisherman and artist, such as are equaled by few places in the State.

Blue River Valley contains one lake which is distinguished as being inter-morainic rather than intra-morainic. Blue River Lake, in sections 9, 10, 15 and 16, Smith, has a basin one-half mile by a mile and a half, with low shores and a very uniform depth of forty to fifty-five feet. Aquatic vegetation in great variety and profusion furnishes a botanist's paradise. The shores are nearly surrounded by a broad belt of plants arranged in distinct zones, according to the depth of the water. On approaching the shore the first zone appears at depths between eight and six feet, and consists of *Brasenia*, *Potamogeton*, species with filiform leaves being very abundant, *Utricularia* and *Myriophyllum*. At a depth of four feet *Nuphar* covers the water with its leaves, the spaces between being filled with a dense mass of *Chara* covered with a mantle of *Lemna*. Here navigation becomes difficult. At a depth of three feet *Pontederia* appears with *Polygonum Amphibium*. At two feet the water passes gradually into a jungle of *Decodon*, *Typha*, *Polygonum nodosum*, *Phragmites* and *Salix*, passable only by birds and reptiles. This lake is the only locality known to the writer in Northeastern Indiana where the splendid *Nelumbo lutea* occurs, and here it is as abundant as *Nymphæa*. Flowers are difficult to procure because they are gathered by numerous visitors as fast as they open, but the leaves, rolled up and rocking like a boat, or expanded into an orbicular shield twenty to thirty inches in diameter and flapping in the wind, present an interesting and attractive sight. The water in mid-summer has the appearance of muddy coffee, and through the whole season teems with plant and animal life. Such a lake as this would repay a thorough and prolonged biological examination, and would furnish the naturalist with material enough for several years' study. Here also the artist would find a rich and unworked field. He would transfer to his sketch book the dark, glossy green triangular leaves and showy purple spikes of the pickerel weed, the symmetrical oval crimson shields of *Brazenia*, the boat-bell shaped saucers of the *Nelumbo*, the *Victoria regia* of the North, the graceful dignity of the reed grass, the swaying stems and densely whorled capillary leaves of the water milfoil, and numberless forms of *Chara*, pond weed, and bladderwort which would be new to decorative art, and in place of the conventional cat-tail and pond lily, would astonish and delight not only the natives but the world.

The lakes of Whitley County are not numerous, but they include some of the brightest gems of their class. Easily accessible from Columbia City and Cherubusco, they will prove equally delightful to the sportsman, the naturalist, the artist, and the lover of nature in her most charming aspects.

The surface of Smith Township, and the greater part of Union, is gently undulating, of a subdued morainic type. The long slopes, large fields, and open forests give to many portions of it the appearance of an English park. Around Coesse it is more irregular, with sharper ridges and numerous tamarack swamps. Southern Union, northern Jefferson and northeastern Washington are very flat and marshy. Mud Creek is very nearly the dividing line between the flat and the crumpled country. One feature of this region, not in itself obtrusive, is of special significance to the geologist. A mild bowlder belt can be traced from section 34, Smith, in a southwest direction, to section 32, Union, beyond which it is lost in the thickly wooded swamps. So far as traced, it is about seven miles long, and from one-half to one mile wide, with well defined edges, and as unmistakable as a highway. The bowlders are chiefly granite, rounded and subangular, averaging two to three feet in diameter, and the largest twice that size. This belt bears directly toward the divide in sections 35 and 36, Washington, where, also, bowlders were noticed as being unusually large and numerous. This line, extended southward, would pass near Huntington City, where the immense accumulation of bowlders has long been a puzzle to geologists. Whether a distinct bowlder belt exists in northern Huntington County has not yet been determined, but the writer believes that the portion above described is the superficial representative of the Salamonie or third Erie moraine, with which the morainic features of Huntington County, whatever they may be, must be correlated.

The drainage system of Whitley County does not conform, except in the most general way, to the chief topographical features. The great divide between the tributaries of Eel River and the Tippecanoe, in the nortwestern part of the county, is a comparatively level table-land; in fact, an interval between the Saginaw moraine, in Kosciusko County, and the fourth or outer Erie moraine. Through the valleys and gorges of the latter flow the northwestern tributaries of Blue and Eel rivers. The principal drainage line of the region is Blue River, which rises near Avilla, in Noble County, and passes through a tortuous and varied course to its junction with the Eel, in section 23, Columbia. Most of the way it occupies a channel much too big for it, and is bordered by marsh a quarter of a mile wide, but in some portions, as at Columbia City, the valley is no wider than the stream. The wide parts are undoubtedly fragments of a once continuous glacial drainage channel, or system of channels, from one to another of which the present river has cut its way in past glacial times. In doing so it has left, here and there, an old bayou at one side, the largest of which now forms a great marsh, extending from the bend of the river, in section 17, Smith, southward two miles. The valley of Blue River marks the interval between the third and fourth Erie moraines.

The Eel River rises in the interval between the second and third Erie moraines in northwestern Allen County, and flows across the third moraine to the mouth of the Blue. Thus far it is geologically a younger and less important stream than the latter. Three miles below their junction, in section 32, Columbia, the united streams turn westward and cut directly through the fourth moraine, after passing which they resume their original southwesterly direction.

The first and second Erie moraines have already been described in a previous report* under the name of the St. Mary's and St. Joseph and Wabash-Aboit moraines. Since that report was submitted two more morainic lines have been distinguished north of the Wabash River, as belonging to the Erie system and corresponding to similar lines south of the Wabash. The existence of these moraines and the general plan of the system was indicated and outlined in the previous report (Sixteenth Report, p. 123-4). A private letter from Mr. Frank Leverett, of the United States Geological Survey, who is engaged upon an extensive examination of the drift of Illinois, Indiana and Ohio, confirms and supplements the predictions there made in a very gratifying manner. The third or Salamonie moraine follows the right bank of the Salamonie River through the counties of Jay, Blackford and Wells into the southeastern part of Huntington County. According to Leverett, its features are weak, irregular and discontinuous. The fourth or Mississinewa moraine follows the right bank of the Mississinewa River through the counties of Jay, Delaware, Blackford and Grant into the eastern part of Wabash, where, according to the same authority, it is very strong, crossing the Wabash River at Lagro, and passing northward to the southeast corner of Whitley County. The counties of Steuben, Lagrange, Noble, Dekalb, Whitley and Kosciusko have long been known to be occupied by a broad and strong-featured mass of drift, the joint product of a tongue of ice proceeding from Saginaw Bay and another thrust forward from Lake Erie, and known as the *Saginaw-Erie interlobate moraine.* From this great mass it has been the privilege of the writer to distinguish and separate two morainic lines, forming continuations of the Salamonie and Mississinewa ridges. While the work of differentiation and correlation has been in some places difficult, in others it has been so easy as to leave no doubt in regard to the general conclusions. South of the Wabash River the Erie moraines are separated by intervals of ten to fifteen miles, while north of that river, owing to the obstruction offered by the Saginaw glacier, they are so crowded together

*See Reports upon the Geology of Allen and Dekalb Counties in the Sixteenth Report of the State Geologist.

as to be almost contiguous. While it is thus rendered impossible to fix their exact dividing lines throughout their whole extent, certain features here and there are so obvious and suggestive as to be unmistakable. The third moraine extends from the northeastern corner of the State through eastern Steuben, northwestern Dekalb, the southeastern corner of Noble, the northwestern corner of Allen and the eastern part of Whitley counties. In the southeastern part of the latter county it ceases to be a prominent topographical feature, but is represented by a mild bowlder belt. The interval between the third and fourth moraines is, in Steuben County, from three to six miles wide, but in Dekalb County the two moraines are contiguous and undistinguishable. In Noble and Whitley counties they are very close together, but separated by the valley of Blue River. The fourth moraine is very strong in north central Steuben and the line of demarkation between the Erie and Saginaw drift is very distinct. In southwestern Steuben and in Noble County this line, if it exist, has not been determined. In Whitley County a level interval of three or four miles bounds the outer Erie moraine on the west. The present divide between the basins of Lake Erie and Lake Michigan lies, in Steuben County, between the third and fourth moraines, in Dekalb and Noble counties, along the crest of the fourth; while in Whitley County the divide between the Eel River and the Tippecanoe lies in the interval outside of the fourth. The following tables, gleaned from various sources, give a general idea of the elevations of these moraines:

ELEVATIONS ON THE SALAMONIE, OR THIRD ERIE MORAINE.

| | *Altitude.* |
|---|---|
| One mile north of Reading, Hillsdale County, Mich. | 1,220 |
| Ray (Michigan and Indiana line) | 1,073 |
| Fish Lake, Steuben County, Indiana | 887 |
| Summit Station, Dekalb County, Indiana | 1,001 |
| Summit west of Corunna, Dekalb County, Indiana | 991 |
| Swan, Noble County, Indiana | 905 |
| Potter's, Noble and Allen Counties, Indiana | 881 |
| Churubusco, Whitley County, Indiana | 899 |
| Summit near Coesse, Whitley County, Indiana | 877 |
| Huntington, Huntington County, Indiana | 741 |
| Plateau south of Huntington | 813 |
| Keystone, Wells County, Indiana | 895 |
| Summit west of Portland, Jay County, Indiana | 955 |
| New Bremen, Mercer County, Ohio | 1,038 |
| St. John's, Auglaize County, Ohio | 1,063 |

ELEVATIONS ON THE MISSISSINEWA, OR FOURTH ERIE MORAINE.

| | Altitude. |
|---|---|
| Fremont Station, U. S. Lake Survey, Steuben County, Indiana . . . . . | 1,142 |
| Angola, Steuben County, Indiana . . . . . . . . . . . . . . . . . . . | 1,052 |
| Summit 3 miles south of Kendallville, Noble County, Indiana . . . . . | 1,017 |
| Columbia City, Whitley County, Indiana . . . . . . . . . . . . . . . | 837 |
| South Whitley, Whitley County, Indiana . . . . . . . . . . . . . . . | 805 |
| Divide between Eel and Wabash Rivers, Wabash County, Indiana . . . | 829 |
| Lagro, Wabash County, Indiana. . . . . . . . . . . . . . . . . . . . | 698 |
| Summit south of Hartford City, Blackford County, Indiana . . . . . . | 955 |
| Summit north of Ridgeville, Jay County, Indiana . . . . . . . . . . . | 1,053 |

A confusion of these elevations with those of the first and second Erie moraines given in the Sixteenth Report of the State Geologist, pp. 115 and 122, shows the same general descent in each from the extremities toward the apex, and a progressive elevation of the extremities and a depression of the apices from the first to the fourth. The first and second are composed of the same material as the general ground moraine of the region, a stiff, gravelly clay; kettle-holes, lakes, domes, peaks and the usual features of moraine topography being almost wholly absent. The third and fourth north of the Wabash River contain large masses of sand and gravel, and present all the peculiar morainic characters in strong development. In Northeastern Indiana the story of the advance, the struggle and the retreat of the glaciers is written in characters so plain that he who runs may read.

Two borings for gas have been made in Whitley County, one at Columbia City, and one at Larwill, sections of which are given as follows:

| | Drift. | Niagara. | Hudson. | Utica. | Trenton. |
|---|---|---|---|---|---|
| Columbia City . . . . . . . | 224 | 526 | 400 | 217 | 40 |
| *Larwill . . . . . . . . . | 220 | 565 | 512 | | |

No gas was found in either; but at Larwill a little oil, and at Columbia City a strong flow of excellent water, with a temperature of 45° F.

*The data for Larwill are very uncertain.

# GEOLOGICAL AND NATURAL HISTORY REPORT OF CARROLL COUNTY.

BY MAURICE THOMPSON.

## I.

### HISTORICAL SKETCH.

Carroll County was named in honor of Charles Carroll, of Carrollton, who at the time of the organization was the only living representative of those who signed the immortal Declaration of American Independence.

The legislative act which gave validity to the organization of this county was passed by the General Assembly of Indiana on January 7, 1828. The first circuit court was held in the private home of Daniel Boone, and the first civil election took place on the 4th of August, 1828. In 1838 the first court house was completed.

The earliest sale of the public lands in Carroll County took place on the 24th of December, 1824. At that time the land office was at Crawfordsville, and there were but few white inhabitants in the county, which had been first entered by a permanent settler, Henry Robinson, in March, 1778.

From these brief notes it will be seen that Carroll County has existed but sixty-three years. The first regular entry of public land by a citizen was made by Ephraim Chamberlaine on the 17th of February, 1824, ten months prior to the first public sale of government lands.

Although the span of time is so brief between the days when wild beasts and wilder human savages held full possession of the area under present discussion, the progress of Carroll County has placed it fully abreast of any part of the West in all that makes a people prosperous and a region of country beautiful and productive.

Agriculture has reached a high state of perfection in this county. As far back as 1852 an Agricultural Fair was instituted, since which time there has been an annual exhibition of the products of the soil and of the quality of live stock reared in the county.

Delphi, which up to May 24, 1824, was called Carrollton, is the chief town, as well as the seat of justice, of Carroll County. It is a beautiful little city built on a picturesque hill, overlooking the valley of the Wabash. General Milroy had the honor of christening it with its present name.

The history of Delphi has been one of prosperity, health and happiness. While many other towns of Indiana have outstripped her in the race for population, commerce and wealth, not one has shown a healthier development of all the elements that go to make up a sound and safe civilization. Schools, churches, homes—in these Delphi is beautiful, and her people have shown a large intelligence and a solid integrity in developing their social, commercial and manufacturing interests. The public buildings are substantial and handsome, and many beautiful residences and grounds attest the cultured taste of the people.

It is always safe to judge a county by its county seat, and measured by this test, Carroll County is now entering upon a new era of great prosperity. Delphi shows every sign of renewed life. At the time when the final notes for this report were taken the contractors were at work putting in an excellent system of water works. The supply is to be piped to the city from a magnificent spring of cold, pure water, situated on the farm of George Snyder, three miles northeast of the city, and will be distributed by means of stand-pipe and direct pressure. By the time that this report is printed the completion of these works will have made Delphi one of the most beautiful and healthy cities in the State.

## II.

### TOPOGRAPHICAL FEATURES.

The Wabash River cuts through Carroll County in a direction somewhat southwesterly from where it enters the northern limit, leaving a roughly triangular area to the northwestward. The main portion of the county lies south and east of the river and is watered by a number of streams that flow from east to west, dividing this area into shallow valleys that afford excellent bases for a system of agricultural drainage.

Although in a general way level, and in some places flat, the surface of the country is sufficiently rolling to admit of the most improved methods of cultivation.

North of the Wabash River in Tippecanoe Township is considerable tract of prairie land surrounded by lands that resemble "barrens," but which are by no means barren in fact. This is a magnificent agricultural region producing enormous crops of cereals and pasture grasses.

The "bottoms" of the Wabash are the richest of alluvial soils, and since the general drainage of the country has been effected and the old scourge of malaria has almost wholly disappeared, the cultivation of these famous "flats" has been prosecuted in accordance with the most approved system of farming. Viewed from the highlands the broad fields of corn and wheat grown in the valley are well worth a long journey to see.

There are no high or abrupt hills or ridges in this county; but often enough the bluffs of the Wabash and of the smaller streams are quite steep, almost perpendicular, showing fine sections of the drift formation. In many places the deposits of bowlders are strikingly suggestive of the great forces that transported the upper rocks—that is the drift clays and gravels—to their present situation over the stratified limestones and shales that are in most places so deeply covered by them.

Rock Creek and Little Rock Creek run partly across Carroll County and empty into the Wabash River. South of these Deer Creek passes in a general course westward across the county and falls into the Wabash near the south side of Delphi. Still south of this the middle fork of Wildcat Creek and Wildcat Creek proper follow a practically parallel direction, and so the whole surface of the county is cut into divisions bounded by the shallow valleys of these streams.

As has been already remarked, the location of these valleys afford bases for a system of agricultural drainage which has acted like magic in reclaiming large areas of wet land which are now amazingly fertile.

Many of the smaller streams tributary to those already mentioned have been straightened and deepened so as to increase their fall, thus turning them into main ditches upon which numerous systems of tile sub-soil drains are based. Indeed the middle fork of Wildcat is itself scarcely more than a ditch, as it now exists, into which the thrifty farmers have cut their minor drains, and thus at comparatively small expense made their estates doubly productive and valuable.

Paint Creek is another considerable stream that has been deepened and straightened for this purpose, and the number of long and well constructed canals in the county is surprisingly great. A few of the most important of these works may be mentioned here to give some idea of the thrift and progressive energy of the Carroll County farmers.

Sugar Creek ditch, running east and west, in its general course, reaches two-thirds of the way across the county. It is a most thoroughly well constructed work and drains a large and exceedingly beautiful farming region. It is safe to say that although this ditch cost a large amount it now drains lands whose average increase of productiveness repays annually the total expense of the construction.

The Patton ditch runs southward into the Wabash River. The Calhoun ditch and the McKinney ditch are valuable pieces of work. The Cullum ditch runs into the Wabash and drains a considerable area of fine land.

The straightening and deepening of the middle fork of Wildcat was a skillful and paying piece of engineering by which a large, impassable swamp, known as Maple Swamp, was drained and reclaimed.

Speaking broadly, Carroll County is a plain whose surface has been eroded, by the action of wind and water, into valleys and dells of varying sizes and forms, separated by areas of the unchanged original drift mass deposited at the close of the glacial age. Under the head of Geology will be found some interesting studies of the sections shown by stream erosions of the clays, sands and gravels of this glacial deposit, as, also, some notes on the bowlders of granite, and other old rocks, scattered over the county.

Of Indian mounds proper there are none, at least none that I could find; but there are some reputed mounds, one of which is locally quite famous. This is, however, nothing more or less than a huge cone of drift material which has been rounded and truncated by wind and rain. It stands in section 13, township 26 north, range 3 west, in the civil township of Jefferson. The country around it is a thinly wooded prairie "barren," though the soil is very good. Some smaller formations of the same sort are found in different parts of the county.

In the northern townships there are large areas of bowlder deposits, many huge blocks, interspersed with smaller ones, lying scattered over the surface. One notable bowlder lies in the bed of a ravine near the northeast corner of Conner's Reserve. It is a gray granite fragment, and would weigh many tons. Wherever the higher areas have been eroded to any considerable extent by the action of gentle currents of water the bowlders are exposed, and in many places they are to be seen protruding from the clay bluffs of the streams.

The surface conformation of Carroll County has been produced almost wholly by the influence of the Wabash River which, in controlling the drainage of the higher areas, has shaped the lesser valleys. The great ice flow grooved out the valley of the Wabash, and receding, left it filled, in a large degree, with drift clays. When the water from the melting glacier began to run in this valley it soon furrowed a channel for itself, and immediately the surface drainage of the country on either side of the newly formed stream began to cut its tributary grooves, which, in turn, received their feeders, and so the whole present system of apparent hills and hollows is but a modification of the original drift plain whose general surface is marked to-day by the high plateaus between the eroded valleys. Almost every drop of water that flows from the surface of the county thus finds its way into the Wabash River, and, consequently, the configuration of the land must be constantly referred to that stream as its base of development.

What are locally known as the "breaks" of the creeks and river are nothing more than the deepening of the drainage valleys into more or less precipitous ravines, whose bold bluffs show every variety of the bowlder drift clays. These breaks are interesting to both geologist and botanist; for not only are the natural sections of the soils and clays thoroughly exposed, but here in the ragged and uncultivated ravines still linger the wild plants which afford a key to the botanical history of the county.

As a rule the wet and swampy lands of Carroll County marked the highest areas of the land's surface, consequently their drainage has been easily accomplished. Many of these over-wet tracts were originally heavily set with forests of burr oak, and of course the soil when ditched is remarkably productive. A peculiar feature of all these semi-swamp regions is the abrupt changes in the character of the soil. Through the areas of the black muck-like deposit run low ridges of whitish clay, elevated often not more than from six inches to eighteen inches. The muck is the natural soil for burr oak, ash and certain species of maple, while the clay is chosen by beech and white oak.

## III.

### CHARACTERISTICS OF SOILS.

As might be expected, the soil of Carroll County is diversified. Many factors have entered into the work of preparing it for the various needs of agriculture, and it now presents to the observant eye a problem more interesting than any ever written in a book.

Most of the surface of Carroll County is, as has been already described, covered with a great drift deposit of from ten feet to two or more hundred feet in depth. Upon this mass of clay, gravel and sand the various soils have been formed, save those over a small area around Delphi, where the stratified rocks have decayed.

In studying the soils of the Indiana drift region not enough attention has been given to the effect of various natural agencies on the substance of the drift itself. A large amount of calcareous and other matter easily destroyed has entered into the composition of the drift clays, and when these are acted upon by frost and rain a change takes place in them and a modified subsidiary soil is formed of a depth about equal to the average winter freezing. This can be readily proven by observing that where the drift is largely calcareous the soil is loose and deep, while the parts that are silicious have practically no soil on them save where it has been formed by the decay of vegetable matter. Silicious earth, besides not being affected by frost or rain, lies very compactly and is almost impervious to surface water and even to air, while the calcareous earth becomes sponge-like, light and perfectly ærated to a considerable depth.

The blue and gray bowlder clays are often highly silicious, and where natural depressions or basins of large extent occur in them, and have been filled with the residuum of decayed vegetable matter, the soil, until drained, is a black, wet muck; but after draining it often is so light and chaff-like that, during a drought, nothing will grow upon it. If, however, the clay is near enough to the surface to be reached by deep plowing, a thorough subsoil cultivation will obviate this latter difficulty by mixing the clay with the soil and thus giving it body.

On some of the highest parts of Carroll County there is a soil which at first appears to be lacustral; but I am inclined to think that in most cases it is a modified drift in which the calcareous and magnesian elements have been dissolved, leaving on the surface a sandy residuary layer of from one to three feet in thickness. This soil is very warm and light, usually of a brownish or grayish brown color.

The residuary rock soils around Delphi are mostly decomposed shales of the Devonian period. These shales are soft and heavily charged with iron, hence when they decay on exposure the resulting soil is of a reddish color; but analysis will show that it contains a large quantity of silica and alumina.

The bottom land along the Wabash and the several larger creeks has a deep black alluvial soil, while that of the prairie is of a blackish gray or grayish brown color. The soil of the so-called barrens is of various shades of brown and gray, showing a mixture of lime, silica and alumina with vegetable mold.

All of the soils grow lighter in color after drainage and cultivation for several years. As a rule, the darker and the more compact the earth the greater the improvement of its productive power when thorough æration takes place. Deep plowing and the rotation of crops are sufficient to keep up the fertility of prairie and alluvial soils for a long time, but it is a fact too little heeded by the farmers of Indiana that what is taken away from the soil must be returned by some kind of fertilization or land must inevitably fall away from its original productiveness.

The level surface prevailing over a large part of Carroll County prevents any destructive washing of the soils, consequently the farm lands will improve year by year under efficient tillage and care. This is especially true of the deep, wet soils that have been thoroughly drained and ærated.

Upon the whole, no county in the State has more diversified and productive soils than the county of Carroll.

## IV.

### GEOLOGY.

Although two most eminent geologists have given to the world, in the form of brief sketches, their observations on the geological aspects of Carroll County, there has never been, up to this time, a thorough examination and report including an exhaustive study of the very interesting rock formations around Delphi.

Before any gas wells had been bored in Indiana, and before any geologist had suggested the possibility of the existence of any evidence of an important rock disturbance across the northern part of the State, Dr. Ryland T. Brown called attention to the tilted and broken condition of the Niagara rocks along the Wabash River at Huntington and Wabash. Professor John L. Campbell, of Wabash College, once suggested to the present writer that there must be some unusual condition of the stratified rocks of Indiana from Momence, in Illinois, across to some point on the Ohio line. Previous to this I had, while prosecuting some extensive railroad surveys, made many examinations of the stratified outcrops along the line mentioned, especially in the banks of the Wabash and the Tippecanoe, and had become convinced that some extended fracturing, uplifting or folding of the Niagara rocks had taken place at the close of the Upper Silurian epoch, and that this disturbance, whatever its nature, had been projected across the State.

Later, when I had been made State Geologist, I procured the assistance of Professor S. S. Gorby, the present efficient chief of the Geological Department, who consented to make a survey of the field with a view to ascertaining the facts as a whole. To him is due the credit of having made the first comprehensive examination of this subject, and his report thereon is of permanent interest and value. In another place I have copied what he had to say regarding the rocks at Delphi.

In order that a perfect understanding may be had of the geological problem presented in Carroll County, it will be necessary to bear in mind constantly that the only exposures of stratified rocks within the county's area occur at and near Delphi. Elsewhere the whole surface is one vast mass of glacial drift, furrowed by streams and worn into vast rounded plateaus by the action of frost and rain. What may be the condition of the stratified rocks underlying the drift can only be inferred by reference to the outcrops already mentioned and to the gas well sections, and by comparing the outcrops in the Delphi neighborhood with those in the line indicated by Professor Gorby's report, already mentioned.

As I shall have something to say about rock disturbances, and in view of the fact that this report is for the people as well as for scientists, it may be well to define in a general way what is meant by what we call a "disturbance" of the stratified rocks.

Any displacement of the original order of deposit is a disturbance. Expansion and contraction are the chief agents in crushing and folding the rocks or splitting them into chasms or fissures. Upheavals are usually referred to the pressure caused by the shrinking of the earth's crust, the fold or arch of upheaval occurring along the line of least resistance. But what geologists call an arch is not necessarily a perfect arc of a circle, or anything much like it. Any appreciable breaking and lifting of the crust of the earth is an arch or synclinal in the sense of the word as used by Professor Gorby in his paper on the "Wabash Arch," published in the Fifteenth Indiana Geological Report.

In examining the rock exposures, therefore, with a view to determining whether or not an arch exists as suggested by Professor Gorby, we shall have to be careful not to overlook any feature, however apparently trivial, that might in the least affect the outcome of our work, and before giving the results of the examinations made by the present writer, let us see what other geologists have had to say about the interesting and complicated rock-problem presented by the relative forms and positions of the strata at and near Delphi.

Professor Owen was the first geologist to do noteworthy work in this field, though a number of intelligent non-professional men of considerable scientific knowledge had previously visited and examined the locality.

In 1859–60 Dr. David Dale Owen, assisted by Dr. Richard Owen, made a hasty survey of this county, from which the following excerpt is taken:

"This county, entered from the south, exhibits, near the town of Prince William, in the valley of the middle fork of Wildcat, as well as later, at the north fork, a considerable amount of quaternary, comprising from thirty to thirty-five feet of bluish hard-pan clay, observed on ascending from the river, then yellowish, loose gravel, with interspersed bowlders, the various layers separated by distinct horizontal lines of stratification, and springs occasionally welling from above the lower aluminous stratum. Near Delphi we obtained the following section:

| | Feet. |
|---|---|
| Soil and loose gravel, etc | 10–15 |
| Quaternary hard-pan and conglomerate | 15–20 |
| Devonian black slate | 50–60 |
| Devonian limestone | 20 |
| Upper Silurian Pentamerus beds | 20 |

"At the lime kiln just below town we found a local dip to the southeast, amounting to 40 degrees.

"The black slate has been washed out in the valley between Deer Creek and the Wabash, and the detritus scattered over the Devonian limestones, which contain *Emmonsia hemispherica*, and other fossils, overlying the *Strematopora concentrica* and *Pentamerus occidentalis* limestone.

"Between two and three miles from Delphi considerable samples of gold have been washed from the drift in the bed and bank of the creek, a locality well meriting further examinations.

"On Deer Creek, a few miles from Delphi, vast quantities of calcareous tufa have been formed, by filtration of water through the overlying quaternary deposits, and subsequent evaporation and consolidation, while trickling slowly over the black slate bluffs of the stream. The stalactitic and columnar forms, often ornamented by the distinct impressions of leaves on the soft tufa, with cavernous niches decked out in the rich profusion of cryptogamic vegetation."

Professor Cox made a very slight sketch of Carroll County, which may be seen in the now scarce report of 1871–2. I here present all that part of his remarks which relate to the condition of the stratified rocks:

"At the close of the glacial epoch this county was probably a level plain. Since that time the Wabash River and its tributaries have eroded a very considerable amount of clays and bowlders deposited by the great ice flow, forming a valley in this natural plain from ten to twenty miles wide and from 100 to 200 feet in depth, and cutting their channels down into the underlying rocks about ninety feet. Hence, a great variety of soil is found to exist, ranging from the stiff clays of the bowlder drift, through many modifications, to the ancient and modern alluvial loams which are found on the terraces bordering these rivers."

The rocks exposed in this county belong to the Devonian and the Silurian ages, but it is probable that in the southern parts the subconglomerate Knobstone (Waverly sandstone) will yet be found.

The following connected section, combined from measurements taken at several localities near Delphi and at the bluff below Pittsburg, will give a general view:

CONNECTED SECTIONS.

| | | | |
|---|---|---|---|
| Bowlder drift | 50 to 200 ft. | 0 in. |
| Terraces and gravel beds thrown upon and against the last | 20 to 90 ft. | 0 in. |
| Louisville-Delphi black slate, Devonian | 50 ft. | 0 in. |
| White alluvium, hard | 2 ft. | 0 in. |
| Black slate | 18 ft. | 0 in. |
| Clay shale, light color | 4 ft. | 0 in. |
| Blue slate | 8 ft. | 0 in. |
| Band of large concretions | 2 ft. | 0 in. |
| Black shale | 12 ft. | 0 in. |
| Band of concretions | 1 ft. | 6 in. |
| Drab shale | 10 ft. | 0 in. |
| Gray shale | 3 ft. | 6 in. |
| Devonian limestone | 22 ft. | 0 in. |
| Pentamerous limestone, silicious | 30 ft. | 0 in. |
| Petroleum limestone, silicious | 20 ft. | 0 in. |
| | 474 ft. | 0 in. |

The black slate is a prominent feature of the foregoing section. Although the exposures are disconnected, yet combined they afford a view reaching from the bottom to within a few feet of the upper layer. The name is established in geological nomenclature, but is hardly significant. The slate is, at exposures, a brownish-gray shale with considerable iron finely disseminated. Bituminous matter is present, with petroleum in small quantities, and bituminous tar or albertite in fissures and partings. No fossils were noticed in the upper beds. In the lower beds Mr. George Vandeventer reports having found some fern leaves. Breaking open the concretions, locally known as "bowlders," obscurely marked trunks of *Lepidodendron* and *Stigmaria* were found, the spines of the latter containing petroleum. Both were probably of new species. In another bowlder I found large teeth of a fish belonging to the shark family. This horizon is rich with fish remains, and further explorations will richly reward the scientific worker.

Immediately below the slate a coarse, impure limestone is found, twenty-two feet thick when seen. It is of little economic value, but has been used for foundations and rough walls. It contains *Cyathaphylloid* corals, *Spirifer auritisma*, *Atrypa reticularis* and *Chonetes setigera*.

The Pentamerous bed is an irregular deposit, variable in its mode of occurrence and thickness, evidently deposited by currents flowing across inequalities in the surface of regularly deposited rocks below. It is generally found upon or against these inequalities, and consequently this deposit exhibits remarkable peculiarities of false bedding. The lines of deposit are never horizontal, sometimes nearly vertical, and at all angles between their directions. This phenomenon is often pointed at as the effect of subsidence and upheaval, but may be easily and more truthfully accounted for by studying the mode of deposit peculiar to this bed. The stone is crowded with casts and fossils, the animal matter being wholly removed, as *Pentamerus knightii*, large and very abundant, *Halysites catenulata*, corals, crinoid stems and *Bryozoans*.

The lower part of the bed is burned for lime and furnishes an article of high grade in the market. The lower bed is but partially explored at the quarries. It is similar to the last, but being free from animal and mineral impurities, presents a superior article of lime. Only a few fossils have been found, all being of the Niagara epoch of the Silurian age.

Professor Gorby's notes upon the Delphi rocks form a part of his paper on the Wabash Arch, and they are so clear, direct and interesting that I quote them entire.

Professor Gorby says:

"The Niagara limestones are exposed in the vicinity of Delphi, in Carroll County, and, as usual, where these rocks appear along the course of the Wabash River the strata seem to have been greatly disturbed. The Devonian rocks in the immediate vicinity, Corniferous limestone and black slate, show little if any evidence of disturbance. The Niagara rocks, however, are tilted in various directions. At the quarry of the Delphi Lime Company, one mile north of Delphi, the strata dip to the north at an angle of 45 degrees. Between the city and the quarry is an ancient water channel, once the Deer Creek bed. The ravine is probably 100 or 150 feet in width, and is partially filled with Drift material. The local name of this ravine is 'Folly Slough,' or 'Grime's Folly.' The course of the slough is nearly east and west. On the north side of it the strata dip to the north at an angle of 45 degrees. On the south side of it the dip is to the south at the same angle. The depth of this ancient creek bed is unknown, but it seems to be an ancient rift through which the waters of Deer Creek formerly ran. On the north side of the slough, near the creek, the strata in one place are in an almost vertical position. The slough is about three-fourths of a mile in length. At other localities in the neighborhood of Delphi the strata dip in various directions."

It will be seen that Dr. Owen makes no further note of the marked peculiarity in the condition of the Niagara rock than merely to mention having found in one place a dip of 40 degrees in the strata. From the very nature of the survey made by Dr. Owen it was quite impossible for him to give more than a passing glance at the outcrops, as he was simply sketching an outline of the geology of the State with a view to making a general preliminary report. At that time, and even for long after, it was considered absolutely impossible that any disturbance of the stratified rocks of Indiana had ever occurred, and wherever any breaking or unusual displacements of the rocks were discovered it was thought safest to refer them to local and accidental forces rather than to any derangement of the earth's crust.

That eminent and enthusiastic geologist, Dr. John Collett, for many years State Geologist of Indiana, was inclined to attribute the remarkable rock phenomena at Delphi, Kentland and other points to "profound false bedding," and it will be seen from Professor Cox's report that he was not willing to consider the question of upheaval as at all open for discussion.

The present writer must firmly disclaim any controversial purpose in whatever may be here said. His profound respect for the eminent scientists above mentioned is supplemented by warm personal friendship. Truth is the object sought after by science, and it is truth that must stand in this report. It is not, therefore, any discredit to Dr. Owen, Professor Cox or Dr. Collett that subsequent and most careful surveys have disclosed conditions incompatible with the conclusions indicated by their necessarily hasty and imperfect examinations and reports.

I began my studies of the rock disturbance in Northern Indiana as far back as 1874, when I had no other object in view than to satisfy my own desire for knowledge. I certainly never dreamed of making my observations public, nor had I any theory for a hobby. When I first saw the outcropping rocks at Monon and at Kentland I was struck with the many evidences of a disturbance which had crushed and distorted the strata. Subsequently I visited, at various times, all of the rock exposures along the Wabash and the Tippecanoe, including those at Delphi. When I became State Geologist it was but natural that my attention should turn at once to this subject, but the many duties claiming my attention and other counties having precedence in the order of examination, I was prevented from completing the survey of Carroll County, although I prosecuted many studies and surveys with the object of making the result a key to the solution of a vexed question.

At the request of Professor Gorby, the present State Geologist, I have now concluded a thorough examination of the county, and am ready to report with all the facts before me.

The rock exposed at Delphi belong to the Niagara Group of the Upper Silurian age and to two divisions of the Devonian age.

The fossils by which I have identified the Niagara rock are the following: Fragments of *Pentamerus chicagoensis;* Orthoceras (a fragment, but probably *annulatum*); *Atrypa cassirostra;* imperfect casts of *Orthoceras simulator; Platyostoma Niagarense* and fragments of *Cyrtolites sinuosus.* A few minute casts of what I took for *Cornulites proprius* were also observed. One obscure impression closely resembled *Delmanites verrucosus.*

Between Delphi and the river are patches of the Niagara limestone outcropping from the level ground-surface. Here the strata are dipping to the southward at an angle of nearly forty-five degrees. In the ravine just east of the town is a fine exposure where the structure of a segment of an arc can be clearly traced. Near this ravine, in the bed of Deer Creek, the Devonian limestone lies flat and level, while a little farther east, just above the Hagan mill-dam, the Devonian shale stands up in a bold cliff from twenty to forty feet high.

The Niagara limestone may be traced to where it passes under the Devonian, and there it shows that the deposition of the latter was made after the former had been uptilted as we now find it, so that if the situation indicates an upheaval at all, it occurred at the close of the Niagara period.

As to the fact that it is an upheaval there can not now be a doubt. Every detail of the Niagara formation, wherever exposed, shows that the rock once stood in the form of a low cone, which has since been truncated by the glacial forces that plowed out the Wabash Valley. Like the similar outcrop at Kentland, the Delphi rocks are full of unmistakable evidence that the pressure which upheaved the cone came at a point of time when the material of the Niagara formation here was still in a plastic or semi-plastic state. The cone-in-cone structure is found with the axis of formation, indicating clearly that the force came from below; moreover, the rock-substance itself shows the dough-like and mixed texture always associated with the structure of tough mortar or kneadable plastic, clayey material, after it has been subjected to great pressure.

A careful survey of all the area of Niagara rock, exposed at Delphi, disclosed the fact that the strata dip at such angles as would, if the lines were produced, form an irregular cone or elongated dome, at the base of which the Devonian limestone and shale are in place and level, like water around the base of a hill. The structure of this Niagara limestone does not in the least indicate false bedding. Cone-in-cone is not a feature of accidental deposit; it is the unmistakable index of pressure in the direction of the vertical axis from base to apex. Nor is a mixed and contorted rock-fiber (so to call it) a result of false-bedding. Rock strata lie, when undisturbed, always parallel to one another, and at right angles to the line of precipitation, and by "line of precipitation" I mean the line through which the original particles of the rock fell in the process of deposition. But even a casual examination of the strata at Delphi will show that the rock does not now lie as originally deposited. If the rock had been deposited as it now lies the lines of cleavage and of structure would have shown themselves in nearly horizontal and parallel lines. This is a law of nature dependent upon the universal and uniform action of gravitation. Of course this applies to limestones and other silt-stones; for sandstones are often formed by the shore-wash of seas, and in this case the bedding is as irregular as the surface of the shore and the eccentric action of storms and waves may make it.

There is another feature of these tilted rocks which shows that upheaval and not any irregularity of deposition is the true theory. The strata or layers, which here are from four inches to ten inches thick as a rule, show even, regular and parallel lines of separation, and where an axis of pressure passes from one to the other it is always from below upward. The reverse would be the case were the formation due to false bedding, for then the only force generating pressure would be that of gravitation. Furthermore, upon close inspection the minutest foliations of the rock-substance show that they follow the direction of the strata. A most striking example of this sort was observed in the bluff of the ravine above mentioned, where a fine thread-like line of clay or marl parting runs for some distance along one of the layers perfectly parallel with the dip. In a word, every feature of the bedding, the substance and the structure of this formation testifies conclusively to the fact that the strata of the Niagara limestone have been upheaved into a cone which has since been truncated by glacial action.

The similar eroded cone at Kentland shows, in still another way, that the rocks have been upheaved. In the quarries located there the Niagara strata stand at a great angle, almost vertical, indeed, and in the clayey partings between the layers are found minute Lower Silurian fossils that have been forced up from the inferior formation by the action of either gases or water. The presence of these fossils led Dr. Collett to refer these Kentland outcrops to the Lower Silurian; but Professor Gorby and myself discovered Niagara fossils in the solid body of the rocks on either side of slender partings that were filled with minute Lower Silurian forms.

Here is what Professor Gorby has to say about the Kentland cone in his report on the Wabash arch:

"On the farm of Messrs. McKee and Means, three miles east of Kentland, Newton County, may be observed most remarkable evidences of disturbance. The rocks are exposed at the surface upon probably the highest eminence in the county. The exposure is upon the open prairie, several miles away from any stream of water. The Iroquois River, several miles north, is the nearest stream. The elevation of rock forms a low, broad mound in the prairie. The surrounding country is covered with drift to a great depth. A mile away from the quarries, on the north, it is 150 feet down to the rock. In the vicinity of Kentland the drift is near 100 feet thick. At Mr. McKee's residence, 200 yards east of the quarry, it is 15 to 30 feet down to the rock. Two miles south, on the farm of Mr. Schlautenhofer, just on the edge of Benton County, the drift is more than 100 feet thick. The simple presumption would be that this great mass of rock is merely a portion of greater masses that escaped the destroying influences of advancing glaciers and the erosions and the disintegrations of time. However, the glaciers have evidently enveloped it; they have passed around and over it, but the mass remains as a monument of greater forces that were in existence at a period long antedating the glacial period.

"There are several places on Mr. John McKee's farm, and two on the farm of Mr. Means, where the rocks are exposed at the surface. The principal exposure is the most easterly, which Mr. McKee is operating as a stone quarry. At this point there is an exposure sixty or seventy yards long by fifty wide. The stone is nearly vertical in the quarry, dipping east at an angle of about eighty degrees."

Since the gas wells have been so persistently bored in Indiana, the surface of Niagara rocks have been pretty well explored all over the State, and it has been found that in a large area known as the Gas Belt the occurrence of cones of upheaval is frequent and general; and it is in the Trenton formation, under these bubbles of upheaval, that our magnificent supply of gas is found.

It is doubtless true that but for the glacial erosion which cut off the apices of the cones at Kentland and Delphi, these formations would have been full of gas. Every appearance goes to show that at Kentland when the ice truncated the cone and thus opened the folds of the strata, it was like pricking a bubble, and the gas rushed out (probably for years), bearing with it water and the mud which contained the small Lower Silurian fossils found at present between the Niagara layers.

Four gas wells have been bored at and near Delphi. A trace of gas was found in two of these; it came forth accompanied by a strong flow of artesian water, offensive in taste and smell. This water rises to a great height above the ground surface. The boring of these wells has shown conclusively that the disturbance observable at the outcrop of the Niagara rock extends down into the Trenton formation and affects its limestone. Were the distortion of the Niagara strata due to false bedding this would not be the case, as any, even the most casual reader, must see.

The connected section given by Professor Cox and quoted on a preceding page, coincides so closely with careful measurements made by myself that I accept it as correct and will not, therefore, take space for repetition. At Falling Springs, near the mouth of Deer Creek, the Devonian shales crop out in the bluffs forty feet thick. These shales are aluminous and contain a great deal of iron pyrites. Crystals of natural sulphate of alumina have been picked up here, and in the vertical crevices of the Devonian limestone in the bed of the creek farther east small quantities of gold have been found.

Aside from these outcrops at and near Delphi there is nothing in Carroll County to aid in solving the great rock problem of Indiana. What we have said, however, will lead any clear mind to at least one fixed conclusion, viz.: that the cones at Delphi and Kentland are but extraordinary manifestations of the force that made our great gas field for us. At the close of the Niagara epoch there was a subsidence and upheaval that affected the crust of the earth over a large area of Ohio and Indiana. The "arch" formed by this upheaval consists of a vast series of low bubbles or cones that make the surface of the Niagara limestone somewhat like that of a sea in a brisk breeze. It is, indeed, a range of rudimentary mountains whose highest peaks are only a few feet in altitude. This series of liliputian Alps, buried for the most part under a heavy drift deposit, is our great natural gas field.

Having reached this conclusion before any gas wells were bored along the Wabash River, and before any large extent of the "Gas Belt" had been explored with the drill, I ventured to predict through the columns of the press of Indianapolis that no gas would be found in paying quantities along the river or in the immediate vicinity of the truncated Niagara cones exposed at Kentland and Delphi. Time has amply proved that I was right, and I may be pardoned for saying so in view of the fact that my words at the time were not heeded; and there is no harm in adding that if my advice had been taken it would have saved the people many thousands of dollars uselessly spent in boring for gas in a region where it was plain to the scientific eye that gas could not and did not exist.

There is no better field in Indiana than Carroll County for studying the drift formation. The three considerable streams, besides the Wabash River, that cut across the county, show every variety of section from the old blue bowlder till to the most recent fluviatile terrace sands and alluvial loams.

The bowlders thickly tumbled over large areas of Carroll County are of almost every variety of granitic and schistose rocks. Beautiful, smoothly planed fragments of greenstone, quartzite, mica schist, gray, brown, white and red mottled granite, various sorts of trap, and heavy lumps of magnesian limestone are found in all the morainic mass.

Along Wildcat Creek, in the southwest part of the county, and not far from the line, are some bluffs of grayish till in which there are singular lines of gravel and sand, parting the clay into layers. This formation is observed also in the south part of the county, near the Clinton line, on the Vandalia Railroad, where human remains were found some years ago. The skeleton was that of a man of average size, and it fell to dust soon after exposure. It was found while making the railroad cut. It lay in a two foot vein of fine, yellow sand between two heavy layers of bluish hard-pan.

The bluffs of Rock Creek (and those of Deer Creek above where the Devonian shale outcrops) are often precipitous, the stiff grayish and blueish clays being cemented with calcareous matter mixed with sand and gravel. As a rule, where large bowlders are thickly strewn through the clay the latter is silicious, but it is always more or less calcareous where limestone fragments preponderate. The silicious clays make excellent brick and tile, a great many of which are manufactured in the county.

## V.

### ECONOMIC GEOLOGY.

There is no good building stone, bowlders excepted, within the limits of Carroll County. Some of the Niagara limestone, and a good deal of the Devonian, may be used for cellar walls and for foundations below the frost-line. I saw some stone fences in Delphi, and though they had been built for some years, they were standing well.

For lime making the Delphi rocks are most excellent, and have been long utilized by expert burners. Indeed, the lime of Delphi is known all over the country as of a high grade, and is much sought after by builders and contractors.

The Delphi Lime Company and the firm of Charles E. & Wm. H. McGown are the two principal lime manufacturers in the county. Their kilns are at and near Delphi, and they are turning out large quantities of the very best article of lime.

As has been already stated elsewhere, the gas-bearing Trenton rocks of this region have been drained through the Delphi cone, just as the Kentland area has been exhausted through the truncated cone there. The bores at Delphi showed that water had taken the place of gas. In the well at the foot of Union Street the artesian pressure was so great that the water rose and flowed forcibly from the top of a pipe elevated one hundred feet above the mouth of the bore. Just enough gas to burn feebly comes out with the water jet.

There is, of course, no coal in place in Carroll County. Bituminous shale has been often mistaken for coal, and at one time there was considerable excitement over the prospect of discovering valuable carboniferous deposits near Delphi, but every geologist can see at a glance that the coal beds have their horizon far above the Devonian shales, which are the uppermost stratified rocks of the county, and that it is impossible for coal to be found in place here.

The only workable clays that I observed in the county were of such quality as is usually worked into building brick and drainage tiles. Of these clays there are inexhaustible quantities all over the county.

There are no iron deposits of importance in Carroll County.

## VI.

### NATURAL HISTORY.

Fossil remains, with the exception of the forms found in the Pentamerus beds at and near Delphi, are very scarce in Carroll County. Discoveries of mastodon teeth and bones were reported to me, but I saw none of them and can not therefore further identify them. A few casts and impressions of paleozoic forms, so indefinite in outline as to be beyond specific recognition, were noticed in some shale on Deer Creek above the dam. Professor Cox obtained some impressions of ferns and other plants from concretions in the same formation. I found a few obscure leaf outlines in the rotten, gray-brown shale at the railroad cut east of Delphi.

At the present time Carroll County is an interesting field for the botanist. It is in the area which marks the dividing line between the northern and southern regions of the State, botanically speaking, and here, where the excellent agriculture of the farmers has not yet covered all the space, patches and nooks are found where the ax, the plow and the hoe have not interfered with the old order of nature. My examination of the county did not permit me to spend much time with botany, but I made notes and collections for identification wherever I went, and these, with notes previously made, have enabled me to present a sketch of the principal trees and smaller plants. I do not offer it as at all complete, but it will, I think, be found interesting to those who are making a study of the botany of Indiana as well as to those who, looking always on the economic side of every question, have an eye to the conditions that surround the traffic in timber and lumber.

For handy reference I have arranged the list alphabetically.

### PARTIAL LIST OF THE PLANTS OF CARROLL COUNTY.

*Anemone Virginiana.*
*Anemone Nemorosa.*
*Arabis Lyrata.*
*Arabis Levigata.*
*Aster Longifolius.*
*Aster Prenathoides.*
*Aralia quinquifolia.*
*Aralia Nudicaulis.*
*Asclepias quadrifolia.*
*Asclepias cornuti.*
*Asclepias purpurascens.*
*Arethusa bulbosa.*
*Alnus incona.*
*Allium cernuum.*
*Anaphalis Margaritacea.*
*Artemisia biennis.*
*Achillea millefolium.*
*Archemora rigida.*
*Acer dasycarpum.*
*Acerates longifolia.*
*Ambrosia bidentata.*
*Brachychœta cordata.*
*Bignonia capriolata.*
*Betula pumila.*
*Clematis viorna.*
*Clematis pitcheri.*
*Clematis Virginiana.*
*Celastrus scandens.*
*Caltha palustris.*
*Cardamine hirsuta.*

*Cardamine pratensis.*
*Cyperus Schweinitzii.*
*Carex microdonta.*
*Carex viridula.*
*Carex aurea.*
*Dicentra canadensis.*
*Dicentra cucullaria.*
*Delphinum tricornia.*
*Equisetum robustum.*
*Erysimum asperum.*
*Hydrophllum canadense.*
*Lilium philadelphicum.*
*Lilium superbum.*
*Mentha canadensis.*
*Mitella diphilla.*
*Microstilis monophyllos.*
*Naias flexilis.*
*Nabalus crepidineus.*
*Poa trivialis.*
*Ranunculus sceleratus.*
*Ranunculus abortivus.*
*Ranunculus fascicularis.*
*Rosa nitida.*
*Rosa Carolina.*
*Rubus canadensis.*
*Rubus rubrum.*
*Rubus prostratum.*
*Silphium trifoliatum.*
*Scirpus Smithii.*
*Silene nivia.*
*Scultellaria nervosa.*
*Solidago latifolia.*
*Solidago canadensis.*
*Solidago Ohioensis.*
*Toiticum violaceum.*
*Thalictrum purpurascens.*
*Thelypodium pinnatifidum.*
*Viola blanda.*
*Viola restrata.*
*Viola delphinifolia.*

The following lists contain both the common and the scientific names of most of the forest trees occurring in Carroll County that I find in my notes:

## LIST OF COMMON NAMES OF FOREST TREES.

Ash, *Fraxinus*.
Butternut, } *Juglans*.
Black Walnut, }
Beech, *Fagus*.
Basswood, *Tilia*.
Dogwood, *Cornus*.
Elm, *Ulmus*.
Hackberry, *Celtis*.
Hickory, *Carya*.
Maple, *Acer*.
Mulberry, *Morus*.
Oak, *Quercus*.
Plane, or Sycamore, *Acer*.
Poplar, or Tulip, *Liriodendron*.
Redbud, *Cercis*.

The ash has but one species that I noted (*Fraxinus viridis*), but others are probably present. Two species of walnut (*Juglans cinerea* and *J. nigra*), the former scarce, the latter almost cut out; one species of beech (*Fagus ferruginea*); one species of basswood (*Tilia Americana*); one species of dogwood (*Cornus canadensis*), of which but a single, very small specimen was found; three species of elm (*Ulmus Americana*, *U. fulva* and *U. racemosa*), the last not seen by me, but reported by Mr. Lake; one species of blackberry (*Celtis occidentalis*); four species of hickory (*Carya alba*, *C. sulcata*, *C. porcina* and *C. amara*); species of maple (*Acer pseudo-platanus*. *A. saccharinum* and *Negundo aceroides*), the last known as box elder; one species of mulberry (*Morus rubra*); five species of oak (*Quercus alba*, *Q. macrocarpa*, *Q. bicolor*, *Q. nigra*, *Q. palustris*); one species of tulip, more commonly called poplar (*Liriodendrum tulipifera*); one species of redbud, or Judas tree (*Cercis canadensis*).

The foregoing lists do not, of course, contain all or any approximation of all the plants in the county, but they show what I was able to make a note of during the time occupied by my survey. To the botanist interested in the problem of plant migration these notes may have some value.

The following notes made in Clinton, Cass, Carroll, Howard, Montgomery, Park and Tippecanoe counties may be appended here, and will serve to show what wild birds are still most common in the area comprising those counties. The birds found in any one of the counties may be taken as belonging also to Carroll.

Kingfisher (*Ceryle alcyon*). Common along the streams.

Yellow-billed cuckoo (*Coccygus Americanus*). Heard frequently and seen in orchards.

Woodpeckers (*Picus villosus*, *P. pubescens*, *Sphyropicus varius*, *Centurus carolinus*, *Melanerpes erythroocephalus* and *Colaptes auratus*).

Orioles (*Icterus spurius* and *I. galbula*).

Bluejay (*Cyanocitta cristata*). Common.

Quail (*Ortyx Virginiana*). Plentiful.

Hen hawk (*Buteo borealis*). Killed two in Montgomery County.

Sparrow hawk (*Falco sparverius*). Common.

Thrushes (*Mimus Carolinensis*, *Harporhuncus rufus*, *Turdus mustelinus*, *T. unalescæ nanus*, *T. Swainsoni* and *T. nugratorius*).

Herons (*Ardea herodias*, *Herodias egretta*, *Butorides virescens*, and the bittern *Botaurus mugitans*).

Owls (*Scops asio*, *Asio Wilsonianus*, *Nyctea scandiaca*, *Strix cinerea*). One specimen killed in Montgomery County.

Bluebird (*Sialia sialis*). Common.

Indigo bird (*Passerina cyanea*). Frequent.

Redbirds (*Cardinolis Virginianus* and *Pyranga rubra*). Both rather rare.

Dove (*Zenaidura carolinensis*). Common.

Pigeon (*Ectopistes migratorius*). Rare, but formerly abundant.

Sparrows (*Spizella domestica*, *Zonotrichia albicollis*, *Z. querula*, *Chondestes grammica*, *Melospiza palustris* and *M. fasciata*).

Blackbirds (*Molothrus ater*, *Angelæus phoeniceus*, *Scolecophagus ferrugineus*, *Quiscolus purpureus* and *Q. paeneus*).

Ducks (*Clangula albeola*, *C. glaucium*, *Aix sponsa* and *Guerquedula discors*.)

Woodcock (*Philohela minor*). Scarce.

Snipe (*Gallinago Wilsoni*). In spring quite plentiful on wet, soft meadows and prairie marshes.

Rail (*Rallus elegans* and *R. Virginianus*). The latter common in grassy marshes. I have killed an occasional *Porzona carolina*.

Gallinule (*Gallinula galeata*). Scarce. Seen at rare intervals in rushy marsh plats of the prairies.

## GENERAL REMARKS.

Carroll County is one of the best counties in the State, and will grow in agricultural and commercial importance apace with the progress of drainage and road-building. Nowhere have I seen finer soil or land surface, better adapted to the various needs of the farmer and stock-raiser. The population is thrifty, intelligent and progressive. Schools and churches abound, and the country homes show that a high state of prosperity prevails. It may be well said that to own an estate in Carroll County is to own a part of the great garden-spot of the West.

# GEOLOGY OF WABASH COUNTY.

BY MOSES N. ELROD, M. D., AND A. C. BENEDICT.

## GENERAL AND DESCRIPTIVE.

Wabash County is bounded on the north by Kosciusko and Whitley; on the east by Whitley and Huntington; on the south by Grant and Miami, and on the west by Grant and Fulton Counties. It is twenty-seven miles long and sixteen miles wide, except three by two miles off the northeast corner of the county which forms a part of Whitley County. It contains 432 sections of land, or about 426 square miles, equal to 272,640 acres.

The county was organized by an act of the Legislature approved January 22, 1835, which took effect on the first day of the following March. Since its organization the county has been divided into seven townships: Pleasant, Pawpaw, Noble and Waltz on the west side of the county, and Chester, Lagro and Liberty on the east side. Pawpaw is the smallest township in the county, and contains forty sections; Lagro is the largest with eighty-four square miles, and is said to have a greater area than any other township in the State by one-half a section; as a school corporation it has twenty-nine school houses, and its township trustee employs thirty-four teachers annually. Noble township is the next in size, with nearly sixty-eight square miles of territory.

Wabash, the capital of the county, is seventy-two miles north and seventeen miles east, or about eighty-eight miles northeast of Indianapolis. It is beautifully located on the north bank of the Wabash River at the site of the old Indian treaty grounds, and was platted in the spring of 1834 by Col. H. Hanna and David Burr. The first houses built in the new town were erected on the river terrace, and all the early stores were confined to the same neighborhood. The completion of the Wabash and Erie Canal made it an important commercial centre, and gave great impetus to its growth that has been steady and vigorous. At this time it is a city with all the conveniences of modern city life. The lower or south part of the city is occupied by large manufacturing establishments and stores. Generally the residences are confined to the plateau back of Hill Street, which is four squares north of the canal. It has broad, well paved streets that are set with handsome shade trees, and shut in by fine residences. The court house is a beautiful structure, surrounded by well-kept grounds, that reflect the taste and culture of the people.

North Manchester is an important town, located on the level plain just north of Eel River. It is noted for its mills, factories and business energy, and has a bright prospect for the future.

North Manchester and Roann are incorporated towns, and La Fontaine, Liberty Mills and Somerset have sufficient postal business to give them money order privileges. Besides these there are twenty other postoffices in the county, all of them thriving towns and villages, and centers of an active country trade.

The Wabash Railway, in crossing the county, follows within one mile the course of the north bank of the Wabash River from east to south of west. The Eel River division of the Wabash System enters the county from the west, near the middle of Pawpaw Township, and runs northeast through Pawpaw, Pleasant and Chester townships. The Chicago & Erie Railroad crosses the county in a northwest course from near the southeast corner of Chester Township and out through the west part of Pleasant. The Cincinnati, Wabash & Michigan Division of the Big Four System enters the county near the middle of Liberty Township, and in a general way runs west of north until it reaches Wabash. From there it passes north near the line dividing Noble from Lagro and Chester from Pleasant and Pawpaw townships. With the exception of a small part of the southwest corner of Waltz Township, none of the citizens of the county are more than six miles from a railroad station, and those living north of the Wabash River are more than well supplied with marketing facilities. The railroad stations are Belden, Lagro, Wabash and Keller's (Rich Valley P. O.), on the main line of the Wabash; Roann, South Laketon, North Manchester and Liberty Mills, on the Eel River Division; Servia, Bolivar, Newton, Laketon and Disko, on the Chicago & Erie, and Lafontaine, Treaty, Wabash, Urbana, Bolivar, North Manchester and Rose Hill on the Cincinnati, Wabash & Michigan.

The principal pikes are the Wabash and North Manchester, Wabash and Lafontaine, Wabash and Dora, Wabash and Mt. Vernon, Mill Creek, Lagro and North Manchester, Lagro and Township Line, the New Holland, the Jesse D. Scott Pike, and many others which have been built very recently. The absence of that old nuisance, the toll-house and its well-sweep, is a mark of progress that no one should more fully appreciate than the farmer who, heretofore, has been commanded to stand and deliver before he could pass. Good roads are essential to good markets, and no people appreciate this fact more than the citizens of Wabash County. The common roads are in good repair, and only need that the present practice of annually adding a few more miles of gravel shall be continued to make them equal to pikes. A conspicuous effect of the enforcement of the law against permitting stock to run at large is noticeable in the increased growth of bluegrass on the roadsides, which is killing off the common weeds that are so unsightly on many highways.

Schools and churches are numerous, and in educational matters the county has long stood in the front rank. All of the towns, and nearly all of the villages, have large, two-story brick buildings in which graded schools are taught, requiring the services of from three to seven teachers for eight or more months each year.

The earliest and latest written accounts of the Indian tribes of Indiana are connected with the history of the Wabash Valley, and it seems proper to notice the impress they have made on the geography of the county. This is especially seen in the regular boundaries of the farms on the Wabash and Mississinewa Rivers where the Indians were allotted reservations which follow the meanderings of the streams on one side and cut the section lines at an angle on the other. Lagro and La Fontaine are names of towns given in honor of Indian chiefs. Treaty and Treaty Creek commemorate historical events of interest to the whole State. The idea of admitting the wild Indians of the west to White's Manual Labor Institute has its origin in the presence of a few of their partially civilized brethren, survivors of once powerful tribes, located on the banks of the Mississinewa River. This institution owes its existence to the benevolence of Josiah White, of Philadelphia, Pa., a member of the Society of Friends, who left a sum of money to establish manual labor schools in Indiana and Iowa. With a part of this money a section of land on Treaty Creek, four miles southeast of Wabash, was purchased in 1852 of Washingomasha, a native Indian. On this purchase handsome brick buildings have been erected, surrounded by beautiful groves and driveways. The splendid farm connected with the Institute is one of great fertility and is kept in a high state of cultivation. It is at least poetic justice to an oppressed race that this school has been opened to the education of the Indian, where he is taught the arts and sciences, together with practical farming.

## TOPOGRAPHY.

The lowest railroad elevation in the north part of the county, 666 feet above water, is at Keller's Station (Rich Valley P. O.), and the highest, 843 feet, is at the point where the Chicago & Erie Railway crosses the boundary line between Wabash and Huntington Counties. The altitude of the highest table land between the Wabash and Eel Rivers, south of North Manchester, is stated to be 824 feet, which is the same as that of New Harrisburg. Thirteen railroad elevations on the lines north of the Wabash River give 769 feet as the average height of the land; but as this average is estimated mainly from points on the roads that follows the river valleys, it is not so high as an average would be made from the Chicago & Erie Railway. It is probable that the average altitude of the high lands on the divides between the rivers that cross the county will at least reach 800 feet. It is very much regretted that no report of the elevations on the line of the Cincinnati, Wabash & Michigan Railroad could be secured so as to give an idea of the topography south of Wabash. The only data available bearing on the subject are derived from gas well borings made in the vicinity of La Fontaine. These borings are reported in three wells to have passed through 300, 180 and 167 feet respectively of clay, sand and gravel before striking stone. Rejecting the first measurement as anomalous and adding the mean of the other two wells, 174 feet, to the altitude of the surface of the country rock in the court house square, 730 feet, gives an elevation of 904 feet* for that part of the county, an excess of 61 feet above the highest point given north of the Wabash River. Low water in the river at Belden is reported at 680 feet above high tide in the Gulf of Mexico; the mouth of the Salamonie River is 667 feet, and the surface of the stream at Wabash is 638 feet, a fall of 42 feet within 11 miles. The difference between the level of the grade, 701 feet, and the level on the boundary line where the Chicago & Erie Railway crosses, 843 feet, shows a rise of 138 feet within 5 miles. The court house square, 730 feet, is 92 feet above the surface of the Wabash River, and 102 feet below the table lands between the county seat and North Manchester.

The general surface of the county is level or rolling. The so-called hills seen along the rivers, creeks and ravines are the bluffs formed by the valleys and channels of the country. There are no hills in the county except a few isolated gravel mounds in the northwest portion of Pleasant Township. The creek valleys and beds in the uplands, which constitute a vast majority of the surface of the county, are slight depressions in the soil, clay and gravel. The river valley bluffs at Dora are forty feet, at Lagro fifty feet, and at Wabash City from sixty to seventy feet high. On Eel River they are from twenty-five to thirty feet high, and on the Missisinewa they average sixty feet. All of the creek valleys and many of the ravines in their lower courses cut down to a level with the river terraces. These cross-valleys diversify the outline of the river bluffs and cause the adjacent upland surface to be broken. The clay-covered bluffs gradually sweep down to the valley meadows and present a rounded appearance; the gravel bluffs are more abrupt in outline and frequently precipitous; those built up of exposed stone are often perpendicular cliffs. Frequently two or more of these types are merged together and modify the form of the elevation. As a rule, clay-covered bluffs are common to streams north of the Wabash River and to the creeks in the south part of the county. Gravel banks are seen in greatest force on

*This estimate is ten feet higher than the altitude given by the railroad.

Salamonie and Mississinewa Rivers, and the rocky cliffs are confined to the Wabash, Mississinewa and Salamonie River Valleys.

The surface drainage of the county finally reaches the Wabash River. The general direction of the course of the rivers is to the west and that of the creeks to the southwest or the northwest. An exception to the rule as applied to the creeks is seen in the northwest corner of the county, where the flow is to the south and southeast. Eel River and the Mississinewa are crooked streams, with rather sluggish currents, and the water of the former more or less muddy. The direction of the water shed between the Wabash and Eel Rivers is well marked on a good map of the county, and runs nearly parallel with those streams from east to west. The divide between the creeks flowing into the Wabash and those flowing into the Mississinewa River runs nearly due west through Liberty and Waltz Townships.

Round, Long, Mud, Bull, Bear, Lukins, Flora's, Flat and Twin Lakes are small bodies of water covering from twenty-five to eighty acres, and are confined to the northwest part of the county. They are fed by springs, and once were well stocked with fish. It is in the vicinity of these lakes that the "oak openings" occur. In the early history of the county the undergrowth common to the timber lands was replaced in the "openings" by a rank growth of grass. This grass was burned annually by the Indians, to the destruction of the young timber, but not to the injury of the larger trees. Near the "openings" were treeless swamps that have been reclaimed by drainage and are now known as among the most fertile lands in the State.

### PALÆZOIC GEOLOGY.

The following connected section is intended to show the average thickness of the various formations exposed in the county and their relations to each other in successive periods of time:

## GENERAL SECTION OF WABASH COUNTY.

### CENOZOIC TIME.

### QUARTERMARY AGE.

RECENT PERIOD.

*Recent, Alluvial and Lacustral Epochs.*

*No.* 1. Surface soil, river terrace and black soil . . . . . . . . . . . 4 feet.

DRIFT PERIOD.

*Glacial Epoch.*

*No.* 2. Clay, gravel, sand, blue and yellow clays and modified drift . . 100 feet.

# PALÆZOIC TIME.

## UPPER SILURIAN AGE.

### Niagara Period.

*Niagara Epoch.*

| | | | |
|---|---|---|---|
| *No.* 3. | Even bedded, fossiliferous, buff fag and quarry limestone . . . | 17 | feet |
| *No.* 4. | Irregular, nonstratified, gray limestone, from 15 to 60 feet thick, and locally known as picket rock . . . . . . . . . . . . . . | . | " |
| *No.* 5. | Laminated, generally even bedded, buff shale . . . . . . . . . . | 15 | " |
| *No.* 6. | Upper portion shaley or amorphous cement rock, bedding compound; lower portion evenly bedded hydraulic limestone; fossils rare . . . . . . . . . . . . . . . . . . . . . . . . | 135 | " |
| | Total . . . . . . . . . . . . . . . . . . . . . . . . . . . . . | 267 | feet. |

The term "quarry stone," wherever it occurs in this report is used to include No. 3 of the general section. No. 4 is not carried into the column of average thickness for the reason that it seems to represent a group of rocks that are the result of changes which have taken place since the original strata were deposited. Frequently its materials are the modified strata of Nos. 3 and 4, and the upper portion of No. 6. It always includes a portion of No. 3 in its structure. This formation is locally known at Wabash City as "picket rock," and as the term is a convenient one, it is used to distinguish the stone of this remarkable group from all others, and for the further reason that it does not carry with it any preconceived theory as to its origin. "Laminated shale" is used as the equivalent of No. 5, and "cement rock" to embrace the shaley and amorphous upper portion of No. 6. The use of the term "hydraulic limestone" is restricted to the lower stratified beds of No. 6.

With the exception of the quarry stone, which is distinct in structure from the contiguous and underlying shale, the lines of separation and transition from one formation to another are not well marked. In passing downward No. 4 gradually changes from thin laminated shale to blue cement shale. The whole of No. 6, whether massive or shaley, horizontal or inclined, evenly or compoundly bedded is more or less hydraulic. It is distinguished from the laminated shale by its hydraulic qualities, and for the same reason is described as a distinct group.

The local dip is so extremely variable that no exposures are to be found on which conclusions as to the direction of the general dip can be based. The only data available is derived from measurements made in making the survey for the Wabash and Erie Canal. By this survey it was found that the court house square at Huntington was 741 feet, and the court house square at Wabash 730 feet above the ocean, a difference of only 11 feet. As both court houses are built on the same geological horizon, the top of the quarry stone, the dip west from Huntington to Wabash is found to be less thon eight inches to the mile. More recent surveys made in running the levels for the Wabash Railroad show that the Wabash station is eight feet higher than the station at Huntington, but this apparent contradiction of the figures derived from the Wabash and Erie Canal surveys is because they are not built on the same geological level, the station at Huntington being below the top of the Niagara group quarry stone. Passing down the Salamonic River the top of the hydraulic limestone beds, near the mouth, rise to a higher level above the channel than they do at Dora; but as this rise may be wholly due to the increased depth of the channel, it is not possible to determine the degree of dip without running levels.

## LIST OF FOSSILS FOUND IN WABASH COUNTY

### CŒLENTERATA.

#### *Anthrozoa.*

*Zaphrentis celator*, Hall.
*Zaphrentis* sp (?).
*Favosites niagarensis*, Hall.
*Halysites catenulatus*, Linn.
*Dictyonema* sp (?).

### ECHINODERMATA.

#### *Crinoidea.*

*Pisocrinus gemmiformis*, S. A. Miller.
*Pisocrinus campana*, S. A. Miller.
*Pisocrinus benedicti*, S. A. Miller.
*Pisocrinus gorbyi*, S. A. Miller.
*Pisocrinus* n. sp.

### MOLLUSCOIDA.

#### *Bryozoa.*

*Lichenalia concentrica*, Hall.
*Ichthyorachus*, n. sp.
*Sagenella elegans*, Hall.
*Paleschara macula*, Hall.
*Trematopora varia*, Hall.
*Trematopora granulifera*, Hall.
*Fenestella parvulipora*, Hall.

### MOLLUSCA.

#### *Brachiopoda.*

*Orthis benedicti*, S. A. Miller.
*Orthis elegantula*, Dalman.
*Orthis biloba*, Linn.
*Atrypa reticularis*, Linn.
*Meristina nitida*, Hall.
*Sperifera crispa*, Hisinger.
*Strophomena rhomboidalis*, Wilckins.

#### *Cephalopoda.*

*Orthoceras crebescens*, Hall.
*Orthoceras unionense*, Worthen.
*Orthoceras regidum*, Hall.
*Orthoceras columnare*, Hall.
*Orthoceras strix*, Hall.
*Orthoceras obstrictum*, Newell.
*Gomphoceras wabashensis*, Newell.
*Phragmoceras linearis*, Newell.
*Phragmoceras augustum*, Newell.
*Phragmoceras parvuni*, H. & W.
*Phragmoceras nestor*, Hall.
*Phragmoceras projectum*, Newell.
*Hexamoceras cacobiformis*, Newell.
*Lituites bickmoreanus*, Whitfield.
*Lituites graftonensis*, M. & W.
*Lituites multicostatus*, Whitfield.
*Lituites marshi*, Hall.
*Trochoceras desplainense*, McChesney.

### LAMELLIBRANCHIATA.

*Ambonychia acutirostra*. Hall.

### CRUSTACEA.

#### *Trilobita.*

*Calymene niagarensis*, Hall.

All the fossils of the foregoing list were found in the quarry stone. The laminated shale and hydraulic limestone strata, so far as examined, are devoid of organic remains. The cement shale, in the vicinity of Lagro, gives promise of yielding fine specimens of trilobites. At Hanging Rock many fragments of *Calymene niagarensis* and other genera were found in the blue, amorphous stone that had fallen from the overhanging rock. One specimen each of *Orthoceras strix*, a *Lituites*, and the mould of a *Pleurotomaria*, were found in the cement shale of Lagro Creek, two hundred yards below the Sheets stone quarry. The quarries at South Wabash, Wabash, Lagro and on the Missisinewa River are all good fields in which to collect fossils. There is said to be a three-inch stratum of stone in the quarry east of Wabash and near the railroad tracks that is a mass of trilobites. Making due allowance for the exaggerations one hears about such things, from those not familiar with collecting, there remains no doubt but fine specimens are to be found in that vicinity. Good ones were seen on the face of the flagging in the Lambert quarry at South Wabash. Of course it is not to be presumed that the annexed list is complete; it embraces only such species as were found in the hurry of other work. This county is a good one in which to collect, and promises to become especially noted for its fine specimens of cephalopodæ. A cast of a *Pentamerus* was seen at Rockyway Falls, and a single specimen of *Pisocrinus* was found in the picket rocks near the mouth of Charley Creek. Other forms not identified were seen in the equivalent stone at Hanging Rock.

The Niagara Group stone of this county, like that of Southeastern Indiana, is remarkable for the size and abundance of the chambered shells found in it, and the scarcity of brachiopodæ. The various species of *Phragmoceras*, *Gomphoceras* and *Lituites* named in the list seem to be restricted to the northern part, and the species of *Gyroceras* to the southern part of the State. *Orthoceras strix* has never been found on Clifty Creek, but is quite common in Wabash County, where it grew to a great size. A fine specimen, slightly curved, was seen near the Watson Briggs Ravine, that measured twenty inches long. Other curved forms were seen at Wabash. *Orthoceras annulatum*, a species common at St. Paul and Hartsville, seems not to occur here.

## GENERAL GEOLOGY.

### NIAGARA GROUP.

Nowhere in the State can the stratigraphical geology of the Niagara Group be so thoroughly studied as in Wabash County. All the phenomena peculiar to the stratification of the county are found at other places on the Wabash River and elsewhere, but, interesting and remarkable as they are, none of them shows so well the vertical extent and the relation of the different members of the group. The Hanging Rock exposure has a vertical range of seventy-eight feet and includes all the divisions of the general section. Many other exposures show sixty feet of stone.

The problems to be discussed in stratigraphy grow out of the local variations in the dip and the compound bedding of the strata. This is made apparent to any one who will examine the outcrops in Wabash and vicinity. At the east end of the Cincinnati, Wabash & Michigan Railway bridge over the Wabash River is seen a large cone-shaped mass of stone that at first glance seems to be the result of an upheaval. This impression is confirmed by the high angle dip of the exposed side. Further examination shows fifteen or more feet of thin laminated shale, approximately horizontal, resting against the sides of the cone. East of the city, near where the Wabash Railroad crosses the Cincinnati, Wabash & Michigan Railway, the laminated shale is found to be covered with even-bedded quarry stone. Here the quarry stone and the underlying laminated shale are stratified in the same plane and apparently lying in a different plane unconformable to that of the picket rock. The question at once arises: Were all these formations the result of sedimentary deposits which took place in regular geological sequence? Are the picket rock cones the result of changes that have taken place since the close of the Niagara period, and was the material of which they are composed once evenly stratified and identical in structure with the surrounding quarry stone and shale? If so, what have been the conditions and what the physical and chemical forces which have changed the quarry stone and soft laminated shale into hard, amorphous limestone? Are the picket rock cones the result of an upheaval? Are the lines of separation on which the dip is taken stratification planes, or are they a peculiar form of jointed structure and cleavage? It is the purpose of the portion of the report devoted to general geology to make such answers to these questions as seem to be probably correct, and to describe the structure and geographical distribution of each division of the general section.

The outcroping stone seen in the county belongs to the hyraulic limestone division of the general section. It is the stratified stone quarried in the vicinity of New Holland on Rush Creek, and appears in heavy beds at Dora in the banks of the Salamonie River. As a gray stratified stone it is common in the vicinity of Lagro. It is the bed-rock of the lower course of Treaty and Helm's Creeks, in the lower bluff banks of the Wabash River at Rich Valley, and in the banks of the Missisinewa. It will be found as the bed-rock over which the waters of the Mississinewa, Wabash and Salamonie Rivers flow throughout the county. Overlaying the hydraulic limestone, and having the same geographical range, comes the cement shale and amorphous cement rock, except where eroded away in the river valleys. The irregularly bedded, unstratified amorphous rock and cement shale are found in greatest force in the vicinity of Lagro, where forty-six feet of it are exposed in the higher bluff banks of Lagro Creek. That these formations extend below the level of the bottom of the Wabash River, was shown by the boring made in sinking the Lagro public well, on Washington Street, where the cement shale and hydraulic limestone were penetrated to the depth of sixty-eight feet. The depth of the well added to the forty-six feet of stone exposed in the bluffs above the level of Washington Street gives a total thickness of one hundred and fourteen feet. It has been estimated from data derived from gas well borings made in the county that the total thickness of the shale and stone having hydraulic properties may reach two hundred and fifty feet.

The hydraulic limestone, wherever seen, was found to be uniformly stratified with clay or shale partings, and without more than a slight dip of one or two degrees. At the north end, and below the Lagro wagon bridge over the Wabash River, there is an exposure of the lower beds that beautifully show the stratification, level as a house floor, and cut by two vertical seams, ten feet apart, that run exactly parallel for more than one hundred feet. Above the lower dam across the Salamonie River, by taking a boat, the exposure can be easily traced for nearly one mile with but a slight dip to the northwest. The color is generally blue, weathering to gray. Where the percentage of alumina is large it gives the stone a laminated structure that is shown in some of the blocks used in building the locks on the old Wabash and Erie Canal. In the quarry a short distance above Hanging Rock the argillaceous constituent is so much increased as to cause some of the strata to crumble to dust and thin laminated fragments; the lower beds, however, are massive and show little tendency to change. The fracture is generally conchoidal, but is not so well marked as in typical specimens of the amorphous cement rock, and breaks without visible evidence of crystalization. Typical specimens of hydraulic limestone are found in the New Holland quarries, at the old Wabash and Erie Canal quarry on the west bank of the Salamonie River, in the lower beds of the Somerset quarries, and near the mouth of Treaty Creek, of the amorphous cement rock in the quarry of the Lagro Cement and Manufacturing Co., and at the mouth of Helm's Creek.

### SECTION OF THE QUARRY OF THE LAGRO CEMENT AND MANUFACTURING CO.

*West Bank of Lagro Creek, Near Town of Lagro.*

| | | |
|---|---|---|
| Soil | 1 ft. | 6 in. |
| Quarry limestone, flag | 2 ft. | 0 in. |
| Blue amorphous cement rock to the creek bottom | 47 ft. | 0 in. |
| Total | 50 ft. | 6 in. |

A short distance up the creek from the cement quarry the following measurements were made:

SECTION.

*West Side of Lagro Creek.*

| | |
|---|---|
| Soil and covered slope | 10 ft. |
| Gray stratified quarry stone, flag. | 6 ft. |
| Amorphous cement rock and cement shale to the bottom of the ravine | 35 ft. |
| Total | 51 ft. |

The amorphous cement rock of these sections is too massive to be called a shale. It also lacks the laminated structure of most shales. But in composition it is nearly identical with that of the cement shale, the term generally used to designate beds of this geological age.

Strictly speaking, the amorphous cement rock and cement shale are unstratified where the sections were made, and the same is true of the whole exposure along the banks of Lagro Creek. The face of the outcrop has lines of irregular bedding, which careful examinations show are due to changes in the lithological character of the stone, and not to clay or shale partings. Frequently the vertical section of a lenticular or triangular mass of stone, as it rests in place in the exposure, is seen to be surrounded, or bedded, in one or more thin crusts of stone that are broken into short fragments. These broken fragments, following the lines of bedding, indicate the planes of the so-called stratification, and doubtless show what, under other conditions of deposition, would have resulted in either a shale or clay parting. It is not all the planes of separation which show this tendency to stratification, many of them are true seams, or fracture lines, through the homogeneous mass of stone. This imperfect stratification forms the transition type of bedding between the horizontal strata of the hydraulic limestone and the cleavage structure of the picket rocks. At the cement quarry are lenticular masses five feet thick in the middle, which thin to a feather edge within thirty-five feet or less, and angular or wedged-shaped pieces that rapidly reverse the dip. The dip measured on the different lines of separation varies, within a few feet, from horizontal to an angle of thirty degrees. The upper part of the cement shale on Lagro Creek is very much broken by vertical and cross seams into irregularly shaped, angular pieces, varying from a few inches to as many feet in diameter. In the lower beds the seams are nearly vertical. At the cement quarry is a closed seam that reaches from the top to the bottom of the bluff, and can be readily traced across the bed of the creek. Where the adjacent stone has been removed from one side of the seam, in quarrying, it leaves the other side exposed with a face as smooth as polished marble. No vertical seams filled with earth were anywhere seen in the hydraulic limestone or cement shale; dirt seams are limited to the quarry stone. The Lagro Creek stone does not show appreciable change in physical appearance except in the top members of the exposure, which have a lighter color on the surface that is due to weathering.

SECTION AT HANGING ROCK.

*South Bank of the Wabash River Near Lagro.*

| | |
|---|---|
| Massive, unstratified, fossiliferous limestone, equivalent of the picket rock | 35 feet. |
| Thin bedded limestone, alternating with shale, lower strata thicker, with obscure fracture lines of separation | 30 feet. |
| Amorphous cement rock | 4 feet. |
| Even-bedded hydraulic limestone, with thin clay or shale partings, stratificatiou approximately horizontal | 5 feet. |
| Slope to water's edge | 4 feet. |
| Total | 78 feet. |

Hanging Rock is one of two isolated, cone-shaped hills that stand in close proximity on a north and south line. The river-bottom highway passes between them, over a slight rise in the road. The base of the larger hill, Hanging Rock, covers about half an acre. The river front is precipitous and towers more than eighty feet above extreme low water. Standing on its isolated top, a magnificent view is presented to the eye of the Wabash River as it sweeps in gentle curves down the valley. To the north and east one sees dimly outlined the ancient bed where long years ago it ran, unruffled by the devices of civilization, in its course to the sea. Below can be traced its junction with the Salamonie. The beholder wonders, as he gazes over the broad valley with its high bluffs, what were the forces of nature, which have not only carried away the clay, sand and gravel of the Drift Period, but have by long erosive action removed miles of stone that once came above a level with the top of Hanging Rock. It is not alone the wonderful and picturesque scenery of the Quarternary Age that should invite attention. Here, better than anywhere else in the county, can the secrets of a much older world be read.

The upper member of the section has the same lithological characters as typical picket rock from the Wabash Cone. Below is seen beautiful examples of compound bedding, and under all evenly stratified limestone that does not show the slightest evidence of having been disturbed since its material fell as sediment on the bottom of the ocean. The upper thirty-five feet is without stratification or cleavage structure, but is divided into two nearly equal masses by a line of separation that has a slight dip to the southwest. The irregularly-bedded limestone is in strata estimated at four inches thick, alternating with thinner layers of shale. The edges of the limestone project beyond the more friable shale and show quite a curve, as if the strata had been bent upward at the northeast end, or it had been deposited in a trough. At the northeast angle of the river front of the outcrop a bed of stone composed of thin strata five feet thick was measured, which in twenty feet diminished to one foot, and another that diminished from four feet to two feet, both beds thinning in the same direction. Other measurements were made in which the layers became thinner in the opposite direction; and it is by this system of alternating dip that the strata pass through the compound bedding from a horizontal plane below to a nearly level surface above. The dip varies from twenty degrees to five degrees. In physical appearance and fossils these limestone beds are the equivalent of the quarry stone of the general section, and occupy the same geological horizon. Below the quarry stone beds the physical characters of the strata change, without showing the intervening laminated shale of the Wabash quarries, to the cement rock of Lagro Creek. The stratification changes to obscure lines of separation that have the appearance of being fracture seams. In this portion of the section one stratum within a distance of twelve feet eight inches thins from twenty-one inches to nothing, and the stratum above it, measuring nine inches in the middle, vanishes to a point each way within eighteen feet. Under the irregularly-bedded shale is four feet of dark blue, amorphous cement rock. The external surface of this stratum has been polished by high water until it presents a very striking appearance, and has been freely used by visitors as a register on which to carve their names or initials and the date of their visit. The hydraulic limestone strata are approximately level, and as the equivalent beds, a short distance above and below on the Wabash River—in fact, wherever exposed—are without measurable dip, the inference is that this condition is not peculiar to the section. Thin clay or shaley partings between the layers indicate conclusively that they are truly stratified and of sedimentary origin. Closed seams that are nearly vertical are not infrequent. A very marked example is seen in the west face of the outcrop that runs southwest and cuts through both upper divisions of the section for more than fifty feet. At the top it passes through the west and lower part of the picket rock, causing all that part of the stone west of the seam to fall away and leave a smooth, vertical face. In no instance do these seams show that the relations of the strata have been disturbed. They appear to be due to the same causes which have produced seams, or a jointed structure, in all stratified rocks.

The fossils of the picket rock top of the section are so fragmentary as to render their identification difficult, but enough nearly perfect specimens were found to show that they were of the same species as those from the underlying quarry stone. This is the only exposure of the former stone which clearly shows that it does not reach the bottom of the latter strata. Near Charley Creek, in Wabash City, the picket rock seems to rest on the quarry stone, but does not clearly show that such is the case.

On Lagro Creek and at Hanging Rock the cement shale underlies the quarry stone, but this is true in certain localities. At the Martin Willis quarry and on the Salamonie River there is about fifteen feet of even bedded, buff, or ochery colored, laminated shale overlying the cement shale. This formation differs, not only in color and want of hydraulic properties from the cement shale, but contains a much larger per cent. of argillacious matter. In it the proportion of clay is so large as to cause it to split into thin *laminæ* or plates. Typical specimens are found at South Wabash. As a rule the laminated shale underlies the quarry stone, but there are exceptions as at the Martin Willis quarry where it occupies the same level, and all over the county it, or the cement shale, will be found in connection with the quarry stone.

The quarry stone is probably the stratified surface stone underlying the drift of the whole county, except an occasional exposure of picket rock which replaces it. It is found outcropping in all the bluffs and ravines of the Wabash and Mississinewa Rivers, on Ross Run and Rockyway Creek, except where covered with soil and gravel, and in the high banks of the Salamonie. It shows in greatest force in the vicinity of Wabash, Rich Valley, Lagro and Somerset. It is generally of a buff or an ochery color. The color varies with the degree of exposure, and resulting higher oxidation of its constituent salts or iron. At places in South Wabash and near Lagro it presents a hard, dark gray appearance. Strictly speaking it is not an argillaceous or magnesian dolomite, but is more nearly a silicious limestone. Many of the strata are very free from flinty nodules, while others are almost wholly made up of chert. The cherty layers are mostly confined to the top of the formation and do not average more than one inch in thickness. Near the center of the exposure the ledges become two or more inches thick with occasionally an intercallated stratum of chert. The lower strata measure from six to twelve inches. Rarely the thicker strata are cherty, and when this is the case here, as elsewhere in all the Niagara stone, it is refractory and can only be used in rough masonry. Near Lagro, at the Kisner quarry, the middle members of the formation are cherty and coalesce. The cherty matter does not appear in stratified beds, but is generally disseminated through the mass, and cause it to break into rather smooth, round and oblong pieces, from one to four inches in diameter. On the Mississinewa River, and at some of the quarries west of Wabash in the river bluffs, the quarry stone exposures, by an increase in the number and thickness of the strata, reach a total thickness of thirty-five feet, but preserve the same lithological characters as those described as typical from South Wabash, where the outcrop does not measure more than seventeen feet thick.

The apparent identity of the top cherty member of the Wabash County quarry stone with the corresponding formation of Huntington County seems to show that the chert beds in both counties represent the close of the Niagara epoch. But it is not every outcrop which shows the top strata; in the vicinity of Lagro the denuding forces which have excavated the Wabash Valley have removed a part of the Niagara stone.

A most remarkable example of unconformability of the quarry stone to the cement rock was seen in the east bank of Lagro Creek, one-half mile north of Lagro, where the following sections were made:

### SECTION ON LAGRO CREEK.

East ½ southwest qr. section 27, township 28 north, range 7 east.

| | |
|---|---|
| Soil and slope | 10 feet. |
| Blue cement rock, obscurely bedded, breaking with a distinct conchoidal fracture | 30 feet. |
| Total | 40 feet. |

### SECTION ON LAGRO CREEK.

| | |
|---|---|
| Soil and slope | 10 feet. |
| Hard limestone, equivalent of the quarry stone, with distinct and regular planes of separation | 30 feet. |
| Total | 40 feet. |

The sections were made within a distance of twenty feet. The passage from the cement rock to the limestone is abrupt, and, viewed on a horizontal plane, looks as if one formation had been forced past the other by an upheaval. The dividing line between the formations is somewhat obscured by fragments of cement rock, but the relation of the two is very clearly defined. The hard limestone of the last section is readily identified as a modified form of quarry stone, but has characters that show it to be closely allied to the picket rock formation. It is without the characteristic shaley partings of the former, and has the physical appearance, crystalline structure, and cleavage planes of the latter. The top of the sections are on the same level, but the cement rock of the first passes down, without a break in its continuity, to the bottom of the creek and up the creek under the limestone beds. Here is an apparent fault of thirty feet. But the exposure, for quite a distance up the creek, under the limestone, shows that the peculiar relations of the two sections are not the result of a fault, and this conclusion is confirmed by a few clean cut, closed seams in the underlying stratum which are so nearly vertical as to exclude any idea that the rock in which they occur has been disturbed by an upthrust. The reader will not only note the absence of the laminated shale from both sections, but that in the second the base of the quarry stone drops thirty feet below the top of the cement rock. The dip, taken on the obscure planes of separation, is marked at the lower end of the outcropping limestone, but soon changes to nearly horizontal, and the stratification becomes distinct and can be plainly traced in prominent ledges, with shaley partings, up the creek for more than one-eighth of a mile, where the following section was made:

SECTION OF J. W. SHEETS' QUARRY.

East side of Lagro Creek, one-half mile north of Lagro.

| | | |
|---|---|---|
| Soil | 8 ft. | 0 in. |
| Thin bedded, gray limestone, with clay partings | 3 ft. | 8 in. |
| Heavy bedded, dark-blue quarry stone | 1 ft. | 2 in. |
| Heavy bedded, dark-blue quarry stone | 2 ft. | 6 in. |
| Heavy bedded, dark-blue quarry stone | 1 ft. | 6 in. |
| Heavy bedded, dark-blue quarry stone | 1 ft. | 0 in. |
| Total | 17 ft. | 10 in. |

A short distance north the quarry stone and underlying shale disappear, owing to the slight dip and to the rise in the bed of the creek. The fossils seen were: *Lichenalia concentrica*, *Ichthyorachis*, n. s., *Zephrentis celator*, *Pisocrinus gorbyi*, and many of the Bryozoans common in the Waldron and Hartsville Niagara shales. Doubtless many other species will be found by the diligent collector. Near where the George Todd section was made an *Orthoceras strix* and the cast of a *Lituites* and *Pleurotomaria* were found in the cement rock of the creek channel.

It has already been shown that the apparent fault at the lower end of the quarry stone on Lagro Creek is not due to an upheaval, but it remains to account for the unconformability of the two formations just described. The most reasonable solution of the question, and one that agrees well with the facts, is that the quarry stone strata were deposited in a trough or valley in the cement shale, and that the first section made at the George Todd farm represents the south bluff bank of the valley. This probability is further corroborated by the quarry stone showing again in the Wabash River bluffs east of Lagro, indicating that the ancient valley had an east and west trend. At the Martin Willis quarry, on the Township Line Pike, is an exposure of the stratified quarry stone where the workmen have taken out stone at a lower level than the top of the adjacent laminated shale. The extent of the unconformability could not be determined, as the quarry has not been opened to the bottom of the formation, but enough stone has been removed to show an apparent fault of more than ten feet. Here the depression occurs in the laminated shale and occupies a different geological horizon from that in the cement rock on Lagro Creek, but they are alike in having an east and a west trend. The stratification of both formations is nearly level. Especially is this true of the shale in the Martin Willis quarry which outcrops in places west of the pike and between the quarry and the river bottom. The bedding of the underlying cement shale where it shows is quite irregular. Similar depressions in the shale occur elsewhere, and particularly at the quarry of Leonard Hyman on the Mississinewa River, in Waltz Township.

SECTION AT THOMAS BRIDGES' QUARRY.

*Northeast part of South Wabash.*

| | | |
|---|---|---|
| Thin, laminated limestone, slightly cherty | 1 ft. | 6 in. |
| Chert in thin strata | 1 ft. | 0 in. |
| Shale | | 8 in. |
| Thin, even bedded limestone | 1 ft. | 4 in. |
| Chert stratum in limestone matrix | | 4 in. |
| Even bedded flag, strata averaging two inches in thickness | 8 ft. | 8 in. |
| Shale | | 3 in. |
| Hard, blue, even bedded dimension stone | | 10 in. |
| Hard, blue, even bedded dimension stone | | 9 in. |
| Hard, blue, even bedded dimension stone | | 7 in. |
| Laminated shale, not measured | | |
| Total | 18 ft. | 7 in. |

This quarry is located on the top of a ridge, one face of which is formed by the river bluff and the other by a deep ravine or valley running east and west through the town, and is a typical quarry of the vicinity. Other sections will show variations in the succession of the chert, shale and limestone layers, and in the thickness of each stratum, but the average total thickness of the exposure is nearly constantly found to be nineteen feet. In the south face of the quarry, near the ravine side of the ridge, is a fissure or seam filled with earth two feet wide at the top and bottom. The stone between the fissure and the ravine has the appearance of having separated from the mass by bodily sliding toward the valley, and now rests on a very insecure base. A few feet north is another seam that is uniformly fifteen inches wide, but does not reach down to the shale. A number of other seams of less width were examined and all found filled with earth, and of nearly the same extent throughout. They are called "dirt seams" by the quarrymen and have no special features to distinguish them from similar seams in the quarry rocks of Southeastern Indiana. Several hundred feet of the surface of the laminated shale has been exposed by the quarrymen and it is almost perfectly level. No place was found in the immediate vicinity where its thickness could be measured, but in the bluff at the south end of the iron bridge over the Wabash River, it outcrops in strata that soon pass into the compound bedding of the cement shale and the latter into the hydraulic limestone.

Having, in a general way, described the stratified formations of the county, it remains to take up the picket rocks and treat of them in the same manner. Because of their very peculiar structure, and relations to the other subdivisions of the general section, they have been left until the last for consideration. In vertical exposure they always reach the level of the top of the adjacent quarry stone. Wherever their relations to the underlying strata could be seen they never were found resting on the laminated shale. The laminated shale frequently lies on the sides of the picket rocks, but under them has constantly been found some form of homogeneous stone, either cement rock, hydraulic limestone or limestone and shale.

The striking and diagnostic features of the formation are its outcroping in cone-shaped masses, with so-called stratification lines dipping to all points of the compass, or as an irregularly shaped deposit with lines of separation in one or two directions only. Typical cones appear to be the result of an upheaval. It is a hard, solid or spongy crystalline limestone that readily burns to lime. The spongy structure is due to cavities, ranging from one-sixteenth of an inch to an inch in diameter, which do not affect the hardness of the stone. The exterior of the exposure is rough, and looks as if it might have resisted the eroding effects of summer and winter for ages. The color is generally gray or grayish white, and varies with the composition of the stone. It shows no tendency to split, and breaks into irregular, angular fragments. The cone at Wabash is typical as to form and structure. The lithological characters of typical specimens of the formation are unlike any other stone seen in the county. The only formation with which it might be confounded is that of the quarry stone. Compared with the thicker beds of the latter, the picket rocks are seen to be more highly crystalline, massive, and generally of a uniform color and structure throughout. When the color and structure of a specimen does change within the mass, the stone never shows the stratified parallel bands of crystallization or blue, gray and buff color seen in the ten and twelve inch strata of the quarry stone. The marked appearance of stratification common to all the quarry stone layers is wanting in the typical picket rocks. At many places the one formation passes into the other by imperceptible changes of color and structure.

It is possible that circumscribed deposits of picket rock occur throughout the county under the Drift, but it is only exposed in the river bluffs. It outcrops in the eastern part of Wabash, at the north end of the Cincinnati, Wabash & Michigan Railway bridge; east of Charley Creek, and north of the Wabash Railroad; near the south end of the old wooden bridge over the Wabash River; on the farm of William P. Stanffer, two miles west of South Wabash; east of Rich Valley, on Rockyway Creek, near New Holland; at Dora; in the top of Hanging Rock; at the Narrows; one-eighth of a mile west of Lagro, on the Wabash & Erie Canal; in the east bank of the Salamonie River, one and a half miles above its mouth; on Lagro Creek; at the mouth of the Watson Briggs Ravine, and at Belden.

SECTION AT DORA.

*East End of the Wagon Bridge Over the Salamonie River.*

| | |
|---|---|
| Soil and slope | 10 ft. |
| Cone-shaped mass of rough, dark colored picket rocks | 12 ft. |
| Horizontal cement shale and hydraulic limestone to the water | 25 ft. |
| Total | 47 ft. |

SECTION AT DORA.

*In the West Bank of the River Below the Mill, and Nearly Opposite the Preceding Section.*

| | |
|---|---|
| Soil and covered slope | 4 ft. 0 in. |
| Amorphous cement rock and cement shale | 18 ft. 0 in. |
| Stratified, blue hydraulic limestone, dip 2° north | 1 ft. 6 in. |
| Amorphous, blue stratum | 2 ft. 6 in. |
| Total | 26 ft. 0 in. |

The last section is equivalent to the lower twenty-five feet of stone imperfectly exposed on the opposite bank of the river under the picket rocks. The two sections are separated only by the width of the river, and taken together exclude all idea of either one ever having been disturbed by an upheaval. The picket rock outcrop is in the form of an oblong cone, three hundred feet long by twelve feet thick, with its long axis parallel to the bluff. The dip on the north end is markedly to the north and to the opposite point of the compass at the other end; on the river front it is distinctly to the west. The dip on the lines of separation is not so acute or irregular as that of the typical cone, but is well marked, and when taken with the physical characters of the stone clearly identifies the formation with the picket rocks And, while there is very little evidence that the cone is directly due to false or compound bedding, it is very probable that it rests on irregularly stratified cement rock; but the want of marked false bedding does not prove an upheaval. It is not conceivable that a mass of stone three hundred feet long by twelve feet thick and of an unknown width could have been forced into its present position from below, or the dip changed to such a degree and leave the strata in the immediate vicinity undisturbed. Neither theory seems to be a satisfactory explanation of the phenomenon. At Hanging Rock the equivalent beds are unstratified; here the lines of separation are obscure and resemble fracture lines or joint seams. These fracture lines preserve a rough parallelism, and are generally referred to as lines of stratification. If a shale or clay parting between the so-called strata is essential to true stratification, the picket rocks of Wabash County are not stratified; and it is scarcely conceivable that in true stratification they should not occasionally occur. In explanation, it is proper to say that it is not here claimed that there can not be stratification without clay or shale partings.

The parting may be "dry"—that is, without either clay or shale between the layers—but in every case of true stratification there is a peculiar changed appearance of the surface of the bedding, and the internal structure of the stratum shows chert or color bands that readily indicate that the stone under observation may be classed with the stratified rocks. It is not so with the picket rocks; the lines of separation seen in them show no surface changes on the bedding. They are devoid of regular, parallel bands of chert, color, or altered internal structure. Whatever internal changes they may show indicate that the mass has been disturbed.

The quarry stone is not exposed near by, but is replaced by the picket rocks, which cap the cone on a level with the top of the bluff. The laminated shale occurs at both ends of the exposure, and at the south end passes into the cement shale.

The very remarkable exposure at the north end of the Cincinnati, Wabash & Michigan Railway, in Wabash, may be considered as not only typical of the formation in the county, but also of the Wabash Valley from Delphi to Huntington. This exposure is four hundred feet long and thirty-five feet high. The dip on the so-called lines of stratification varies from forty-five to sixty degrees and covers all points of the compass. It has so much the appearance of being the results of an upheaval as to attract the attention of the most careless observer. The cone rises to a level with the uplands, and presents a gray, stony surface down to the railroad track that forms a conspicuous landmark when seen from the bluffs and approaches to the city south of the river. The base of the cone below the outcrop is covered with soil and gravel. The magnificent exposure of equivalent stone on the south side of the river near the wooden wagon bridge is confined to the same level in the top of the bluff, and seems to rest on the cement rock. The hydraulic limestone in horizontal strata is well exposed in heavy beds a short distance east on Treaty Creek, and is imperfectly exposed at a short distance west, at the south end of the iron bridge.

The lines of separation between the strata of the Wabash Cones are so far removed from true stratification as to show that they are due to some other cause than sedimentary segregation. They seem to be due to the same causes which have produced one form of cleavage structure, and hereafter they will be referred to as cleavage planes.

The bedding of the cones at Wabash is very remarkable for its compound character, and the rapidity with which the planes of cleavage change. A general rule governs and keeps the plane within certain bounds so that they are never at right angles. Looking up the long axis of the cone from the west end, the surface of the exposure is seen to rise and fall like waves. Standing in front where the exterior layers have been removed, so as to get a cross section of the waves, it is seen that the undulating appearance is due to the thinning and thickening of the strata, and to intercallated lenticular shaped masses of stone. One mass was seen that measured five feet through the short and fifteen feet through the long axis. Vertical and diagonal seams occur, but should not be confounded with the cleavage lines, which they somewhat resemble. Where vertical seams occur they are closed and never show faults or other evidence of a sliding movement. Where they occur the stone is broken into angular fragments that complicate and appear to contradict the general law mentioned as governing the irregular cleavage planes. The vertical seams in the cones at Wabash, and across the river, may be readily distinguished from the cleavage lines by the scratched or furrowed structure which shows on the cleavage surface and not on the other. This furrowed appearance is confined to the interior layers, and is shown in both outcrops here by the removal of a part of the cones—in the one place to give room for the railroad tracks, and in the other for making lime. That the cone on the Salamonie River, and below Lagro, may show the same internal structure is very probable, but if the theory of their origin, to be explained further on, is correct, it should not show on the outside layers. Closely examined, the cleavage planes appear as if covered with columnar furrows and slight ridges. In general appearance the furrows are identical with the columnar structure of the suture joints, or crow feet of the quarrymen, found between and at right angles to the horizontal stratification of the Niagara and St. Louis Group limestone. Elsewhere than in the picket rocks the columnar structure only shows when the stone is broken at an angle to the bedding. Here its long axis is parallel to the seam and is plainly visible on the cleavage surface which it covers, except when it is obscured by a deposit of calcite. These furrows and ridges are longer than those commonly seen in suture joints, and measure from one to four inches in length by from one-sixteenth to one-half an inch in diameter. The interior of the picket rocks also frequently disclose the form common to the Niagara Group stone, and this interior structure should not be mistaken for that confined and peculiar to the surface. The columnar structure on the exterior of the stratum reminds one very much of the surface of a colony of Favosites, and that of the interior resembles a short, longitudinal section of coarse wood fibre. In addition to the greater size of the surface furrows and ridges, they have a peculiar cone-in-cone appearance that is due to faint corrugation lines that cross the sides of the furrows at an angle. The corrugations have corresponding internal conical diaphragms with the point of the cone directed downward. Occasionally there is an air space between the diaphragms where the point of the cone does not quite reach to the bottom of the concavity below. These air spaces in part account for the spongy character of the stone. Specimens of stone taken from the top of the Wabash Cone, where the Cincinnati, Wabash & Michigan Railway Company were quarrying and crushing it for railroad ballast, show that its internal structure is not homogeneous. It more nearly resembles a hard, solid breccia than an even textured sedimentary rock. Careful inspection shows that the fragments are made up of irregular, angular masses of buff, irregular bands of blue, and cavities lined wlth quartz crystals, all imbedded in white crystalline limestone. Occasionally thin scales of blue shale were found between the bands of buff and blue limestone, and on the top of the distorted internal columnar structure. The stone appears as if it were the result of an imperfect mixing of the different strata of the adjoining quarry rocks while they were yet plastic, with the addition of crystalline matter. The quarry stone and the top of the exposure are on the same level, and both formations occupying the same geological horizon is very suggestive as to the origin of the materials of a portion of the cones. These, and other picket rock exposures are described as cones, but the reader will bear in mind that the term is not used to indicate an isolated hill of stone. The cone north of the river at Wabash rises slightly above the laminated shale because the quarry stone in its immediate vicinity has been eroded away by the forces which have excavated the Wabash Valley, but were powerless to reduce the adamantine picket rocks. The cone south of the river does not rise above the top of the bluff, and viewed at a distance looks like a great mass of smooth, dark stone set in a high earth and gravel bank. It is only when the observer approaches near and examines the dip in front and on the sides of the exposure that he discovers the true form of the outcrop.

SECTION ON WILLIAM P. STANFFER'S FARM.

*One and one-half miles west of South Wabash.*

| | |
|---|---|
| Soil | 3 feet. |
| Hard gray picket rock obscurely bedded, dip ten degrees west, in only one direction | 40 feet. |
| Covered slope (shale?) | 20 feet. |
| Total | 63 feet. |

This exposure is in the bluff that forms the south wall of the first terrace one-fourth of a mile back from the river. The massive wall of the outcrop rises in a sheer precipice forty feet high by one thousand feet in length. Its dark and frowning front, covered with gray lichens, look as if only eternity could reduce it to dust. The cleavage lines are obscure, closely resembling ordinary fracture seams and might be classed as such if they all did not have the same general dip. Passing west along the bluff, the dip of the massive stone at the lower end is seen to change from ten degrees, and gradually become horizontal, the lithological character of the formation at the same time changing, first into even bedded buff limestone and this last passing into thin bedded cherty quarry stone,

One-eighth of a mile west of the last section the following section was made on the farm of John Ridenhour:

SECTION AT SHANTY FALLS.

| | | |
|---|---|---|
| Soil | 1 ft. | 0 in. |
| Thin bedded, cherty quarry stone, weathered into large cavities | 35 ft. | 0 in. |
| Heavy bedded, gray limestone | 1 ft. | 6 in. |
| Heavy bedded, gray limestone | | 10 in. |
| Heavy bedded, gray limestone | | 10 in. |
| Gray laminated shale | 20 ft. | 0 in. |
| Total | 59 ft. | 2 in |

In the ravine at this place there is a picturesque fall of twenty-two feet formed by the little stream having cut through the cherty layers until the thicker strata are reached overlying the shale.

The picket rocks of the Stanffer section are striking examples of the absence of all evidence that they are the result of an upheaval. The horizontal and vertical extent of the exposure, together with the uniformity of the slight dip in one direction only, and the gradual transition into typical quarry stone point to some other theory of their origin. On the other hand the absence of true stratification and the structure of the stone are so characteristic as to leave no doubt as to their classification. The two sections taken together seem to indicate that the materials of both are of a common sedimentary origin and that the picket rocks are nothing more than modified quarry stone. The top of the quarry stone at Shanty Falls is slightly lower than the top of the picket rocks, and the same is true of the two formations on Lagro Creek and at Rockyway Falls. At Hanging Rock the latter formation does not show cleavage lines, here they are obscure, and at Rockyway they very nearly approach stratification.

SECTION ON ROCKYWAY CREEK.

*Two hundred feet below Rockyway Falls, N. E. Qr. Sec.* 19, *Town.* 27, *Range* 8, *East.*

| | |
|---|---|
| Thin bedded, nearly horizontal, quarry stone made up of 60 strata ranging from one to four inches thick, with shale and clay partings | 12 ft. |
| Underlying hard, blue shale, not measured | |
| Total | 12 ft. |

At the falls the dip is 38 degrees north, 20 degrees east; twenty feet below the dip is 8 degrees, and one hundred and fifty feet below it is 14 degrees. Following up the creek from the point at which the section was taken, the banks are precipitous walls of stone until the falls are reached. The ascent over the falls is not abrupt, but follows the dip of the cleavage. From here to the road the edges of the layers present to the surface and cross the stream at right angles. If the reader will imagine a channel one thousand feet long, twenty feet wide and twelve feet deep filled with broad sheets of stone ranging from four to eight inches in thickness placed at an angle of 38 degrees, the edges of the layers pointing up stream, he can form an imperfect idea of the appearance of the creek bed above the falls. The general statement that the dip is 38 degrees north of the falls is true as to the upper two-thirds, but the lower third becomes more nearly horizontal by a gentle curve in the layers that is clearly shown in the side wall of the channel. Here, again, the gradual change from picket rock to quarry stone is very readily traced, and scarcely leaves a doubt as to their being of the same geological age. Examined above the falls where the upturned edges of the stones are prominent, the cleavage seams are found to be enlarged by erosion, and seem to indicate true stratification; but that it is picket rock is evident from its external appearance alone. Add to this the internal structure and the absence of shale parting and it amounts to a demonstration. The Rockyway Section also shows by the fossil remains found in it, that the formation above and below the falls belong to equivalent beds of stone. On the farm of Mrs Thomas, one-half mile south of the falls, the extension of the picket rock beds was found in digging a well at the depth of forty feet. Supposing these exposures to be continuous, and the result of an upheaval, would make the Niagara Group stone here 1,859 feet thick after making due allowance for the dip, nearly double the recorded vertical extent of these rocks anywhere in the State.

The Narrows or Black Pool, one mile south of Lagro and Township Line Pike, is an exposure of picket rocks similar in dip and cleavage to that of Rockyway Falls. Having referred to the cañon-like defile which cuts the face of the bluff, it is called the Narrows; having reference to the dark basin of water at the foot of the Narrows under the toppling rocks, it is known as the Black Pool. Hidden away from the highway in a dense forest, as it is, the traveler would never suspect the existence of a place of such romantic and geological interest. The little rivulet that runs from the pool down to the road passes over twenty feet of hydraulic limestone and cement shale. The rock overhanging the pool and mouth of the Narrows is twenty feet high, very massive and obscurely divided into huge blocks by cleavage lines which dip down the rivulet at an angle of thirty-five degrees. The defile is one hundred and fifty feet long, at first narrow and shallow until it is about eight feet wide and the walls more than twelve feet high. Its course is crooked, some of the bends being nearly at right angles, and it has a fall of twenty-five feet from the top of the bluff to the foot of the Narrows. In its upper course the dip increases to forty-five degrees, and vertical and cross seams become very numerous. The numerous seams have broken the stone into small fragments, many of them not much larger than the fist. This broken condition of the layers is in strong contrast with the massive rock at the foot of the Narrows, and is in part due to the pressure of cherty matter. Even bedded quarry stone occurs near by, at the Martin Willis quarry, and laminated shale shows abundantly in the adjacent bluffs. The obscure cleavage and massive character of the stone at the Black Pool strikingly resembles that of the equivalent beds at the Stanffer Farm and Hanging Rock. The whole of this exposure is peculiar in being the only place seen where the picket rocks show surface erosion, and a part of it is unlike any other outcrop, as the only place where the stone was broken into small fragments. Looking at this geological freak of nature, the question arises, how was it formed? The little stream which flows through the defile at the present day has not sufficient power to wash away the slime and moss that covers the floor of the channel, much less wear away the hard stone. The greatly increased dimensions near the mouth indicate that it is the result of the same forces that excavated the Wabash Valley. It is probable that the glen, of which the Black Pool and the Narrows are a part, was once a wave swept cove, and that the waves acting from below were the instruments in the hand of Nature for doing this fantastic work.

The picket rock sections described in the foregoing pages, with one exception, do not present any appreciable difference in the lithological structure of the stone, whether taken from the top or the bottom of the section. The exception was seen in the East Wabash Cone, where the quarried rock has an ochery color, and physical characters quite different from the stone at the base near the railroad tracks. The remaining picket rock sections and descriptions are introduced to illustrate these changes. One-fourth of a mile below Lagro, in the bluff on the north side of the Wabash & Erie Canal, is a well-marked cone where three divisions or grades of stone are shown in a vertical section.

### SECTION WEST OF LAGRO.

*Fossiliferous Picket Rock Limestone, the Equivalent of the Quarry.*

| | |
|---|---|
| Stone strata | 18 ft. |
| Cherty picket rock, same age as the quarry stone | 15 ft. |
| Gray picket rock limestone, weathering to buff, cleavage well marked | 17 ft. |
| Total | 50 ft. |

The measurements here given are estimated, as it was not practicable to get them accurately on the uncovered and precipitous surface of the cone. The vertical limits of the divisions are not well defined, and so gradual are the changes from the one to the other that no two observers are likely to make the thickness of each the same. At the east end of the section the blue cement stone passes into gray stratified limestone and the stratified material is built up by compound bedding until it stands at an angle of thirty to forty degrees. At the west end the slope is particularly covered with earth, but the shale shows half way up the side. Here, and at the J. D. Shultz Cone, on the Salamonie River, the cones are well defined, and look as if they had been first built and the remainder of the bluff deposited around them on three sides leaving the river front bare. The horizontal transition of quarry stone into picket rock has already been shown, and it is not difficult to grasp the idea of a chemical change so far modifying the former as to give it the character of the latter; but to conceive that cement shale has been transformed into picket rock is not such an easy matter. The fossiliferous and cherty divisions of the last section are undoubtedly of the same geological horizon as the quarry stone, and it is equally certain that the lower seventeen feet has been derived from the adjacent shale. The best example of the modified lower picket rock limestone was seen south of the Wabash River, in the Watson Briggs Ravine, about one mile west of Lagro.

SECTION AT THE WATSON BRIGGS RAVINE.

*Upper Section of Reservation No.* 14.

| | |
|---|---|
| Hard, crystalline picket rock | 10 ft. |
| Transition limestone | 5 ft. |
| Cement shale | 10 ft. |
| Total | 25 ft. |

No single section can give the variable thickness of the divisions, and the whole exposure is peculiar in being the only one in which the cleavage lines are in opposite directions from the center. At all other points the cleavage has been found running all in one plane or in every direction from a common center or oblong cone. The ravine cuts a channel forty feet wide in the bluff nearly down to a level with the river terrace. Near the mouth of the ravine its banks are very steep and rocky. On the west side the wall for three hundred feet is made up of picket rock that forms an arch over a central cone of cement shale. The arch appears as if it was formed by removing one-half of a cone, and this may have been the case, but does not seem probable, as the wall on the opposite side of the narrow ravine, narrow when compared with the length of the arch, is composed of irregularly bedded hydraulic limestone dipping twenty degrees south, the cement shale overlying the even bedded, horizontal quarry limestone. The ends of the arch are about twenty-five feet thick where it dips down to the bottom of the ravine and passes under the surface. Taken on the cleavage lines at the ends the dip is at first twenty degrees, then twelve degrees, and gradually less until the planes are horizontal over the center where the section was made. The middle division of the section overlying the central cone of cement shale is five feet thick and presents a hard, dark-weathered surface and a dark gray, homogeneous, noncrystalline interior. This stone is a fairly pure limestone and is used by the Lagro Cement and Manufacturing Co. for mixing with the cement rock to increase the quantity of the quick-lime in the finished product.

By taking a boat above the dam near the mouth of the Salamonie and rowing up stream a beautiful exposure of the hydraulic limestone is seen in the west bank of the river. For half a mile the stone rises in a perpendicular wall from ten to fifteen feet high that forms the base of the high bluff. As a general rule the bedding is even, with an occasional stratum which thins out or grows thicker on long lines. Vertical fractures are not numerous and are all closed seams. On the east side of the river, a short distance above, where the hydraulic stone passes under the slope, is a cone which rises from below the water's edge to the top of the bluff. Its exact height was not measured, as neither of us cared to risk a fall into the water, but it is estimated to be about fifty feet. It is proposed that this exposure of picket rock shall be known as the J. D. Shultz Cone, in honor of Rev. J. D. Shultz, of Lagro, who took us to this and many other points of great interest, which, without his intelligent guidance, we probably would not have seen. In passing up the river between the high bluffs, if the voyager expects to see a mass of rock standing out from the bank in bold relief, as the name would seem to indicate, he will be disappointed. The dip of the river front of the cone is parallel with the slope of the bluff at an estimated angle of sixty degrees. At each end of the outcrop the dip is north and south at the same high angle. The south side of the cone has irregularly bedded cement rock resting unconformably against it, which farther up the stream becomes horizontal and gradually passes into laminated shale. A portion of the river front at the south side does not come quite to the water's edge and is deeply undermined, indicating that this part of the cone once rested on shale which has been eroded away by the river. In this outcrop and the one below Lagro, the high angle cleavage planes come nearly down to a level with the hydraulic limestone which is seen in force near by in the river banks. But it is especially interesting to note that here the lower member of the cone, just above the water, is the exact counterpart of the transition stone seen at the Briggs Ravine and at the Lagro Cone. These exposures were the only ones of considerable vertical extent which were seen whose formations are laid in the cement shale or hydraulic limestone, and which clearly exhibit the modified lower members of the cone passing into shale.

In concluding the section on general geology the following extracts from other observers who have written on the geology of the Wabash Valley are introduced for the purpose of corroborating and completing the descriptions already given of equivalent formations in the county.

A very interesting outcrop of picket rocks in the railroad cut, one-half mile east of Rich Valley, is described in Indiana Geological Survey, 1859–60, page 68, by the late State Geologist, Prof. Richard Owen. He says: "Entering at the west end we find beds inclined to the west at an angle of 45°; approaching the center, an anticlinal axis partakes rather of the character of curved or folded strata, with huge masses of the purest crystalline calcite, partially covered by a crust of tufa. This is doubtless derived by infiltration from the calcareous matter of the superincumbent Drift, as somewhat farther east we encounter gravel, sometimes consolidated by this cement into a hard conglomerate, resting now on beds that occupy the railroad level, although at the center of the cut these strata were nearly thirty feet over our heads. Beneath this bed we discern chert, sometimes pure and detached, sometimes apparently the result of silicious filtration into the cavities of the limestone. Emerging from this remarkable section at the eastern end, we find shales with an easterly dip at the rate of about 25°."

The present State Geologist, Prof. S. S. Gorby, in the 15th Report, page 231, says: "In the vicinity of Belden, Wabash County, the limestones are tilted to a great degree, and they dip in every direction. The river at this point seems to be following the course of an anticlinal, as on the south side of the river the rocks dip east, south and west, while on the north the dip is generally north or northwest. The extent of the dip on the south side of the river is from twenty to sixty degrees, while on the north it varies from twenty to forty-five degrees. Occasional exposures are seen here also, where the rocks lie in a nearly horizontal position. There is one point, however, on the north side of the stream, a mile or so west of Belden, where the dip is to the south to the extent of about twenty-five degrees.

"Throughout this whole extent of territory, where the rocks have been exposed by the denudations of the Wabash, scarcely two closely connected points will show the strata in the same position. At one point they dip abruptly to the north, while at another, only two or three rods away, they dip strongly to the east or west. Cone-shaped masses are common. The quarries reveal them, semi-circular, with the strata dipping in every direction from the summit."

## DYNAMIC GEOLOGY.

The presence of alumina in the hydraulic limestone indicates that they were deposited from impure waters, and the absence of fossils shows that the conditions were unfavorable to animal life. The even, horizontal bedding shows they were formed at the bottom of a sea unswept by currents and tidal waves. During the time in which the cement shales were in process of formation the conditions had very materially changed. The semi-impurity of the waters continued, but the compound bedding points to the existence of currents and waves of no mean power. Standard text-books on geology teach that irregular bedding is of three kinds: beach structure, the ebb-and-flow structure, and the sand-drift structure, each having a different origin, as the names indicate. It is self-evident that none of the rocks of Wabash County are the result of a sand-drift. The very great irregularity in the thickness of the strata, which rapidly thin out on short lines of bedding, point to their origin on a sea-beach, but rendered improbable by the uniformity of their lithogical structure. Dana's Manual of Geology, page 93, in describing the ebb-and-flow structure, says: "The bed, although it be but a few feet thick, consists of layers of various kinds, some of which are horizontally laminated and others obliquely so, with great regularity. The successions of members indicate frequent changes or reversals in the currents during the deposition. Such changes attend the ebb and flow of the tides or tidal currents or waves over a shallow bottom." And it is doubtless largely to such conditions as these the compound bedding of the cement shale and amorphous cement rock is due. Overlying the cement shales come the laminated shales and quarry stone beds, which are approximately level, indicating that the sea had again become quiet. The water, however, was charged with clayey matter while the laminated shales were being deposited, and the frequency of shaley partings between the quarry stone strata show that the sea was still at times muddy, but not to such an extent as to destroy animal life.

While the uneven surface left by the compoundly bedded cement rock was the foundation and primary cause of subsequent irregularities, the subsequent irregular bedding was not alone due to currents and tidal waves. The presumption that all strata formed at the bottom of a quiet sea must originally have been level was disproved by a very remarkable section exposed in the south side of the James Lambert quarry in South Wabash. Here was seen a plano-convex mass of shale seven inches thick in the middle, and six feet long, intercalated between the quarry stone layers. Below the mass several strata of even bedded, horizontal stone were exposed, while the strata above passed over the shale as if they had been separated when plastic and the shaley mass inserted between the layers. The overlying strata were about an inch thick, with an east and west dip, on the sloping sides, of twelve and sixteen degrees. The curved strata did not show fracture lines or sensible evidence of thinning on the anticlinals. This illustration of the origin of a tilted structure, however, is seldom applicable to the quarry stone of Wabash County, which was generally deposited on a level surface, but explains many of the irregularities seen in the equivalent beds at Huntington. It explains the formation of the synclinals in the Hippskind quarry, east of Wabash and at Hanging Rock, and the anticlinal in one of the quarries near the mouth of Charley Creek

While the greater part of the quarry stone of Wabash County was deposited on a level plane, formed by the laminated shale filling up the uneven superior surface of the cement rocks, there are marked departures from this rule where the laminated shale is absent, as at the Todd farm, on Lagro Creek; at the Martin Willis quarry, and at the quarry of Leonard Hyman, on the Mississinewa River, where the lower part of the formation is below the common level of the under surface of the quarry stone. At the Stauffer farm and the William Moelering quarry the bluffs have nearly the same relative height above the river as at South Wabash, and show thirty-five feet of quarry stone against less than twenty feet at the latter place. The reasons have already been given for believing that the top of these sections are of the same geological age, and represent the close of the Niagara Period. That the top of the country rocks should present an uneven surface, diversified by hills and valleys, is accepted by every one as a matter of course, without reflecting that the contour of the under surface of the formation may be nearly as irregular. It has been suggested that the origin of these anomalous irregularities may be accounted for by the theory that the quarry has been deposited in a trough or valley in the laminated shale. Any other theory would make the shale of the same, or of a subsequent geological age to the quarry stone. It seems probable that while the sediment which forms the laminated shale was falling from the sea generally over the uneven surface left by the ebb-and-flow period of the cement rock there were places still swept by currents, which carried away the sediment and produced valleys that were subsequently filled with quarry stone.

The unequal shrinkage because of the unequal density of the shales during the process of lithification was another factor in the distortion of the quarry stone beds and the picket rocks. It has already been shown that the laminated shale does not occur uniformly under the quarry stone, but is frequently replaced by cement rock, and it is easy to understand, where the one form of shale passes into the other, how the greater shrinkage of the one will cause the overlying rocks to dip, and perhaps otherwise disturb the strata.

Compound bedding, conformation to irregular surfaces, and unequal shrinkage, either alone or in combination, are sufficient to explain the variations of the dip in true stratification, but fail to account for the phenomenon where it exceeds twenty-five degrees. Some other theory must be applied to the rocks in which a high angle dip is the most obvious feature.

The generally accepted theory of the origin of the picket rocks is that they are the result of an upheaval, and the supposed upheaval is regarded as a satisfactory explanation of the related phenomena. The tilted condition of the stone, and the presence of laminated shale apparently resting unconformably against the sides of the cones are the strong points in favor of the theory. And it is granted that the unconformability of the two formations is a very strong argument and might be accepted as conclusive were there not exposures where the underlying rocks can be seen and studied. Such exposures are not infrequent, and show stone of the same geological age and identical in structure with that of the Wabash Cone resting on cement shale and hydraulic limestone, which have not been disturbed since they were deposited on the bottow of the ocean. The origin of the Dora Cone, those in the vicinity of Lagro, and the picket rocks generally, must be accounted for in some other way. Without appealing to the testimony of the underlying rocks, there are other facts in the geological history of the Wabash County Cones, and of the whole State, so far as seen by us, which render the application of the accepted theory very doubtful. It has been shown that the top of the picket rocks are of the same geological horizon as the quarry stone, never higher or lower, and it is difficult to understand how a subterranean force acting over many miles of territory and through thousands of feet of stone could have been graduated in power, and so timed, as to form cones not exceeding a few hundred feet in extent, all reaching in altitude the close of the same geological period and nearly the same geodetic level. No such uniformity and limited results have been recorded of mountain ranges. Gas explosions as factors in the supposed upheavals are excluded because of their erratic effects. The argument here presented is only applicable to the isolated exposures of picket rocks, and is not in any way intended to apply to the question as to the existence of the Wabash Arch described in the Fifteenth and Sixteenth Indiana Geological Reports. It can be readily understood how long stretches of coast line were gradually elevated, or how a broad axis like the Cincinnati Arch may have been formed. But it is another matter to apply the same slow processes or broad movement to the growth of the Wabash County Cones, where the vertical movement has been confined to inches over an area measuring a few feet in diameter. That the vertical movement is confined to inches has been demonstrated by showing that the materials composing the picket rocks have been derived from the adjacent and equivalent stratified stone. Careful examination will convince any one of the truth of the last statement, and it is not necessary to add anything more in the way of confirmation.

In many places the unconformability of the strata is more apparent than real. At the Todd Farm Section the unconformability is real, and due to the deposition of the quarry stone in a depression in an older formation, but is not equal to a fault in the sense that one stratum or formation has been forced past the other. There is unconformability at the Wabash Cone, and in many other places, in the sense that one formation does not pass into the other on the same horizon, and a real fault to the extent of a few inches. By the term "fault" it is here meant that the materials which have been transformed into picket rocks have been slightly displaced from their primary place in the bedding. In a rough way the picket rock cones and other exposures bear the same relation to the Niagara Period rocks, taken as a whole, as a mass of chert does to the stratum in which it is imbedded. The internal structure of the mass lies unconformably to the stratification bands of the stratum, and, if in the process of lithification the mass has been displaced by shrinkage or otherwise, a slight fault will be produced. And in a still rougher way the chemical processes which have resulted in chert are the counterpart of the changes that have transformed the quarry stone and laminated shale into picket rock. The infiltrated calcite described by Professor Richard Owen as occurring at the Rich Valley Cone seems to furnish a clew to the chemical processes involved long before the date assigned by him, but does not help to elucidate the related phenomena or explain how the changes were initiated.

It is well known to collectors that fossils may be either calcareous or silicious, as the chemical composition of the matrix is slightly varied. Under certain conditions a fossil may determine the shape of a silicious geode a thousand times larger than the mould on which it is built, or the fossil may furnish the starting point around which a large concretion has grown and the fossil still retain its original form. And while our knowledge of the processes by which the sedimentary products of the ocean have been converted into stone is imperfect, enough is known to warrant the conclusion that by chemical action certain isolated patches of stone in Wabash County have become more highly calcareous than the surrounding strata, and that a break or disturbance of the strata was the nucleus from which the chemical changes spread. The first effect of the disturbance was to re-expose the broken strata to the action of the water of the ocean and initiate chemical changes which obliterated the stratification of the limestone and shale beds and rendered the amorphous mass more highly calcareous. While the chemical changes were in progress, cleavage lines were formed which cut the original bedding at a high angle.

No matter what the disturbing element may have been, whether an upheaval or something else, the supposed stages of lithification were necessary to account for the final product. The changes must have occurred while the material was still plastic, as a disturbance at a later date would have resulted only in masses of broken rock and shale, identical in structure with that now found in the undisturbed strata. This theory is corroborated, notwithstanding the brecciated form of the stone, by the bent and tortuous course of the color lines in the top members of the Wabash Cone, and the bands of the buff and blue show that the strata had sufficient consistency, before the disturbance, to preserve the characteristic colors of the quarry stone. It is possible the theory here presented may be made clearer by applying it to the life history of the Wabash Cone. At the close of the Niagara Epoch all the sedimentary deposits which now form the various grades of Niagara limestone and shale were in place. The stratified material of the hydraulic limestone beds, the lowest and oldest of the series exposed in the county, was probably of much its present degree of hardness on the same level that is shown by the outcrops above the mill on Treaty Creek and near the south end of the iron wagon bridge. On the hydraulic limestone rested the cement rock thrown into cones, ridges and slight valleys by irregular and compound bedding. The surface irregularities of the cement rocks were generally, but not wholly, filled up by the superimposed laminated shale, and over all came an unbroken sheet of quarry stone of uniform structure throughout. Because of the absence of the laminated shale on the higher cement rock cones and ridges, the foundation of the quarry stone was of unequal density, and it was at the points where the cement rock came in contact with the overlying quarry stone that the strata were afterward transformed into picket rocks from Huntington to Delphi, and perhaps further west. The central core of the Wabash Cone rested on one of these hard cement rock cones, surrounded on all sides by the less dense laminated shale, like the cones and other exposures in the vicinity of Lagro. After the process of lithification was sufficiently advanced to give the characteristic color to the quarry stone beds, the equilibrium of the mass was disturbed by the unequal shrinkage of the shales under the cone and surrounding it. That the shrinkage was greater in the laminated shale seems evident from the dip of the quarry stone strata falling away from the cones on the slightly lower level of the laminated shale.

It has already been pointed out that the picket rock lines of separation partake of the characters of both joint and cleavage planes. As to their origin Prof. James D. Dana says: "Joints are due to the same cause as slaty cleavage and may occur in slaty as well as other rocks." But it should be borne in mind that the layers of the picket rock formation differ from slaty cleavage in not being susceptible of further subdivision on the same plane. On this subject Sir Archibald Geikie in his text-book on Geology, second edition, pages 289-90, says: "More recently (1884) Fisher has proposed the view that in nature it is not to the pressure which plicated the rocks that cleavage is to be attributed, but to the shearing movement generated in large masses of rock left in a position too lofty for equilibrium. If such, however, had been the origin of the structure it is difficult to understand why there should be such prevalent relation between the strike and the cleavage, for if descent by gravitation were the main cause we should expect to find the rocks sheared far more irregularly than even the most irregular disposition of cleavage. That in cleavage, then, has been true shear of the rocks is indubitable; and the amount of shear may be ascertained by the extent of the distortion of fossils in the planes of cleavage." The unstable equilibrium of the mass of stone on the cement rock cones and ridges exactly fill the conditions required by Mr. Fisher's theory, and notwithstanding the objections urged against it seems to be a satisfactory solution of the problem. It can be readily understood how the direction of the cleavage has been determined by the shape of the internal core of the cone or ridge, and "why there should be such prevalent relation between the strike and the cleavage." The "irregular disposition of cleavage" seems to be exactly what Prof. Geikie would have expected the results to have been from the shear movement theory. No "distortion of fossils" show the "amount of shear," but the "cone-in-cone" structure probably does indicate it, and it is measured by the length of the columnar marking on the cleavage plane. At the Wabash Cone the shear has appearently not been more than four inches, quite enough to disturb the mass of stone and continue the chemical action which obliterated the original partings between the strata. The cleavage planes once started in the top member of the exposure, by unequal stress on the strata, would be continued downward at the same angle through the limestone and shale beds, the shear movement gradually diminishing until the equilibrium was again restored. The equilibrium would be restored on the level in which the density of the strata became uniform on a horizontal plane, and hence the downward changes have been frequently arrested above and never reach below the top of the hydraulic limestone beds.

Identical movements and changes were in operation during the formation of the cone south of Wabash, where the columnar structure of the stone is apparent; and it is probable that similar causes were active at the Lagro and Shultz cones, which, if opened to view, as the former have been, would reveal the same internal results of the shear movement. At Rockyway Falls quite an amount of quarrying has been done, but it does not show the columnar structure or other marked evidence of shear. Here, at the Narrows, the Watson Briggs Ravine, the Stanffer Farm, and at many other places the movement was very much limited, but was sufficient to account for the chemical changes and cleavage. In these outcrops the laminated shale only occurs on one side of the exposure and the direction of the movement is indicated by the cleavage.

### LOCAL DETAILS.

Just north of the Wabash Railroad, between Charley Creek and Thorn Street in Wabash City, is an exposure of picket rock that is about seven hundred feet long and rises from ten to fifteen feet above the level of the railroad track. Approached from the north the outcrop presents a gentle swell across the creek bottom, with stone sticking here and there above the surface. The railroad front is more abrupt, but is generally covered with soil. In color, obscure cleavage, crystalline structure and fossiliferous remains, it closely resembles the equivalent stone at Hanging Rock. Less than three hundred feet west of where the picket rocks are seen in the angle formed by the railroad and the east bank of Charley Creek, the following sections forty feet apart were made, the first facing south and the other facing west:

SECTION ON RAILROAD NEAR CHARLEY CREEK.

| | |
|---|---|
| Slope | 6 ft. 0 in. |
| Thin bedded, cherty limestone. | 4 ft. 0 in. |
| Buff laminated shale | 2 ft. 0 in. |
| Shale | 2 ft. 0 in. |
| Thin bedded cherty limestone | 1 ft. 3 in. |
| Total | 15 ft. 3 in. |

SECTION ON CHARLEY CREEK.

| | |
|---|---|
| Cherty limestone. | 5 ft. 0 in. |
| Thin bedded, shaley limestone. | 6 ft. 0 in. |
| Buff, heavy bedded, quarry stone, evenly stratified | 3 ft. 0 in. |
| Heavy bedded, irregularly stratified, blue hydraulic limestone | 1 ft. 9 in. |
| To bed of creek | 14 ft. 0 in. |
| Total | 29 ft. 9 in. |

These sections show with what rapidity the character of the stone changes in the vicinity of the picket rocks, and the irregular bedding and hydraulic stone indicate the kind of stratification and stone likely to be found under them. The floor of the quarry is crossed by an anticlinal swell or hummock, which seems to be the west end of a ridge that increases in force, and extends east parallel with the center of the picket rock exposure. The laminated shale shows in the east bank of the creek near the quarry, and gradually passes beneath the channel as the creek bed rises toward the table-lands back of the river.

Across Charley Creek, west of the last section, the following measurements were made:

SECTION WEST OF CHARLEY CREEK.

| | |
|---|---|
| Soil | 1 ft. 6 in. |
| Thin bedded limestone | 5 ft. 0 in. |
| Shale | 2 ft. 0 in. |
| Thin bedded flag | 1 ft. 5 in. |
| Shale | 2 ft. 0 in. |
| Total | 11 ft. 11 in. |

SECTION AT THE WEST END OF THE BRIDGE OVER CHARLEY CREEK.

| | |
|---|---|
| Thin, irregularly bedded quarry stone, somewhat cherty, lower strata, fair flagging | 10 feet. |
| Buff laminated shale | 18 feet. |
| Total | 28 feet. |

All the quarry stone strata of the Charley Creek quarries are thin, the best beds yielding fair flagging, subfoundation stone and rubble. It will be noticed at the bridge section, and in passing up the creek that the intercallated shale strata disappear, and the texture of the stone becomes more uniform.

East of Wabash in the triangle formed by the Wabash Railroad crossing the track of the Cincinnati, Wabash & Michigan Railway, where the former road cuts through the quarry stone strata, and into the laminated shale beds, the following section was made on the north side of the cut:

QUARRY EAST OF WABASH.

| | | |
|---|---|---|
| Soil | 1 ft. | 6 in. |
| Thin bedded limestone | 1 ft. | 0 in. |
| Thin cherty limestone | 1 ft. | 6 in. |
| Flagging from one to three inches thick | 1 ft. | 5 in. |
| Laminated shale to level of railroad track | 12 ft. | 0 in. |
| Total | 17 ft. | 5 in. |

Quite an amount of work has been done in this quarry, and as the strata are thin, the product is handled without derricks. The high banks of the cut furnish very favorable facilities for loading the output on the cars.

Farther east, and more nearly on the line of the Cincinnati, Wabash & Michigan Railway than the last section, is the

PHILLIP HIPPSKIND QUARRY.

| | |
|---|---|
| Soil | 6 feet. |
| Buff, irregularly bedded quarry stone, strata from four to eight inches thick | 8 feet |
| Total | 14 feet. |

This quarry is connected with the main line of the C., W. & M. Railway by a switch and is easily worked. The thicker strata furnish fair building stone that finds a ready market for local use. In the vicinity of these quarries the denuding forces which have formed the Wabash Valley have removed nearly all the upper cherty members of the quarry stone beds, and hence the quarrymen have but little stripping to do to get at the lower eight or ten feet of good stone.

DAVID RIDGEWAY'S QUARRY, SOUTH WABASH.

| | | |
|---|---|---|
| Soil and slope | 4 ft. | 0 in. |
| Stratified cherty limestone | | 6 in. |
| Cherty limestone | 1 ft. | 0 in. |
| Thin bedded, cherty limestone | 5 ft. | 7 in. |
| Shale | | 3 in. |
| Shale and limestone | 1 ft. | 0 in. |
| Even bedded flagging | 2 ft. | 8 in. |
| Total | 15 ft. | 0 in. |

This quarry is located in the top of the river bluff, at the south end of the iron wagon bridge, sixty feet above low water. Here and elsewhere in South Wabash the chert is found in nodules and narrow, thin plates in the center of a limestone stratum, or in thin layers held together by a slight matrix of limestone. By the occurrence of a thicker stratum of shale than that usually seen between the strata, the thin layers are collected into groups on the face of the exposure. These groups are used in making the subdivisions of the sections, and the first one in this quarry is represented by the six inches of stratified cherty limestone. The beds containing a large per cent. of chert are worthless, and increase the expense of stripping down to the merchantable stone. Vertical seams occur thirty feet apart and run west, ten degrees south, and at right angles. The bedding of the shale underlying the section is very irregular, with the dip at all angles, from nothing up to seventy degrees, and in all directions. It is probable that in part the irregularity has been increased by the displacement of the strata from their original plane in the bluff. Some of the top shale are very earthy and friable. Near the level of the bridge the bedding becomes regular and assumes the character of hydraulic limestone.

SCHOULER HAFF'S QUARRY.

*West End of South Wabash.*

| | | |
|---|---|---|
| Soil | | |
| Cherty limestone in thin even bedded strata, top of the quarry stone formation | 6 ft. | 0 in. |
| Even bedded limestone | 1 ft. | 0 in. |
| Chert | | 1 in. |
| Thin flagging | 4 ft. | 0 in. |
| Chert | | 2 in. |
| Flagging | 2 ft. | 0 in. |
| Chert | | 1 in. |
| Flagging | 1 ft. | 8 in. |
| Chert | | 1 in. |
| Flagging and dimension stone | 4 ft. | 0 in. |
| Total | 19 ft. | 1 in. |

There is a number of other quarries besides those of Thomas Bridges, David Ridgway, Schouler Haff and Jacob Lambert, but none of them have been worked sufficiently to show the whole of the formation down to the laminated shale. All over South Wabash, on back lots and down crooked alleys, are piles of thin flagging taken from the surface. On the main street of the town was seen a front yard from which the owner had removed a quantity of stone and left his residence high and dry. As there is very little stripping to be done in developing one of these surface quarries, they can be worked at a good profit when there is a demand for light stone. As an evidence of ease and profit at which these quarries can be worked, it is told that the contractor who laid the foundation of the Presbyterian Church in Wabash City realized enough from the stone sold from the building site to pay his bill.

The South Wabash flagging, when carefully quarried, comes up in large pieces that have a beautiful smooth surface. The mode of quarrying varies with the use to which the product is to be applied. Where it is wanted for rubble and wall work light blasts are put in a few inches back from the face of the exposure and the front loosened, but not thrown down. Blasts are not admissable in a flagging quarry, but as the bedding is very loose the stones are easily removed and readily cut to the required dimensions. Vertical seams obviate the use of a channeler and keep the face of the wall perpendicular.

To the unaided eye the strata in these quarries appear to be horizontal, but when tested with the clinometer show a slight dip to the southwest. The vertical seams of the quarry stone in the vicinity of Wabash all have much the same characters, and generally cross the bedding at nearly right angles. In no case where removed from the edge of the bluffs do they show evidence that they have very great vertical range or are the result of upheaval. In South Wabash no evidence was seen to indicate that the same penetrate the laminated shale.

### WILLIAM MOUELERING'S QUARRY.

*Section* 17, *Township* 27, *Range* 5, *East.*

| | |
|---|---|
| Soil | 1 ft. 6 in. |
| Thin bedded, gray, cherty limestone | 1 ft. 3 in. |
| Clay parting | 2 in. |
| Thin bedded, cherty, gray limestone | 4 ft. 6 in. |
| Thin bedded, gray, good quarrystone | 4 ft. 0 in. |
| Soft buff stone, splitting into shapeless masses, worthless | 1 ft. 10 in. |
| Thin gray limestone | 3 in. |
| Good buff quarry rock | 3 in. |
| Good buff quarry rock | 5 in. |
| Good buff quarry rock | 3 in. |
| Good buff quarry rock | 7 in. |
| Good buff quarry rock | 3 in. |

| | | |
|---|---|---|
| Good buft quarry rock | | 5 in. |
| Good buff quarry rock | | 4 in. |
| Good buff quarry rock | | 6 in. |
| Good buff quarry rock | | 10 in. |
| Heavy bedded buff quarry stone. | 1 ft. | 4 in. |
| Heavy bedded buff quarry stone. | 1 ft. | 2 in. |
| Heavy bedded buff quarry stone. | 1 ft. | 0 in. |
| Heavy bedded buff quarry stone. | | 7 in. |
| Heavy bedded buff quarry stone. | | 9 in. |
| Heavy bedded buff quarry stone. | 1 ft. | 2 in. |
| Shale and cement rock to the river bottom | 18 ft. | 0 in. |
| Total | 41 ft. | 4 in. |

This quarry is extensively worked, and the output all shipped to Ft. Wayne. It is connected with the main line of the Wabash Railroad by a switch, and the stone handled with derricks and other labor-saving appliances.

### SECTION NEAR THE MOUTH OF HELM'S CREEK.

*Two Miles West of Wabash.*

| | | |
|---|---|---|
| Soil | 1 ft. | 6 in. |
| Cherty limestone | 2 ft. | 8 in. |
| Thin bedded gray limestone | 1 ft. | 10 in. |
| Thin bedded buff limestone | 1 ft. | 5 in. |
| Thin bedded gray limestone | | 8 in. |
| Clay parting | | 1 in. |
| Thin bedded gray limestone | 1 ft. | 9 in. |
| Clay parting | | 1 in. |
| Thin bedded gray limestone | 1 ft. | 5 in. |
| Gray limestone | | 4 in. |
| Gray limestone | | 8 in. |
| Gray limestone | | 6 in. |
| Gray limestone | | 3 in. |
| Clay parting | | 3 in. |
| Thin bedded buff limestone, passing into buff shale | 1 ft. | 6 in. |
| Buff shale (laminated) | 6 ft. | 0 in. |
| Blue cement stone, with conchoidal fracture, to the bottom of the ravine | 22 ft. | 0 in. |
| Total | 43 ft. | 1 in. |

The lower member of this section has hydraulic properties, but to make good cement needs an addition of lime, which can be obtained by burning the thin bedded strata of the overlying quarry stone formation. It is very probable a paying industry could be established here. The land adjoins the Wabash Railroad and a spur could be run to kilns so that the product could be handled expeditiously and cheaply.

In the bluff in the north part of Rich Valley there is a mass of apparently tilted buff limestone. Passing over the bluff the stone is seen dipping to the north, and on down the road a small stream is encountered in the bottom of which the same buff material is regularly stratified in a horizontal position. Three hundred yards east of the apparently upthrust bluff, in the north part of Rich Valley, the following section was made on the farm of William Jackson:

SECTION NEAR RICH VALLEY.

| | | |
|---|---|---|
| Soil | 1 ft. | 0 in. |
| Thin cherty limestone | 8 ft. | 0 in. |
| Buff limestone | | 6 in. |
| Buff limestone | | 8 in. |
| Buff limestone | | 6 in. |
| Total | 10 ft. | 8 in. |

This stone is approximately horizontal and is a continuation of the horizontal buff stone underlying the "tilted" material in the bluff.

In a cut on the Wabash Railroad, one mile west of Rich Valley, and one-eighth of a mile east of the county line, the following section was measured:

SECTION WEST OF RICH VALLEY.

| | | |
|---|---|---|
| Soil | 1 ft. | 0 in. |
| Chert stratum | 2 ft. | 2 in. |
| Cherty limestone | 3 ft. | 0 in. |
| Shale filled with cherty concretions | 9 ft. | 0 in. |
| Total | 15 ft. | 2 in. |

A short distance south of this, in the bank of the Wabash and Erie Canal, at an abandoned quarry the same formation, but of a harder quality, outcrops, and like that of the section is useless except for macadamizing.

SECTION ON BURR CREEK.

*South Part of Reservation* 16, *Near the Reservation Line.*

| | |
|---|---|
| Slope and thin nodular shale | 6 feet. |
| Argillaceons stone in thick beds, stratification not well defined | 8 feet. |
| Shale and covered space | 3 feet. |
| Hydraulic limestone | 7 feet. |
| Total | 24 feet. |

But little work has been done at this place, not enough to clearly show the relation of strata, and the indications are not favorable that it will yield good quarry stone.

ROSS RUN QUARRY NO. 1, RESERVATION 14.

| | |
|---|---|
| Soil | 2 feet. |
| Stratified limestone, strata ranging from 1 to 8 inches thick, some of them cherty | 15 feet. |
| Blue hydraulic stone in beds from 2 to 20 inches thick, bedding uneven | 8 feet. |
| Total | 25 feet. |

In the middle member of the section fifty-nine strata were counted, making the average thickness of the layers more than three inches. Vertical seams are so numerous as to destroy the value of the stone for flagging.

ROSS RUN QUARRY No. 2.

| | | |
|---|---|---|
| Even bedded, horizontal quarry stone | 3 ft. | 0 in. |
| Shale stratum | | 5 in. |
| Thin bedded gray stone | | 4 in. |
| Fair heavy flagging | | 10 in. |
| Fair heavy flagging | | 9 in. |
| Fair heavy flagging | | 6 in. |
| Fair heavy flagging | | 7 in. |
| Covered slope to bottom of the run | 4 ft. | 0 in. |
| Total | 10 ft. | 5 in. |

This section was taken above No. 1, and about one hundred and fifty feet below the creek falls, where the quarry stone has four feet of hydraulic limestone underlying it. The top member of No. 2 is made up of fourteen layers, some of them being very cherty, while others can be used for light work. These quarries are favorably located and can be easily developed.

MARTIN WILLIS' QUARRY.

*South of Lagro, on the Township Line Pike.*

| | | |
|---|---|---|
| Soil and gravel | 5 ft. | 6 in. |
| Thin, irregularly-bedded, shaley limestone | 4 ft. | 0 in. |
| Thin-bedded buff limestone, in layers ranging from 1 to 6 inches thick, texture coarse and surface somewhat rough | 5 ft. | 4 in. |
| Total | 14 ft. | 10 in. |

This quarry has not been opened down to the underlying laminated shale, and it is probable that thicker and more valuable stone would be found were this done. At all other quarries the best quality and thickest stone has been found at the bottom of the quarry stone formation. What stone has been removed has been sold at the quarry for local use. On the east side of the quarry is a ravine running north that presents some of the characters of a glacial groove. The ravine or groove is now nearly filled with gravel, but where the stone covering the bottom has been uncovered it presents a smooth, hard surface, very different from that of the recently exposed strata. This peculiar appearance may be the result of either glacial action or of running water and exposure to atmospheric influences. The peculiar relations of the quarry stone to the laminated shale, and the evidence of a trough-like structure in this quarry, have been already described.

SECTION IN THE WEST BANK OF THE SALAMONIE RIVER.

*Below the Dam and One-Half Mile West of Hanging Rock.*

| | |
|---|---|
| Soil | 8 ft. 0 in. |
| Yellow and gray shale | 4 ft. 0 in. |
| Brown arenaceous limestone | 2 in. |
| Yellow-gray shale | 5 ft. 0 in. |
| Heavy-bedded, blue cement stone | 1 ft. 2 in. |
| Shale parting | 2 in. |
| Heavy-bedded, blue cement stone | 1 ft. 10 in. |
| Blue cement stone, with conchoidal fracture, to the water's edge | 3 ft. 0 in. |
| Total | 23 ft. 4 in. |

The stratified material here dips slightly to the north and seems to occupy the same relative position as the hydraulic limestone seen under Hanging Rock at the north end of the wagon bridge over the Wabash at Lagro, above the dam in the west bank of the Salamonie at Dora, and New Holland. Stone from equivalent beds was used in the locks of the Wabash & Erie Canal in the vicinity of Lagro, and came from an abandoned quarry near the foot of the bluff on the west side of the river.

SECTION NEAR BELDEN.

*Well on the Farm of Masso Jackson.*

| | |
|---|---|
| Soil | 1 foot. |
| Limestone | 15 feet. |
| Chert | 9 feet. |
| Total | 25 feet. |

The chert of this section was so hard that the well-diggers abandoned it before finding water. They say the stone was very irregularly stratified and dipped in all directions.

QUARRY OF ASA KINLEY.

*On Rush Creek, Near New Holland.*

| | |
|---|---|
| Soil | 5 ft. 0 in. |
| Blue even-bedded flagging | 6 in. |
| Buff thin-bedded flagging | 3 in. |
| Buff thin-bedded flagging | 3 in. |
| Heavy-bedded blue limestone to bed of creek | 1 ft. 6 in. |
| Total | 7 ft. 6 in. |

Across the creek the following section is shown:

| | |
|---|---|
| Soil | 1 ft. 6 in. |
| Yellow, rotten shale | 5 ft. 0 in. |
| Heavy-bedded blue limestone, hydraulic cement rock to water's edge | 12 ft. 0 in. |
| Total | 18 ft. 6 in. |

This last overlies the quarry rock of the preceding section. All the stone quarried here seems to have hydraulic properties, and would probably make good cement if burned and mixed with the proper proportions of lime and sand.

The abutments of the bridges across Rush Creek above and below New Holland are built of stone from the Kinley quarry, and it bids fair to be very durable. Its color and smooth fracture give it a remarkably handsome appearance in the wall.

### SECTION AT THE MOUTH OF JOSINA CREEK.

*Section 32, Town. 26, Range 7 East.*

| | |
|---|---|
| Soil | 7 ft. 0 in. |
| Indurated yellow shale | 1 ft. 10 in. |
| Blue heavy-bedded hydraulic quarry rock to the water's edge | 2 ft. 4 in. |
| Total | 11 ft. 2 in. |

The last member is a medium quality building stone if quarried and allowed to season before exposure to frost. This outcrop dips rather rapidly and disappears just where the creek empties into the Mississinewa River.

It was near here that the memorable battle in which Lieut. Waltz, for which Waltz Township is named, was killed on the morning of December 18, 1812.

### SECTION AT LEONARD HYMAN'S QUARRY.

*On the Mississinewa River in Waltz Township.*

| | |
|---|---|
| Soil and covered slope | 3 ft. 0 in. |
| Thin bedded buff limestone, quarry stone formation | 4 ft. 4 in. |
| Shale | 9 in. |
| Thin bedded buff limestone | 2 ft. 10 in. |
| Thin, even bedded blue limestone | 7 ft. 0 in. |
| Total | 17 ft. 11 in. |

The limestone strata here dip rapidly to the southwest at an angle of eleven degrees. This dip is probably due to the rocks having been deposited in a trough-like depression or channel in the underlying shale, as the strata a short distance west, and resting on a continuation of the same shale, are approximately horizontal. The shale underlying these apparently upheaved rocks is horizontal, and the same is true of all the equivalent beds seen in this vicinity. The upper part of the shale is buff colored and the lower part a blue-gray.

The following fossils were seen: *Atrypa reticularis*, *Orthis biloba*, *Zaphrentis*, sp.(?), *Halysites catenulatus*, young of *Ambonychia*, *acutirostra*, *Lituites marshi*, *Calymene niagarensis*, *Dictyonema*, sp.(?), *Tenestella parvulipora*, *Orthis elegantula*, *Meristina nitida*, *Favosites niagarensis*, *Spirifera crispa*, *Strophomena rhomboidalis*, *Lichenalia concentrica*, and crinoid stems.

SECTION ON THE MISSISSINEWA RIVER.

*Three hundred yards below the last section.*

| | |
|---|---|
| Thin bedded, gray, shelly limestone, full of crinoid remains | 4 ft. 4 in. |
| Rotten, buff limestone | 1 ft. 8 in. |
| Thin bedded, gray limestone, largely composed of comminuted crinoids | 8 ft. 0 in. |
| Cherty limestone | 9 in. |
| Chert band | 4½ in. |
| Cherty limestone | 2 in. |
| Chert band | 5 in. |
| Thin, gray laminated limestone | 6 in. |
| Chert band | 1 in. |
| Gray limestone | 4 in. |
| Chert band | 2 in. |
| Thin bedded, gray limestone, with *Pisocrinus gemmeformis* and *Pisocrinus gorbyi* | 8½ in. |
| Cherty limestone | 1 ft. 3 in. |
| Shale, with *Zaphrentis celator*, *Cladopora reticulata*, and *Lichenalia concentrica* | 1 in. |
| Heavy bedded, blue limestone; good quarry rock | 1 ft. 0 in. |
| Heavy bedded, blue limestone; good quarry rock | 1 ft. 0 in. |
| Shale at the water's edge | 8 ft. 0 in. |
| Total | 28 ft 10 in. |

PHILLIP DAVIS' QUARRY ON THE MISSISSINEWA RIVER.

*Section 27, Town. 26, Range 7 East.*

| | |
|---|---|
| Soil and slope | 4 ft. 0 in. |
| Thin bedded, buff limestone | 16 ft. 0 in. |
| Heavy bedded, blue limestone | 1 ft. 0 in. |
| Heavy bedded, buff limestone | 10 in. |
| Buff shale to bed of river | 17 ft. 0 in. |
| Total | 38 ft. 10 in. |

This quarry furnishes a good, durable building stone for light structures, but is entirely too thin bedded for heavy work. An occasional piece of flagging is gotten out, but is very rough owing to the layers coalescing. The strata are approximately horizontal here, while at other places there is a rapid dip, caused by intercallated, wedge shaped masses of stone.

Formerly this stone was burned for lime, making a dark, "hot" lime, for which there was a limited local demand, but after the railroads became so numerous it was unable to compete with the product of the modern kilns.

### JACOB ULLERY'S QUARRY NEAR SOMERSET.

*Southeast Quarter of Northeast Quarter of Section 32, Town. 26, Range 6 East.*

| | | |
|---|---|---|
| Soil | 6 ft. | 0 in. |
| Thin bedded, gray limestone | 1 ft. | 6 in. |
| Buff shale | | 10 in. |
| Chert | | 1 in. |
| Thin bedded limestone | | 11 in. |
| Cherty limestone | 1 ft. | 0 in. |
| Shale and chert | | 7 in. |
| Thin bedded, gray limestone | 1 ft. | 7 in. |
| Gray limestone, flagging | | 6 in. |
| Flagging, surface smooth | | 3 in. |
| Flagging, surface smooth | | 4 in. |
| Flagging, surface smooth | | 4 in. |
| Thin bedded gray limestone. | | 6 in. |
| Heavy bedded gray limestone | 1 ft. | 6 in. |
| Heavy bedded gray limestone | | 6 in. |
| Heavy bedded dimension stone | 1 ft. | 6 in. |
| Shale | | 2 in. |
| Heavy bedded gray limestone | 1 ft. | 2 in. |
| Shale | | 5 in. |
| Heavy bedded gray dimension stone | | 10 in. |
| Heavy bedded gray dimension stone | 1 ft. | 0 in. |
| Heavy bedded gray dimension stone | 1 ft. | 5 in. |
| Total | 24 ft. | 11 in. |

The heavier bedded members of this section contain excellent material for foundations, bridge abutments and piers. Specimens of *Pisocrinus gorbyi*, *Pisocrinus gemmiformis*, *Orthoceras crebescens* and *orthis elegantula* were seen.

Across the ravine from the preceding the following section was made:

| | | |
|---|---|---|
| Soil and slope not measured. | | |
| Cherty limestone | 2 ft. | 2 in. |
| Shale | | 2 in. |
| Thin bedded limestone | | 9 in. |
| Heavy bedded limestone | | 10 in. |
| Heavy bedded dimension stone | 1 ft. | 0 in. |
| Heavy bedded dimension stone | 1 ft. | 2 in. |
| Heavy bedded dimension stone | | 6 in. |
| Heavy bedded dimension stone | 1 ft. | 11 in. |
| Heavy bedded dimension stone | | 6 in. |
| Heavy bedded dimension stone | 1 ft. | 7 in. |
| Shale | | 2 in. |
| Heavy bedded buff dimension stone | 1 ft. | 3 in. |
| Heavy bedded buff dimension stone | 1 ft. | 10 in. |
| Heavy bedded buff dimension stone | 1 ft. | 4 in. |
| Total | 15 ft. | 2 in. |

The stone of this section has apparently been deposited in a trough of the underlying shale that is seen a few rods farther down the ravine, occupying a higher position than the bottom of the quarry. The strata are approximately horizontal, and no other explanation of its relations to the shale seem tenable. This is a splendid quality of stone, and, with railroad facilities, would be a fortune to the owner.

S. B. SHULTZ'S QUARRY, ONE MILE WEST OF SOMERSET.

*Sec.* 29, *Town.* 26, *Range* 6, *East.*

| | | |
|---|---|---|
| Soil | 3 ft. | 0 in. |
| Thin bedded, cherty, buff limestone | 7 ft. | 0 in. |
| Buff limestone, surface smooth | | 6 in. |
| Buff limestone, surface smooth | | 6 in. |
| Buff limestone, surface smooth | | 6 in. |
| Buff limestone, surface smooth | | 6 in. |
| Buff limestone, surface smooth | | 6 in. |
| Buff limestone, surface smooth | | 8 in. |
| Buff limestone, surface smooth | | 8 in. |
| Buff limestone, surface smooth | | 6 in. |
| Buff limestone, surface smooth | | 4 in. |
| Buff limestone, surface smooth | | 4 in. |
| Buff limestone, surface smooth | | 7 in. |
| Buff limestone, surface smooth | | 4 in. |
| Buff limestone, surface smooth | | 5 in. |
| Buff limestone, surface smooth | | 4 in. |
| Buff limestone, surface smooth | | 4 in. |
| Buff limestone | | 10 in. |
| Buff limestone | 1 ft. | 6 in. |
| Total | 19 ft. | 4 in. |

This is a very excellent building stone, the iron in it being thoroughly oxydized, it is not affected by the changes of temperature.

None of the sections given on the Mississinewa River, except that taken at the mouth of Josina Creek, have vertical range sufficient to include the hydraulic limestone. It is exposed, however, at many other points in the bottom of the deep ravines, and, wherever seen, presents much the same characters as the equivalent beds on the Salamonie and Wabash rivers.

[redacted]

QUATERNARY

DRIFT PERIOD.

In sinking gas wells, at Lafontaine, rock was struck by the drillers of the well near the flour mill at a depth of 300 feet, at 180 feet one-third of a mile south, and at 167 feet one-half of a mile south. In boring for water on the farm of Mr. William Kester, in Chester Township, rock was encountered at 181 feet from the surface, and in the well of Mr. Lat.

Waggoner, of Liberty Township, at 96 feet. The average of these wells is 185 feet. The 274 feet of Drift passed through in the gas well at North Manchester, and the 120 feet at Somerset, are not included in the calculation, as they are both in river valleys, where it is probable the original deposit has been very much modified since the climax of the Glacial Epoch. It is probable the 185 feet once very nearly represented the original average thickness of the deposit as it lay spread over the county. All measurements under this indicate the amount of material which has been swept away by the floods, and dropped elsewhere in the valleys and deltas.

Unmodified Drift is everywhere made up of blue glacial clay, yellow clay, sand, gravel and bowlders. Generally the materials are roughly arranged in strata, but it is only the glacial and yellow clays which seem to occupy a special place in a systematic classification. The glacial clay is always at, or near, the bottom of the formation, and the yellow clay at the top. Both were present in all sections of unmodified Drift seen in the county, but it is not to be understood that this is stated as a general rule applicable to other parts of the State.

The yellow clay ranges in thickness from 7 to 25 feet, the latter being the measurement made at Lafontaine, a point well removed from modifying influences. The blue clay stratum is very variable in thickness, and ranges from 9 to 140 feet. The glacial clay is frequently divided into layers by one or more strata of sand or gravel, or of sand and gravel, which are continuous for many feet, and the whole formation may rest on gravel. The sand and gravel beds in the yellow clay are much more limited in extent, and are usually found in lenticular masses. Along the rivers and creeks, where the clay has been dissolved out by the water, the sand and gravel have been left behind in beds and mounds which show their origin by their internal structure.

Bowlders of large size are infrequent, except in the valleys. Perhaps the greater part of those exposed are to be found in Pawpaw Township, where the denuding force which formed the Wabash Valley has acted over a wider range of territory than usual. All seen were representations of primitive rock; the most common being varieties of gniess, greenstone, mica schist, granite and hornblende. In weight they vary from a few pounds to seven tons. They do not seem to be peculiar to any stratum, and are found in greater quantity at certain places on the surface because the clay in which they were originally imbeded has been washed away.

No moraines or kames were seen, but the surface of the yellow clay is dotted with slight mounds containing an increased quantity of sand and fine gravel. Surface points of interest that should have more careful study than we were able to give them are the hills and gravel mounds of Pleasant Township. To properly investigate their relations to the other members of the drift, they should be examined in connection with similar deposits in Fulton County, of which they seem to be the eastern prolongation.

The muck beds of the same vicinity are very remarkable for their depth and are doubtless the result of vegetable decay in ancient glacier channels where it has accumulated since the close of the Glacier Epoch. Because of its antiseptic properties it often contains bones that would have decayed long ago in ordinary clay, and if the muck is of later origin than the drift, it is reasonable to suppose that the bones found in it are the remains of animals which were not yet extinct.

Marl is found in the northwest part of the county lying several feet above the lakes and ponds. The vegetation growing over this region is peculiar, and it was known in the early settlement of the country as the "barrens;" but the land was anything but barren. Mr. R. G. Arnold, who lives in this neighborhood, says that when he settled there fifty years ago he cut a hickory tree for a barn timber that squared six inches in diameter at the top, and was not more than ten inches in diameter at the stump.

### RECENT PERIOD.

Along the water courses alluvial deposits of dark clay and sand occur which have wholly lost all indication of their drift origin. In the river banks it has a depth of twenty-five feet, and is subject to constant changes near the channel. The alluvium of the uplands is represented by the black soil in the surface depressions. In the swamps it frequently reaches quite a depth. The materials composing that in the valleys and swamps are the same; but they slightly vary in proportion, the latter often containing more organic matter.

### FOSSIL BONES OF THE DRIFT.

Mammoth bones, *Elephas primigenius*, were found several years ago in Pleasant Township, where some men were throwing up an embankment for a bridge across Silver Creek, under about five feet of muck. Some of these bones are said to be in the Wabash College, at Crawfordsville. On the farm of Mr. Jesse L. Williams, section 8, township 29, range 5, east, two miles west of Laketon, near the bank of Silver Creek, in 1872, nearly a complete skeleton of a *Mastodon americanus* was found by Mr. Jacob Steveson while digging a ditch at the side of the road. Considerable litigation was indulged in over the ownership, but the matter was finally settled, and they were taken to Fort Wayne and put on exhibition. The head and antlers of an elk were unearthed by Mr. Longnecer in a swamp he was draining near the west county line. The antlers measured eight feet from tip to tip.

Three miles due east of North Manchester on the northwest quarter of the northeast quarter of section 1, township 29, range 7, east, Mr. Simon S. Morrow discovered a jawbone with two teeth in it. In a communication to the *Toledo Blade*, Mr. Morrow says: "One of the teeth measured 7¾ inches from back to front by 4 inches broad, and weighed 6½ pounds. It has three roots which measured from 5 to 6 inches long, but the points were gone." The other tooth was smaller and more decayed. He says they were found beneath 2½ feet of "solid blue-clay, where a hickory-elm eighteen inches over had blown out of root."

Mr. John H. Pefley, east half of the southwest quarter of section 18, township 27, range 8, east, near Dora, found two large teeth on his farm, one of which we saw, and identified as that of a fossil elephant, *Elephas primigenius.*

On the farm of Mr. William Ruckle, three and one-half miles north of Roann, Mr. Rantz, in 1882, while digging a ditch, unearthed the antlers and part of the skeleton of a deer, *Cervus virginianus*, at a depth of nine feet.

SECTION OF WELL ON THE FARM OF JOHN H. PEFLEY.

*East Half of Southwest Quarter of Section* 18, *Town.* 27, *Range* 8 *East.*

| | |
|---|---|
| Soil and yellow clay | 7 ft. 0 in. |
| Blue clay, sand and gravel | 24 ft. 0 in. |
| Blue hardpan clay | 1 ft. 6 in. |
| Dry sand | 8 ft. 0 in. |
| Blue hardpan clay, sand and gravel | 12 ft. 0 in. |
| Blue hardpan clay, not penetrated by sand, water-bearing | 9 ft. 6 in. |
| Total | 62 ft. 0 in. |

This farm is on the bluff northwest of Dora. The measurements were furnished by the proprietor, an intelligent observer, who has paid considerable attention to Geology, and may be accepted as correct and typical of the Drift deposits in all things except thickness. The three strata of hardpan clay and the sand and gravel found between them are probably the direct results of glacial action as the ice sheet advanced from north to south, while the upper members, composed of plastic blue and yellow clay, were formed as the glacier receded.

SECTION OF SAND BANK ON THE FARM OF BEN WOLFE.

*West Side of Rush Creek.*

| | |
|---|---|
| Soil and gravel | 3 feet. |
| Dark, earthy sand | 10 feet. |
| Cavities in loose sand | 2 feet. |
| Dark, earthy sand | 3 feet. |
| Irregularly-bedded gravel | 5 feet. |
| Fine sand, with bands of sand and small gravel | 20 feet. |
| Total | 43 feet. |

The strata of this section vary in thickness and somewhat change in dip. Especially is this true of the lower twenty-five feet, which clearly shows in the stratification the assorting action of water, and fairly well represents the modified Drift of the Terrace Epoch. The sand here is an excellent material for building and plastering purposes, and is extensively used in the neighborhood. Gravel beds are frequent in the valley of the creek, and are fairly represented by the following measurements:

SECTION OF GRAVEL BED ON THE FARM OF ASA KINLEY.

*South of New Holland.*

| | |
|---|---|
| Soil | 6 in. |
| Yellow gravel | 2 ft. 0 in. |
| Coarse, gray gravel | 10 ft. 0 in. |
| Total | 12 ft. 6 in. |

Between this exposure and Holland twenty feet of sand was seen occupying a higher level than these beds of gravel.

SECTION OF WELL ON THE FARM OF JESSE D. SCOTT.

*Liberty Township.*

| | |
|---|---|
| Soil | 1 foot. |
| Yellow clay | 5 feet. |
| Blue clay | 3 feet. |
| Fine, blue water-bearing sand | 4 feet. |
| Total | 13 feet. |

This well furnishes an abundance of good, cold water. In the field about fifteen rods northwest there is another well that passes through the following strata:

| | |
|---|---|
| Soil | 2 ft. 6 in. |
| Yellow clay | 9 ft. 0 in. |
| Gravel, first water-bearing stratum | 1 ft. 0 in. |
| Total | 12 ft. 6 in. |

Blue clay not measured.

In 1886 this well failed and the wall was taken out so as to remove the gravel. Since then it has furnished an abundance of water. In wells of this character it is probable that the whole of the water-bearing stratum of sand and gravel is saturated and not traversed by veins. Such wells are very liable to become contaminated from surface drainage.

GENERAL SECTION OF WELLS IN LAFONTAINE.

| | |
|---|---|
| Soil | 1 ft. 6 in. |
| Gravel | 20 ft. 0 in. |
| Total | 21 ft. 6 in. |

East of the creek adjoining the town the wells pass through—

| | |
|---|---|
| Soil | 4 feet. |
| Yellow clay | 25 feet. |
| Gravel, water-bearing | 2 feet. |
| Total | 31 feet. |

SECTION OF GRAVEL BANK ON THE MISSISSINEWA RIVER.

*Liberty Township.*

| | |
|---|---|
| Soil | 2 feet. |
| Good, coarse gravel to the water's edge | 30 feet. |
| Total | 32 feet. |

There is an immense amount of first-class road gravel in this part of the township, and leaves its citizens with no better excuse for bad roads than the simple plea that they have not put it where it will do the most good.

WELL ON THE FARM OF MR. KNEE.

*Liberty Township.*

| | |
|---|---|
| Soil | 1 ft. 6 in. |
| Gray clay | 18 ft. 0 in. |
| Total | 33 ft. 6 in. |

Water was found in this well, but the gravel clogged the pump and rendered it useless.

WELL ON THE FARM OF ALEX. DAVIS.

*Section* 27, *Town.* 26, *Range* 6 *East, Waltz Township.*

| | |
|---|---|
| Soil | 2 ft. |
| Stone and shale | 40 ft. |

Good water was found in the shale, and wells put down to the same geological level should be safe from surface contamination.

GRAVEL BANK NEAR THE OGAN GRAVEYARD.

*N. W.* ¼ *of S. W.* ¼ *of Sec.* 23, *Township* 26, *Range* 6 *East.*

| | |
|---|---|
| Soil | 1 ft. 6 in. |
| Good, coarse gravel to level of the pike | 10 ft. 0 in. |
| Total | 11 ft. 6 in. |

This exposure is on the Vernon Pike, one mile north of the Mississinewa River. It furnishes good road making material, and was used as far as it was possible to mine it readily, in building the Wabash and Vernon Pike. It probably extends to a much greater depth than is here recorded, but the section shows all that is exposed in the cut, where the road is graded through the hill.

GRAVEL PIT ON THE FARM OF JOHN NEFF.

*Section 36, Township 26, Range 6 East, Waltz Township.*

| | |
|---|---|
| Soil | 3 ft. |
| Coarse, gray gravel | 10 ft. |
| Total | 13 ft. |

This pit has been worked extensively for local use, and makes a good road.

WELL ON THE FARM OF JOHN NEFF.

| | |
|---|---|
| Black soil | 1 ft. 6 in. |
| Yellow clay | 3 ft. 0 in. |
| Gravel, lower part water bearing | 21 ft. 0 in. |
| Total | 25 ft. 6 in. |

In the gravel members of this section layers and lens shaped masses of fine yellow sand occur. Occasionally the masses are white, and probably indicate that the surface Drift of this region was deposited from the water coming from the foot of a glacier as it receded north.

DRIFT ON THE FARM OF JOHN GARST.

*S. W. Qr. of Section 28, Township 26, Range 6 East.*

| | |
|---|---|
| Soil | 4 ft. |
| Coarse, gray gravel | 12 ft. |
| Blue clay | 15 ft. |
| Total | 31 ft. |

A short distance east of this and north of the road the following section was measured:

| | |
|---|---|
| Soil | 3 ft. |
| Coarse, gray gravel, good road material | 15 ft. |
| Total | 18 ft. |

A greater number of sections might have been taken in this, Waltz Township, but they would have been essentially a repetition of those already given. There is an unlimited amount of good road gravel, easy of access in the township; enough, in fact, to gravel all the roads in the county.

AVERAGE OF WELLS IN RICH VALLEY.

| | |
|---|---|
| Soil | 1 ft. 6 in. |
| Yellow sand | 9 ft. 0 in. |
| Gravel, water bearing | 2 ft. 0 in. |
| Total | 12 ft. 6 in. |

An abundant supply of water is found wherever the gravel is reached by boring or digging.

### WELL ON THE FARM OF WILLIAM JACKSON.

*Near Rich Valley.*

| | |
|---|---|
| Soil | 1 ft. 6 in. |
| Yellow clay | 7 ft. 0 in. |
| Yellow sand | 4 ft. 0 in. |
| Blue clay | 3 ft. 0 in. |
| Coarse, gray gravel | 6 ft. 0 in. |
| Impression cemented sheet of black gravel | 3 in. |
| Total | 21 ft. 9 in. |

After passing through the last member of the section an unlimited amount of water was found that rose to the top of the cemented layer and flowed off through the overlying gravel.

### SECTION OF GRAVEL ON THE FARM OF WILLIAM JACKSON.

*Sec.* 13, *Town.* 27, *Range* 5, *East.*

| | |
|---|---|
| Soil | 3 ft. |
| Coarse, gray sand | 8 ft. |
| Coarse, gray gravel | 30 ft. |
| Total | 41 ft. |

This gravel bed extends along the bluffs one-half mile, and contains enough material to make and keep in repair all the roads in the township for ages.

### GRAVEL PIT ON THE FARM OF SAMUEL KUFFEL.

*Sec.* 26, *Town.* 29, *Range* 5, *East, Pawpaw Township.*

| | |
|---|---|
| Soil | 2 ft. |
| Coarse, gray gravel | 25 ft. |
| Total | 27 ft. |

Enough material has been taken out of this pit to macadamize seven miles of township roads.

### GRAVEL PIT ON THE FARM OF A. T. GIDLEY.

*Sec.* 36, *Town.* 29, *Range* 5, *East, Pawpaw Township.*

| | |
|---|---|
| Soil | 1 ft. 6 in. |
| Coarse, gray gravel | 14 ft. 0 in. |
| Total | 15 ft. 6 in. |

The gravel of this section extends to a much greater depth than is here indicated, but the total thickness has not been determined. This farm lies adjacent to Eel River, in the northwest part of the township.

WELL ON THE FARM OF A. T. GIDLEY.

*Sec. 2, Tp. 26, R. 5 E., Pawpaw Township.*

| | |
|---|---|
| Soil | 2 ft. |
| Gravel and sand alternating | 24 ft. |
| Coarse gravel, water bearing stratum | 2 ft. |
| Total | 28 ft. |

Near the bottom of the well a good sized branch of a tree was found, and it is a common occurrence to find vegetable remains in the gravel at depths ranging from eighteen to thirty feet. This well is only twenty feet from a dry well, yet it furnishes an abundance of water for a stock farm. The stream encountered in digging the well filled it so rapidly that it was with difficulty it was walled. One hundred and fifty feet away a driven well was put down one hundred and five feet before finding a limited quantity of water.

WELL ON THE FARM OF R. G. ARNOLD.

*S. E. Qr. Sec. 12, Tp. 29, R. 5 E., Pleasant Township.*

| | |
|---|---|
| Soil | 1 ft. |
| Sandy loam | 30 ft. |
| Water bearing gravel, not measured | |
| Total | 31 ft. |

The water in this well is abundant in quantity and excellent in quality.

SECTION OF WELL IN ROANN.

*Corner of Chippewa and Allen Streets.*

| | |
|---|---|
| Soil | 1 ft. 6 in. |
| Gray sand and gravel alternating | 36 ft. 0 in. |
| Total | 37 ft. 6 in. |

The diggers of this well contracted to put it down forty feet, but they encountered large bowlders and were forced to suspend operations; not, however, before finding a good supply of water.

WELL ON THE PROPERTY OF J. V. BUSKIRK.

*Laketon.*

| | |
|---|---|
| Soil | 1 ft. 6 in. |
| Coarse, gray gravel | 7 ft. 6 in. |
| Total | 9 ft. 0 in. |

An abundance of water was found here, and while it is used as a town well it has never been pumped dry.

WELL ON THE PROPERTY OF W. C. OGDEN.

*Laketon.*

| | |
|---|---|
| Soil | 3 ft. |
| Gravel, water bearing | 10 ft. |
| Blue clay | 6 ft. |
| Coarse, gray gravel, not measured | |
| Total | 19 ft. |

If the accepted theory as to the origin of typhoid fever from polluted drinking water is correct, this last well, judging from geological data, should be the safer one for household use. Experience shows that wells which stop in the first gravel are very liable to contamination, and the argument that because a well so far has been a safe one it will continue healthful is fallacious, and does not prove that the typhoid germ can not more readily find lodgment in such wells. The safe rule is to dig deep and shut out all surface water. Every property owner should be able to show a clean sanitary history of his pump along with his abstract of title.

TOWNSHIP GRAVEL PIT.

*West end of town of Laketown.*

| | |
|---|---|
| Soil | 2 ft. 4 in. |
| Coarse, gray gravel | 9 ft. 0 in. |
| Total | 11 ft. 4 in. |

This pit yields an excellent road making material. The gravel is underlaid by a blue glacial clay with gravel sparingly intermixed.

WELL ON THE FARM OF RANKIN HOOVER.

*S. W. Qr. Sec.* 26, *Town.* 29, *Range* 7 *East, Chester Township.*

| | |
|---|---|
| Soil | 1 ft. 6 in. |
| Yellow clay | 18 ft. 0 in. |
| Blue clay | 140 ft. 0 in. |
| Water-bearing gravel | 5 ft. 0 in. |
| Total | 164 ft. 6 in. |

The water stands one hundred and thirty feet deep in this well.

WELL ON THE FARM OF EDWARD ALSPAUGH.

*Chester Township.*

| | |
|---|---|
| Soil | 1 ft. 6 in. |
| Yellow clay | 18 ft. 0 in. |
| Blue clay | 140 ft. 0 in. |
| Fine gray sand passing into gravel | 26 ft. 0 in. |
| Total | 185 ft. 6 in. |

This farm adjoins that of Mr. Rankin Hoover. Water here rises one hundred and twenty feet in the well. The surface at this well is slightly higher than at the former.

### WELL ON THE FARM OF WILLIAM KESTER.

*N. E. Qr. of S. E. Half of Sec. 11, Town. 29, Range 7 East, Chester Township.*

| | |
|---|---|
| Soil | 1 ft. 6 in. |
| Yellow clay | 18 ft. 0 in. |
| Blue clay | 140 ft. 0 in. |
| Gray sand | 21 ft. 6 in. |
| Gray stratified limestone | 26 ft. 0 in. |
| Total | 207 ft. 0 in. |

No water was found.

### WELL ON THE PROPERTY OF LEVI SNELL.

*North Manchester.*

| | |
|---|---|
| Soil | 2 ft. 0 in. |
| Coarse, gray gravel | 17 ft. 0 in. |
| Blue clay | 10 in. |
| Gray sand | 30 ft. 0 in. |
| Coarse, gray gravel | 4 ft. 0 in. |
| Total | 53 ft. 10 in. |

### WELL ON THE PROPERTY OF E. I. TAYLOR.

*North Manchester.*

| | |
|---|---|
| Soil, black muck | 4 feet. |
| Gray sand | 67 feet. |
| Total | 71 feet. |

A bed of bowlders, the size of one's fist, was encountered in sinking this well, but an abundant supply of water was found that rises one-half an inch above the ground.

The three last sections when compared with the preceding three show in a very marked manner the difference between modified and unmodified drift. The sections of modified drift at North Manchester are not only different from the others, but they differ very much among themselves.

### WELL ON THE FARM OF HENRY HINKLE.

*Seven Miles West of North Manchester.*

| | |
|---|---|
| Soil | 1 ft. 8 in. |
| Black muck | 108 ft. 4 in. |
| Coarse, gray gravel | 4 ft. 0 in. |
| Total | 114 ft. 0 in. |

Water rose 101 feet. The well is put down on the highest land in the neighborhood, the drillers estimating that the surface is thirty feet above the surrounding country, and they wonder where the water comes from. The bed of muck indicates the existence of an ancient glacial channel.

WELL ON THE FARM OF NATHANIEL BANNISTER.

*Lagro Township.*

| | |
|---|---|
| Soil | 1 foot. |
| Yellow clay | 9 feet. |
| Blue clay | 68 feet. |
| Coarse, gray sand | 6 feet. |
| Total | 84 feet. |

Water rises thirty-eight feet in this well and furnishes an abundant supply. The drillers say that wells put down in this vicinity, five miles south of Lagro, do not vary materially from that of the last section. Five miles north of Lagro, in certain neighborhoods, the wells reach the stone at seventy and seventy-five feet, especially is this true of the wells in the vicinity of the Fultz' farm.

WELL ON THE FARM OF CHRISTOPHER SPEICHER.

*Lagro Township.*

| | | |
|---|---|---|
| Soil | 1 ft. | 8 in. |
| Yellow clay | 19 ft. | 0 in. |
| Blue clay | 60 ft. | 0 in. |
| Coarse, gray gravel | 4 it. | 0 in. |
| Blue clay | 65 ft. | 4 in. |
| Gray coarse gravel | 6 ft. | 0 in. |
| Total | 156 ft. | 0 in. |

Water stands 117 feet deep in this well. At the top of the blue clay, the drillers passed through a thin stratum of water bearing sand and they say the water invariably rises in the well to the height of the first water bearing stratum. This statement agrees with the conclusions reached by the late State Geologist, Prof. E. T. Cox, that the temperature of the water in a deep well is determined by the temperature of the first water which finds access to the bore. If the first water bearing stratum passed determines the height of the water and its temperature, the inference is plain that it will also determine its sanitary condition. Such wells are unsafe. To make them germ proof they should be tubed and packed like a gas well, and all chance of surface contamination cut off.

WELL ON THE LOT OF THE LAGRO CEMENT MANUFACTURING CO., IN LAGRO.

| | |
|---|---|
| Soil | 3 ft. |
| Cement rock | 21 ft. |
| Total | 24 ft. |

This well and the Lagro public well, which penetrates the hydraulic limestone sixty-eight feet, show that the cement rocks are water bearing. They both furnish an abundant supply of good water.

WELL ON THE FARM OF PETER CHRISTMAN.

*S. W. Qr. of Sec. 33, Town. 28, Range 7, East.*

| | |
|---|---|
| Soil and clay | 6 ft. |
| Blue cement rock | 54 ft. |
| Total | 60 ft. |

Water in abundance. This well is on the bluff, one-fourth of a mile north of the Wabash River and one mile west of Lagro.

GRAVEL PIT ON THE FARM OF MRS. RAMSEY.

*Sec. 2, Town. 27, Range 7, East.*

| | |
|---|---|
| Soil | 3 ft. |
| Good, coarse, gray gravel | 15 ft. |
| Yellow-gray shale | 18 ft. |
| Blue cement stone | 32 ft. |
| Total | 68 ft. |

Gravel from this pit was used in building the Lagro and Township Line Pike and on the State Road, and is an excellent road making material.

WELL ON THE FARM OF JACOB THOMAS.

*Liberty Township.*

| | |
|---|---|
| Soil | 1 ft. |
| Yellow Clay | 9 ft. |
| Blue clay | 50 ft. |
| Coarse, gray, water bearing gravel | 4 ft. |
| Total | 64 ft. |

The water here rose ten feet, and is in inexhaustable quantity.

WELL ON THE FARM OF LAT. WAGGONER.

*Liberty Township.*

| | |
|---|---|
| Soil | 1 ft. 0 in. |
| Yellow clay | 9 ft. 0 in. |
| Blue clay | 70 ft. 0 in. |
| Coarse, gray gravel | 4 ft. 0 in. |
| Gray hard-pan | 4 in. |
| Thin blue mud | 8 ft. 0 in. |
| Fine, gray sand | 3 ft. 0 in. |
| Gray, stratified limestone | 8 in. |
| Total | 96 ft. 0 in. |

An abundance of water was found in the coarse, gray gravel, and the drillers set the pump screen on the underlying hard-pan; the water passing over it, and into the screen, washed through the hard-pan and let the water pass down into the next stratum so as to necessitate further drilling. The drill finally passed into a crevice in the limestone that furnished an ample supply of water which rose fourteen feet in the well. The measurements and other details here given were furnished by Mr. John A. Martin, of North Manchester.

GRAVEL BED NEAR ROCKYWAY FALLS.

*On the Farm of Jacob Falls, Lagro Township.*

| | |
|---|---|
| Soil and clay | 5 ft. |
| Coarse, gray gravel, with a few medium sized bowlders scattered through it, | 25 ft. |
| Total | 30 ft. |

## NATURAL GAS.

A number of gas wells of average capacity have been put down in the south part of the county, in the vicinity of Lafontaine, Vernon and Somerset. Several test wells have been bored in other parts of the county, but no gas in paying quantities found north of Lafontaine. In fact, Lafontaine seems to be located on the extreme northern prolongation of the Anderson-Muncie gas field.

There are no surface indications of the existence or non-existence of gas, and those who go about the country pretending that they can tell where a successful bore may be made, are either fools or knaves. The only way in which to determine whether gas exists under a given spot or not is to put down a test well.

LAFONTAINE.

*Gas Well No. 1, Near the Flour Mill.*

| | |
|---|---|
| Drift | 300 ft. |
| Niagara limestone | 225 ft. |
| Hudson River limestone and shale | 175 ft. |
| Utica shale | 200 ft. |
| Trenton limestone | 23 ft. |
| Total depth | 923 ft. |
| Trenton, below sea level | 6 ft. |

Yielding a very strong flow of gas.

In this section it will be noticed that the thickness of the Drift is given at the enormous depth of three hundred feet and the intervening strata above the Trenton at only six hundred feet. These measurements indicate the existence of a deep ravine in the upper limestone stratum.

LAFONTAINE.

*Average of Five Gas Wells.*

| | |
|---|---|
| Drift | 160 to 200 ft. |
| Niagara limestone | 300 ft. |
| Hudson River Group limestone and shale | 300 ft. |
| Utica shale | 100 ft. |
| Trenton | 16 to 28 ft. |
| Total depth | 928 ft. |
| Altitude of the railroad station | 894 ft. |

SOMERSET.

*Gas Well No. 1.*

| | |
|---|---|
| Drift | 120 ft. |
| Limestone | 230 ft. |
| Shale | 60 ft. |
| Hudson River and Utica shale | 450 ft. |
| Trenton | 40 ft. |
| Total depth | 900 ft. |

This well is located on the farm of Edward Tucker, ten miles south of Wabash City, on the Vernon Pike, and one mile southwest of Vernon. It furnishes only a small quantity of gas, and was plugged with two plugs, one at the top and the other at the bottom.

SOMERSET.

*Gas Well No. 2.*

| | |
|---|---|
| Drift | 28 ft. |
| Limestone (Niagara?) | 300 ft. |
| Hudson River and Utica shale | 370 ft. |
| Trenton | 30 ft. |
| Total depth | 928 ft. |

This well is on the farm of Edward Tucker, Jr., and furnishes a large quantity of gas, which is piped to Wabash.

SECTION OF SOMERSET GAS WELL.

| | |
|---|---|
| Soil | 3 ft. |
| Blue clay | 55 ft. |
| Gravel | 1 ft. |
| Limestone (Niagara?) | 340 ft. |
| Hudson River shale | 150 ft. |
| Red shale (Utica?) | 277 ft. |
| Trenton | 27 ft. |
| Total depth | 853 ft. |

This well was spoiled by letting it blow until salt water came in and ruined it. One hundred and twelve feet from the surface a heavy flow of chalybeate water commenced that continued until a well on the farm of James Anderson was drilled, which, being on lower ground, drained it. Water was also found in the limestone at a depth of 485 feet. Two other wells were drilled in this field, one northeast and the other southwest, at about one-fourth of a mile distance, but no gas was found.

### WABASH.

*Gas Well No.* 1.

| | |
|---|---|
| Hydraulic limestone, Niagara | 150 ft. |
| Niagara limestone | 230 ft. |
| Shale (Hudson River?) | 223 ft. |
| Slate (Utica?) | 325 ft. |
| Limestone and shale, Trenton | 512 ft. |
| Sandstone and shale | 10 ft. |
| Total depth | 1,450 ft. |
| From surface to Trenton limestone | 925 ft. |

### WABASH.

*Gas Well No.* 2—*Dr. Ford's Record.*

| | |
|---|---|
| Drift | 28 ft. |
| Niagara | 525 ft. |
| Hudson and Utica shale | 325 ft. |
| Trenton | 54 ft. |
| Total depth | 932 ft. |
| Trenton below sea level | 198 ft. |
| Altitude at mouth of well | 680 ft. |
| Altitude of Court House square | 730 ft. |

### WABASH.

*Gas Well No.* 2 *Contractor Robinson's Record.*

| | |
|---|---|
| Drift | 28 ft. |
| Niagara | 425 ft. |
| Hudson and Utica | 425 ft. |
| Trenton | 54 ft. |
| Total depth | 932 ft. |

### NORTH MANCHESTER.

*Gas Well No.* 1.

| | |
|---|---|
| Drift | 274 ft. |
| Niagara limestone and shale | 300 ft. |
| Hudson River limestone and shale | 250 ft. |
| Utica shale | 306 ft. |
| Trenton | 50 ft. |
| Total depth | 1,180 ft. |
| Trenton below sea level | 355 ft. |
| Altitude of surface | 775 ft. |

## MINERAL WATER.

The test well bored for gas on the farm belonging to White's Manual Labor Institute yielded no gas, but developed an abundant flow of chalybeate water. The flow is delivered from a metal stand pipe, which is so arranged with a cap on the top as to cause the water to fall in a dome-shaped sheet of great beauty. No buildings have been erected in the vicinity of the well. The water probably has all the medicinal properties of springs containing iron. From the appearance of the sedimentary deposit seen around the well it is safe to say that the salt of iron dissolved in it is in a form to be easily assimilated by the system. The taste is not unpleasant, and it will be found very valuable in all diseases where iron is indicated.

## BLOWING WELLS.

A well on the farm of Mr. John H. Pefley has barometric properties of a marked character. The well is sixty-two feet deep and is cased with nine-inch sewer tile pipe from the top to the bottom. In it has been placed an ordinary deep well pump, the base of which closes the top of the well. After the pump was put in position Mr. Pefley noticed that during unsettled weather the wind was either passing in or out of the well with great force. To render the force more apparent he had a large whistle made of two convex disks of tin with a hole in the center, like those boys get in prize packages of candy. This he attached to a short piece of gas pipe which had been screwed into the base plate of the pump. The device had the desired effect, and so intensified the sound of the air as it passed through the whistle as to cause it to be heard two miles distant; and it is a very frequent occurrence for it to be heard blowing at Dora, one-half mile away. The sound is most intense when the weather is stormy, or at a time when the mercury in the barometer is rapidly falling. At the time of our visit the indications were for fair weather, and the air was rushing into the well, but not in sufficient force to cause the whistle to sound. The flame of a candle or match when held near the opening in the base plate was strongly deflected, and the smoke rapidly carried into the well. On placing the ear over the opening a commotion could be heard very distinctly, as if the air was passing through the water at the bottom of the well, and there is no doubt but this was the case. Mr. Pefley says that when the disturbance is at its highest water and spray is thrown to the top of the well and the pump thrown into a violent tremor.

By reference to the section of this well given under Drift Details, it will be seen that the water comes from a stratum of sand lying between strata of impervious hard-pan clay. A reasonable explanation of the phenomenon is the supposition that sand is saturated with water below and filled with air above, each occupying a place in the stratum determined by it specific gravity. In addition to the small air spaces there may be larger cavities. The theory is that these air spaces communicate with the well through the water, and that when the density, or pressure of the outside atmosphere is the same as that within the sand, there will be no current either way. This state of equilibrium corresponds with a stationary barometer. Increased density of the atmosphere on the outside, indicated by a rising barometer, would cause the air to pass into the well, through the water and into the sand, so as to equalize the pressure. On the other hand a falling barometer, with a corresponding decrease of density on the outside would disturb the equilibrium and reverse the flow. The well-known fact that the barometer rapidly changes with the changes in the density of the atmosphere in stormy weather explains the greater rush of air in or out of the well at such times.

### DEEP WELL IN WABASH.

Several years ago a deep well was put down in the Court House Square. The bore started in the Niagara limestone and continued in limestone and shale to the depth of 2,270 feet without finding water that would flow from the mouth of the well. The first water was found at 85 feet. It is said that the water in the well rises and fall with the stage of the water in the river. In 1875 Dr. G. M. Levette carefully tested the temperature of the water, which rises within 85 feet of the surface, and found it uniformly 50½° F. at 100 feet, 500 feet, 1,000 feet and 2,270 feet down. The atmospheric temperature was 85° at the time the well was tested.*

### ARCHÆOLOGY.

A few small mounds are said to exist in the southern part of the county. One mile west of Roann near the north bank of Eel River, on the farm of Mr. Silas E. Shoemaker, is an extensive burial place of the Miami Indians, and bones are frequently exposed in plowing the land. On the farm of Mr. R. G. Arnold in Pleasant Township, Sec. 12, Tp. 29, Range 5 East, there is a mound having an elevation of sixty feet above Silver Creek, which the Indians used as a burial place. The mound consists of gray gravel to the bed of the stream. Mr. Arnold says that in cultivating the burial place soon after it was cleared the plow turned out pipes, arrow-heads, peelers and parts of human bones, but they were carried away years ago by relic hunters. Notwithstanding relics are scarce some fine specimens have been picked up, and valuable collections made by Mr. Herman U. Blood, of Lafontaine, Mr. Thomas Pefley, of Dora, and Dr. M. E. Renner, of Lagro.

*Geological Survey of Indiana, 1875, pages 43 and 44.

## ECONOMIC GEOLOGY.

*Agriculture* is the principal industry dependent upon the geology of the county. Its soil is adapted to all branches of farming, and the industry is so varied as to prevent a failure because of unfavorable season. If the wheat yield is short the proprietor is nearly sure of an abundant corn crop; if his swine die he will push the growth of his young cattle; if his apple orchard is barren he will make up the deficiency from his small fruit garden. Times may be hard, but with a Wabash County farm to fall back upon for money, he should be thankful and happy.

In the production of wheat and corn it ranks with twenty of the best counties in the State, and especially is the Eel River country noted for its big wheat crops. In the number of horses, cattle and swine grown, it takes rank as one of the fifteen leading counties. The care given to protecting the fertility of the soil and rotation of crops is shown by the number of acres sown to clover, in which it ranks as the fourth in the State.

In 1891 the land with improvements was appraised at $32.19 an acre, which is higher than that of any other county on the Wabash River.

*The Quarry Interest* of the county is still in its infancy. Many of the best quarries have been very slightly developed. Especially is this true of those on the Mississinewa River, which should have railroad facilities to make them valuable. The details already given show the extent of the beds and the quality of the stone.

At this time nearly all the quarrying is confined to the upper limestone strata. In the future more attention should be paid to the lower hydraulic beds. If this stone is selected it gives promise of great durability, and there is no handsomer stone anywhere for rough or foundation work. It will doubtless dress well under the hammer, and if it does it is hard to conceive of a prettier stone. In proof of its durability the doubting ones are referred to Mr. William Hazen, County Auditor, who has a door-step which came from the Treaty Creek beds, above Messrs. Small & Co.'s mill, that has been in use for forty years, a part of this time in front of the old court house, and is still a good door-step.

The Treaty Creek stone was used by Mr. James M. Furrow, in 1850, in building the piers and abutments of the Cincinnati, Wabash & Michigan Railroad bridge over the Wabash River. The abutments have stood the test fairly well with occasional repairs. The same stone was used in 1853 in building the Wabash Railway bridge over Charley Creek, but was not well selected, some of the stone crumbling so badly that the structure was replaced in 1889. The stone used in the locks of the Wabash and Erie Canal, in the vicinity of Lagro, came from equivalent beds on the west bank of the Salamonie River, and shows that the strata having a laminated structure, or too large a percentage of earthy matter, do not weather well. The dark, blue stone of uniform internal texture is the portion of the formation most likely to stand the test in a wall. The New Holland stone seems to have the typical characters described.

*Hydraulic Cement* was manufactured on the south bank of the Salamonie River, one mile above the dam, in 1834, by David Watkins, who burned several kilns for use in building the locks of the Wabash and Erie Canal near Lagro. The old kiln is still standing in the mouth of a ravine opening to the river. The product of this kiln is to be seen in the old locks, and witnesses the good quality of the hydraulic rock of the Salamonie for the manufacture of cement. In 1840 a company was formed at Wabash for the manufacture of cement from the hydraulic limestone beds of Treaty Creek. Kilns were erected, machinery purchased and several hundred barrels of excellent cement made, but owing to the lack of shipping facilities they were unable to sell the product, and the enterprise was abandoned. Some of this cement was used in building the piers and abutments of the Wabash Railroad bridge over Charley Creek. It stood firm until 1889, when the bridge was taken down because some of the stone had gone to pieces; but the cement was unchanged and apparently good for several centuries of service.

The following analyses are taken from the Geological Survey of Indiana, 1873, pages 116–117: The analysis of the Wabash County cement stone, collected from a bed ten or twelve feet thick, on the Davis farm, near Somerset, has the following composition in one hundred parts of stone:

| | |
|---|---|
| Moisture at 212° F. | 1.000 |
| Silicic acid | 30.600 |
| Alumina | 16.720 |
| Carbonate of lime | 25.600 |
| Carbonate of magnesia | 12.713 |
| Carbonate of iron | 2.480 |
| Organic matter, alkalies undetermined and loss | 10.887 |
| | 100.000 |

Another sample from a seam five to ten feet thick, on Helm's Creek, two miles west of Wabash City, contains:

| | |
|---|---|
| Moisture | 2.000 |
| Silicic acid | 34.200 |
| Carbonate of lime | 28.000 |
| Carbonate of magnesia | 3.117 |
| Carbonate of iron | 1.242 |
| Alumina | 18.760 |
| Loss and undetermined | 12.681 |
| | 100.000 |

On Chapelle (Lagro) Creek, Lagro. The seam is ten and fifteen feet thick, and contains:

| | |
|---|---|
| Moisture at 212° F. | 1.80 |
| Silicic acid | 35.60 |
| Alumina | 17.86 |
| Carbonate of lime | 26.00 |
| Carbonate of magnesia | 2.42 |
| Carbonate of iron | 4.14 |
| Loss and undetermined | 12.18 |
| | 100.00 |

Judged by their composition, these stones should make a good hydraulic cement.

The thickness of the hydraulic strata, as given in the quotation by Prof. E. T. Cox, is much under that of many of the exposures seen by us in various parts of the county.

Nothing was done, after the Wabash Company quit business, to develop the cement industry until 1891, when the Lagro Cement and Manufacturing Company, Rev. J. D. Shultz, President; A. J. Abbott, Vice-President; M. Hogan, Treasurer, and J. W. Egnew, Secretary, was organized, and commenced work by erecting a calcining kiln. The company is composed of men of energy and intelligence, who have carefully experimented with the product of their kiln, and are producing a cement of splendid quality. They have put on the market a water lime which is not excelled by any natural cement; and they have specimens of artificial stone that are equal in strength to the best Portland stone. It seems not to be generally known, but it is a fact, that some of the American imitations of Portland stone have been found superior to the original when carefully tested by engineering experts, and there is good reason to expect that, with superior hydraulic stone in great abundance, extensive beds of marl, and other materials necessary to make an artificial stone readily available, the company will succeed in establishing a paying industry in other lines than the production of ordinary water lime.

*Lime* was formerly burned at Wabash from the picket rocks, and made a good "fat" lime of about the same quality as that made from equivalent beds at Delphi. The lower ledges of the quarrystone beds, where free from chert, will make an excellent quality of lime, but will not pay a profit while kilns more favorably located in the gas belt are supplied with cheap fuel.

*Sand*, for plastering and building purposes, is found abundantly in the river and creek bars and in the bluffs, where it has been deposited by the forces which have produced the modified Drift strata.

*Clay* for making brick and tile can usually be found wherever needed. Good drain tile is made by the Hubbard Brothers, in Liberty Township, section 16, township 26, range 7 east; and by Mr. Cothanhour in Waltz Township, section 10, township 26, range 6 east, who has extensive works driven by steam. On section 36, township 29, range 5 east, in Pleasant Township, one mile east of Roann, an excellent clay is found that is used for the manufacture of brick. Good brick clay was seen in a number of places in Lagro Township.

*Bog iron ore* is not infrequently found just beneath the surface in draining swampy lands, but such ores at the present time have no commercial value, and it is not likely they will have any again soon.

In 1888 Wabash County had 884,714 rods of drain tile in operation, which was more than that of any other county in the State, and in the same year 164,969 rods were laid. This is a splendid record and speaks volumes in testimony of the thrift of its farming community. It seems to us that in many places long lines of tiling might be obviated by sinking dry wells down to the underlying porous gravel, where it has been found to occur in digging stock wells, and running the drains into it rather than to a long distance surface outlet.

# A PARTIAL LIST OF THE FLORA OF WABASH AND CASS COUNTIES WITH NOTES.

BY A. C. BENEDICT AND M. N. ELROD, M. D.

No attempt was made to collect specimens for determination, and this list is, of necessity, provisional. There are many other species not identified. The botanical names are those of Gray's Manual of Botany, Revised Editon, 1890.

*Acer saccharinum*, Wang.

Sugar Maple.

Once very common. This is the tree that furnishes the well-known syrup. There is a growing demand for sugar maple lumber for making inlaid work and furniture, and for veneers, etc.

*Acer rubrum*, Linne.

Red, or Swamp Maple.

This tree is less valuable for lumber than the former, and it is rarely "tapped" for the sap. In early spring it is a mass of brilliant bloom, flaming like a huge ruby against the background of the bare branches of its flowerless neighbors. As a shade tree it does not make the rapid growth of the silver maple.

*Carya alba*, Nutl.

Shell-bark Hickory.

Once very common, but now very rare. This is the tree which furnishes the shell-bark hickory.

*Carya tomentosa*, Nutl.

White-heart Hickory.

A few of this species were seen, but it, like the other, is becoming rarer each year. It may be known by the very thick hull of the nut and the small kernel.

*Carya porcina*, Nutl.

Pig-nut Hickory.

A large, valuable tree. The wood is extensively used for carriage work of the best class. The fruit of this tree is small and sweet at first, but leaving a bitter, disagreeable taste in the mouth. The bark of this species was formerly much used for chair seats, as, being tough, it could be woven readily into any shape desired.

*Celtis occidentalis*, Linne.

Hackberry.

A worthless tree that bears an edible fruit of which the birds are very fond; beyond this and as a fuel, it has no excuse for cumbering the ground on which it grows.

*Platanus occidentalis*, Linne.

Sycamore. Common.

A striking tree, both by reason of great size and color. At a distance a grove of these trees look like they had been white-washed and then splashed with patches of umber. The wood is in demand for the manufacture of cigar and tobacco boxes, it being one of the few woods that does not flavor the tobacco packed in it.

*Corylus americana*, Walt.

Hazel-nut.

This shrub grows extensively in Cass County and very sparingly in Wabash. The fruit is excellent after it is properly cured.

*Hamamelis virginiana*, Linne.

Witch Hazel.

A single specimen of this species was seen in Wabash County. It seems to be rare and is growing rarer each year, as it will not bear domestication, and is not worth the trouble if it would bear it.

*Fagus ferruginea*, Ait.

Beech.

This and the sugar maple constitute three-fourths of the forests of the two counties. In the early settlement of the State the settlers depended on the mast of this tree to grow and fatten their year's supply of pork, and the failure of the mast crop was a serious matter to them; now no one pays any attention to this subject, and a failure or abundance is not noted.

*Carpinus caroliniana*, Walter.

Water Beech.

A scrubby little tree that was formerly, at log-rollings, used for hand-spikes; but now is altogether useless economically.

*Fraxinus americana*, Linne.

Gray Ash, White Ash.

This noble tree was once common all over the State wherever there was a rich, moist soil. The great demand for it both for lumber and for fencing rails has about swept the remaining forests of it, but occasionally one remains towering above the surrounding beech and maple, its spreading top, crowning some ridge, visible for miles. Cut into veneers, there is no other native wood that surpasses it for beauty of grain and durability.

*Fraxinus viridis*, Michx.

Green Ash.

A smaller tree than the *F. americana*, and used principally for fencing rails and firewood.

*Fraxinus sambucifolia*, Lam.

Black Ash, Basket Ash.

A small tree used principally in the early settlement of the country for making baskets and bottoming chairs. It was prepared for this purpose by being cut to suitable lengths, soaked in water and then pounded with a mallet or billet of wood until it would separate along the lines of growth. It was then split into strips of the desired width and woven into baskets and chair bottoms.

*Fraxinus quadrangulata, Michx.*

Blue Ash.

A large tree found growing in boggy and swampy places, and, like the gray ash, it reaches noble proportions. Its well-known power to resist decay made it an universal favorite for rails and fence posts, and consequently it has nearly disappeared. A few years since one of us was shown a fence built of this timber, on the farm then owned by Levi Poke, of Fayette County, that had been built fifty-three years and appeared good for another half century.

*Asimina triloba*, Dunal.

Pawpaw.

One of our best native fruits, but sadly neglected. It is certainly worthy of cultivation, and doubtless could be very much improved in size and productiveness.

*Juglans cinerea*, Linne.

Butternut.

A few scrubby, half-dead butternuts, the last of their race, were seen. This tree seems unable to adapt itself to new conditions, and is rapidly dying out. This is a pity, for it furnishes a beautiful wood for the cabinet maker and an excellent nut.

*Juglans nigra*, Linne.

Black Walnut.

A few noble specimens of this grand tree were seen on some of the Indian Reservations, south of the Mississinewa River, in Wabash County. The exceedingly high price paid for walnut lumber a few years since induced nearly all the owners of trees to sell, and one may now travel for days before finding a single fair-sized tree when once they could be counted by the thousands.

*Liriodendron tulipifera*, Linne.

Yellow Poplar, Tulip-tree.

This beautiful and valuable tree was once common over the greater part of the State, but it is now rare. Its bloom is the most beautiful of any of our native trees, rivaling that of the far-famed magnolia of the South. It secretes a great deal of nectar, of which the bees and ants are very fond, the latter climbing to the top of the tallest trees to feed on the bloom. This I know to be true for I have shot the blossoms off the tall trees and found ants feeding in them when they fell to the ground. A. C. B.

*Quercus phellos*, Linne.

Willow-Oak.

A grove of this was seen in Cass County, one and one-half miles east of Lake Cicott, and another in Bethlehem Township. It is a rare tree, growing only on the sand ridges. It may be readily recognized by its dwarf growth and long, narrow, willow-like leaves.

*Quercus rubra*, Linne.

Red Oak.

Once very common; has now become rare, owing to the demand for it to make "quarter-oak" lumber for furniture and interior decorations. It was regarded by the farmer as of little value for the reason that when made into rails, unless they were made very small, they rotted in the center and left nothing but a thin shell on the outside.

*Quercus alba*, Linne.

White Oak.

A few trees of this species were seen in both Cass and Wabash Counties, but they were dying at the top and will soon be gone. A number of young groves are scattered over the two counties and in time will be very valuable, for there is no other tree in this latitude that can replace it for certain uses.

*Quercus muhlenbergii*, Engelman.

Chinquapin.

A medium sized tree with a sweet fruit of which children, squirrels and birds are very fond. The woodpecker lays up great hoards of this, beechnuts and other fruit. Ornithologists say the birds do not eat of these nuts, but feed on the grubs that are hatched in them.

*Quercus macrocarpa*, Michx.

Burr Oak.

Some magnificent trunks of this tree were seen in the southern part of Cass County, probably the last of a mighty race of giants once dominating the forest. These tree trunks were gotten out for shipment to Liverpool, England, and measured 26x28 inches, fifty feet long. The wood of this tree is more open than that of the white oak, and therefore in less demand by those acquainted with its qualities. This accounts for the preservation of the specimens seen.

*Ulmus americana*, Linne.

American Elm.

This is the noblest of our forest trees, and has greater individuality than any other I have ever seen. When one has seen a beech, maple, sycamore, poplar, or any other of our trees, he has seen all, for they are all alike. But it is not so with the elm, each one differs from all others, and herein lies its great charm. The young tree is as lissome and graceful as a maiden, and the old trees, even when a part of the crown is dead, and it has grown one-sided, is still pretty. If those who plant shade trees would select this instead of the maple, buckeye or Carolina poplar, they would have a tree that would live two or three hundred years and constantly increase in beauty and majesty as it grew older, instead of becoming a standing brush pile as most other trees do after twenty or thirty years—A. C. B.

*Pinus serotina*, Ehrh.

Wild Black Cherry.

A large tree that was formerly in demand for making furniture, but of late years has fallen into neglect.

*Pinus virginiana*, Linne.

Choke Cherry.

Was seen growing abundantly on the bluffs at Hanging Rock, in Wabash County.

*Myosotis arvensis*, Hoffman.

Wild Forget-me-not.

This beautiful little plant was found growing sparsely in Cass County, near Lake Cicott, and in Bethlehem Township. It seems to prefer the sand ridges and sandy fields, and was not seen elsewhere. It is very beautiful and is worthy of a place in every garden.

*Clematis viorna*, Linne.

Leather-Flower.

This odd and beautiful flower was seen on Shultz' Cone, in Wabash County, but not elsewhere. Numerous fragments of the sepals were scattered about and bore the appearance of having been partly eaten by some animal, possibly the ground squirrel, *Tamia striata*, as their burrows were here numerous. Some years since I saw this same vine in Cass County, near Curocton, but have not seen it since, though it may be abundant there.—A. C. B.

*Clematis virginiana*, Linne.

Virgins-Bower.

Common in Cass and Wabash Counties.

*Anemone pennsylvanica*, Linne.

Pennsylvania Anemone.

Rather common in the bogs and sloughs of Cass County.

*Anemone virginiana*, Linne.

Occurs in the open woods of Wabash and Cass Counties, where it seems to flower two or three weeks later than in the latitude of Indianapolis.

*Anemone nemorosa*, Linne.

Wind-flower.

This was not seen in bloom, but the plant was readily recognized by its general appearance.

*Hepatica acutiloba*, D. C.

Liver-Leaf.

This was not seen in bloom. It occurs in both counties; in fact, it seems to be pretty well distributed over the State.

*Myosurus minimus*, Linne.

Mouse-Tail.

Cass County. Rare.

*Caltha palustris*, Linne.

Marsh Marigold.

Rather rare in Wabash, but common in the swamps of Cass County.

*Aquilegia canadensis*, Linne.

Wild Columbine.

This beautiful flower is rather abundant on the rocks of the Wabash River west of Logansport, and it occurs rather sparingly in Wabash County along the river bluffs.

*Hydrastis canadensis*, Linne.

Golden Seal.

Rare.

*Delphin exaltatum*, Ait.

Tall Larkspur.

Rare in Wabash County.

*Delphinum azureum*, Michx.

Rare in both counties, not more than half a dozen plants having been seen.

*Podophyllum peltatum*, Linne.

May-Apple.

Common everywhere.

*Brasenia peltata*, Pursh.

Water-Shield.

Cass County. Not common.

*Nymphæ odorata*, Ait.

Sweet-scented Water-Lily.

In ponds and lakes in both counties. One of our most beautiful and striking flowers.

*Nuphar advena*, Ait.

Spatter-Dock.

Common in Cass County.

*Stylophorum diphyllum*, Nutt.

Celandine Poppy.

Rather common in rich woods, where its large flowers attract attention wherever seen.

*Sanginaria canadensis*, Linne.

Blood-Root.

A beautiful flower, with probably the purest white petals of any one of our native flowers. Common everywhere.

*Capsella bursa-pastoris*, Moench.

Shepherd's Purse.

Common.

*Dicentra cucullaria*, D. C.

Dutchman's Breeches.

A common and pretty little flower.

*Corydalis aurea*, Willd.

Golden Corydalis.

This is described in some of the text-books as low and spreading, but specimens were seen fully 18 inches high.

*Dentaria laciniata*, Muhl.

*Dentaria heterophylla*, Nutt.

Pepper-Root.

The former is rather abundant along streams and in rich, damp woods, while the latter is not common, and was only seen in rich woods.

*Saponaria officinalis*, Linne.

Bouncing Bet.

*Viola cucullata*, Gray.

Common Blue Violet.

*Viola striata*, Ait.

Pale Violet.

*Viola canadensis*, Linne.

Canada Violet.

*Viola pubescens*, Ait.

Yellow Violet.

*Viola pedatifida.*

Larkspur Violet.

Lake Cicott.

*Parnassia caroliniana*, Michx.

Grass of Parnassus.

Cass County on the banks of Crooked Creek.

*Silene stellata*, Ait.

Starry Campion.

Common in rich, moist woods and on the shaded side of fence rows.

*Silene virginica*, Linne.

Fire Pink, Indian Pink.

Next to the cardinal flower, this is the showiest of our wild flowers.

*Portulaca oleracea*, Linne.

Purslane.

A well known pest of the garden, and common everywhere.

*Claytonia virginica*, Linne.

Spring Beauty.

Common in warm, rich woods, and one of the earliest to bloom in this latitude; the pepper-and-salt and blood-root preceding it by a few days only.

*Abutilon avicenne*, Gaertn.

Indian Mallow, Velvet Leaf, Stamp Weed, Butter Print.

The common name, velvet leaf, aptly describes the leaves of this plant, which are as fine as a piece of the finest silk velvet; and butter print is from the fancied resemblance of the seed vessels to the print or mould housewives use in moulding butter.

*Oxalis stricta*, Sav.

Wood Sorrell, Sour Clover.

Much relished by the children for pleasant acid taste.

*Oxalis violacea*, Linne.

Violet Wood-Sorrell.

A rather handsome plant, common in most localities.

*Rhus typhina*, Linne.

Staghorn Sumach.

*Rhus glabra*, Linne.

Smooth Sumach.

*Rhus toxicodendron*, Linne.

Poison Ivy.

This is often confounded with the American ivy, but the latter differs in having five leaflets, while the former has but three. It is very variable in its mode of growth, when growing away from any support it is creeping, along fence rows it is shrubby and again it will climb to the top of the tallest trees. The latter form of growth is so striking that it was formerly erected into a distinct species as *R. radicans*.

*Vitis æstivalis*, Michx.

Summer Grape, Blue Grape.

A pleasant fruit, ripe in October.

*Vitis cordifolia*, Michx.

Frost Grape.

In favorable conditions of the atmosphere the fragrance of the bloom of this grape may be detected a long distance. Its fragrance is unlike that of any other flower in its wildness.

*Amphelopsis quinquefolia*, Michx.

Bitter-Sweet.

Seen only in Wabash. This climber is remarkably handsome in autumn when the vine is transformed into a flame of scarlet by the open covering of the seeds. It should be more generally cultivated as an ornamental plant.

*Enonymus atropurpureus*, Jacq,

Burning-Bush, Wahoo.

Conspicuous in autumn by its bunches of drooping crimson fruit.

*Staphylea trifolia*, Linne.

Bladder-nut, Rattle-box.

Not rare in either county. Rather conspicuous in autumn, after the leaves have fallen, by its inflated, three-cornered seed vessels.

*Trifolium pratense*, Linne.

Red Clover.

*Trifolium repens*, Linne.

White Clover.

*Melilotus officinalis*, Willd.

Yellow Sweet Clover.

The whole plant is fragrant.

*Melilotus alba*, Lam.

White Sweet Clover.

*Physocarpus opulifolius*, Maxim.

Nine-bark.

Rocks and cliffs of Cass County.

*Spiræa salicifolia*, Linne.

Willow-leaved Meadow-Sweet

Common in rich, wet ground.

*Spiræa lobata*, Jacq.

Queen of the Prairie.

Rare. The handsomest species of the genus; the flowers, a deep peach-blossom color, withering quickly on being plucked.

*Rubus occidentalis*, Linne.

Black Raspberry.

Common.

*Rubus villosus*, Ait.

Common or High Blackberry.

*Rubus hispidus*, Linne.

Swamp Blackberry.

Rather rare. Cass County.

*Rosa Carolina*, Linne.

Swamp Rose.

Common in Cass County.

*Rosa lucida*, Ehrhart.

Wild Rose.

Grows on the rocks of Wabash County and on the rocks and sandy ridges of Cass County.

*Rosa rubiginosa*, Linne.

Sweet Brier, Eglantine.

*Cratægus cocinea*, Linne

Red Haw.

Common.

*Cratægus tomentosa*, Linne.

Apple Haw.

Our largest fruited haw, the fruit often attaining a diameter of more than one inch.

*Cratægus crus-galli*, Linne.

Cock-spur Thorn.

May be known by its dark green shining leaves, and its long, slender, sharp thorns.

*Pyrus coronaria*, Linne.

Wild Crabapple.

The fragrance of its bloom is appreciated wherever it grows, and thrifty housewives utilize its fruit for jellies.

*Amelanchier canadensis*, F. & G.

Serviceberry.

Lagro, Wabash County.

*Œnotheria biennis*, Linne.

Evening Primrose.

Common.

# REPORT OF THE INSPECTOR OF MINES.

OFFICE OF THE INSPECTOR OF MINES,
BRAZIL, INDIANA, NOV. 1, 1891.

HON. S. S. GORBY, *State Geologist, Indianapolis, Ind.:*

SIR—Complying with section 5 of Senate Bill No. 118, passed by the Fifty-Seventh General Assembly of the State of Indiana, I herewith transmit the accompanying report of the Inspector of Mines, and his assistant, to you. This report is for the year ending Oct. 31, 1891, and is the eleventh report on coal mines in this State. It contains the estimated coal production for the year; also, estimated additional capital invested, a brief description of the mines visited, list of scales tested, accidents, fatal and non-fatal, and such other information as we could give that was deemed of importance.

Respectfully,

THOMAS McQUADE,
*Inspector of Mines, Indiana.*

# REPORT OF THE INSPECTOR OF MINES.

BY THOMAS McQUADE.

By way of explanation, I desire to say that no data or information of any kind was furnished me by my predecessor in office, covering the time from November 1, 1890, to the time of my appointment, March 15, 1891. In view of these facts, there might have been several accidents in the State that do not appear in this report. There might also have been several urgent calls for the Inspector that were not answered. But since the time of our entering upon the duties of the office up to the present time no requests for our presence, or legitimate demands for assistance from this office, have been allowed to pass without getting the attention the circumstances of the case required. In doing this we have been very busy, and have been compelled to do almost one year's work in a little over seven months. However, we are pleased to be able to state that in our efforts to have the laws complied with we have not met with any serious opposition, and although in a few instances we have had to prosecute on account of failure to comply with the laws, the general disposition is to comply without trouble. Another thing I desire to mention is the passage of Senate Bill No. 118, which gives the Inspector appointed under that act authority to appoint an assistant. This was certainly a step in the right direction, and affords much needed assistance to the Inspector and puts the mines of the State in a better position than ever before to receive the full benefit of the laws passed for their protection.

After it had become generally known among the mines that an assistant was to be appointed there were several applications for the position, any of whom would have made worthy officers. Out of the number applying, Mr. Wellman Lackey, of Sullivan County, was selected, who has performed the duties of his office in a highly satisfactory manner. For convenience we have divided the coal producing counties into two districts, Mr. Lackey taking the southern district, comprising the counties of Sullivan, Greene, Knox, Daviess, Martin, Pike, Gibson, Dubois, Perry, Spencer, Warrick and Vanderburgh, while I have the northern district, composed of the counties of Clay, Vigo, Parke, Vermillion, Fountain and Warren. It will be observed that the southern district is the larger in area, while the northern district gives employment to more men and produces the larger portion of our total output of coal; thus, in the end, the two districts are about equal.

Below is given the estimated production of coal for the year, which is 3,819,600 tons. This indicated a greater production than for any previous year, excepting 1890, when my predecessor, Mr. Tislow, estimated the production at 8,676,000 tons. This estimate must have been in excess of our total output in any two years, and consequently wrong and of no value. Therefore I claim that the year 1891 has seen the greatest production of coal in Indiana, and am of the opinion that had the supply of coal cars for transportation been equal to the demand our production this year would have reached almost five million tons. In estimating the capital invested this year in new mines, improvements, coal lands, railroad facilities, etc., we put it at one hundred and eighty-five thousand dollars ($185,000). This is perhaps low, indeed, it may be too low, but according to the figures obtainable we believe it to be as nearly correct as we can make it.

## WAGES.

Since the historical strike of the year 1889, in Clay County, when the miners struck against a reduction of wages, and after about seven months of a desperate struggle were compelled to accept the terms proposed by the operators, that friendly feeling that had existed for some years between operators and miners was broken, and has not, up to this time, been restored. The operators seem to think the men should be willing and ready to work at whatever price is offered. The miners take the position that their labor is all the capital they have, and to sustain themselves and families they must sell it at the highest possible price; but, notwithstanding this, there was almost universal peace in this county from November, 1889, to November 2, 1891, at which time the men held a mass meeting in the city of Brazil and decided to make a demand for an advance of ten cents per ton. The committee of miners who waited upon the operators reported that the demand had been refused. After some debate an adjournment was taken, to give the miners in all parts of the State an opportunity to meet and decide whether a universal demand by the miners of the State should be made for what is known as the "Columbus scale." After a meeting in Terre Haute and one in Brazil, on November 7th a strike for the scale (mentioned above) was inaugurated. This strike is for an advance of ten cents per ton in the block coal mines and five cents per ton in the bituminous mines of the State. This is the beginning of the greatest strike among the miners in the history of the State—that is, more men have this week laid down their tools than at any one time since the first ton of Indiana coal was mined and put on the market. This strike, if a protracted one, will bring privation and want into many a home in Indiana. It will also compel people to be very economical in burning coal, in order that they may be more certain to have their necessities supplied until peace is again restored. In observing the changes that have come to the miners in laws passed for their benefit in almost every coal-producing State, I find myself asking the question, Is there not some other and better way for labor and capital to adjust differences than by always having recourse to strikes as soon as a misunderstanding occurs between them? I can not say that I have a remedy to suggest, nor even a new idea to present, but it does seem that the miner or some one else ought to develop some satisfactory plan by which the disputes that arise from year to year may be adjusted without the miners having to lay down their tools to enforce a just and reasonable demand. In conversation with an old miner recently, he said: "I believe we are beyond doubt entitled to an advance, but we should not be compelled to strike for that which the operators can well afford to give and still have a handsome profit on every ton of coal we produce, which profit he is deprived of as soon as we quit work, while we lose the only thing we have, that is, the product of our labor." Continuing, he said: "It is but a few years since we had to strike to have the mine owners in many places supply us with sufficient air in the mines to enable us to work, and again on account of scales being incorrect. After a while the State took up the matter and appointed men to look after the ventilation in mines, examine and test scales, and thus remove the cause of strikes of former days, making it safer and better for all concerned; and now, why not have the State authorize the appointment of a Board which shall have the right to investigate causes of complaint and render decisions that will be final and binding on all parties interested, and thus do away with strikes altogether?" I do not know that the State could do this, but certainly strikes are a great evil and should be done away with.

## ACCIDENTS.

In giving the list of accidents reported to me I have no comment to offer on any of them, except that of John Jenkins, which occurred at Pratt Mine, October 21, 1891. This accident occurred in a room. The deceased was a youth in his fifteenth year. He was working with his father and brother, and while passing under what is known to miners as a "slant," it fell out, killing him instantly. A piece of the slant had already fallen, showing plainly there was a slant in this room, and to secure it properly should have been the first duty of the man working there, but this was not done. There was nothing to show that any special attention was given this bad stone. The result was the boy's death. The mine boss said that he had paid the deceased's father to properly timber the room, but this was not done. It seems that, despite Mr. Jenkins', Sr., statement to the effect that he wanted nothing but what was at hand to timber the piece properly, the fact remains that his son lost his life through carelessness or ignorance, and possibly both. The other accidents were of the kind that are liable to occur in any mine at any time.

## ACCIDENTS—FATAL.

March 18, 1891, Charles Dixon; killed by fall of slate in No. 8 Mine, owned by Brazil Block Coal Company, in Clay County.

April 8, 1891, John O'Donnell; killed while driving mule in No. 8 Mine, owned by Brazil Block Coal Company, in Clay County.

April 29, 1891, G. Martin; killed by premature explosion of blast in Pratt Mine, owned by Coal Bluff Mining Company, in Clay County.

September 8, 1891, Wm. Sanders; killed by railroad cars while trying to let one down to be loaded, at No. 8 Mine, owned by Brazil Block Coal Company, in Clay County.

October 21, 1891, John Jenkins; killed by fall of slate in Pratt Mine, owned by Coal Bluff Mining Company, in Clay County.

## ACCIDENTS—NON-FATAL.

January 2, 1891, Joe McCann; leg broken by fall of slate in Diamond Mine, owned by Coal Bluff Mining Company, in Vigo County.

April 1, 1891, Robert Watts; seriously injured in back by fall of slate in Pratt Mine, owned by Coal Bluff Mining Company, in Clay County.

April 20, 1891, Charles Sinns; arm broken by fall of coal in Gartsherrie, No 3, owned by Brazil Block Coal Company, in Clay County.

May 20, 1891, Lindsey Morton; seriously injured by falling down Columbia Shaft, from the top to the bottom, a distance of 22 feet. Mine owned by Zeller & Sigler, in Clay County.

June 15, 1891, James R. Yaden; leg broken by fall of slate in Mine No. 2, Coxville, owned by Brazil Block Coal Company, in Parke County.

July 10, 1891, D. Byrs; injured in back by fall of slate in Watson's No. 3 Mine, owned by Gartsherrie Coal and Mining Company, in Clay County.

July 12, 1891, George Potts; injured in back by fall of slate in Mine No. 10, owned by Brazil Block Coal Company, in Clay County.

July 15, 1891, William Taylor (colored); back and leg injured by fall of slate in Jumbo Mine, owned by Watson, Little & Company, in Clay County.

August 20, 1891, David Moody; seriously injured by fall of slate in Jumbo Mine, owned by Watson, Little & Company, in Clay County.

September 2, 1891, Roe Crable; squeezed between bank cars at Mine No. 9, owned by Brazil Block Coal Company, in Clay County.

September 10, 1891, Morgan Summers; injured in back by fall of coal in Newburg Mine, owned by P. Ehrlich & Company, in Clay County.

September 18, 1891, S. Diggerish; foot injured while coupling railroad cars at Jumbo Mine, owned by Watson, Little & Company, in Clay County.

September 30, 1891, James Hawkins; leg broken while driving at Crawford's No. 2, owned by Crawford Coal Company, in Clay County.

October 21, 1891, F. Messinger; shoulder and back injured by fall of slate in Pratt Mine, owned by Coal Bluff Mining Company, in Clay County.

October 26, 1891, John Lark; collar bone broken by fall of slate in Gartsherrie No. 1, owned by Brazil Block Coal Company, in Clay County.

### SCALES TESTED.

June 3, 1891, Diamond Mine, located just north of Clay City, in Clay County. Scales tested and found incorrect.

June 3, 1891, Morrier Mine, located just north of Clay City. Scales tested and found correct.

June 5, 1891, No. 7 Mine, located near Minshall, in Parke County. Scales tested and found correct.

June 13, 1891, No. 8 Mine, located just north of Perth, in Clay County. Scales tested and found correct.

June 19, 1891, Grant Mine, located near Grant, in Vigo County. Scales tested and found incorrect.

June 26, 1891, Gartsherrie No. 1, located north of Knightsville, in Clay County. Scales tested and found correct.

July 2, 1891, No. 6 Mine, located west of Cardonia, in Clay County. Scales tested and found correct.

July 2, 1891, No. 7 Mine, located west of Cardonia, in Clay County. Scales tested and found correct.

July 6, 1891, Banner Mine, located east of Carbon, in Clay County. Scales tested and found incorrect

July 9, 1891, Diamond Mine, located just north of Clay City, in Clay County. Scales tested and found correct.

July 13, 1891, White Elephant Mine, located just west of Newburg, in Clay County. Scales tested and found incorrect.

July 15, 1891, Gartsherrie No. 2, located north of Harmony, in Clay County. Scales tested and found correct.

July 15, 1891, Watson's No. 3, located south of Brazil, in Clay County. Scales tested and found correct.

August 11, 1891, Grant Mine, located near Grant, in Vigo County. Scales tested and found correct.

August 17, 1891, Jumbo Mine, located just north of Knightsville, in Clay County. Scales tested and found correct.

August 17, 1891, Columbia Mine, located southwest of Knightsville, in Clay County. Scales tested and found correct.

August 28, 1891, Watson's No. 2, located near Newburg, in Clay County. Scales tested and found correct.

Upon examination of the report of scales tested in the Northern district it will be observed only a very few were found incorrect. This shows that more attention is paid to scales than formerly, or that scales do not get out of repair to as great an extent in summer as in winter, which is probably true.

Below will be found a brief description of mines visited, their location, etc.:

## CLAY COUNTY.

GARTSHERRIE, No. 1. This mine was visited three times. Upon my first visit there were but few men at work, most of whom were working pillars near the shaft. A tunnel was being opened from the bottom to the top vein. The ventilation was poor. Immediately after this visit the company put down an air shaft at the top of the tunnel, thus making an upcast for the air and an escape shaft at the same time. Upon my second visit I requested that the air-course be cleaned and enlarged so that the volume of air might be increased, also that the air be split. On visiting the mine a third time, to see that the work had been done according to instructions, everything was found in a fairly satisfactory condition. Only the top vein is being worked at this time. The mine is owned by the Brazil Block Coal Company. Seventy-seven men are employed.

GARTSHERRIE, No. 2. This mine was visited twice and found in fair condition. It is the bottom vein that is being worked. They employ about forty-eight men. This mine is owned by the Brazil Block Coal Company.

GARTSHERRIE, No. 3. This mine was also visited twice and found in fair condition. Both veins are being operated here. Seventy-five men are employed. This mine is owned by the Brazil Block Coal Company.

GARTSHERRIE, No. 4. This mine was not visited. It is a new mine, which is just being opened. The bottom vein is operated. Twenty-five men are employed. The mine is owned by the Brazil Block Coal Company.

GARTSHERRIE, No. 6. This mine was visited three times. The two veins are operated. The men working in the bottom vein were well supplied with air, but the men at work in the top vein had not enough. At my request some changes were made that gave all a sufficient supply. On my second visit what is known as the "old top vein" had been reopened, but the ventilation was poor in that part of the mine. At the expiration of ten days, given to make necessary changes, I again visited the mine and found it in satisfactory condition. Seventy-one men work here. It is owned by the Brazil Block Coal Company.

GARTSHERRIE, No. 7. This mine was visited twice. On both occasions it was found in good condition. Two veins are being worked here. Sixty-three men are employed. It is owned by the Brazil Block Coal Company.

GARTSHERRIE, No. 8. This mine was visited twice. On both visits it was found in good condition, although in one south and one east entry there was not enough ventilation. At my request the south entry was stopped, and to improve the east entry an additional split in the air was made. The top vein is worked here. The shaft is down to the lower vein, but there are no men at work in it yet. They employ 170 men. It is owned by the Brazil Block Coal Company.

GARTSHERRIE, No. 9. This mine was visited twice. On both visits it was found in good condition; the only change was to split the air and drive an air course with an entry on west side of the mine. The mine is owned by the Brazil Block Coal Company.

GARTSHERRIE, No. 10. This mine was visited twice. On my first visit the supply of air was inadequate. At my request the fan house was changed. When visited the second time the mine was in good condition. The only change needed was to split the air on east side of mine. This shaft is down to bottom vein. They employ 109 men. It is owned by the Brazil Block Coal Company..

CHICAGO. This mine was visited three times, but inspected only twice. On my first visit there was a lack of a sufficient supply of air. The mine boss put men at work clearing the air course and making the breaks through air-tight. On my second visit the condition of the mine was so much improved there was no cause for complaint. They employ 86 men. It is owned by the Brazil Block Coal Company.

CRAWFORD'S, No. 2. This mine was visited twice. On my first visit the mine was in good condition. On my second visit I found they needed the air split on east side very badly. This work is now being done. When completed it will improve the air very much. They employ 155 men. It is owned by the Crawford Coal Company.

CRAWFORD'S, NO. 3. This mine is a new one, and was visited once. The shaft is 92 feet deep; they finished sinking it in August. It is ventilated by fan. The lower vein is operated, in which 21 men are at work. The mine is owned by the Crawford Coal Company.

CRAWFORD'S, NO. 4. This mine was visited twice. On my first visit it was operated by the Schrepferman Coal Company, and several changes were suggested. On my second visit the present owners had taken charge and had begun making the changes needed, the most important of which was the making of an outlet for the men. Fifty-seven men work here. This mine is owned by the Crawford Coal Company.

NICKEL PLATE. This mine was visited twice, but aside from taking a few men out of places that were unfit for them to work in no changes were made, as the mine is an old one and nearly all the men are working on pillars. Eighty-six men are employed. It is owned by the Jackson Coal and Mining Company.

CHICAGO. This mine was visited twice. On my first visit the condition of the mine was fair. The only place that had not a sufficient current was that part known as the tunnel. On my second visit this tunnel was still short of air. The company went to work to improve it, and though I did not visit it a third time I am reliably informed it is in good condition. One hundred and twenty men are employed. It is owned by the Nickel Plate Coal and Mining Company.

NEWBURG. This mine was visited twice. On both occasions the ventilation was fair, but not perfect, owing to the air courses not being kept up with the entries. I have the assurance of the Superintendent of the company that this will be attended to in future. One hundred men are employed. It is owned by P. Ehrlich & Company.

WATSON'S, NO. 3. This mine was visited once, and found in good condition. It is a new mine, and has only been in operation a short time. In fact, this opening is simply the continuance of what was formerly known as the "Brushville Mine," owned by the same company, the old Brushville being abandoned about the middle of July. Fifty-five men are employed. It is owned by the Gartsherrie Coal and Mining Company.

WATSON'S, NO. 2. This mine was visited twice. On my first visit there was no escape shaft, but at my request one was put down immediately. On my second visit the mine was found in as good condition as it was possible to have it. The roof at this mine is very poor, causing extra work, care and attention. Thirty-five men are employed. It is owned by the Gartsherrie Coal and Mining Company.

DIAMOND. This mine was visited once. That part of the mine, where the men were there at work, was fairly well ventilated, but only a few men were then at work on account of the mine being then flooded with water, which was not all pumped out, and about the time the water was all out the pump buildings and engine-house took fire, from some unknown cause, and burned to the ground, and have not yet been rebuilt It is the intention of the company to temporarily rebuild, so as to enable them to take out the pillars, when the mine will be abandoned. Prior to the fire fifty-five men were employed. It is owned by Zeller & Sigler.

COLUMBIA. This mine was visited three times. On my first visit it was in fair condition. On my second visit it was in very poor condition. Almost everything presented the appearance of neglect. Ten days was given to make needed changes; at the expiration of that time the mine was again visited and found in a satisfactory condition. One hundred and sixty-eight men are employed. The two veins are operated. It is owned by Zeller & Sigler. This company own the Vandalia Mine, but it has been idle nearly all the year, only a few men having been at work.

CHURCHILL. This mine was visited twice. On my first visit an insufficient amount of air was in circulation in the top vein. Cages were not properly covered. After ten days' time had expired I again visited the mine, and finding the work had not been done, I filed complaint before Esquire Schultz and had the Superintendent arrested, but after a statement to the court, which went to show that the work was delayed unavoidably, he was allowed to pay the costs and depart, agreeing to at once finish the work. Since that time I have had no complaint, and now believe the mine to be in good condition. They employ eighty men. It is owned by Weaver, Getz & Co.

JUMBO. This mine was visited twice and found in good condition. They need the air split very badly, and are now at work to make the changes. Both veins are being operated here. The coal from top vein is taken out by means of two slopes running down to lower vein. One hundred and ninety-four men find employment here. The mine is owned by Watson, Little & Co.

MORRIS. This mine was visited twice. On my first visit I found the fan needed changing. The air course on the east side was too small. The air nearly all over the mine was poor. These things needed changing at once. Ten days was given to do the work, and though the time was short, when it had expired I brought suit against the company, but on learning the mine had changed hands during the time, the case was not pressed to trial, and the work was done without further delay. Sixty-four men are employed here. It is owned by the Sherburne Coal Company.

Harrison. This mine was visited twice, and found in fair condition, employing 77 men. It is owned by the Chicago & Indiana Block Coal Company.

Anchor. This mine was visited three times. On my first visit it was found in good condition. On my second visit they needed new cages and a new air shaft from top to bottom vein. On my third visit the work was all done except the air shaft, which was just being completed. Sixty-six men are employed. It is owned by the Coal Bluff Mining Company.

Pratt. This mine was visited three times. On my first visit it was found in bad condition. The Superintendent was instructed to clean out the air shaft, put stairs in escape shaft, split the air, cover the cages and put on safety catches. On my second visit none of this work was done, the Superintendent having left a few days after my former visit. I then gave fifteen days to have the work all completed. On my third visit the work was all finished, and the mine in good shape. During the summer a drop shaft was put down from top vein to bottom. It is located on south side of shaft, and all the coal from the south and west, in the top vein, is dropped to bottom vein, and there hoisted. Eighty-nine men find employment here. It is owned by the Coal Bluff Mining Company.

Swamp Angel. This mine was visited twice. On both visits it was found in fair condition, and yet there were many complaints about leaving doors open, shooting during the day, and water in an abandoned mine. After careful investigation I concluded there was no danger from water at present, and the boss agreed to stop the shooting during the day, and see the doors was kept shut. This mine is a new one, having been put down during the past winter. Last summer an escape shaft was completed, and they are now driving a tunnel from top to bottom vein. They employ 31 men. It is owned by the Hoosier Coal Company.

Nellie. This mine was visited three times. On my first visit the mine was in bad condition. There were several entries driven without air courses. The cages had neither safety catches nor covers on them; in short, it seemed to be operated without any regard for law. After two more visits had been made I found they were driving entries and air courses together. The cages had been covered, safety catches put on, and the mine was being put in good condition. One hundred and twenty men are employed. It is owned by the Otter Creek Coal Company.

Eureka. This mine was visited twice and found in good condition. It is a new mine, having been put in operation this year. The bottom vein is operated. The coal is four feet high and the mine is ninety feet deep. After my first visit they immediately began sinking an escape shaft, which was finished in September. The mine is owned by Woodruff & Co., and is located one-half mile east of Carbon, on the Indianapolis & St. Louis Railroad. Fifty-five men are employed.

MORRIER. This mine was visited twice. On my first visit there was no escape shaft, no brake on drum, no indicator, a very bad rope inside the mine, and the breaks through were either too small or almost entirely filled up. On my return visit all those evils had been remedied, except the escape shaft, which they now have finished. Fifty-six men are employed. It is owned by the Morrier Coal Company.

DIAMOND. This mine was visited twice, but there is no necessity for me to speak of what was done, as the mine is now abandoned. The company have sunk a shaft west of this one, and are now taking the coal all out of the new shaft, and are using this shaft for an escape shaft. They employ forty-nine men. It is owned by the Lancaster Coal Company.

In addition to the mines mentioned in Clay County, the Davis Coal Company are now at work sinking a new shaft about two miles northeast of Brazil. This is a new company that has not, prior to this time, been engaged in the coal business. Weaver, Getz & Co. are finishing a new mine near Center Point. This mine is on an extension of the Knightsville South Branch, owned by the Vandalia Railroad Company. This extension was made during the summer, and is intended to open a new field of coal land lying between Asherville and Center Point, and is the only one built in Indiana this year of any importance for the developing of the coal field.

VIGO COUNTY.

FOUNTAIN, NO. 2. This mine was visited twice. On my first visit it was found without an escape shaft, and the 39,420 cubic feet of air produced by the fan was circulating in one volume around the mine. I asked that an escape shaft for the men be made and the air divided. On my second visit I found the escape completed and nearly all the work complete. Since that time I have been informed that all is now finished. One hundred and fifty-two men are employed. It is owned by the Coal Bluff Mining Company.

NEW EDGAR. This mine was visited twice, but inspected once. The condition of the mine at that time was good. Forty-four men are employed. It is owned by the Coal Bluff Mining Company.

DIAMOND. This mine was visited twice. On my first visit they needed covers on cages and safety catches, brake on drum, air divided, etc. On my second visit all was done except safety catches, which were put on immediately afterward. Eighty-eight men are employed. It is owned by the Coal Bluff Mining Company.

SEELYVILLE. This mine was visited twice. On my first visit an entry was stopped at my request, on account of being ahead of air. On my second visit everything was in a satisfactory condition. Fifty-three men are employed. It is owned by P. Ehrlich & Co.

GRANT. This mine was visited twice. On my first visit there appeared to be no regard for the law in the manner of operation. On my second visit very little change had been made. I then filed an affidavit against the Superintendent, who pleaded guilty and was fined. I have not been at the mine since the affidavit was filed, but have information to the effect that the mine is now all right in every particular. Fifty-five men are employed. It is owned by Woodruff & Trunkey.

In addition to the mines in this county mentioned above, the Indiana Coal Company is preparing to sink a shaft one mile northwest of Coal Bluff.

The Otter Creek Coal Company is still doing business on a small scale north of Cloverdale.

## OWEN COUNTY.

LANCASTER, No. 3. This mine was visited twice. On my first visit several entries were driven without air courses, and one east entry had fallen in, and had almost completely cut off the return of the air. The cages were in very poor condition. On my second visit, which was twelve days after my first, I found cages fixed, the return air courses reopened, and I received assurances from the bank boss that no more entries would be driven without air courses being driven with them. One hundred and three men are employed. It is owned by the Lancaster Coal Company.

In addition to this mine there is another one in Coal City, which is owned by a resident of that place. I visited this mine twice, but never went down, as it was not in operation.

## VERMILLION COUNTY.

NORTON CREEK. This mine was visited once. At that time it was found in fair condition. The only objection made was on account of the breaks through not being properly constructed. The mine boss promised to remedy the defects at once. Fifty-nine men are employed. It is owned by the Norton Creek Coal Company.

NORTON CREEK, No. 2. This mine was visited once, and found in fair condition. Sixty-five men are employed. It is owned by the Norton Creek Coal Company.

NORTON CREEK, No. 3. This mine was visited once. On that occasion I found that the air should be divided on the north side of shaft, and covers put on the cages. I returned several days after, and without entering the mine I found the work was all done. One hundred and eighteen men are employed. It is owned by the Norton Creek Coal Company.

HAZEL CREEK. This mine was visited twice. On my first visit the only objection made was the distance between breaks through between entry and air course, and the failure to split the air. On my return visit the overcast made to enable them to split the air was almost complete, and the bank boss assured me that in future breaks through would be made not more than fifteen yards apart. One hundred and twenty men are employed. It is owned by the Hazel-Dell Coal Company.

In addition to the mines above mentioned in this county, the old Brown mine was being cleaned up, a new tipple being built, and extensive preparations were being made to get out large quantities of coal.

## PARKE COUNTY.

No. 6. This mine was visited twice, and found in fair condition on both visits. Eighty-seven men are employed. It is owned by the Parke County Coal Company.

No. 7. This mine was visited twice, and found in good condition on both visits. Seventy-three men are employed. It is owned by the Parke County Coal Company.

No. 8. This mine was idle a good portion of the year, consequently was visited but once. It was found in good condition. Twenty-three men are employed. It is owned by the Parke County Coal Company.

No. 9. This mine was visited twice. The general condition of the mine is good, but breaks through are not made often enough, and when they are filling them up again they are not made air-tight. They have orders to split the volume of air. The changes that are necessary here the mine boss promised to make at once. One hundred and four men are employed. It is owned by the Parke County Coal Company.

No. 3, COXVILLE. This mine was visited twice. When first visited they were taking up the bottom at bottom of shaft, preparing to start the mine. On my second visit a great many complaints were made about the breaks through not being made often enough, and the air not being split on northeast side of mine. After going all through the mine I arranged, with the assistance of the Superintendent, to remove the causes of complaint at once. One hundred and twenty-nine men are employed. It is owned by the Brazil Block Coal Company. This company was also operating Mine No. 2, at Coxville, which was worked out and abandoned in August.

BLAINE. This mine was visited twice, but owing to it not being in operation I did not enter on both occasions. This mine has been idle for two years, and has been reopened with a view to working it out and abandoning it at an early date. The mine boss thinks this can be done in about seven months. The general condition of the mine was fair. The slopes that were operated in connection with this mine are abandoned, except one, and only three men are at work in it. Fifty men are employed, and it is owned by the Brazil Block Coal Company.

McCUNE. This mine was visited once, and the ventilation is good, but they have no escape shaft. Twenty-three men are employed. It is owned by S. S. McCune.

WABASH VALLEY, No. 1. This mine was visited once. This is a new mine. The shaft is 153 feet deep, and it is located just across the river from Clinton. This company intends sinking several shafts in this territory, they having purchased and leased several hundred acres of land. At the time of my visit twenty-nine men were employed. It is owned by the Wabash Valley Coal Company.

---

OFFICE OF ASSISTANT INSPECTOR OF MINES,
DUGGER, IND., November 1, 1891.

THOS. MCQUADE, *Inspector of Mines of the State of Indiana:*

SIR—In accordance with the statutes, the first annual report of the Assistant Inspector of Mines is submitted.

Respectfully,
WELLMAN LACKEY,
*Assistant Inspector of Mines of the State of Indiana.*

### LOCATION AND DESCRIPTION OF MINES IN DAVIESS COUNTY, INDIANA.

BUCKEYE MINE. Operated by the Mutual Mining Company. It is located at Cannelburgh, on the O. & M. R. R. This mine was inspected twice and found in good condition. The mine will be worked out in about eight months. The men are now all working on pillars.

MUTUAL MINE. Operated by the Mutual Mining Company. It is located one mile south of Cannelburgh. On my first visit to this mine the air was very bad. On my second visit I found that they had made repair in doors and brattice, but had not as yet sealed their downcast through which the most of the air was escaping, and was returning up the main shaft without reaching the working part of the mine. They will fix the air shaft soon, and then the air will be good.

MURRAY & BAILEY'S MINE. Operated by White River Valley Coal Company. It is located seven miles south of Washington on the E. & I. R. R. This mine was only inspected once; the air was good. On my last visit the mine was idle on account of a change of ownership.

WILSON, No. 2. Operated by Wilson & Co. It is located one and one-half miles northwest of Washington on the E. & I. R. R. This mine was inspected twice and found in good condition on both visits.

WILSON'S MINE. Operated by the Wilson Coal Company. It is located near Montgomery on the O. & M. R. R. On my first visit to this mine the air was not good in some parts of the mine, on account of connecting with some old works. But on my last visit these old works had been cleaned up and they were using the old shaft as an upcast and the air was good. The south side of this mine has not been worked for a long time, on account of a large hill which they are now cutting through, the highest point being eight feet. After this work is completed they will be able to drain their mine, which is very wet on that side.

MAPLE VALLEY MINE. Operated by Cable & Company. It is located two miles southwest of Washington, on a branch of the O. & M. R. R. This mine was inspected twice and found in good working order. Almost every feature of the law was complied with. This mine has a fifteen foot fan; seam being the thickest in Southern Indiana.

No. 6 MINE. Operated by Cable & Company. It is located two miles west of Washington. This mine will soon be worked out. All the men are drawing pillars. It was inspected twice and found in good condition.

No. 7 MINE. Operated by Cable & Company. It is located one and one-half miles west of Washington. This mine was inspected twice. The ventilation is good, though the roof is very bad. Two entries going west have run into quick sand and are closed in at face. All entries going east have raised until they have almost reached the surface.

No. 4 MINE. Operated by Cable & Company. It is located two miles south of Washington. On both visits to this mine it was found in good working condition. The north side of this mine is worked out with the exception of the pillars. They are now working sixteen men on them, and will have them completed by the first of February, 1892.

PIKE COUNTY.

BLACKBURN MINE. Operated by the Posey Coal Company. It is located three miles east of Petersburgh, on the E. & I. R. R. This mine was inspected twice. It was filled with water last winter and laid idle until the first of July, and on my first visit they had just started to work. The doors and brattice were all down and the air was very bad. On my second visit they had remodled the mine, but the air was not good yet. They are sinking a new slope just west of the old one, which they will have completed by the first of January. They will connect the old and new mines together and the air will be good.

ROGER'S MINE. Operated by Samuel Rogers. It is located at Rogers Station, on E. & I. R. R. This mine was only inspected once. On my last visit the men were on a strike. This mine is very wet. The air was good, with very few exceptions.

LITTLE'S MINE. Operated by S. W. Little. It is located at Littles, five miles east of Oakland City, on the E. & I. R. R On my first visit to this mine there was plenty of air, but it was very hot, on account of fan-room being connected with the boiler house. On my second visit they had disconnected the two rooms, and the air was cool, and the mine in good condition. This mine has been working electric mining machines, and on my second visit they had taken them out for some cause, which I was unable to ascertain.

AYSHIRE MINE. Operated by David Ingle. It is located at Ayrshire, on the Air Line Railroad. This mine is ventilated on one side by fans, and other side by a furnace. This is a very large mine. On both my visits the air was not what it should have been. They are sinking a new shaft east of the old slope. This shaft was down to the coal on my last visit. Both mines will be connected in a very short time, as there is only about thirty yards of entry to drive. When this is completed there will be no trouble in ventilating the mine.

GIBSON COUNTY.

FRANCISCO MINE. Operated by E A. Powell. It is located at Francisco, on the Air Line Railroad, six miles west of Oakland City. This is a new mine. On my first visit the condition was not very good. The air-ways connecting with the downcast were so small that it was impossible for a sufficient volume of air to be forced through them. I gave instruction, and on my last visit they had widened the air-ways, and the air was good. This company is putting in mining machinery. They have no man-way, but will sink one at once.

PERRY COUNTY.

CANNELTON MINE. Operated by the American Cannel Coal Company. It is located three miles northeast of Cannelton. This mine was inspected twice, and found in good working condition.

TROY MINE. Operated by Bergamroth Bros. It is located one half mile south of Troy. I visited this mine twice. On first visit the air was very bad, and the furnace stack had been blown down, but on my second visit they had rebuilt the stack, and the air was better. The Superintendent promised to put up a fan at once.

GREENE COUNTY.

SUMMIT MINE. Operated by the Summit Coal Company. It is located four miles southeast of Dugger, on the I. & I. S. R. R. and Greene County Coal Branch Railroad. On my first visit to this mine there were only about forty men in, and the air was good. On my second visit they were working ninety-five men, and the air was bad on account of leak in the downcast, which they have since sealed, and the air is now good.

BUCKEYE MINE. Operated by the Linton Coal and Mining Company. It is located one mile south of Linton, on the Greene County Coal Branch Railroad. It was inspected twice, and found in good working condition.

ISLAND, NO. 1. Operated by Island Coal Company. It is located two miles south of Linton, on the Greene County Coal Branch Railroad. On my first visit this mine was found in bad condition. On my second visit, September 28, it was closed for repairs. The curbing in shaft was decayed.

ISLAND, NO. 2. Operated by the Island Coal Company. It is located at Linton, on the Greene County Coal Branch Railroad. This mine was inspected twice. On my first visit the air was bad in a great many rooms, on account of having no break through. Some rooms were in seventy yards without any circulation of air through them. On my last visit they had made breaks through, and the air was good. They now have a man employed to look after the circulation of the air. All coal in this mine is produced by machinery. They are now using twenty-five mining machines, and producing more coal than any other mine in Southern Indiana. They hoist from nine to twelve hundred tons per day.

SPENCER COUNTY.

LINCOLN MINE. Operated by Scott & Schafer. It is located one mile east of Lincoln, on the Cannelton branch of the Air Line Railroad. This is a new mine, and had never been inspected until July 28, 1891. The mine produces but very little coal, but considerable of fire clay, which finds a ready market in Evansville. This mine was inspected twice. On my first visit the doors and brattice were in a bad condition. On my second visit they had improved the ventilation of the mine. They have no man-way, but will sink one at once. The coal is only thirty feet from the surface.

### WARRICK COUNTY.

STAR MINE. Operated by John Archbold. It is located one-half mile east of Newburgh. This mine was inspected twice. On my first visit the air was very bad on account of not having an air shaft. On my second visit they had sunk an air shaft and erected a fan, and the ventilation was good.

GOUGH MINE. Operated by Robert Gough. It is located one-half mile north of Boonville, on the Boonville branch of the Air Line R. R. On my first visit to this mine I found the air very bad. On my second visit they had put np a good furnace, doors and battrice, and the air was good.

CHANDLER MINE. Operated by Hall & Brewis. It is located at Chandler, on the Boonville branch of the Air Line R. R. This mine was inspected twice. On my first visit the air was very bad on account of the air-ways being closed up by falls of slate. On my second visit they had cleaned up the air-ways, but the air was not very good yet, on account of having to travel through old works. They will put up a fan, and then they can circulate the air without going through the old works. The head gearing is not good, but will be rebuilt at once.

LOWDER MINE. Operated by the Lowder-Wooley Company. It is located one mile east of Boonville, on the Boonville Branch of the Air Line R. R. This is a new mine. On my first visit the mine was found in good working condition. On my last visit the mine was closed on account of a strike.

ST. ELMO MINE. Operated by Gaslee & Lockwood. It is located two miles west of Boonville, on the Boonville branch of the Air Line R. R. This mine was only inspected once. On my first visit they were working four men and it did not come under the law. On my second visit they were working 15 men and two mining machines. The air was not very good, but they will put up a fan at once.

### VANDERBURGH COUNTY.

FIRST AVENUE MINE. Operated by the First Avenue Coal Company. It is located north of Evansville. On my first visit to this mine it was found in bad condition on account of its having been idle three months, and was just starting up. On my last visit the mine was in better condition. They had connected their east and north works together and had better ways of conducting the air. This mine is not worked on any system and is very hard to ventilate. There is considerable of the gas known as "black damps" to contend with.

DIAMOND MINE. Operated by the Diamond Coal Company. It is located northeast of Evansville. This mine is worked on the system of double entries. It has a good fan. It was inspected twice and the ventilation was very good.

INGLESIDE MINE. Operated by John Ingle & Company. It is located west of Evansville. This mine is affected some with "black damps." It was inspected twice and found in good working condition. It is ventilated by a fan, and has an upcast. The company is putting in electric drills.

SUNNYSIDE MINE. Operated by the Sunnyside Coal and Coke Company. It is located north of Evansville on the Belt R. R. This mine was inspected twice and its condition was good. This mine is worked by machinery.

UNITY MINE. Operated by the Sunnyside Coal Company. It is located north of Evansville on the P., D. &. E. R. R. On my first visit to this mine it was lying idle. On my second visit there were four men employed. They were driving an entry to connect with Sunnyside Mine.

## KNOX COUNTY.

BICKNELL MINE. Owned by the Bicknell Coal Company. It is located east of Bicknell on the I. &. V. R. R. This is a new mine and has been in operation about nine months. It was inspected twice and found in good condition.

FREEMAN MINE. Owned by the Vincennes Coal Company. It is located east of Vincennes. On my first visit to this mine there was plenty of air, but it was not conducted throughout the mine properly on account of not having enough doors and brattice. On my second visit they had made repairs and the air was good.

PROSPECT HILL MINE. Operated by Frank Clark. It is located one-half mile southeast of Vincennes. On my first visit to this mine they were working about fourteen men. The air was not good on account of not having an air shaft. On my second visit they were working two men and sinking an air shaft. They will not have good air until the air shaft is completed.

SULLIVAN COUNTY.

New Pittsburgh Mine. Located ten miles southeast of Farmersburg, on a branch of the E. & T. H. R. R. On my first visit to this mine it was idle on account of the miners being on a strike. On the 9th of July, 1891, the engine room and tipple were burned down. They are now sinking a new shaft, and will abandon the old works.

Dugger Mine. Operated by the Dugger & Neal Coal Company, located at Dugger, on the I. & I. S. R. R. and Green County Coal Branch Railroad. When first inspected this mine was found in bad condition; the air-ways were closed up; the main air-way leading to the downcast was stopped up, so that it was impossible for a man to get through. They at once proceeded to repair defects in the air-ways, and on my second visit I found the mine very much improved. This mine has two men employed now to work on ventilation.

Old Pittsburgh Mine. Operated by Stark & Company. It is located one-fourth of a mile west of Hymera. This mine is run on a small scale. On my first visit the air was not very good. On my second visit they had connected the mine with the Hymera mine. The mine was not running, and I could not get in. They will sink an air shaft at once.

Jumbo Mine. Operated by Jackson Hill Coal and Coke Company. It is located three miles south of Hymera, on a branch of the E. & T. H. R. R. This is a machine mine, all the coal being produced by machinery. It was inspected twice, and found in good working condition.

Hymera Mine. Operated by the Pittsburgh Coal and Coke Company. It is located one-half mile south of Hymera, on a branch of the E. & T. H. R. R. This mine was inspected twice, and found in good condition. This company is putting in electricity for mining and hauling coal.

Lyonton Mine. Operated by the Lyonton Coal and Coke Company. It is located at Lyonton, two miles northwest of Dugger. Very little coal is produced at this mine. On my first visit very few men were employed. The air was bad, the furnace stack was down and the air-ways closed up. On my second visit they had made repairs, and the air was much better.

Shelburn Mine. Operated by the Shelburn Coal Company. It is located at Shelburn, on the E. & T. H. R. R. This mine contains a considerable amount of "fire damps," but is well ventilated, and is inspected every morning by a competent man before the miners are permitted to go into the mine. This mine was inspected twice and found in good condition. Coal is produced in this mine by machinery.

CURRIESVILLE MINE. Operated by the Curriesville Coal Company. It is located one-half mile north of Shelburn, on the E. & T. H. R. R. This is an old mine, and is not operated on a very large scale. Machines are used to produce the coal. This mine contains considerable "fire damp," but is well ventilated. It was inspected twice and found in good condition.

SUPERIOR MINE. Operated by the Island Coal Company. It is located two miles west of Dugger, on the Greene County Coal Branch Railroad. This mine is just being started up, after an idleness of two and one-half years. Nearly all of the entries are in rock rools, cutting the coal entirely out. The air in this mine is good. It is a machine mine.

FARMERSBURG MINE. Operated by the Farmersburg Coal and Mining Company. It is located one-half mile south of Farmersburg, on the E. & T. H. R. R. Very little work has been done in this mine during the past year. On my first visit this mine was lying idle, on account of misunderstandings in the company. On my last visit they had resumed work. There were twelve men employed. The air was good. They had no safety catches or bonnets on the cages, but were arranging to put them on at once.

BUNKER HILL MINE. Operated by Hancock & Conkle. It is located at Farnsworth, on the I. & I. S. R. R. This mine was inspected twice and found in very good condition. They have no manway, but are sinking one.

### FATAL ACCIDENTS.

July 9, 1891, Fred Daniels was killed by a fall of slate in Rogers Mine, in Pike County. Mine owned by Samuel Rogers.

### NON-FATAL ACCIDENTS.

April 13, 1891, Charley Taylor, finger taken off by fall of coal from top of shaft while caging in Dugger Mine. Mine owned by Dugger & Neal Coal Company, in Sullivan County.

June 20, 1891, M. Back, burned by gas. The cause of the explosion was a shot in the mine. Mine owned by Robert Gough, in Warrick County.

July 28, 1891, John Jarbor, injured by fall of coal in Sunnyside Mine. Mine owned by the Sunnyside Coal Company, in Vanderburgh County.

July 28, 1891, J. Troyer, collar-bone broken by fall of clay in Jumbo Mine. Mine owned by the Jackson Hill Coal and Coke Company, in Sullivan County.

September 15, 1891, John Keith, arm dislocated by bank cars, in Ayshire Mine. Mine owned by David Ingle, in Pike County.

## SCALES TESTED.

July 30, 1891, Francisco Mine, owned by E. A. Powell, in Gibson County. His scales were tested and found to be correct.

July 31, 1891, Little's Mine, owned by S. W. Little, in Pike County. His scales were tested and found to be correct and in good condition.

---

*Table Giving Names of Mines in Indiana, with Name and Address of Owners and Total Number of Employes.*

### CLAY COUNTY.

| Name of Mine. | Address of Owner. | No of Men Employed Inside. | No. of Men Employed Outside. |
|---|---|---|---|
| Gartsherrie, No. 1 | Brazil Block Coal Co., Brazil | 72 | 5 |
| Gartsherrie, No. 2 | Brazil Block Coal Co., Brazil | 44 | 4 |
| Gartsherrie, No. 3 | Brazil Block Coal Co., Brazil | 70 | 5 |
| Gartsherrie, No. 4 | Brazil Block Coal Co., Brazil | 23 | 2 |
| Gartsherrie, No. 6 | Brazil Block Coal Co., Brazil | 65 | 6 |
| Gartsherrie, No. 7 | Brazil Block Coal Co., Brazil | 57 | 6 |
| Gartsherrie, No. 8 | Brazil Block Coal Co., Brazil | 155 | 10 |
| Gartsherrie, No. 9 | Brazil Block Coal Co., Brazil | 170 | 7 |
| Gartsherrie, No. 10 | Brazil Block Coal Co., Brazil | 100 | 9 |
| Chicago Carbon | Brazil Block Coal Co., Brazil | 78 | 8 |
| Crawford, No. 2 | Crawford Coal & Mining Co., Brazil | 149 | 6 |
| Crawford, No. 3 | Crawford Coal & Mining Co., Brazil | 18 | 3 |
| Crawford, No. 4 | Crawford Coal & Mining Co., Brazil | 57 | 4 |
| Nickle Plate | Jackson Coal & Mining Co., Brazil | 78 | 8 |
| Chicago | N. P. Coal & Mining Co, Brazil | 107 | 14 |
| Newburg | P. Ehrlich & Co., Newburg | 90 | 10 |
| Watson's, No. 3 | Gartsherrie Coal & Mining Co., Brazil | 30 | 5 |
| Watson's, No. 2 | Gartsherrie Coal & Mining Co., Brazil | 30 | 4 |
| Diamond | Zeller & Sigler, Brazil | 50 | 5 |
| Columbia | Zeller & Sigler, Brazil | 160 | 8 |
| Churchill | Weaver, Getz & Co., Brazil | 74 | 6 |
| Jumbo | Watson, Little & Co., Brazil | 185 | 9 |
| Morris | Sherb. Coal Co, Brazil | 60 | 4 |
| Harrison | C. & I. Block Coal Co., Terre Haute | 70 | 7 |
| Anchor | C. B. M. Co., Fontanet | 61 | 4 |
| Pratt | C. B. M. Co., Fontanet | 82 | 8 |
| Swamp Angel | Hoosier Coal Co., Brazil | 26 | 5 |
| Nellie | Otter Creek Coal Co., Brazil | 115 | 5 |
| Eureka | Woodruff & Co., Carbon | 50 | 5 |
| Morrier | Morrier Coal Co., Clay City | 50 | 6 |
| Diamond | Lancaster Coal Co., Clay City | 45 | 4 |

## VIGO COUNTY.

| Name of Mine. | Address of Owner. | No. of Men Employed Inside. | No. of Men Employed Outside. |
|---|---|---|---|
| Fountain, No 2 | C. B. M. Company, Fontanet | 130 | 22 |
| New Edgar | C. B. M. Company, Fontanet | 40 | 4 |
| Diamond | C. B. M. Company, Fontanet | 80 | 8 |
| Seelyville | P. Ehrlich & Co., Newburgh | 45 | 8 |
| Grant | Woodruff & Trunkey, Grant | 50 | 5 |

## OWEN COUNTY.

| | | | |
|---|---|---|---|
| Lancaster, No. 3 | Lancaster Coal Company | 98 | 5 |

## VERMILLION COUNTY.

| | | | |
|---|---|---|---|
| Norton Creek, No. 1 | Norton Creek Coal & Mining Co., Clinton | 54 | 7 |
| Norton Creek, No. 2 | Norton Creek Coal & Mining Co., Clinton | 55 | 10 |
| Norton Creek, No. 3 | Norton Creek Coal & Mining Co., Clinton | 108 | 12 |
| Hazel Creek | Hazel Dell Coal Co., Clinton | 113 | 13 |

## PARKE COUNTY.

| | | | |
|---|---|---|---|
| No. 6 | Parke County Coal Co., Rosedale | 75 | 12 |
| No. 7 | Parke County Coal Co., Rosedale | 65 | 8 |
| No. 8 | Parke County Coal Co., Rosedale | 18 | 5 |
| No. 9 | Parke County Coal Co., Rosedale | 92 | 12 |
| No. 8, Coxville | Brazil Block Coal Co., Brazil | 120 | 9 |
| Blaine Shaft | Blazil Block Coal Co., Brazil | 46 | 4 |
| McCune | S. S. McCune, Rockville | 21 | 2 |
| Wabash Valley, No. 1 | Wabash Valley Coal Co., Clinton | 22 | 7 |

## SULLIVAN COUNTY.

| | | | |
|---|---|---|---|
| Dugger | D. & N. C. Co, Dugger | 125 | 15 |
| Lyonton | L. C. & C. Co., Lyonton | 12 | 2 |
| Little Pittsburgh | Stark & Co., Hymera | 15 | 2 |
| Hymera | P. C. & C. Co., Hymera | 100 | 10 |
| Curriesville | C. C. Co., Shelburn | 50 | 6 |
| Shelburn | S. C. Co., Shelburn | 50 | 6 |
| Alum Cave | N. P. C. & C. Co., New Pittsburgh | 80 | 15 |
| Jumbo | J. H. C. & C. Co, Hardersville | 60 | 10 |
| Superior | I. C. Co, Linton | 25 | 7 |
| Bunker Hill | H. & C., Farnsworth | 40 | 4 |
| Farmersburg | F. C. & M. Co., Parkersburg | 12 | 3 |

VANDERBURGH COUNTY.

| Name of Mine. | Address of Owner. | No. of Men Employed Inside. | No. of Men Employed Outside. |
|---|---|---|---|
| Ingleside | J. Ingle & Co, Evansville | 60 | 9 |
| Sunnyside | S. C. Co., Evansville | 50 | 9 |
| First Avenue | F. A. C. Co.. Evansville | 45 | 8 |
| Diamond | D. C. Co., Evansville | 25 | 7 |
| Unity | S. C. Co., Evansville | 20 | 4 |

PIKE COUNTY.

| | | | |
|---|---|---|---|
| Ayrshire | D. Ingle, Oakland City | 135 | 15 |
| Rogers | S. Rogers, Washington | 25 | 6 |
| Blackburn | P. C. Co., Blackburn | 25 | 5 |
| Littles | S. W. Little, Littles | 50 | 8 |

KNOX COUNTY.

| | | | |
|---|---|---|---|
| Freeman | V. C. Co., Vincennes | 25 | 5 |
| Prospect Hill | F. Clark, Vincennes | 14 | 3 |
| Bicknell | Bicknell C. Co., Bicknell | 25 | 4 |

GIBSON COUNTY.

| | | | |
|---|---|---|---|
| Francisco | E. A. Powell, Francisco | 20 | 5 |

GREENE COUNTY.

| | | | |
|---|---|---|---|
| Island, No. 1 | Island Coal Co., Linton | 60 | 7 |
| Island, No. 2 | Island Coal Co., Linton | 150 | 12 |
| Buckeye | L. C. & M. Co., Linton | 45 | 8 |
| Summit | Dugger & N. Co., Dugger | 110 | 8 |

PERRY COUNTY.

| | | | |
|---|---|---|---|
| Cannelton | A. C. C. Co., Cannelton | 55 | 10 |
| Troy | Bergenroth Bros., Troy | 15 | 2 |

SPENCER COUNTY.

| Name of Mine. | Address of Owner. | No. of Men Employed Inside. | No. of Men Employed Outside. |
|---|---|---|---|
| Lincoln | S. & S., Lincoln City | 15 | 2 |

WARRICK COUNTY.

| Name of Mine. | Address of Owner. | No. of Men Employed Inside. | No. of Men Employed Outside. |
|---|---|---|---|
| Star. | J. Archbold, Evansville | 24 | 6 |
| Gough | R. Gough, Boonville | 14 | 3 |
| St. Elmo. | G. & L., Evansville | 20 | 4 |
| Chandler | H. & B., Chandler. | 18 | 3 |
| Lowder | L. W. Co., Boonville | 25 | 4 |

DAVIESS COUNTY.

| Name of Mine. | Address of Owner. | No. of Men Employed Inside. | No. of Men Employed Outside. |
|---|---|---|---|
| Maple Valley | C. & Co., Washington | 75 | 10 |
| No. 4 | Cable & Co., Washington | 90 | 8 |
| No. 6 | Cable & Co., Washington | 30 | 4 |
| No 7 | Cable & Co., Washington | 30 | 5 |
| Wilson | Wilson & Co., Washington. | 18 | 3 |
| Wilson's, No. 2. | Wilson C. Co , Washington | 28 | 5 |
| Murry | W. R. V. C. Co., Washington. | 12 | 3 |
| Buckeye. | M. M. Co., Cannelburg | 16 | 4 |
| Mutual | M. M. Co., Cannelburg | 28 | 5 |

NAMES OF COUNTIES, WITH NUMBER OF MEN AND MINES IN THE SOUTHERN DISTRICT.

| | No. of Mines. | No. of Men Employed Inside. | No. of Men Employed Outside. |
|---|---|---|---|
| Daviess County | 9 | 327 | 47 |
| Gibson County | 1 | 20 | 5 |
| Greene County | 4 | 405 | 32 |
| Knox County | 3 | 64 | 12 |
| Perry County | 2 | 70 | 12 |
| Pike County | 4 | 235 | 34 |
| Sullivan County | 11 | 500 | 82 |
| Spencer County | 1 | 15 | 2 |
| Vanderburgh County | 5 | 200 | 37 |
| Warrick County | 5 | 100 | 20 |
| Total | 45 | 1,936 | 283 |

MAMES OF COUNTIES, WITH NUMBER OF MEN AND MINES IN THE NORTHERN DISTRICT.

| | No. of Men Employed. | No. of Mines. |
|---|---|---|
| Clay County | 2,800 | 41 |
| Vigo County | 500 | 15 |
| Owen County | 200 | 8 |
| Vermillion County | 450 | 11 |
| Parke County | 600 | 12 |
| Warren County | 35 | 5 |
| Fountain County | 30 | 4 |
| Total in Northern District | 4,615 | 96 |
| Total in Southern District | 2,219 | 45 |
| Total in State | 6,834 | 141 |

In giving the number of men and mines in the Northern District, the number of small mines and men employed in them is given along with the large mines. In the Southern District only the mines that employ ten or more men are considered in giving the total number of men and mines, but in estimating total production of coal, and additional capital invested this year, all are considered.

# REPORT OF STATE SUPERVISOR OF OIL INSPECTION TO STATE GEOLOGIST.

---

OFFICE OF STATE SUPERVISOR OF OIL INSPECTION,
INDIANAPOLIS, IND., NOV., 1891.

*To Hon. S. S. Gorby, State Geologist of Indiana:*

SIR—In conformity with the provisions of the law relating to the inspection of illuminating oils, I have the honor to present a detailed report of the transactions of this department for the period commencing March 2, 1891, to and including October 31, 1891.

Respectfully,

N. J. HYDE,
*State Supervisor of Oil Inspection.*

# REPORT OF THE STATE SUPERVISOR OF OIL INSPECTION.

On the 2d day of March, after having complied with all the requirements of the law, I assumed the duties of State Supervisor of Oil Inspection, with the gentlemen named below as my deputies.

You will perceive by one of the tables included in this report that there has been inspected 106,491 barrels of oil. Of this number 105,263 barrels were approved and 1,228 barrels rejected. None of the rejected oil was positively dangerous nor explosive for illuminating purposes, but it would not pass the standard test required by our State laws. Nearly if not all the same oil was of sufficient high grade to pass inspection in all other States having inspection laws, and inspection laws are in force in thirty or more States of the Union.

The following is a list of the Deputy Supervisors appointed in the several Congressional Districts of the State and at outside shipping points:

*List of Deputies, with Postoffice Address and Date of Appointment.*

| NAME. | POSTOFFICE ADDRESS | DATE OF APPOINTMENT. |
|---|---|---|
| First District, Harry Hedden. . . . | Evansville. . . . | March 10, 1891. |
| Second District, W. B. Purcell . . . . | Vincennes. . | March 10, 1891. |
| Third District, Nicholas Ruppert. . . | New Albany. . . | March 16, 1891. |
| Fourth District, Peter Klein . . . . . | Madison. . . . . | March 2, 1891. |
| Sixth District, Joe J. Gorrell* . . . . | Winchester . . . | March 5, 1891. |
| Sixth District, W. K. Young . . . . . | Richmond. . . . | August 12, 1891. |
| Sixth District, Walter Davis . . . . . | Muncie . . . . . | March 3, 1891. |
| Seventh District, Michael Ginz. . . | Indianapolis. . . | March 2, 1891. |
| Eighth District, Henry Miller . . . . | Terre Haute. . . | March 2, 1891. |
| Ninth District, W. A. Byers . . . . . | Lafayette . . . . | March 2, 1891. |
| Tenth District, John Day . . . . . . | Logansport . . . | March 9, 1891. |
| Eleventh District, John R. Porter. . . | Peru . . . . . . | March 3, 1891. |
| Twelfth District, Louis Hazzard | Fort Wayne. . . | March 2, 1891. |
| Thirteenth District, Charles L. Goetz . | South Bend . . . | March 2, 1891. |
| J. L. Rhinock . . . . . . . . . . . | Cincinnati, O . . | March 2, 1891. |
| F. W. Green . . . . . . . . . . . . | Cleveland, O. . . | |
| Jacob Kohn . . . . . . . . . . . . | Toledo . . . . . | March 17, 1891. |
| B. D. Kauffman. . . . . . . . . . . | Lima, O . . . . | March 21, 1891. |
| C. C. Dorrem . . . . . . . . . . . | Mansfield, O. . . | |

*Resigned. W. K. Young appointed.

A printed copy of the following rules was mailed to each Deputy, with instructions to observe them strictly in every case, so far as practicable:

OFFICE OF STATE SUPERVISOR OF
OIL INSPECTION FOR STATE OF INDIANA,
INDIANAPOLIS, March 2, 1891.

*To Deputy Supervisors of Oil Inspection for Indiana:*

The law for inspection of mineral or petroleum oils in force September 19, 1881, requires the State Supervisor of Oil Inspection to prepare rules and regulations for the direction of Deputy Supervisors. In pursuance of the authority, I call your attention to the following directions which you will please observe in the discharge of your official duties:

1. Your especial and careful attention is called to the act under which your appointments have been made (Revised Statutes of Indiana, 1881), with a view to your instruction upon many points, not necessary to be referred to in this circular.

2. The process for testing oils is fully explained in the first and last sections of the law, and your first duty is to thoroughly familiarize yourself with those sections.

3. The standard test for all illuminating oils in Indiana is the gravity test of Beaume's hydrometer not below 46 degrees or higher than 50 degrees; that said oils shall bear a flash test not below 120 degrees Fahrenheit, and a fire test not below 140 degrees Fahrenheit.

4. The Deputies must keep a record of each inspection in a book, noting the gravity flash and fire test. In testing from tanks the greatest care should be taken in seeing that the same oil tested goes into the barrels before branding. The safest way is to take samples from several barrels after being filled, mix together, and test from that.

5. The brands for "approval" and "rejection" and all books and blanks used for the purpose will be furnished from this office, at the expense of the Deputy, none others than those furnished from this office must be used.

6. Deputies will, under no circumstances allow their brands to be used by others, but will brand the barrels themselves or have it done under their personal supervision.

7. The brand impression will be, ordinarily, placed upon the gauge end of the barrel; but when other marks interfere, then wherever practicable, but always where it can be plainly seen.

8. Each Deputy is required to make his report promptly upon the first day of every month with blanks furnished from this office, and they must correspond with his books on all inspections.

9. The fees are as follows, as allowed by law, and are collectable upon approval or rejection of each consignment of oil inspected:

Forty (40) cents per barrel where the number does not exceed two; where the number exceeds two and does not exceed ten, fees as above on the first two and 20 cents on each additional barrel; where the number exceeds ten and does not exceed forty-five, fees as above on first ten and 10 cents on each additional; where the number exceeds forty-five, fees as above on the first forty-five, and three cents on each additional barrel; fees accruing shall be a lien on the oil inspected.

10. The State Supervisor enjoins upon each Deputy a personal supervision relative to the enforcement of the law, and all violations thereof shall be promptly reported to the Prosecuting Attorney of the county in which the violation occurs, and the facts reported to this office.

11. For all points not covered by these instructions the Deputies will strictly examine the law, bearing in mind that only oils sold or manufactured for illuminating purposes for use within the State are subject to inspection.

12. Although not provided by law, it is exceedingly desirable that all accidents arising from the use of petroleum, and its products as an illuminating fluid, should be thoroughly investigated and the facts reported to this office.

13. In conclusion I desire to impress upon you an appreciation of the responsibility resting upon you officially; trusts are committed to you which should never be lost sight of. Human lives, as well as the safety of property, may depend on the issue of an inspection.

The law must be inforced impartially and honestly, without fear or favor.

N. J. HYDE,
*State Supervisor of Oil Inspection.*

On August 12 I appointed W. K. Young as deputy, at Richmond, in the place of Joe J. Gorrell, resigned.

The following table shows the number of barrels of illuminating oils inspected by myself and duputies, for the period commencing March 2, 1891, up to and including October 31, 1891, and also the points at which inspections were made:

*Table Showing Number of Barrels of Oil Inspected at the Several Points Named.*

| | Approved. | Rejected. | Total. |
|---|---|---|---|
| Evansville | 7,328 | ...... | 7,328 |
| Vincennes | 2,895 | ...... | 2,895 |
| New Albany | 5,872 | ...... | 5,872 |
| Madison | 1,234 | ...... | 1,234 |
| Richmond | 2,344 | 18 | 2,362 |
| Muncie | 1,520 | ...... | 1,520 |
| Indianapolis | 29,759 | 1,210 | 30,967 |
| Crawfordsville | 1,240 | ...... | 1,240 |
| Columbus | 360 | ...... | 360 |
| Terre Haute | 4,616 | ...... | 4,616 |
| Lafayette | 5,180 | ...... | 5,180 |
| Logansport | 4,463 | ...... | 4,463 |
| Peru | 4,581 | ...... | 4,581 |
| Fort Wayne | 6,427 | ...... | 6,427 |
| South Bend | 10,762 | ...... | 10,762 |
| Cincinnati | 4,635 | ...... | 4,635 |
| Cleveland | 7,340 | ...... | 7,340 |
| Toledo | 3,580 | ...... | 3,580 |
| Lima | 383 | ...... | 383 |
| Mansfield | 746 | ...... | 746 |
| Total | 105,263 | 1,228 | 106,491 |

The following table shows the number of barrels inspected each month:

| | Approved. | Rejected. | Total. |
|---|---|---|---|
| March | 10,558 | 730 | 11,288 |
| April | 12,158 | 13 | 12,171 |
| May | 8,709 | 5 | 8,714 |
| June | 9,712 | ...... | 9,712 |
| July | 10,575 | 120 | 10,695 |
| August | 11,412 | ...... | 11,412 |
| September | 19,334 | ...... | 19,334 |
| October | 22,805 | 360 | 23,165 |
| Total | 105,263 | 1,228 | 106,491 |

The following table shows the points at which the oil inspected was manufactured:

| | No. of Barrels. |
|---|---|
| Cleveland, O. | 55,255 |
| Lima, O. | 32,973 |
| Toledo, O | 3,706 |
| Findlay, O | 1,306 |
| Pittsburgh, Pa. | 2,095 |
| Oil City, Pa | 6,302 |
| Washington, Pa | 640 |
| Warren, Pa | 210 |
| Bear Creek, Pa | 1,620 |
| Franklin, Pa | 484 |
| Titusville, Pa | 90 |
| Rens, Pa | 350 |
| Oak Grove, Pa. | 410 |
| Allegheny City, Pa. | 520 |
| Parkersburgh, W. Va | 530 |
| Total | 106,491 |

Below is given the number of barrels of oil shipped into Indiana from the different States in which refineries are located:

| | |
|---|---|
| Manufactured in Ohio | 93,240 |
| Manufactured in Pennsylvania | 12,721 |
| Manufactured in West Virginia | 530 |
| Total | 106,491 |

As my predecessor filed no report of inspection, I am not able to give the increase or decrease of number of barrels consumed in this report, but shall be able to do so in my next.

There have been a disposition on the part of several refiners to introduce into the State a class of oil that would not stand the test of our law, and it has required considerable vigilance on the part of myself and deputies to prevent it. But since they have been given to understand that all such illuminating oils would be promptly rejected as soon as offered for inspection, they have desisted.

Manufacturers and dealers generally, however, have cheerfully complied with the law, and those who do not fear fair and honorable competition have heartily co-operated with me in having the law impartially enforced.

There have been some few cases of erroneous construction of the law and unintentional violation of the same, but I have found no deliberate violations of the law, and it affords me pleasure to say that I have every reason to believe that the law is being enforced impartially and honestly.

Respectfully submitted,

N. J. HYDE,
*State Supervisor of Oil Inspection.*

# PETROLEUM IN INDIANA.

BY A. C. BENEDICT.

A variety of liquids, variously known as coal oil, crude petroleum, earth oil, maltha, mineral tar, naphtha, steinol, bitumen liquid, etc., and corresponding in the characters of inflammability and insolubility in water with the animal and vegetable oils, have long been known to occur in many parts of the earth.

The countries most famous for the occurrence of mineral oils are the United States, Russia, Burmah and the West Indies. It also occurs in China, India, Italy, Germany, Switzerland, and in limited quantity in France and England.

Chemically, all the various products known as naphtha, petroleum, etc., are closely allied, as they consist mainly of oils of different density and volatility.

The earlier analyses of oils were crude, inasmuch as no further attempt at separating the substances they contained was made than merely heating the oil, cooling the vapors of distillation, and treating the product with sulphuric acid. This sufficed to show that the constituents of petroleum are compounds of hydrogen and carbon. It was not until a comparatively recent date that any advance was made in the chemistry of the hydrocarbons, but now we have a long list of articles of the utmost importance in the arts and sciences derived from the researches of the chemists in this direction.

The earliest analysis of petroleum I have been able to find a record of is that of Winterl, made in 1788, of a black, heavy-bodied petroleum from Hungary; which yielded a colorless oil, a yellow oil, and a buttery mass. The last was probably an impure paraffine. In 1817 the native naphtha of Miano, in the duchy of Parma, Italy, was used for lighting the streets of Genoa. This is probably the earliest use of a city of crude petroleum for lighting purposes. In an account published at that time it is described as being a transparent, thin, yellow liquid, lighter than water, with a strong, persistent smell.

Bitumens are found of all degrees of consistency and of many shades of color. The naphtha of Georgia, on the Caspian Sea, is as colorless as pure water, while the asphaltum from the Island of Trinidad is a black semi-solid body called the "bitumen lake." The light, clear oils consist almost wholly of carbon and hydrogen, while the heavier, darker and more solid varieties usually contain oxygen, and frequently sulphur and its compounds, carbon and bituminized carbonaceous matter.

The well-known odor of crude petroleum is nearly always due to bituminous matter, spoken of above, or to sulphur compounds, as sulphuretted hydrogen. To the last is due the odor noticeable in the waters of many of the artesian wells of this State.

From the colorless varieties pass by imperceptible gradations through the heavier and darker varieties of petroleum to mineral tar or pitch, that is generally considered petroleum, in which there is enough bituminous matter either dissolved or suspended to render it black and of a semi-fluid consistence. This mineral tar is intermediate between the light-bodied oils and the solid asphaltum.

## HISTORY OF PETROLEUM.

The earliest account we have of bitumen is found in the writings of Herodotus describing the building of Babylon. He also describes the method of collecting petroleum in Zante, one of the Ionian Islands, then called Zacynthus. This product he calls "pitch," and says it was obtained by thrusting a pole, having a bunch of myrtle tied to it, to the bottom of the spring and the pitch adhered to it. This spring is still yielding as plentiful as ever, and there can be no reasonable doubt that it has been yielding petroleum for more than 2,000 years. Dr. Paul has stated that five barrels a day may be collected from these wells, and there is little doubt that if proper means were used this quantity might be greatly increased.

Pliny and Dioscorides described the oil from Agrigentum, in Sicily. The latter states it is used in lamps under the name of Sicilian oil, and remarks that this name is erroneous, inasmuch as it is nothing but a species of bitumen. At Clermont and Gabian, in the Province of Languedoc, France, oil springs have been known from time immemorial. Italy also has numerous oil springs. As early as 1817, Genoa was lighted with oil from Amiano, on the Taro, and other places in the North of Italy. This is the earliest recorded use of petroleum as an illuminant I have been able to find.

Plutarch saw a petroleum lake on fire near Ecbatana, in Persia. Baku, on the bank of the Caspian, has long furnished petroleum, and is to-day Russia's main oil field. In consequence of the great number of oil springs, the vast quantity of inflammable gas and the frequent eruption of mud volcanoes, this region is called the Field of Fire.

In North America are vast oil fields, there being scarcely a State or

Territory in the United States in which oil has not been found; but almost the entire supply comes from the States of Pennsylvania, Ohio and West Virginia. In Pennsylvania there have been found ancient wells that are supposed to have been dug and worked by the Mound Builders. In Canada there are two oil regions The most important one is around Enniskillen, to the South of West Canada; the other is on the Peninsula of Gaspe, Canada East. For a distance of four miles along the bank of the Thames, in the Townships of Oxford and Mosa, are some small oil springs. Near Tilsonburgh two well were sunk in 1861, but these sources have never yielded much oil.

The great Pitch Lake of Trinidad is ninety-nine acres in extent. It contains millions of tons of asphalt and is considered the largest and most wonderful deposit of asphalt in the world. It lies at the western shore of the island, nearly midway from its northern to its southern extremity. Asphalt from here is extensively used in paving streets, but the best material for this purpose comes from Neufchatel, Switzerland, where it occurs in limited quantities. On the eastern portion of Trinidad petroleum springs are found between Holguin and Megari, and also in the southwest near Santiago de Cuba.

In France, in 1840, numerous companies were formed for the extraction and purification of oil from the bituminous schists, and in 1845 sixteen mines were in full operation, but the ventures proved unsuccessful, and much capital was sunk.

At Puy de la Pige there are such quantities of mineral tar that it renders the soil so viscous that it adheres to the travelers' feet. In the Harz Mountains, Germany, the same material is found, while at Beehelbronn a similar substance, called stein oil, and sometimes Strasbourg grease, is found. It is too thick to be used as an illuminant, and is used as a substitute for grease to reduce the friction of machinery, and also for greasing the wheels of carriages.

Dalmatia, in the Austrian empire, contains large deposits of limestone so full of bitumen that it can be cut without difficulty.

Gallacia has attracted attention as a source of oils. In West Gallacia the ground is charged with an oil almost identical with the Pennsylvania product. This oil-field, of an extent of 50,000 acres, lies in a mountainous territory, and the wells need only to be bored ten to fifteen feet to reach the oil horizon. According to reports of experts who have visited this region, it will some day become the European oil creek.

Eastern Gallacia yields an oil resembling that of Canada. The wells here are deeper than in West Gallacia. They here extend to the depth of 300 feet, and have to be pumped.

In Crimea the principal Russian sources of oil are found. The oil springs are confined almost wholly to the peninsula of Kertch, where wells sunk a few yards deep yield an oil of fair quality. The position of the petroleum is indicated by the luxuriant vegetation in early spring, while early in the summer it turns yellow and dries up. This oil-field stretches from the Sea of Azof to the Black Sea, and possibly extends far to the west in the steppes. The rocks here are of Tertiary age, and the oil obtained from them is a deep green in color, thin and transparent. The Tartars sank a large number of wells, and it is found that whenever a well is sunk outside the line of their wells no oil is found, while nearly every one sunk in the vicinity of the ancient wells yields oil.

On the shore of the Caspian Sea there in an immense petroleum area, and Baku has already been mentioned as having long been known as yielding petroleum and natural gas. The oil region here is a tract of country 25 miles long and half a mile in width. Wells are dug here in a porous argillaceous sandstone, of Tertiary age, to a depth of from 16 to 20 feet, and yield a heavy-bodied oil that the natives use in lamps as it comes from the well. These wells were dug by the Russians in 1858, and are still used, for no sooner are they emptied than the oil commences to flow and soon attains its former level.

On the east shore of the Caspian is another field fully equal to the one on the west. The supply seems to be inexhaustible, for a well yielding 500 gallons does not seem to be affected if another is sunk by its side that yields 6,000 gallons.

Sometime since the American method of sinking wells was introduced here, and now the wells are sunk to the depth of 250 feet or more, and the yield of oil thereby greatly increased, the oil frequently spouting to the height of 50 or 75 feet above the surface.

The Persian naptha is of two kinds, black and white. The black is found at Kerkook, and resembles pitch, and is used by the natives along the Euphrates and Tigris for covering the bottoms of their boats, and also for lamp oil.

The main oil regions of Birmah are those near the towns of Teynangyoung and Pagan.

South America furnishes a small amount of solid bitumen or asphalt, but not enough to be of commercial importance.

## UNITED STATES.

From the earliest settlement of the country a small quantity of petroleum had been found floating on the surface of a pond on the premises of Watson & Co., Titusville, Pa., and it had long been collected for medicinal purposes by absorbing it in blankets. In 1854 the Pennsylvania Rock Oil Company was formed for the purpose of refining the oil for illuminating purposes and for lubricating machinery, but for several years the operations of the company were not successful. In 1858 Col. Drake, the Superintendent of the company, conceived the plan of boring wells in the land that had already given so large a surface production of oil. Despite the ridicule heaped on him he continued his operations until 1859, and on the 26th day of August, of that year, found oil at a depth of 71 feet. From this beginning has grown the enormous yield of oil of this country, from which fortunes beyond the dreams of avarice have been accumulated.

The most important oil regions of the United States are in Pennsylvania, New York, Ohio, West Virginia, Kentucky, Indiana, Michigan, Illinois, Tennessee, Wyoming, Colorado, Oregon, Montana and California.

### GEOLOGICAL DISTRIBUTION.

The oils in their various forms are found in geological horizons ranging from the Trenton, or lowest, to the Miocene of Tertiary age, but nearly the whole commercial supply of the world, of oils proper, comes from the rocks of Paleozoic age.

### THE INDIANA OIL FIELD.

The main field of this State, as developed at this writing, borders the northeast extension of the gas belt, and comprises the northeast part of Grant County, the southeast part of Huntington, the south part of Wells, the north part of Blackford, the southwest part of Adams, the western half of Jay and the western half of Randolph. This is practically one field, having the form of a huge L, extending east from Van Buren, Grant County, to Geneva, Adams County, and south from Geneva to Winchester, Randolph County. A small amount of oil in the gas wells of Tipton, Tipton County, and when wells were drilled at Brightwood, Marion County, some years since, in search for gas, some oil was found, but not in sufficient quantities to pay for pumping. In this field the oil is mainly found in Trenton, but in a few wells a small quantity of oil was found in the Utica shale. At Terre Haute there is a trace of oil in the Sub-Carboniferous limestones at a depth of 850 feet, while at the depth of 1,500 feet oil is found in the Knobstone Group of the Sub-Carboniferous. At Francisville, Pulaski County, oil is found in the gas wells in small quantities and a separator is used to remove it from the gas before the latter enters the mains. In Gillam Township, Jasper County, some wells yielding a heavy lubricating oil have lately been bored, and this is probably the most interesting field yet found, and will be treated of at length in its proper place. These comprise all the localities that have furnished oil in any quantities so far developed in the State. Traces of oil were found in drilling the gas wells of Washington, Harrison and Crawford Counties,

## CRAWFORD COUNTY, IND.

In the western part of Crawford County there are surface indications of oil that have an extent of five miles in width by ten miles in length, and consist of tar springs on land formerly owned by L. D. Parker, of Union Township; oil springs and oil rock in great abundance. The tar springs are nine miles northwest of Leavenworth, and have been known from the earliest settlement of the country. These springs are about half way up a hill which is probably one hundred and fifty feet high. They are "wet-weather" springs, delivering a large volume of water after heavy rains, but dwindling to a mere trickle of water in dry weather. In the course of a year a large amount of tar or asphaltum is deposited by these springs. This asphaltum unites with the soil and sand, and has built up quite a trough around the spring.

Oil springs are found on Otter Fork and West Fork, and in the hollows tributary to them; there are quite a number of them from which small quantities of oil can be collected. The oil rock is found in great abundance. At one place on Otter Fork the bed of the creek is a soft black sandstone, or shale, which contains more than thirty per cent. of oil. If a piece of it be placed on a hot fire it will blaze like a candle, and will continue to burn until it has lost one-third its weight. During the oil excitement of 1862–66 oil seekers flocked here, and the excitement ran high, owing to the promising surface indications. Several wells were sunk, but oil in paying quantities was never found.

On the farm of Mr. J. J. Clark a well was bored during the oil craze of 1862–66, but only a very small quantity of petroleum mixed with salt water was found.

### SECTION OF THE CLARK WELL.

| | |
|---|---|
| Kaskaskia limestone | 6 feet. |
| Red shale | 7 feet. |
| Blue Kaskaskia limestone | 20 feet. |
| Shale and chert | 11 feet. |
| Limestone | 6 feet. |
| Shale | 8 feet. |
| St. Louis limestone | 350 feet. |
| Knobstone Group | 240 feet. |
| Total depth | 648 feet. |

At 408 feet natural gas was found, and at 648 feet salt water and a small amount of petroleum.

### MIFFLIN WELL, DRILLED 1865.

| | |
|---|---|
| Drift | 15 feet. |
| Kaskaskia limestone and sandstone | 190 feet. |
| St. Louis limestone | 310 feet. |
| Keokuk limestone and sandstone | 80 feet. |
| Knobstone Group | 490 feet. |
| Genesee shale | 110 feet. |
| Total depth | 1,180 feet. |

At a depth of 135 feet a small quantity of petroleum was found, while at 1,180 feet natural gas in considerable quantities was found, and also a small amount of petroleum. In settled weather the combined weight of the atmosphere and the column of water in the well is sufficient to overcome the pressure of the gas, while just preceding a storm, when the weight of the air is reduced, the gas rises with sufficient force to throw jets of water several feet above the mouth of the well.

SECTION OF TERRE HAUTE WELL.

| | Feet. | Inches. |
|---|---|---|
| Drift | 150 | .... |
| Fire clay and Shale | 14 | 6 |
| Coal L. | 4 | .... |
| Limestone | 2 | 1 |
| Fire-clay | 3 | 2 |
| Brown Limestone | 2 | .... |
| Shale | 1 | 6 |
| Coal K. | .... | 6 |
| Fire-clay | 3 | 2 |
| Limestone | 16 | 5 |
| Shale | 4 | .... |
| Coal I. | 2 | .... |
| Fire-clay | 3 | .... |
| Limestone | 6 | .... |
| Sandstone | 3 | .... |
| Fire-clay | 5 | .... |
| Shale | 4 | 6 |
| Limestone | 5 | 2 |
| Shale | 9 | .... |
| Blue Sandstone | 6 | .... |
| Shale | 2 | .... |
| Fire-clay | 5 | .... |
| Sandstone | 10 | .... |
| Coal G. | .... | 9 |
| Fire-clay | 2 | 5 |
| Limestone | 3 | 4 |
| Shale and Fire-clay | 5 | 3 |
| Limestone | 4 | .... |
| Fire-clay | 5 | 10 |
| Limestone | 3 | 6 |
| Coal F. | 2 | 6 |
| Fire-clay | 1 | .... |
| Sandstone | 28 | 3 |
| Fire-clay | 7 | 2 |
| Blue Sandstone | 27 | .... |
| Shale | 9 | .... |
| Sandstone | 37 | .... |
| Shale | 36 | 3 |
| Sandstone | 1 | 8 |
| Shale | 26 | .... |
| Sandstone | 36 | .... |
| Shale | 79 | .... |
| Sandstone | 23 | 10 |
| Black Limestone | 9 | 6 |
| Shale | 12 | .... |
| Sandstone, Millstone Grit | 127 | .... |
| Limestones, Sandstones and Shales | 922 | 10 |

From the data at hand it is not possible to separate this into horizons, but it is thought that this reaches through the following formations in descending order: Kaskaskia, St. Louis, Keokuk, Knobstone, and possibly into the Devonian.

Prof. Gorby reports* that at 840 feet a show of oil was found; at a depth of 1,296 feet 9 inches a lubricating oil was found, and at a depth of 1,620 feet 10 inches a vein of oil was found. Between the second and third oils a flow of fresh water was found, while below the third vein of oil four strong flows of sulphur water were successively encountered in drilling the well. The oil found at a depth of 840 feet is probably in rocks of the age of the Kaskaskia, and, so far as the writer's knowledge extends, is the highest in the geological series that oil has been found in this State. That found respectively at 1,296 feet 9 inches and 1,620 feet 10 inches is no doubt in rocks of the age of the Knobstone Group, but the oil has probably come from the slow distillation of the carbonaceous Genesee shale underlying these sandstones. The Genesee shale extends in a north-south direction nearly across the State, and contains so much carbonaceous matter that it is frequently mistaken by the uninformed for coal, the more readily so by reason of its burning when placed on a hot fire. At Terre Haute this shale is deeply buried, and a slow distillation has been carried on for countless ages by the chemical forces of nature and has resulted in the oil found here. There is enough oil in this shale, were it distilled, to furnish a large number of "gushers," and it may be that some one will be so fortunate as to find the field where it is located. Certain it is that these Terre Haute wells, isolated as they are, are rather unique, and offer an inviting field for speculation concerning why some of the wells here should yield oil so abundantly and others adjoining them should be dry holes.

The section given above is fairly illustrative of the rocks underlying this region, and it now remains to give the yield of oil for the three yielding wells of the Guarantee Oil and Gas Company:

There were 54,750 barrels of oil pumped from these wells, and it was used for fuel and for gas making, the gas being used both for lighting and heating purposes, and answers admirably for both, and is extensively used because it is sold so cheaply, costing less than half the price charged consumers in many other cities of the same size. While this gas can not be furnished as cheaply as natural gas, and probably does not possess as great heating power, yet it furnishes the best and cheapest substitute for this wonderful fuel and illuminant that is at present available. For heating purposes it is certainly economy, if suitable burners be used, to use the crude oil instead of first converting it into gas, but care must be used in storing, piping and using the oil, or disastrous results will follow. No

*Sixteenth Report of the State Geologist, page 262.

analysis of this oil is at hand, though I made effort to procure it for publication, believing it would be of general interest. I am, therefore, unable to indicate the value of this oil and the uses to which it may be put.

### FRANCISVILLE.

At Francisville, Pulaski County, the Francisville Natural Gas, Oil and Coal Company put down a well October, 1887, which showed the following section:

| | |
|---|---|
| Drift | 8 feet. |
| Niagara limestone | 542 feet. |
| Hudson River limestone and shale | 235 feet. |
| Utica shale | 100 feet. |
| Trenton | 10 feet. |

At seventy-four feet in the Hudson River Group oil was found, and the yield was estimated at twenty-five barrels per day. It was a moderately heavy bodied lubricating oil, and answered satisfactorily the tests to which it was subjected.

At the junction of the Utica shale and Trenton another flow of oil was found, of an estimated flow of ten barrels per day. A small quantity of gas was found in this well, and the company being more desirous of securing gas than oil, had a charge of nitro-glycerine exploded in the well with the result of ruining it for both oil and gas. If the flow of oil be as great as estimated, the territory in the vicinity of this well, and to the west of it, invites further tests of the drill, with a reasonable prospect that paying yields of oil will be found.

In May, 1888, the Union Oil and Gas Company commenced operations and sunk five wells, one of them having a small showing of oil at the depth of 625 feet, and three of the remainder furnishing gas at 895 to 900 feet. The rock passed through did not differ materially from that found in the well of the Francisville Natural Gas, Oil and Coal Company, a section of which is given above. The Trenton Rock Company put down two wells here and found a trace of oil at 625 feet, but no gas. I was unable to get a section of the rock passed through in drilling these wells, but suppose it is similar or identical with the section given above. In 1865 a well was drilled southwest of town, and a considerable flow of gas was found, and also water, but at that time the uses of gas were not known, and the well was abandoned and continued to flow water and gas until 1888, when it was plugged. There is no record that oil was found here, and the above is given as relating to the probable life of a gas well if it is not overworked. The water here spoken of came in above the gas and thus retarded its flow and prevented the well from being overworked and drawing salt water. The gas wells put down in 1888 furnished an abundance of gas, and thus demonstrated that the field was not seriously weakened, although the area of gas-bearing rock here, so far as developed, is small as compared with the main gas-field.

### MEDARYSVILLE.

E. W. Gillette has drilled three producing wells seven miles west of this town, and the following section is shown by the drillings:

| | |
|---|---|
| Drift | 40 feet. |
| Black shale | 50 feet. |
| Limestone | 6 feet. |
| Oil sand | 2½ to 3 feet. |

The estimated yield of two of these wells is twenty-five barrels per day of an oil almost as thick as coal tar, and of excellent lubricating qualities. All that is necessary to render it fit for use is to heat it for a sufficient length of time to allow the sand and other impurities to settle, and then draw off the clear oil ready for use. The farmers have been using this as a lubricant on their wagons, and find it an excellent substitute for tar, so heavy-bodied is it.

The oil sand here is geologically known as the Scoharie Grit, one of the subordinate divisions of the Upper Helderberg Group of the Devonian. The oil, as in the Terre Haute wells, doubtless is derived from the Genesee Shale that is given in the section of the well as black shale. This is further evidenced by an extensive deposit of asphaltum a few miles south of the wells, and could have come from no other known source than the shale. If this field proves extensive, which at present seems doubtful, it will be very remunerative to well owners, as an oil of this quality is worth about half as much per gallon as the ordinary crude oil is per barrel, while the cost of drilling and pumping is much less than for the comparatively deep wells of the other parts of the field.

On the farm of A. W. Williams, six miles west of Medarysville, a well was drilled that showed the following section:

| | |
|---|---|
| Drift | 50 feet. |
| Black shale | 30 feet. |
| Limestone | 500 feet. |
| Sandstone (?) | 10 feet. |
| Hudson River | 250 feet. |
| Utica shale. | 130 feet. |
| Trenton | 60 feet. |
| Total | 1,030 feet. |

At the top of Trenton a small amount of oil was found, and salt water in the rock the remainder of the depth. The ten feet of so-called sandstone in this well is probably a hard ferruginous limestone at the base of the Niagara that has been referred to the Clinton epoch. Stone of this character outcrops in the neighborhood of Madison, west of Laurel in Franklin County, and south of Longwood, Fayette County. If this proves to be the same as the outcrops in the eastern part of the State, it is of interest as showing the western extension of these outcrops. The oil sand is here wanting, and the section indicates that it has thinned out and disappeared in coming east one mile from the wells. This indicates the dip of the underlying Niagara limestone to be to the west, and further search for oil should be in this direction rather than to the east or south.

### ROYAL CENTER.

At the present time operations are suspended here. A company was organized in 1891, with S. P. Sherin, of Logansport, President, but owing to unforeseen difficulties nothing was done last season toward developing this field, but hope to drill several wells soon. The intention of the company is to thoroughly test the territory in hopes of finding an abundance of oil.

SECTION OF OIL WELL AT ROYAL CENTER.

| | |
|---|---|
| Drift | 105 feet. |
| Niagara limestone | 485 feet. |
| Hudson River | 220 feet. |
| Brown shale, Utica shale | 110 feet. |
| Trenton | 42 feet. |
| Total depth | 962 feet. |

Oil was found in Trenton and also a small flow of gas. The estimated yield of oil, if the well was pumped, is twenty-five barrels per day of an excellent lubricating oil. Mr. Layne, owner of the flour mill here, informed me that his miller uses this oil on all the machinery of the mill in preference to any he could get in the market. A practical test, such as this, is worth more to the user than a whole volume of analyses beclouded with technical terms and symbols that it is possible the analyst does not always understand.

In the above test the oil was subjected to a variety of conditions, from the greatest to the least friction, from the slowest to the fastest moving machinery, and gave complete satisfaction everywhere. When an article does this it can safely be stamped *good.*

### FORT WAYNE.

During the excitement attending the discovery of natural gas in the State Ft. Wayne caught the fever and sank some wells, in one of which oil was found, but not in paying quantities.

The following is a section of the well copied from the 16th Geological Report of Indiana.

| | |
|---|---|
| Drift | 77 feet. |
| Water-lime | 30 feet. |
| Niagara. | 570 feet. |
| Hudson River and Utica | 751 feet. |
| Trenton | 15 feet. |

At 1,431 feet oil was found. This would place the oil stratum in the top of the Trenton, and it is possible that when oil is found at top of Trenton the source of supply is carbonaceous Utica shale.

### CICERO.

The following section is also copied from the 16th Indiana Report:

| | |
|---|---|
| Drift | 161 feet. |
| Niagara limestone and shale | 300 feet. |
| Hudson River and Utica | 490 feet. |
| Trenton limestone | 32 feet. |
| Total depth | 983 feet. |

At $974\frac{5}{10}$ feet a considerable flow of oil was found, the yield being estimated from five to twenty barrels per day. The oil here was found twenty-three and one-half feet in Trenton. A medium flow of gas was found at 966 feet.

### MARION.

Some of the wells in the vicinity of Marion, mainly to the east from there, show traces of oil, while some of them yield several barrels per day. When the Stove Foundry well, south of the Canton Glass Works, was drilled it showed traces of oil, but not enough oil was found to interfere with the working of the well. The Jas. Lugar well, five miles east of town, furnished a small quantity of oil, probably two barrels per day, mixed with gas, from which it is removed by a separator. I was unable to get a record of the strata passed through in drilling this well, and therefore give one from the 16th Indiana Report, of a well located in Marion; one furnished by Mr. Sweetser, of a well drilled one mile northeast of town, and a section of a well at Van Buren, furnished by Dr. Lew Corey, of Van Buren.

#### SECTION OF WELL No. 3, AT MARION.

| | |
|---|---|
| Drift | 70 feet. |
| Niagara limestone | 280 feet. |
| Hudson River and Utica | 528 feet. |
| Trenton limestone | 22 feet. |
| Total | 900 feet. |

This well yielded a strong flow of gas, but no oil.

SECTION OF WELL ONE MILE NORTHEAST OF TOWN.

| | |
|---|---|
| Drift | 157 feet. |
| Niagara limestone | 260 feet. |
| Hudson River and Utica | 317 feet. |
| Trenton limestone | 28 feet. |
| Total | 762 feet. |

Here, as above, a strong flow of gas was obtained, but no oil.

If both these records are correct they show a remarkable variation in the thickness of the strata within a small area, the Niagara limestone, the Trenton and Utica in the second section, having lost 231 feet in thickness, while the Drift has gained 87 feet; while Trenton is reached in the first section given at 878 feet, in the second at 744 feet, a rise of 134 feet.

In another well, one and one-half miles southeast of Marion, the Niagara, the Hudson River and Utica had still further thinned out, while the Drift increased in thickness.

SECTION OF WELL ONE AND ONE-HALF MILES SOUTHEAST OF MARION.

| | |
|---|---|
| Drift | 194 feet. |
| Niagara limestone | 233 feet. |
| Hudson River and Utica | 314 feet. |
| In Trenton | 28 feet. |

## VAN BUREN.

There are three wells in Van Buren Township, one being located in the eastern part of the town of Van Buren, and the remaining two in the southern part of the township. The one in town was never fairly tested as an oil well, but was estimated by the driller to yield 25 barrels per day. It being owned by a non-resident is not pumped, although it would pay to do so if the yield of oil is as great as estimated.

The two wells in the southern part of the township yield gas, and the oil is removed by separators. The yield of oil of these wells was estimated by Dr. Lew Corey at 25 barrels per day, but this estimate is probably too high. No wells have been drilled for oil exclusively in this territory, and it may be regarded at once as promising and undeveloped, and will, do doubt, richly repay the driller when he comes to exploit this field.

## WARREN.

In the southeast corner of Jefferson Township, about two miles southwest of Warren, a well was drilled that yielded oil, the estimated flow of which was 25 barrels per day. The drillers were seeking gas and not oil, and therefore the well is not worked. The same remarks used regarding the Van Buren field apply with equal force to this region.

Another well in Warren yields a trace of oil, while one three miles east of town yielded a small amount of oil and salt water in abundance. This indicates, as far as the data goes, that the field west of Warren and north of Van Buren is the better territory. The following section, given from memory by Dr. Good, Sr., is all that I was able to obtain of the wells here. It is to be regretted that accurate and minute records are not kept of each well drilled, for those records are of great value, as they enable the geologist to work out the geology of a region with great minuteness:

SECTION OF WELL SOUTHWEST OF WARREN.

| | |
|---|---|
| Drift | 140 feet. |
| Niagara limestone | 310 feet. |
| Hudson River and Utica | 550 feet. |
| In Trenton, oil in Trenton | 27 feet. |

This shows a thickening of the Niagara limestone, the Hudson River and Utica eastward from Marion.

## WELLS COUNTY.

The Northern Indiana Oil Company, of Bluffton, has fifteen wells in the neighborhood of Nottingham, in the southeastern part of the county, which are in what is called the Montpelier field, lying east of that place, west of Geneva and northwest of Bryant. This is the main oil field as worked at present. If Montpelier were taken as the base and a semicircle described with a radius of fifteen miles extending from Union Grove on the west to Portland on the east, it will enclose all the worked territory in the eastern part of the State. This embraces parts of Grant, Huntington, Wells, Adams and Jay Counties.

There has been no record kept by the Northern Indiana Oil Company of the wells near Nottingham, the section given below being from memory by the driller, but it is doubtless approximately correct.

| | |
|---|---|
| Drift | 80 feet. |
| Niagara limestone | 200 feet. |
| Hudson River | 500 feet. |
| Utica shale | 200 feet. |
| In Trenton | 20 feet. |

The drillers say there is no material difference in the depth at which Trenton is found, ten feet marking the extreme limit of variation of depth.

The wells yield an average of twenty barrels each per day. Some of the wells yield a much greater amount than this, while others fall below it. The highest reported yield is 300 barrels per day.

At each well there are storage tanks, generally two, of 250 barrels capacity, and when these are full the oil is measured by a gauger employed by the company buying the oil, and is then transferred to a pipe line and conveyed to the tank cars. The Standard Oil Company and the Manhattan Oil Company are the largest, if not the only, purchasers here. These companies are reported as paying from 35 to 40 cents per barrel of 42 gallons for the oil from the tanks.

## MONTPELIER.

### *Manhattan Oil Company.*

This company has ten producing and two dry wells in Jackson Township, Wells County. These wells average twenty barrels per day. One of the wells yields one hundred barrels per day, and has been yielding at this rate for two months. All the wells of this company, except one, have to be pumped.

Well No. 1, the McIntire well, was drilled September, 1890. It came in as a twenty-barrel well, and the yield has been constantly increasing. No. 2 furnishes the same amount, while No. 3 is the one yielding one hundred barrels per day. This company ships its oil to Lima, Ohio, where it has refineries. Storage tanks from 250 to 800 barrels capacity are used, the largest tanks, of course, being used at the best wells. The production of this company is estimated to be 60,000 barrels per annum, which they expect to double next season by drilling new wells.

### *The Jackson Oil Company.*

This company commenced operations October 3, 1890, and has drilled twenty-eight wells, five of which are dry.

The following section of a well in Chester Township, Wells County, may be taken as fairly illustrative of that portion of the field lying adjacent to Keystone; premising it by the statement that this township is the northern limit of the field as developed.

KEYSTONE WELL.

| | |
|---|---|
| Drift | 62 feet. |
| Niagara limestone | 260 feet. |
| Hudson River | 375 feet. |
| Utica shale | 300 feet. |
| Trenton | 30 feet. |

Occasionally two strata of oil-bearing rock are found in Trenton, but where these are found the yield of oil is rarely increased, the oil-bearing strata being, in nearly every case, either thinner or denser, so the production remains about the same. This double stratum seems to be only local, and to have been governed by the same laws that caused a division of the coal seams, in the Coal Measures. Here, as there, we have multiplication of product yielding horizons without notable increase of product, as, at first thought, would seem to follow.

WELL IN JACKSON TOWNSHIP.

| | |
|---|---|
| Drift | 243 feet. |
| Niagara limestone | 117 feet. |
| Hudson River | 375 feet. |
| Utica shale | 300 feet. |
| Trenton | 25 feet. |

In this well but a single oil-bearing stratum was found, yielding at the rate of thirty barrels per day of 24 hours.

The reported average yield of these wells is six barrels per day, the best yielding 51 barrels, the next best two 50 barrels each, in 24 hours.

As is the custom, one to two tanks are used at each well of a capacity varying from 250 to 600 barrels. The Buckeye Pipe Line purchase this oil.

Six miles northeast of Montpelier the water is cased out at a depth of 200 feet. Six miles west of town the last flow is found at 370 feet, indicating a dip of the strata to the southwest of 14 feet to the mile.

There are a number of wells, seven in all, owned by various parties at this writing, but the number is being rapidly increased, and by the end of the season of 1892 the total number of wells in this territory will no doubt be doubled. There was shipped from Montpelier during the month of January, 1892, 10,960 barrels of oil, indicating an annual production of 131,520 barrels of forty-two gallons each. The value of this oil at the well is about $50,000. This is a neat little sum, but small in comparison with the amount to be secured in the future when the "gushers," that are so ardently hoped for by both drillers and land owners, are struck.

PORTLAND.

There have been but few wells drilled here, probably four marks the limit. They were put down for gas, and on failure to find it, wells were drilled in the vicinity of Camden and the gas piped to town. On the failure to find gas about Portland, the field was abandoned and the wells not pumped for oil.

SECTION OF WELL THREE MILES WEST OF PORTLAND, ON FARM OF JOHN GILBERT.

| | |
|---|---|
| Drift | 42 feet. |
| Niagara limestone | 225 feet. |
| Hudson River | 435 feet. |
| Utica shale | 300 feet. |
| Trenton | 25 feet. |

Oil reached at ten feet in Trenton, flowing 45 barrels of heavy lubricating oil per day.

The well on A. H. Croninger's farm showed the same section as the above, and flowed twenty barrels per day, but, owing to lack of market, all these wells are closed. There was not enough oil produced by these wells to justify a pipe line, and, for some reason, no other wells were put down, so the field is abandoned at present. The yield shows this to be a very promising field, and the wells being flowing ones, the expense of pumping is saved. This alone is an important item of expense in the production of oil.

The Jas. Penn well, near the above-mentioned ones, yielded fifteen barrels per day, but it did not flow, the oil being pumped.

### WINCHESTER.

The Rock Oil Company control twenty-one wells here, nine of which have had the pipe drawn from them and are abandoned. The first well was drilled here September 28, 1886, and the last one September 16, 1891. A number of the wells now owned by this company were drilled by other parties and sold to the Rock Oil Company, and it is now using them as gas wells, as no well owned by this company yields enough oil to pay for pumping, though each one, except No. 4, yields a small quantity of dark, heavy oil that is removed from the gas by separators and blown out, generally once a week, by the well man. The exception, No. 4, yields a small amount of amber-colored, heavy-bodied oil.

Well No 1 is located near the Court House; No. 4, one and one-fourth miles west of town; No. 5, one and one-half miles northwest; all the others are within a few miles of town in a western direction.

#### SECTIONS OF WELLS FROM RECORD KEPT BY DR. J. C. HIRSH.

*Well No. 4, on Farm of Silas Colgrove. Drilled May 9, 1886.*

| | |
|---|---|
| Drift | 334 feet. |
| Hudson River and Utica | 718 feet. |
| In Trenton | 120 feet. |
| Total | 1,172 feet. |

This record does not show the depth at which gas and oil were found.

*Well No. 5, Jas. Cranor's Farm. Drilled January 11, 1888.*

| | |
|---|---|
| Drift | 331 feet. |
| Hudson River and Utica | 740 feet. |
| In Trenton | 75 feet. |
| Total | 1,146 feet. |

No record of the horizon or the yield of oil and gas by this well. Well abandoned and pipe and casing drawn.

*Well No. 6, James Pierce's Farm. Drilled March* 16, 1888.

| | |
|---|---|
| Drift | 136 feet. |
| Niagara limestone | 65 feet. |
| Hudson River | 543 feet. |
| Utica shale | 300 feet. |
| In Trenton | 27½ feet. |
| Total depth | 1,071½ feet. |

Gas and oil were found from 1,056 to 1,060 feet, but the quantity of oil was small, probably not exceeding one barrel in twenty-four hours.

*Well No. 7, Eliza Goodrich's Farm. Drilled May* 2, 1888.

| | |
|---|---|
| Drift | 102 feet. |
| Niagara limestone | 85 feet. |
| Hudson River | 549 feet. |
| Utica shale | 300 feet. |
| In Trenton | 49 feet. |
| Total depth | 1,085 feet. |

Gas and oil from 1,061 to 1,071 in depth, or from 25 to 35 feet in Trenton.

*Well No. 8, Eliza Goodrich's Farm. Drilled July* 12, 1888.

| | |
|---|---|
| Drift | 70 feet. |
| Niagara limestone | 110 feet. |
| Hudson River | 520 feet. |
| Utica shale | 332½ feet. |
| In Trenton | 51½ feet. |
| Total depth | 1,084 feet. |

Gas and oil were found at a depth of 1,052 feet. Only a small quantity of oil was found. This well is now abandoned.

*Well No. 9, James Pierce's Farm. Drilled September* 7, 1888.

| | |
|---|---|
| Drift | 128 feet. |
| Niagara limestone | 82 feet. |
| Hudson River | 520 feet. |
| Utica shale | 306 feet. |
| In Trenton | 44 feet. |
| Total depth | 1,080 feet. |

Oil and gas at a depth of 1,067 feet. Small flow of oil and good flow of gas.

*Well No. 10, James Pierce's Farm. Drilled October* 16, 1888.

| | |
|---|---|
| Drift | 117½ feet. |
| Niagara limestone | 85 feet. |
| Hudson River | 520 feet. |
| Utica shale | 314½ feet. |
| In Trenton | 43 feet. |
| Total depth | 1,080 feet. |

Oil and gas from a depth of 1,057 to 1,069 feet.

*No. 11, Beech Grove Well.*

| | |
|---|---|
| Drift | 90 feet. |
| Niagara limestone | 100 feet. |
| Hudson River | 543 feet. |
| Utica shale | 320 feet. |
| In Trenton | 42 feet. |
| Total depth | 1,095 feet. |

Gas and oil at 1,075 feet.

*Wild Cat Well, Drilled September* 10, 1889.

| | |
|---|---|
| Drift | 97 feet. |
| Niagara limestone | 120 feet. |
| Hudson River | 540 feet. |
| Utica shale | 313 feet. |
| In Trenton | 50 feet. |
| Total depth | 1,120 feet. |

Gas and oil at 1,100, 1,104 and 1,107 feet.

*John Summer's Well, Drilled September,* 1889.

| | |
|---|---|
| Drift | 170 feet. |
| Niagara limestone | 55 feet. |
| Hudson River | 537 feet. |
| Utica shale | 330 feet. |
| In Trenton | 53 feet. |
| Total depth | 1,145 feet. |

This well is now abandoned, and the record does not show at what depth oil and gas were found, or if they were found at all.

*The Sim-Scott Well. Drilled October,* 1889.

| | |
|---|---|
| Drift | 121 feet. |
| Niagara limestone | 99 feet. |
| Hudson River | 530 feet. |
| Utica shale | 225 feet. |
| In Trenton | 50 feet. |
| Total depth | 1,125 feet. |

This well is now abandoned, but at the time of drilling gas and oil were found at a depth of 1,098 feet.

*The Price Well. Drilled November,* 1889.

| | |
|---|---|
| Drift | 83 feet. |
| Niagara limestone | 149 feet. |
| Hudson River | 530 feet. |
| Utica shale | 308 feet. |
| In Trenton | 32 feet. |
| Total depth | 1,102 feet. |

Oil and gas from 1,085 to 1,095 feet.

*Well No.* 13, *on Mrs. Leitchert's Farm. Drilled November* 26, 1889.

| | |
|---|---|
| Drift | 94 feet. |
| Niagara limestone | 110 feet. |
| Hudson River | 530 feet. |
| Utica shale | 316 feet. |
| In Trenton | 50 feet. |
| Total depth | 1,100 feet. |

At a depth of 1,075 feet a small flow of gas was found, and a trace of oil, but the well is now abandoned.

*No.* 14, *Wm. Coates' Well. Drilled May* 17, 1890.

| | |
|---|---|
| Drift | 88 feet. |
| Niagara limestone | 142 feet. |
| Hudson River | 541 feet. |
| Utica shale | 300 feet. |
| In Trenton | 53 feet. |
| Total depth | 1,124 feet. |

Gas and oil at 1,094 feet. Well now abandoned.

*Well No.* 15, *on Farm of David Hippenheimer. Drilled June* 20, 1890.

| | |
|---|---|
| Drift | 118 feet. |
| Niagara limestone | 110 feet. |
| Hudson River | 525 feet. |
| Utica shale | 323 feet. |
| In Trenton | 36 feet. |
| Total depth | 1,112 feet. |

Gas found at 32 feet in Trenton. A small quantity of oil is mixed with the gas, but is easily removed by the use of a separator, and is blown off once each week.

*Well No.* 16, *on Farm of Jacob Hippenhiemer. Drilled July* 28, 1890.

| | |
|---|---|
| Drift | 98 feet. |
| Niagara limestone | 110 feet. |
| Hudson River | 542 feet. |
| Utica shale | 330 feet. |
| In Trenton | 75 feet. |
| Total depth | 1,155 feet. |

Gas at 32 feet in Trenton.

*Well No.* 17, *on Farm of David Hippenheimer. Drilled July* 31, 1891.

| | |
|---|---|
| Drift | 150 feet. |
| Niagara limestone | 85 feet. |
| Hudson River | 525 feet. |
| Utica shale | 327 feet. |
| In Trenton | 48 feet. |
| Total depth | 1,135 feet. |

Well abandoned. A small flow of gas and oil at 1,104 feet, or 17 feet in Trenton.

# SUPERVISOR OF NATURAL GAS.

OFFICE OF SUPERVISOR OF NATURAL GAS,
INDIANAPOLIS, IND., January 1, 1892.

*To Hon. S. S. Gorby, State Geologist, Indianapolis, Ind.:*

SIR—In conformity with the provisions of the statutes of Indiana, relating to the supervision of natural gas and the inspection of gas wells and gas plants, I have the honor to submit to you the following detailed report of the transactions of this department for the period commencing March 16, 1891, to and including January 1, 1892.

This report is not as full and complete as you may have a right to expect, or as I could wish, for the reasons hereinafter mentioned.

I entered into the discharge of the duties of this department on the 16th day of March, 1891.

These duties have been so many and so various, and as no provisions were made for any assistance in the work, I have been unable to cover the entire field within the limited time I have had for the work.

Another disadvantage, under which I have labored, has been the want of proper instruments and appliances for testing wells, in order to determine their pressure and volume. However, I can assure you that this part of the work can hereafter receive proper attention, as the department has lately been supplied with a complete set of gauges and other appliances necessary for making the tests required.

I consider the duty of inspecting machinery and piping, used in plants furnishing gas to consumers, one of the most important of any I have to perform.

The safety of life and property requires that the machinery for handling this fuel should be kept in the best condition. So far but few accidents have occurred, and these have been caused by defective house plumbing. In a large majority of the plants I have inspected I have found them to be in a condition to give safe and satisfactory service to their consumers. In only two instances have I been compelled to condemn any part of the plant, and in both of these cases I found the managers preparing to substitute new machinery.

As the piping and machinery, which is now comparatively new, becomes old and worn the necessity for careful supervision and frequent inspections will become more apparent.

The law prohibiting the burning of natural gas in flambeaus is obeyed in the greater number of localities. The exceptions are to be found in parts of Madison, Grant and Howard Counties, and possibly, in rare cases, elsewhere.

The local officers charged with the enforcement of the laws appear to have given little, if any, attention to this statute.

This has been, and is, a source of great and needless waste, and should be stopped.

The conditions of some of the pipe lines extending over parts of the field is bad. In some of them leaks can be found at almost every joint. Especially is this true in what is known as the "farmers' plants." These lines have been laid down hastily, and by inexperienced men, which will account for their condition.

In my next report I hope to be able to give you more fully the condition of the pressure and volume, as well as many other facts which I have been unable to reach at this time.

Respectfully,

E. T. J. Jordan,

*Supervisor of Natural Gas.*

# THE GAS AREA

The area of the gas field of Indiana is very much larger than that of any other developed at this time, It embraces the counties of Grant, Howard, Tipton, Hamilton, Madison, Hancock, Delaware, Blackford, Henry and Rush. Adjoining these gas has been found in paying quantities in parts of Marion, Shelby, Decatur, Franklin, Dearborn, Fayette, Wayne, Randolph and Jay counties. This constitutes the main gas belt of the State, and is practically continuous. Inside of this belt but very few well have been drilled that have not furnished more or less gas.

Within this area, the eastern portions of Hamilton, Tipton and Howard Counties, together with the counties of Grant, Madison, Blackford, Delaware and Hancock, the largest wells have been found. Prof. S. S. Gorby, State Geologist, in the 16th Report of the Geology of Indiana, has very fully described this area. Accompanying his report is a carefully prepared map fixing the boundry of the territory I have mentioned. Since that report was written many wells have been drilled by prospectors around the borders of this area, and in other parts of the State, seeking to discover new fields, or to extend the boundaries of the main field. While some show of gas has been discovered in some of these wells, and hopes have been raised that their efforts were in the right direction and would ultimately lead to success, yet by far the larger number has ended in what is known as "dry holes"—that is, no gas has been obtained. Not enough gas has been obtained to necessitate the enlargement of the boundaries of the map to which I have referred. In a word, no new fields have been discovered, either contiguous to the main field or in any other part of the State. In some portions of the area included in this map, the flow of gas has always been weak, and is now practically exhausted. Especially is this true in the localities of Lawrenceburg in Dearborn County, Brookville in Franklin County, Connersville in Fayette County, and Portland in Jay County. In fact the wells in the localities I have mentioned are considered so nearly valueless that they have not been returned for taxation, and the greater number of them have been abandoned.

The leaving out of these places, which lie on the east and southeast of the belt, would be the only change that I would suggest in the map as it now appears. Outside of this main belt, gas has been obtained at Auburn in Dekalb County, Vernon in Jennings County, Salem in Washington County, Francisville in Pulaski County, and at several points in Harrison County. This last field extends across the Ohio River into Kentucky. In all these places the field has been limited in territory and in flow. These localities are not now thought to be worthy of a place in the consideration of the gas areas of the State.

The boundaries of the gas areas of Indiana are so irregular that it has been difficult to arrive at the exact number of square miles included. Probably the nearest estimate is in round numbers, five thousand square miles. This includes all the territory in which a well will produce any gas. Of this great expanse, probably twenty-five hundred square miles were originally underlaid by gas in quantity sufficient to produce wells of the first class.

The gas field of Indiana is many times larger than the field of any other of the gas producing States. In fact it is a great deal larger than the total gas producing area of Ohio and Pennsylvania combined. A very important feature, and one that gives to Indiana a decided advantage in reference to this product over the States I have named, is that the producing territory is practically one continuous field. Whenever the drill penetrates Trenton rock anywhere within the boundaries defined, a flow of gas may be expected in quantities sufficiently large to justify the expense of connecting the well to a pipe line. A failure to do so has been the rare exception.

This is not true of Ohio and Pennsylvania. In those States it has been shown that there are many small fields without any apparent connection with each other. The total areas in the two gas-producing States I have mentioned only aggregate a few hundred square miles, while in Indiana, the continuous territory that has been developed, and the finding of gas reduced to an absolute certainly, amounts, as I have said, to five thousand square miles. This fact alone adds greatly to its value in the production of this fuel.

I consider this condition of the field in this State as one of very great importance in estimating the permanency of the supply. It will readily be seen that, taking only this one condition into account, the supply in Indiana must, of necessity, be many times larger than that of Ohio and Pennsylvania.

The area of the gas-field is not the only condition that must be considered in estimating its productiveness or the permanency of the supply. The source from which gas is obtained is an important factor. The field may be extensive, and yet the source of the supply at any given locality, or in the entire field, may be subject to such conditions as will limit the production. The source of the supply in the main field of Indiana is the Trenton limestone. This rock is reached, in the greater part of the field, at a depth of eight hundred feet to ten hundred and fifty feet, the depth of any given well being governed by the surface elevation. The following is a list of the more important localities, and the depth at which Trenton rock was reached:

DEPTH OF TRENTON ROCK.

| | |
|---|---|
| Broad Ripple | 860 feet. |
| Anderson, Well No. 1 | 850 feet. |
| Anderson, Well No. 2 | 814 feet. |
| Alexandria | 889 feet. |
| Fairmount | 934 feet. |
| Frankton | 840 feet. |
| Greenfield | 985 feet. |
| Union City, Well No. 1 | 1,165 feet. |
| Fountaintown, Well No. 1 | 976 feet. |
| Auburn | 1,933 feet. |
| Jonesboro | 910 feet. |
| Kokomo, Well No. 1 | 934 feet. |
| Kokomo, Well No. 2 | 905 feet. |
| Muncie | 878 feet. |
| Noblesville | 845 feet. |
| Pendleton | 859 feet. |
| Ridgeville | 981 feet. |
| Shelbyville, Well No. 1 | 837 feet. |
| Shelbyville, Well No. 2 | 865 feet. |
| Winchester, Well No. 1 | 1,008 feet. |
| Winchester, Well No. 2 | 1,029 feet. |
| Winchester, Well No 3 | 1,058 feet. |
| Thorntown | 1,204 feet. |
| Van Buren | 960 feet. |
| Elwood | 930 feet. |
| Lapel | 888 feet. |
| Camden | 990 feet. |
| Dunkirk | 950 feet. |

Trenton rock is subject to two conditions as regards the production of gas. The first condition is its thickness. By this I mean the gas-bearing portion. The gas-bearing portion of the Trenton limestone in this State varies much in thickness, and this variation is not, apparently, according to any system or law, but is very irregular, and may be encountered in any part of the field. A few instances have been reported where the gas-rock was found to be not more than one foot thick. I will not, however, vouch for the correctness of the measurements upon which these reports are based I rather believe that the flow in some instances was so weak, owing to the density of the rock and other conditions present, that it was impossible to obtain an accurate measurement.

The greatest thickness that has been discovered is about forty feet. There can be no mistake as to the point where the gas begins to flow, but the drillers may not be so accurate in regard to the point where the increase in the flow stops. As a usual thing no measurement of the flow is taken, and it is left to the eye and ear of the driller to judge when the increase in flow ceases. Exact information upon this point has been hard to obtain, as by far the greater number of wells have been drilled by contracts, and the contractors have been interested only in completing their work, and have not taken the pains, or even possessed the necessary appliances to make accurate measurements. From the meager information that it has been possible to obtain as to this condition of the rock, it may be safe to assert that the thickness of the gas-bearing rock in a large portion of the Indiana field is not equal to the same rock in the Ohio field, or to the aggregate thickness of the different gas-bearing sands that are found in the wells of Pennsylvania. But this is not true of many parts of the territory, notably in Madison, Grant and Blackford counties. In these localities the thickness of the gas-strata compares favorably with that of other gas-fields. However, the lack in this respect in the Indiana gas-rock is many times more than equaled by the extent of its area. These two conditions, area and thickness, when considered together in estimating the productiveness and value of the field, make a very favorable showing.

The density of the rock is another and very important condition to be considered. The more porous the condition of the rock, the more storage there is for gas, and the faster will be the flow through the rock; while in the denser portions the storage capacity is limited and the flow is obstructed. The thickness of the rock being equal, the wells that penetrate the more porous portions of the rock will produce the most gas.

Porosity, then, is to be considered as a very important condition. This is found, like the thickness, to vary very materially in the different portions of the field, and often in the same locality, and is not governed by any known law or system. Porosity and thickness govern the production of any given well or locality. When the greatest porosity is found in connection with the greatest thickness, there we have the best producing wells. In regard to this condition it may not be possible or fair to compare the productiveness of the field under consideration with gas-bearing sands of Pennsylvania. Under no condition could the Trenton limestone be found as porous as the sands I have named, consequently the wells of Indiana could never reach the enormous flow that has been shown in some of the monsters of the Murraysville and other fields of Pennsylvania. It may be argued here, however, that, our resources being so much larger, owing to the large area of the field, the flow of gas, although limited somewhat by the density of the rock, may be of much longer duration, and in the end we will have derived more benefit. It stands to reason that while great porosity will give a larger flow, yet there will be quicker exhaustion of a given supply, and the short life of the field will prevent a perfect utilization of the product.

In the Ohio field, as has been before mentioned, the source of the gas is the same as in Indiana, with some unimportant exceptions. In regard to density, it appears, from the information at hand, that the condition of the Trenton rock in that field does not vary in any material degree from the rock in the Indiana field. As the field there is so limited in extent, perhaps there is a larger area of rock showing the greatest porosity, in proportion to the entire territory, than is to be found in Indiana. The rock in the Ohio field shows at different points different degrees of density, and, as it appears in Indiana, is not subject to any known law. It is not unreasonable that this should be true, as the fields lie almost contiguous, and the Trenton of Indiana is a continuation of the same rock in which gas is found in Ohio. I do not wish it to be understood that the gas-producing area of these two States is continuous; in fact, they are separated by quite an extent of territory in which no gas has been developed, or, if found at all, has been in such limited quantities as to be of no practical value, and hence not worthy of mention in consideration of the field. In this intervening territory the Trenton rock either lies so low as to be filled with salt water, to the exclusion of gas, or the density is such as will entirely obstruct its flow.

There is one more condition to be considered in estimating the value of a field or of individual wells in the production of gas. This is the initial pressure, commonly called rock pressure. By this is meant the pressure exerted by the gas upon the rock in which it is contained. The only means that we have of ascertaining this pressure is by drilling into the gas rock. The pipe that connects this reservoir with the surface will, when closed, contain gas in the same state of tension that exists in the rock. The pressure is determined by a steam-gauge attached to the pipe. This is sometimes called the closed pressure of the well, and it ranges in amonnt from 1 to 1,000 pounds to the square inch. In all the great gas fields the rock pressure ranges from 300 to 750 pounds, and beyond the latter figure it very seldom rises. In shale gas wells the pressure seldom rises to 100 pounds, the ordinary range being from 25 to 75 pounds. As to what it is that originates this force three answers have been given, but for none of them has it been claimed that they are well-defined theories. They have been thrown out as suggestions.

One answer is that the rock pressure is derived from the expansive nature of the gas. In support of this statement, it is claimed that solid or liquid materials in the reservoir are supposed to be converted into gas, as water is converted into steam. The resulting gas occupies many times more space than the bodies from which it was derived, and in seeking to obtain this space it exerts the pressure which we note.

The second explanation, or theory, is to the effect that the weight of the superincumbent rocks is the cause of the high pressure of gas in the reservoirs. In this explanation, the term *rock pressure* is considered to be descriptive of a cause as well as of a fact.

The third theory advanced to account for the rock pressure of gas is entirely different from those already given. It claims water pressure in the gas rock as the cause of the flow. By this theory gas is made artesian in its flow. Each of the theories, or suggestions, has its adherents, but none of them have been expanded into anything like an elaborate or balanced statement.

I shall leave to the scientists the task of finding out the true and satisfactory explanation. I have only introduced these theories in connection with this condition of the development of gas for the purpose of suggesting thought which may lead to the discovery of new facts, or to a more full account than can now be given of the facts involved.

Proceeding with the comparison of the great gas fields, it may be said that in Pennsylvania the original rock pressure was 750, in Ohio 450, and in Indiana 325 pounds to the square inch. These figures have been greatly reduced by the exhaustion of the fields. Especially is this true in the first two States named, and it is also true in many portions of the Indiana field.

Of this I shall have more to say in another part of this report. My object at present is to describe the natural condition of the field, and to compare it with other fields, as to its productiveness. Rock pressure tells nothing of the productiveness of a well when taken by itself. Wells, in any field, are quite likely to have the same closed pressure, no matter what their production may be. That is, when locked in, all such wells will reach the same pressure on the gauge. One well reaches it instantaneously, or in a very short time. In another the pressure increases slowly for hours, but at last it gets to the same point that the stronger well reached in a minute.

If the element of time be combined with the element of closed pressure, an approximate estimate can be made as to the production of a well. It is obvious that a well that gains 100, 200 or 300 pounds in a minute, has a much larger productiveness than a well that gains 5, 10 or 20 pounds in the same interval.

The only scientific system of measuring the flow of gas wells is based on the open pressure of gas, and by means of it the strongest as well as the weakest well can be determined by a simple and single measurement that can be executed in a few seconds at most.

If the theory of artesian pressure be accepted, other things being equal, the rock pressure will be greatest in the deepest wells. The deeper the well, the longer the water column. Other things being equal, the rock pressure will be greatest in those districts where the gas rock rises highest above sea level in its outcrops. The 750 pounds of rock pressure in

Pennsylvania gas wells, as contrasted with the 400 pounds pressure of the Findley wells, and the 325 pounds of the Indiana field, can be accounted for on this principle.

If this theory be true, and it has by far the greatest number of adherents, then the productiveness of the Indiana gas field does not suffer by comparison of the rock pressure, as shown in the different gas fields, when this condition only is considered. In other words, Indiana could show as great a production within a given area as either Ohio or Pennsylvania, providing the other conditions were equal, notwithstanding the fact that her wells show only 325 pounds rock pressure, as against 450 pounds and 750 pounds shown in the States named.

The disturbance of strata in its effects upon the accumulation of gas is a subject that has been discussed ever since the discovery of gas in this country upon a large scale. Geologists have concluded that the disturbed condition of the strata in many, if not all, of the gas producing districts, has modified the distribution of gas to a very material extent.

The occurrence of gas in any district has, in nearly every instance, been found to be connected with more or less marked irregularities of structure. The facts observed in the different oil and gas fields are susceptible of but one explanation, and that is that the accumulation of gas is modified by the structural arrangement of the rocks. In other words, structure is a vital element in the accumulation of gas.

I shall not enter into a description of the structural arrangement of gas bearing rocks of this field at this time. I do not consider it necessary to do so, as they have been very carefully and exhaustively treated of in this connection by Prof. Maurice Thompson and Prof. S. S. Gorby in the 15th and 16th Reports on the Geology of Indiana. Their reports were made after the most careful and painstaking surveys. The reader is referred to these reports for accurate descriptions of the structural arrangement of the Trenton limestone, together with the overlying rocks within the gas field of Indiana. Dr. A. J. Phinney, of Muncie, Indiana, has given much time and attention to the geology of the gas fields of the State, and has written a very careful and elaborate report on the same, which may be found in the latest report of the United States Geological Survey.

## RECAPITULATION.

The conditions which are essential to and govern the production of gas in any field are area, thickness, density, initial pressure and structural arrangements. It is evident that the field in which the largest area is combined with the greatest thickness, the most porosity, together with the highest initial pressure and greatest disturbance of structure, is the most productive. Where all these conditions are present in their most favorable form, abundance and permanency of this valuable fuel is assured.

Whenever any one or all of them are lacking in any considerable degree, then the value of a field as gas producing territory is diminished proportionately. These conditions must all be present to some extent if we would expect to find a flow of gas. A careful observance of these conditions, which are so vitally essential to the existence of gas in any territory, will be of vast importance to the prospector who is seeking to develop new fields. If these things had been known or understood in the first years of gas development in Indiana, as well as the other gas producing States, vast amounts of money, together with needless expenditure of time and labor, might have been saved. The search for gas would have been systematical, and confined to those fields where the vital conditions were present. Even yet, within the State, wells are being drilled in localities in which careful surveys have shown that the requisite conditions are not present, and, in consequence of their absence, gas can not be obtained. However, these things are being better understood. Practical men have been devoting their best thoughts to the subject, and have been making careful observations. By so doing they have obtained a better knowledge of the source of the gas, in its location and conditions. Money, time and labor have been saved thereby. The driller knows where to locate his well, and he can tell, with reasonable certainty, the exact depth he will have to reach in order to find gas. He can also judge from the texture of the rock penetrated whether his well will be a large producer or not.

It is true that within the field "dry holes" are sometimes obtained. However this is only the very rare exception. In such cases it is always found that one or more of the conditions are wanting. Generally in such wells the rock is too dense in its structure to permit the flow of gas, although all of the other conditions may be present. Such spots, as I have said, are rare within the field, and the area of each is very limited. In many cases large producing wells have been developed in close proximity to these failures. The failures within the field, at the present development, are confined to a few spots of small areas.

The facts that have been obtained in the development of the Indiana gas-field are enough to establish the wonderfully productive character of the Trenton limestone that underlies the territory. The gas-rock proper, in most of the field, is very open in grain, as a rule. It occurs in beds of varying thickness, as has been stated. The gas-rock is of as good quality, and is found in nearly as great thickness, in large portions of this field, as has been developed in the other great gas-fields. In explanation of the great production of this gas-field, it is suggested that the best quality of rock is more continuous than in other fields. In a word, the Indiana gas-field possesses all of the requisite conditions that go to make up a large production, and some of them in a marked degree. As an illustration of this, I would again call attention to the vast area of the gas bearing rock, an area that covers, as before stated, at least five thousand square miles of continuous productive territory. In consideration of this condition, I venture the statement that it is the horizontal rather than the vertical extension of the gas-rock to which the great production is owing.

All of the conditions favorable to the largest production of this valuable fuel exist in the Indiana field. Vast amounts of gas have been developed and utilized. Almost equally vast amounts have been wasted in various ways. Of this reckless waste that has been practiced in the field, and its probable effect on the permanency of the supply, I shall have semething to say in another part of this report.

Taking the conditions as they are found combined in this field, as I have endeavored to show them, and especially considering the vast lateral extent of the rock, I think that Indiana can, with consistency, claim the most productive gas area in the known world.

### CONDITION OF THE GAS FIELDS.

In the foregoing pages of this Report, I have endeavored to describe the gas field of Indiana. In that description I have shown that the field possesses all the conditions that are necessary to the production of this valuable fuel. I have shown that the field is of vast extent, greatly exceeding in this respect that of any other field known, and that the density of the gas bearing rock in the greater portion of the territory is favorable to the largest production. The only conditions in which this field suffers in comparison with other fields is in the vertical depth of the productive portions of the rock and the initial pressure. Viewing the field as a whole in regard to its capacity for the production of gas, I may say that the loss in productiveness from the last two conditions named is more than equaled by its vast lateral extent.

Taking all these things into consideration, there may be claimed for the gas field of Indiana a greater productiveness than that of any other field that has yet been developed. The developments, as shown in hundreds of wells with outputs of from two millions to twelve and fifteen millions of cubic feet in twenty-four hours, together with still other hundreds of a lesser flow, go to prove the claim. Such were the conditions and capacity of the field when gas was first discovered in September, 1886. That it has suffered by mismanagement, and that the full benefit of its productiveness has not been realized, is plainly evident to every thoughtful observer.

Ignorance of the condition necessary to and in connection with the production of this fuel, and a mistaken idea that it was a perpetual product, led to this mismanagement. Closely following the first discovery, gas was developed in many different localities in the territory.

In each of these places excitement immediately ran to the highest pitch. Thousands of people visited the wells every day and night. Excursion trains ran almost daily bringing visitors to view the various "wonders." This continued for many weeks in most of the localities, during which time the wells were allowed to stand open and thousands of millions of cubic feet of this valuable fuel was allowed to escape, or was burned for the benefit of the multitudes of sight-seers. Not only was the gas wasted and consumed in this prodigal and senseless manner, but what was worse, the fact that this free, open flow was maintained at the wells for weeks, and in some cases for months, so relieved the rock pressure, that not only wells subjected to this extraordinary draft, but the entire area was permanently injured by the introduction of salt water. This would not have been the case, and the production would have been much larger, if these first wells, as well as many subsequent ones, had not been subjected to such a heavy and unnecessary draft.

Another thing that was practiced during the early discoveries of gas in this field was the overestimation of the capacity of the wells. To some extent this is done yet by boomers and speculators in real estate. Many of the newspapers published in the gas belt have been guilty of the grossest exaggerations in publishing the capacities of the wells in their different localities. This was deplorable from the fact that it not only deceived manufacturers and others desirous of investing in gas industries, but when later and more correct estimates and measurements were made too great a falling off was shown, which led to the belief in a too rapid decrease in the production. I maintain that if proper measurements of the output of all wells had been taken and published, and if the supply had not been drafted on so heavily, and a sufficient back pressure maintained to prevent the introduction of salt water, that many parts of the field would not show the heavy decline in pressure and volume that is now apparent. Some wholesome laws are already in operation, having for their object the preservation of gas and the protection of wells. Much good has already been accomplished by their observance. The burning of this valuable fuel in immense flambeaus all over the field during the early developments was one of the most senseless and wasteful of the many extravagances practiced. The cities and towns within the field, as well as the farms and country roads in many places, were lighted up with these miniature gas wells. In most instances they were allowed to burn day and night. Millions of feet were daily consumed in this wasteful manner, and a heavy and unnecessary draft from this cause maintained on the field, without adequate return. This is now prohibited by law, which I am glad to know is carefully obeyed in the greater part of the field, yet there are localities where it is disregarded and this criminal waste and injury maintained.

I would recommend that such laws be enacted as will prevent gas companies and all other owners and operators of gas wells from drafting their wells to the point of reducing the initial pressure below what may be shown to be the "danger line" in their respective localities, or to the point of admitting salt water into the wells.

This "danger line" is shown not to be uniform throughout the field; that is, a back pressure which would be sufficient to prevent the introduction of liquid in one part of the field would not do so in the other places. This law should be so modeled as to meet the conditions in this respect as they are found in the different localities within the field.

I would also recommend the passage of a law regulating the packing of wells. A large number of wells have what is known as wall packers. By this is meant that the packer and tubing is anchored to the wall of the well in the shales, in many instances as much as four and five hundred feet from the bottom of the well. Incalculable injury is, in nearly every case, done by this method. The gas, after its release from the Trenton rock, permeates every portion of porous rock that forms the wall of the well below the point at which the well is packed. It spreads itself laterally through every crevice and opening that is found, and thus an enormous waste is maintained.

In many parts of the field we find gas escaping through the earth and bubbling up through the water in the streams and in water wells. In some instances the escape into water wells has been so strong that the wells have been closed in, and the gas piped into the houses adjoining and found sufficient for domestic consumption.

All this may be attributed to the insufficient packing of the wells in the vicinity. The great upheaval of earth and rocks, and the explosion which followed in the vicinity of Waldron, Shelby County, which occurred August 11, 1890, was due to the gas escaping through the shales and below the packers from the wells at Waldron and St. Paul. The gas escaping laterally through the shales collected in subterranean reservoirs until the pressure became so great as to cause the upheaval.

The waste from this cause has resulted in vast injury to the field in different localities, by reducing the pressure and the consequent introduction of salt water.

Well owners should be required, in packing their wells, to extend the tubing to the bottom of the well and place the packer at the top of the Trenton rock. I am aware that this can not be done in all cases, as the wall is in such a condition at the top of the rock that the packer will not hold. Especially is this true in wells that have been "shot." But in these wells it should be required that the packer be placed as near the rock as can be made to hold, thereby reducing the exposure to escape laterally to the minimum.

When the gas is released from the Trenton rock by the penetrating of the drill, every precaution should be taken to secure it. This should be done not only for utilization, but to prevent injury to the field.

It is admitted by many scientists, and others who have had much practical experience, and who have given the matter careful thought, that salt water is the final death of gas wells. Salt water, petroleum and gas are found in the porous Trenton rock in the following order: Salt water being the heaviest seeks the lower levels, or is held there by pressure. Whenever oil is present it is found immediately above the salt water, and gas, the lightest of the three, occupies the highest portion of the porous rock. This is the order in which they are found under the initial pressure. When this pressure is reduced by the gas being allowed to escape through the open wells, this salt water rises into that portion of the rock from which the gas escaped and into the well. This also permits it to flow into the adjacent field and shut off the gas which would otherwise flow into this well, or if any still continues to flow, it is greatly retarded by the water through which it must pass.

There has frequently been observed what are known as pulsations in gas wells. By the term pulsations, it is meant that the gas flows at intervals. This is caused by the column of water becoming so great as to entirely suppress the flow, until the gas accumulates in the reservoir in sufficient quantity to lift the overlying water, when it will burst forth apparently with great energy and force. This flow will continue for a time, only to be overcome and partially shut in by the water. It is thus that the struggle continues, the water gradually and surely encroaching on the field. Each succeeding pulsation becoming weaker, the interval of flow shorter, while the time necessary to the accumulation in the reservoir grows longer, until finally the column of water is too great to be lifted by the accumulated gas in the diminished reservoir, and the well is pronounced exhausted and abandoned. Salt water, under the conditions that have been superinduced by the escape of gas, and too great a reduction of the initial pressure, has destroyed not only the well under observation, but more or less of the adjacent field. Many wells in the field have been abandoned from this cause, and many others show so much salt water that their production has been greatly diminished. In nearly every instance the present condition of the wells can be traced to excessive overdraft, either by allowing the well to stand open, to too great a consumption, or to insecure packing.

This exhaustion of gas wells can be postponed, if not prevented, if they are not subjected to such excessive drafts, by which their pressure is reduced to such an extent as will permit the salt water to rise in the wells, or escape into the adjacent fields. To any thinking mind it is evident that serious injury has been done to the gas field of Indiana, in a majority, if not all, of the localities where gas has been procured. I am glad to know, however, that the people in the gas area are at least partially awakened to the injury that is being done, and that wells are now packed and closed in as soon as possible after being drilled in, and that an open flow is not permitted, except on rare occasions when it is necessary to take an observation or measurement.

But wells are still being subjected to dangerously heavy drafts, though not in the unnecessary manner above mentioned. The dangerous drafting now being done is by requiring wells to supply a much larger consumption than their capacity will with safety permit. This is done, in a great many instances, by ignorant management.

I have found that a great many of the companies and individuals who are furnishing gas for consumption proceed right along attaching more consumers without having any kind of a measurement to ascertain the capacity of their wells, and without making any tests of the condition of their supply. Some are too greedy in their desire to make money in the gas business and look upon the drilling of additional wells to supply increased consumption as an unnecessary expense.

There is but one ending to this short-sighted policy, and that is a failure of supply, by reason of the overdraft, and the introduction of liquid into their wells, and they are at last, however unwilling they may be, compelled to drill more wells than they otherwise would have done, by reason of the local field being more or less filled with salt water.

In every case that has come under my observation, in which there has been a partial or total exhaustion of wells, I have found, upon inquiry into the history of their management, that they have been subjected to overdraft, either by having been allowed to stand open, or by being compelled to supply too great a consumption. I have found also, a very few wells that have not been subjected to these abuses. These showed but very little, if any, signs of failure. Notably among these was well No. 1, at Eaton, in Delaware County. This was the pioneer gas well of Indiana, having been drilled in September, 1886. This well has been in constant use ever since it came in, but not having been at any time overtaxed, it was, when I examined it in June, 1891, practically as strong as ever. It showed a rock pressure of 315 pounds, was entirely free from salt water, and although it was connected with the line in such a way, that with the instrument I had with me, I could not measure the volume, yet it gave every indication that the flow was as strong as ever.

I mention this as an example of a well that has been properly cared for, and the result of such management, and I am firmly of the opinion that a very large majority of the wells in our gas belt would show the same results with the same management.

It is held by most scientists that gas is not being generated at the present time in any appreciable quantities, and certainly not in quantities sufficient to meet the enormous drain that is being made on the different fields to-day. This being true, the necessity for husbanding the supply in every conceivable way becomes apparent. It certainly is to the interest of every consumer to make the product last as long as possible. Waste or prodigality in the use of this most valuable fuel becomes at once a crime against the public good. "The greatest good to the greatest number," should be kept in view in the use and management of this fuel.

The condition of the field at the present time shows only too plainly the inevitable results of the mismanagements, and the prodigality that has been practiced. The final failure of the product has been hastened, all too rapidly. This is shown by the diminished initial pressure, and by the presence of salt water. The volume of a well decreases with its loss of rock pressure, but the rate is not the same. If a well is heavily taxed, its volume goes down faster than its pressure. In some of the older centers, the well owners and consumers have awakened to the fact that a failure is fast approaching, and are endeavoring to stop the criminal waste. But it is surprising and discouraging, after all the experience that has been accumulated, to see the same wasteful policy practiced in some of the new centers.

The discovery of a store of fuel and power of this character was so surprising and unexpected that it is no wonder that to those who were so favored it seemed for awhile that it was inexhaustible. Nor is it any wonder that wanton waste was in progress on every side, and that any nice regard for economy seemed as foolish as it was futile.

This state of things is passing away, and the warnings that the supply of this precious stock of heat and power is limited are so plain that no one can any longer fail to recognize them.

The language of Professor Orton, State Geologist of Ohio, in regard to some of the vicious features of the system by which gas was introduced as a fuel into the towns of Ohio, will apply with equal force in Indiana, where the same system has been in vogue, and I can not do better than to quote him. He says: "The system by which gas has been introduced as fuel into the towns by both public and private corporations has, unfortunately, had some vicious features, in some respects, from the beginning. The consumer is charged, not for the amount of gas he uses, but in a general way for the amount that he is able to use by the service with which the company supplies him.

The gas meters in use at the beginning of this experience were not adapted to the natural supply, and their expense stood in the way of their adoption. Charges were thereupon based by the companies upon the size of the burners which they supplied to individual consumers. These burners are technically known as mixers. The openings by which the gas escapes are measured in given fractions of an inch. The mixers in common use are known as 3, 5 and 7. The diameter of the aperture in No. 3 is three thirty-seconds, in No. 5 four thirty-seconds, and in No.

7 five thirty-seconds of an inch. The amount of gas that passes through these mixers depends upon the pressure which is maintained upon it. This whole system of disposing of gas has already been characterized as a vicious one. The objection to it lies in this fact, viz.: that the consumer is under no adequate motive to economize. He is in danger of even making himself uncomfortable by overheating his house in the endeavor to get the worth of his money. The current complaints as to the extraordinary heating power of natural gas have their root in this system. There is no more need of warping and racking a house through the effects of heat by natural gas than by any other fuel. But the fact of its steadiness is made to contribute easily to this result. It can be maintained, day in and day out, without abatement, and it is this fact that mainly leads to this overheating.

The whole system of burning gas is, however, in a very crude state. A small fraction of the heat produced by combustion is at present made available for use. By means of the best appliances now known, the consumption of gas could be reduced to less than one-half, and perhaps to less than one-third of what is now used, without trenching upon the required amount of heat.

The remedy for the evil complained of, viz., extravagance in the use of gas, can be effectively reached by the introduction of meters. Meters have now been constructed for this specific purpose, and they certainly ought to be introduced into all cities and villages, unless the very small villages situated directly in the gas-fields shall be exempt. When a proper price is placed on gas, and when each consumer is obliged to pay for what he uses, an adequate motive to economize will, for the first time, be brought into operation."

Such is the language of one who has had better opportunities for observation and has given the subject more careful thought than most of the writers on this subject. What is true of the system of consumption in Ohio, and other fields that have come under Prof. Orton's observation, is equally true of the system in the Indiana field. I heartily endorse what has been said, and commend it to the careful consideration of all who are interested in economy in the use of gas.

In view of the evident signs of failure which are plainly to be seen in the older gas centers in the field, it is to the common interest of the gas companies and the consumers that these results be attained as soon as possible.

While I have referred to the evident signs of failure that is shown in many localities of the Indiana gas field, in order to call attention to the injuries that have been done by the mismanagement and waste that has been practiced, I would not be understood as saying that the field is exhausted by any means. There are large areas yet to be drawn from;

many new centers can yet be developed. Even in the first areas developed wells are being brought in that show nearly the old-time production. Wells that have been abandoned as worthless have been, after intervals of rest, and by being retubed, and by the aid of separators, found productive.

If proper management of the field by the enforcement of wholesome laws, and if economy in the use of gas is everywhere insisted upon and produced, I believe that there is yet a great future for the natural gas interests of this State, and that the last days of natural gas in Indiana may be its best days. If, on the other hand, the wasteful policy that has been practiced shall be maintained, there is sure to be, at no very distant day, an entire failure and great disappointment.

Prof. Orton so clearly expresses what I believe to be true, in regard to the use of gas as a fuel, that I can not do better than to give his conclusions and to urge their careful consideration:

"*First.* Natural gas finds its highest and most valuable use as domestic fuel. It is here that it does its greatest good to the greatest number. In all our dealings with it this fact should be kept constantly in view. To maintain it for the longest period for this service is our highest interest in relation to it.

"*Second.* If there is any use for which gas should be sold below the price of the fuel which it supplants it is the use in cooking stoves. The less fortunate members of the communities should be the favored ones in this regard. For the gas used in heating there is no occasion to make the price below the cost of coal; neither is there any justifiable demand for a discount on gas bills increasing according to the number of fires supplied. If a sliding scale is introduced it might, perhaps, better be made to slide the other way, charging consumption beyond the average at a higher rate.

"*Third.* An advance in price on the part of all municipal corporations for all the uses they undertake to supply is their proper policy. The price at which they have furnished it hitherto leads to the undervaluing and the wasting of the gas. The supply will do towns more good by serving them longer if they are required to pay a higher price for the gas.

"*Fourth.* All gas should be sold by measured volume. Meters and gauges ought to be introduced everywhere. No adequate motive to economize can be brought to bear on many consumers until they are obliged to pay at a proper rate for what they use.

"*Fifth.* Next to domestic use, the use of gas in the production of steam power is to be counted the most suitable application of it. Comparatively small amounts of it are required for this purpose, and great convenience and economy result therefrom. The most skillful user of it will find a rate of fifty feet to one-horse power sufficient, but the use of more than eighty feet to one-horse power should not be allowed, even if the user is willing to pay for it.

"*Sixth.* Of the various manufacturing uses in which the gas is applied as a fuel proper, glass making has probably the best rights. It contributes larger returns to the community in the shape of wages than other like industries. While its introduction into some parts of the gas field has been greatly overdone, and while much of it has been accomplished by the exercise of a mistaken policy, it should be maintained as long as possible. To this end economy should be everywhere enforced. The window glass works might, perhaps, be required to introduce coal into their furnaces for melting, at an early day, reserving the gas for the stages of flowing and flattening.

"*Seventh.* From certain uses to which gas is now largely applied, it should be at once entirely withdrawn. It is a great wrong to the community to allow it to be used in the burning of common building brick, and in calcining limestone. These processes consume large quantities of gas and make no returns except to their owners. For these uses wood and coal are good enough.

"The industry that consumes gas in by far the largest amount is iron working. It is a grievious mistake on the part of any community or company to allow a rolling mill access to its gas field. An ordinary mill uses as much gas every day as several thousands of families would consume, and the returns to the common good by such an application are small compared with any other way of using gas. Even though a rolling mill stands ready to pay as much per thousand feet as the small consumers pay, it ought not to be supplied. If it is willing to do this, it shows that there is not enough charged for the gas. It may be to the interest of the gas company to get its money back rapidly, it is true, but the community has interests, if not rights as well, that should not be overlooked in relation to this supply. The State interferes when an oil or gas well is left without being plugged, or when a gas well is allowed to blow into the air without use. Why? Because these precious stocks of mobile power are fitted to do good to great numbers of the people and no man has a right to take any action by which they shall be needlessly wasted. A like reason could, perhaps, be found for forbidding entirely the use of gas for the rough work that has been named above.

"*Eighth.* Natural gas is merely a transient phase of the stored power of the earth. It is folly to talk of its taking anything like a permanent place in the work of the world. The claim that it can springs only from enthusiasm or sciolism. There is, in reality, but little of it, and this is found in but limited regions and can not last long whenever its utilization is undertaken by the eagar and masterful activities of our day.

"*Ninth.* Natural gas has a very important work to do. It should prepare the world for something much better than itself. It is giving an object lesson to great communities as to the advantages of gaseous fuel, and it can hardly be that this lesson will be given in vain.

"The exemption from the soot and dust inseparable from the burning of bituminous coal in our cities, and the positive addition that gaseous fuel makes to the comfort and convenience of the entire community, when used as a domestic fuel and as a source of steam-power, are results in themselves too valuable to be abandoned when these small and treacherous stocks of buried power are exhausted. The conversion of the coal now burned in a large city into gas before being used would result in an immense economy in fuel, besides affording the incidental advantages alluded to above, and this economy of stored power is an object to which the civilized world will soon be obliged to address itself in good earnest."

## ECONOMIC USE OF NATURAL GAS.

Natural gas is most important in building up the manufacturing interests of any locality producing it. A review of the manufacturing industries located within the gas area of Indiana since its first development will show its appreciation by manufacturers.

These embrace manufactories engaged in the manufacture of straw board, straw paper, wood pulp and wood paper; steel works, foundries, nail mills, bar and bolt works and bell foundries; plate glass, window glass, fruit jars and bottle factories; crayon factories, fruit canning factories, excelsior mills, saw mills and flouring mills; brick and tile factories, and many other industries, in which a vast amount of capital is invested and thousands of hands are employed. At Anderson, Muncie, Marion and Kokomo are located a number of large concerns, which have changed these cities from quiet commercial places to bustling manufacturing centers. But the location of manufactories has not been confined to the places mentioned. A number of the smaller towns within the gas area have secured one or more large manufactories, and many of these places have shown a phenominal growth. Among these may be mentioned Greenfield, Noblesville, Tipton, Elwood, Alexandria, Pendleton, Carthage, Hartford City, Eaton, Spiceland and Dunkirk. In addition, many towns which lie outside but adjacent to the boundaries of the gas territory are using this fuel extensively for manufacturing purposes. Prominent among these are the cities of Richmond, Fort Wayne, Huntington and Peru. A marked prosperity has attended the development of this valuable fuel within the State. All classes of people have shared in this prosperity.

The summary of manufactories given below is not complete by any means, for the reason that I have not had sufficient time to collect the statistics.

Many new manufacturing enterprises are still being located, and evidence of continuous if not greater prosperity is manifest to the most casual observer.

Prominent among these may be mentioned the location of the DePauw Plate Glass Works at Alexandria, in Madison County. When completed this concern is intended to be the largest of its kind in the world. Many capitalists are locating their manufactories in the smaller towns, in order to reach the undeveloped portions of the gas field without the expense of putting in long and costly pipe lines. For this reason the smaller places will participate in the prosperity now enjoyed by their more pretentious neighboring cities.

GLASS MANUFACTORIES.

| | |
|---|---|
| Number of window glass manufactories | 10 |
| Capital invested in window glass factories | $487,500 |
| Number of pots in window glass factories | 135 |
| Number of employes in window glass factories | 764 |
| Number of boxes (50 ft.) daily output | 1,765 |
| Number of plate glass manufactories | 2 |
| Capital invested in plate glass works | $1,000,000 |
| Number of employes in plate glass works | 1,000 |
| Number of pots in plate glass works | 80 |
| Daily capacity in square feet | 9,000 |
| Number of fruit jar, bottle and opalescent glass factories | 9 |
| Capital invested in fruit jar, bottle and opalescent glass factories | $271,000 |
| Number of pots in same | 92 |
| Number of employes in same | 719 |
| Number of lamp chimney manufactories | 2 |
| Capital invested in same | $120,000 |
| Number of pots in same | 50 |
| Number of employes in same | 750 |
| Daily capacity, cases | 1,000 |
| Total number of glass factories | 23 |
| Total capital invested in glass factories | $1,878,500 |
| Total number of employes in glass factories | 3,233 |
| Total number of pots in glass factories | 360 |

IRON MANUFACTORIES.

| | |
|---|---|
| Number of wire nail manufactories | 1 |
| Capital invested in same | $500,000 |
| Number of employes | 300 |
| Manufactories of steel rod, steel wire and wire nails | 1 |
| Daily capacity of steel rod mill, tons | 100 |
| Daily capacity of steel wire mill, tons | 75 |
| Daily capacity nail mill, kegs | 1,500 |

| | |
|---|---|
| Number of nail manufactories | 2 |
| Capital invested in same | $350,000 |
| Number of employes in same | 300 |
| Daily capacity of nail mills, kegs | 900 |
| Number of foundries | 3 |
| Capital invested in foundries | $75,000 |
| Number of employes in foundries | 102 |
| Value of annual product | $85,000 |
| Knife and bar works | 1 |
| Capital invested in same | $50,000 |
| Hands employed in same | 50 |
| Value of annual product | $100,000 |
| Bolt works | 1 |
| Capital invested in the bolt works | $250,000 |
| Hands employed in same | 100 |
| Amount of daily product, pounds | 15,000 |
| Rolling mills | 1 |
| Capital invested in rolling mill | $200,000 |
| Number of employes | 100 |
| Estimated value of product annually | $500,000 |
| Knife and shear works | 1 |
| Capital invested | $33,000 |
| Hands employed | 30 |
| Amount of daily product, dozens | 15 |
| Bit works | 1 |
| Capital invested | $40,000 |
| Hands employed | 75 |
| Daily product, bits | 1,000 |
| Novelty hardware works | 1 |
| Capital invested | $26,000 |
| Number of hands employed | 50 |
| Estimated value of annual products | $100,000 |
| Malleable iron works | 1 |
| Capital invested | $210,000 |
| Number of employes | 600 |
| Estimated value of product annually | $1,200,000 |
| Total number of iron manufactories | 13 |
| Total amount invested | $1,524,000 |
| Total number of employes | 1,107 |
| Estimated value of product annually | $4,500,000 |

BELL FOUNDRIES.

| | |
|---|---|
| Number of bell manufactories | 1 |
| Capital invested | $30,000 |
| Number of employes | 40 |
| Value of annual product | $40,000 |

### STRAW BOARD AND PAPER MANUFACTORIES.

| | |
|---|---|
| Total number of factories | 5 |
| Total capital invested | $750,000 |
| Total number of employes | 416 |
| Daily product, tons | 108 |

### WOOD PULP WORKS.

| | |
|---|---|
| Total number of factories | 4 |
| Total capital invested | $390,000 |
| Total number of employes | 283 |
| Daily product, tons | 85 |
| Value of annual product | $325,000 |

### BRICK AND TILE MANUFACTORIES.

| | |
|---|---|
| Total number of factories | 9 |
| Capital invested | $295,000 |
| Number of employes | 245 |
| Annual product, brick (tile not estimated) | 41,750,000 |

### WOOD-WORKING MANUFACTORIES.

These include wagon factories, skewer factories, hoop factories, handle factories, butter-tub factories, planing and saw mills, etc.

| | |
|---|---|
| Total number of factories | 16 |
| Total amount invested | $230,800 |
| Total number of employes | 270 |
| Value of annual product | $832,000 |

### EXCELSIOR MANUFACTORIES.

| | |
|---|---|
| Total number of factories | 6 |
| Total amount invested | $38,500 |
| Total number of employes | 75 |
| Total daily product, tons | 45 |

### FLOURING MILLS.

| | |
|---|---|
| Total number of mills | 5 |
| Total amount invested | $80,000 |
| Total number of employes | 168 |
| Total daily product, barrels | 375 |

### MISCELLANEOUS MANUFACTORIES.

| | |
|---|---|
| Total number of factories | 12 |
| Capital invested | $266,000 |
| Total number of employes | 727 |
| Amount of annual product | $500,000 |

### GRAND TOTAL.

| | |
|---|---|
| Total number of mills and manufactories | 94 |
| Total amount of capital invested | $5,478,800 |
| Total number of employes | 6,564 |

## GAS PLANTS.

One of the duties of my office is to inspect all gas plants and appliances connected therewith that furnish gas for consumption in town and country places that are not provided with local inspectors.

This provision of the law is made for the protection of life and property and to secure the health and safety of the consumers, and the public generally. This I consider to be one of the most important duties of my office.

Natural gas being so destructure in its results, when not properly handled and confined, and the lives and health of so many consumers depending upon the proper appliances used to distribute it, make the discharge of this duty of the utmost importance. I regret to say that the furnishing of gas to consumers in many of the smaller towns within the gas belt is in the hands of men who are utterly ignorant of the product which they handle, and of the machinery which they use.

In many towns the owners of the plants seem to think that it is only necessary to lay their mains, put in a reducing station, and attach consumers. They do not seem to realize that the regulator is the only barrier between the consumers and the 250 or 300 pounds of initial pressure, and that this regulator requires constant care and attention. Imagine the results of letting such an enormous pressure into the stoves of the consumers, and this is liable to occur at any time, if the line has not the proper attention. In so many towns, I have found pipes leaking at almost every joint, and the stations a mass of rusty iron. The wonder with me is that accidents have not been of more frequent occurrence.

I attribute the small number of accidents that have taken place to the fact that the regulators have been in use only a short time It is to be hoped that before the time when the gas machinery now in use becomes old and worn, the owners and managers will acquire sufficient knowledge to enable them to handle this dangerous fuel in a manner that will insure safety to the consumers.

I have found only two plants in which the regulators were in such a bad condition that I was compelled to condemn them. The first was at Arcadia, in Hamilton County, and the other at Van Buren, in Grant County. In both of these places, however, the owners were already preparing to substitute new machinery.

As the mains and machinery of the gas plants become old and worn, their inspection should be rigidly enforced. Too many lives are in danger to permit any carelessness in this matter. The avarice or mistaken economy of the owners and managers of gas plants should not be allowed to endanger the consumers.

In connection with the inspections of gas wells and plants, I have endeavored to collect as much information in regard to this product and its use as was possible. In many places, however, very little information could be obtained. In most cases no accurate records of the wells had been kept, and the wells were closed in such a manner that it was impossible to test their pressure or their volume, with the appliances then at my command. In making my inspections, I have been uniformly treated with courtesy by the owners and managers, and every assistance has been given me in this work.

## BLUFFTON.

The wells that supply this city are situated seventeen miles south, near Camden. The system of reducing stations and regulators, together with the careful oversight given by this company, make it one of the safest plants that I have inspected, and calculated to give satisfactory service.

### PRICES OF GAS.

*Bluffton Light and Fuel Company.*

| | |
|---|---|
| Cook stoves per month, November to May | $2 20 |
| Cook stoves per month, May to November | 1 50 |
| Heaters per month | 3 00 |
| Capital invested | 100,000 |
| Number of wells in use | 6 |
| Number of wells abandoned | 2 |
| Number of stoves supplied | 1,400 |
| Number of boilers, total 300 horse power | 11 |

### TEST OF PRESSURE TAKEN JUNE, 1891.

| | Closed. | Open in 2-Inch Pipe. |
|---|---|---|
| No. 1. | 298 pounds | 3 pounds. |
| No. 3. | 312 pounds | 7½ pounds. |
| No. 5. | 310 pounds | 4 pounds. |
| No. 6. | 295 pounds | 16 pounds. |
| No. 7. | 295 pounds | 12 pounds. |

### TEST OF PRESSURE JUNE 1, 1891.

| | Closed. | Open in 2-Inch Pipe. |
|---|---|---|
| No. 1. | 295 pounds | 3 pounds. |
| No. 3. | 290 pounds | 7¾ pounds. |
| No. 5. | 295 pounds | 8½ pounds. |
| No. 6. | 300 pounds | 18¼ pounds. |
| No. 7. | 302 pounds | 13½ pounds. |
| Number of miles of pipe | | 28½ |
| Size of mains, wrought iron. | | 6 and 8 in. |

### MUNCIE.

*Plant of the Muncie Gas Company.*

| | |
|---|---|
| Paid up capital | $81,925 |
| Number of wells | 20 |
| Number abandoned | 1 |
| Number of fires | 3,000 |
| Price per cook stove | 50 cts. to $1 |
| Price per heater | $1.40 |
| Number of miles of pipe in the city | 33 |
| Number of miles of pipe in the country | 5 |
| Size of pipe | 3 in. to 10 in. |

Besides that supplied for domestic consumption this company supplies a number of manufactories. They use the Dresser and the Armour packer, and put their packers as near to the Trenton rock as practicable.

The system of gasometers and regulators used on the lines of this company can not but render the service of gas to their patrons absolutely safe and satisfactory.

The managers of this company have spared no expense in making their plant one of the best in the State.

### ALEXANDRIA.

The People's Natural Gas Company owns one well, "The Jumbo." They supply one hundred houses and one brick yard. The houses are supplied at $5.00 per year.

### ELWOOD.

The Citizens' Natural Gas and Mining Company owns two wells.

| | |
|---|---|
| Number of stoves supplied | 100 |
| Number of houses supplied | 45 |
| Price of perpetual house rights | $50.00 |
| Miles of pipe line | 10 |
| Paid up capital | $5,000 |

#### PRIVATE WELLS NEAR ELWOOD.

| | |
|---|---|
| Marion Plackard, six miles east | One well. |
| Alva Favors, two miles east | One well. |
| Louis Heffner, three miles north | One well. |

*Elwood Natural Gas and Oil Company.*

| | |
|---|---|
| Number of wells | 4 |
| Depth to Trenton rock | 930 feet. |
| Depth in Trenton rock | 20 to 45 feet. |

The first well drilled by this company stopped when seven feet in Trenton rock with a strong flow of gas. Four years later the packer was taken out and the well drilled thirty feet deeper, the result of which was that the capacity of the well was more than doubled.

| | |
|---|---|
| Number of miles of three inch pipe | 10 |
| Price of cook stove per month | $0.50 |
| Price of heater per month | 1.00 |

## PORTLAND.

*Citizens' Gas, Oil and Mining Company.*

| | |
|---|---|
| Capital invested | $20,000 |
| Number of wells in use | 4 |
| Number of abandoned wells | 1 |
| Depth in Trenton rock | 5 to 20 feet. |
| Number of stoves | 460 |
| Number of boilers, total 100 horse power | 3 |
| Price to cook stove per month | $1.25 |
| Price to heater per month | 1.50 |
| Number of miles of pipe line | 25 |
| Size of pipe, iron | 2-in., 3-in. |

The wells of this company are located eight miles southwest from Portland. The original rock pressure, as reported to me by the manager, was 315 pounds, but that it had been drawn down to 150 pounds. The original volume was from 500,000 feet to 2,000,000 feet, which had decreased from twenty to thirty per cent. I had no means of verifying this statement, but am inclined to believe that it is correct.

## PORTLAND.

*Portland Natural Gas and Oil Company.*

| | |
|---|---|
| Capital invested | $70,000 00 |
| Number of wells at Portland | 5 |
| Number of wells at Camden | 5 |
| Number of stoves | 1,000 |
| Number of boilers, total 125 horse power | 4 |
| Price to cook stoves per month | $1 25 |
| Price to heaters per month | $1 50 |
| Capacity of wells at Camden, feet | 2,500,000 |

These wells when closed in showed 310 to 315 pounds pressure, and a line pressure of 250 pounds.

The lowest pressure in the Camden field last winter was 286 pounds.

The wells at Portland are almost worthless, owing to their being filled up with salt water.

## CAMDEN.

*Pennville Natural Gas and Oil Company.*

| | |
|---|---|
| Capital invested | $4,725 00 |
| Number of wells | 1 |

*Section of Well.*

| | |
|---|---|
| Drift, sand and gravel | 40 feet. |
| Niagara limestone | 145 feet. |
| Hudson River limestone and Utica shales | 747 feet. |
| Trenton limestone | 34 feet. |
| Capacity of well, cubic feet | 1,500,000 |
| Number of stoves | 400 |
| Prices for two stoves per year | $15 00 |
| Number of miles of pipe line | 10 |
| Size of pipe, iron | 1½ to 4 in. |

Well drilled in August, 1887.

Besides supplying gas for domestic use, this well furnishes gas for power and heating purposes to one woolen mill with a fifteen horse power boiler, and one grist mill with a sixty horse power boiler. This well has been dry from the first until last winter, when, under a heavy draft, it showed considerable salt water and some oil. But when the draft was relieved, and the pressure allowed to run up, it became dry again.

I had no means for closing the well in, but took the pressure with the line open. Result, 285 pounds.

## CONNERSVILLE.

*Connersville Natural Gas Company.*

| | |
|---|---|
| Capital invested | $200,000 00 |
| Number of wells | 3 |
| Length of main line, miles | 26 |
| Size of pipe, steel, inches | 6 |
| Length of mains in city, miles | 12 |
| Number of stoves | 1,600 |

Besides that supplied for domestic use, this company furnishes for heating purposes to three furniture manufactories, two carriage manufactories, one foundry, one laundry, one machine shop and one flour mill.

The wells are located near Carthage, in Rush County.

Connersville has six wells in the town and vicinity, four of which are in use at present, and are owned by private parties. These wells furnish only a small amount of gas.

*Prices.*

| | |
|---|---|
| Cook stove per month, November to April | $2.00 |
| Cook stove per month, April to November | 1.25 |
| Heaters, per month | 3.00 |

## MILLROY.

*Smith & Dorste, Owners of Plant.*

| | |
|---|---|
| Capital invested | $5,000 |
| Number of wells | 4 |
| Number of stoves | 64 |
| Price to cook stoves, per month | $1.50 |
| Price to heaters, per month | 1.50 |

*Record of Well.*

| | |
|---|---|
| Drift | 30 feet. |
| Niagara limestone | 80 feet. |
| Hudson River and Utica shale | 765 feet. |
| Total depth to Trenton rock | 875 feet. |

These wells are located in townships 12 and 13 north and range 9 east.

Besides these wells there are two others owned by private individuals that supply about twenty-five stoves.

The wells in this locality showed at first 310 pounds pressure after being closed for twenty-four hours. I had no means of testing the pressure, but am confident, from the report of the owners, that there has been a decrease in the pressure.

## ORESTES, MADISON COUNTY.

*J. M. Powell, Proprietor.*

| | |
|---|---|
| Capital invested | $3,000 |
| Number of wells | 1 |
| Number of stoves supplied | 45 |

This well also supplies two boilers, one of 8-horse power and one of 125-horse power.

The owner claimed that this well showed 330 feet pressure when first drilled.

In connection with this well there are two miles of pipe line.

The prices are $1 for stoves and $125 for perpetual right.

## REDKEY.

*North Mercer Natural Gas Company.*

| | |
|---|---|
| Capital invested | $15,000 |
| Number of wells | 2 |
| Depth of Trenton rock | 979 feet. |
| Depth in Trenton rock, No. 1 | 41 feet. |
| Depth in Trenton rock, No. 2 | 31 feet. |

Small amount of salt water in well No. 1. This well was shot. Well No. 2 was not shot, and, although ten feet deeper in the rock, has remained perfectly dry.

| | |
|---|---|
| Number of miles of pipe line, 2-inch | 9 |
| Number of stoves supplied | 500 |

Also, six boilers, aggregating 145-horse power.

*Prices.*

| | |
|---|---|
| Two stoves, per year | $14.25 |

Reported 340 pounds pressure when first drilled.

When I tested the wells in June, 1891, the pressure was 315 pounds.

## MONTPELIER, BLACKFORD COUNTY.

*Montpelier Gas, Oil and Mining Company.*

| | |
|---|---|
| Capital invested | $8,000 |
| Number of miles of piping | 2½ |
| Size of pipe | 2 inches. |
| Number of stoves | 350 |
| Price for two stoves, per year | $15.00 |
| Number of wells | 3 |
| Depth to Trenton rock | 980 feet. |
| Depth in Trenton rock | 20 feet. |
| Depth of Drift | 30 feet. |

These wells show so much oil that a separator is used at each well.

## ALBANY, DELAWARE COUNTY.

*Albany Petroleum and Natural Gas Company.*

| | |
|---|---|
| Capital invested | $5,000 |
| Number of miles of piping | 12 |
| Size of pipe | 3 inches. |
| Number of wells | 1 |
| Line pressure | 260 lbs. |
| Number of stoves | 300 |
| Price per house | $12.00 |
| Depth to Trenton rock | 930 feet. |
| Depth in Trenton rock | 14 feet. |
| Depth of Drift | 12 feet. |

Plant in fair condition.

*Citizens' Natural Gas Company.*

| | |
|---|---|
| Capital invested | $2,300 |
| Number of wells | 1 |
| Number of miles of piping | 5 |
| Size of pipe | 1 and 2 inches. |
| Depth to Trenton rock | 936 feet. |
| Depth in Trenton rock | 76 feet. |

When at a depth of fifty feet in Trenton rock very little gas was shown.

The stock is divided into shares of fifty dollars each. Each shareholder gets free gas. To outside consumers twelve dollars per house is charged.

Home regulators are used.

This well was tested September 10th, 1889, as the record shows, by George M. Smiley.

| | |
|---|---|
| Rock pressure, pounds | 338 |
| Open flow in 2-inch tubing, pounds | 23 |
| Cubic feet in twenty-four hours | 3,275,500 |

When closed the pressure raised to 338 pounds in three minutes.

## DUNKIRK, JAY COUNTY.

### *Dunkirk Gas Company.*

| | |
|---|---|
| Capital invested | $15,000 |
| Number of wells | 2 |
| Number of stoves | 600 |
| Line pressure, pounds | 293 |
| Price per two stoves per year | $15 |
| Price per three or more stoves per year | $18 |

This company also furnishes gas to three factories, one flouring mill, one brick kiln, one tile factory, one excelsior factory and one hoop factory.

## HARTFORD CITY.

### *Hartford City Natural Gas and Oil Company.*

| | |
|---|---|
| Capital invested | $25,000 |
| Number of wells | 3 |
| Number of stoves | 1,200 |
| Price per month, cook stove | 75c |
| Price per month, heater | $1 |
| Number of miles of pipe line | 15 |
| Size of pipe, inches | 1½ to 4 |
| Depth to Trenton limestone No. 1, feet | 952 |
| Depth in Trenton, feet | 32 |

Plant in fair condition.

Well No. 2 was drilled in 1888.

These wells have been in constant use since they were drilled. On July 9, 1891, well No. 1 showed 300 pounds live pressure. When closed in it showed 315 pounds in two minutes. Well No. 2 showed 250 pounds line pressure. These wells are not connected, but supply different parts of the plant.

On account of not being able to disconnect the wells, the open flow could not be taken.

However, Mr. R. M. Carter, the president of the company, to whom I am indebted for valuable information, told me that there was no perceptible diminution in the volume of gas produced.

## EATON, DELAWARE COUNTY.

*Eaton Mining and Gas Company.*

| | |
|---|---|
| Capital invested | $10,000 |
| Number of wells | 2 |
| Number of stoves | 325 |
| Depth to Trenton limestone, feet | 920 |
| Depth in Trenton, feet | 30 |
| Original capacity of well No. 1, cubic feet | 2,500,000 |
| Original capacity of well No. 2, cubic feet | 3,000,000 |
| Number of miles of pipe line | 5 |
| Size of pipe, inches | 2 |

Besides that supplied for domestic use this company furnishes gas to one flouring mill, one excelsior factory, one hoop factory, and one handle factory.

Well No. 1 is the pioneer gas well of Indiana. It was first drilled in 1875 or 1876 by George W. Carter and W. W. Worthington to a depth of six hundred feet. Their object was to prospect for coal and other minerals. Some shale gas was found, but the enterprise was abandoned. In 1886 this old well was reopened and drilled to its present depth, at which a strong flow of gas was obtained.

Mr. A. H. Crannell was the contractor, and he enjoys the distinction of having drilled the first gas-well in Indiana.

## VAN BUREN, GRANT COUNTY.

*Arcana Gas Company.*

| | |
|---|---|
| Number of wells | 1 |
| Number of miles of pipe line | 20 |
| Size of pipe | 1 to 2 inches. |
| Number of stoves supplied in town | 100 |
| Price for two stoves and two jets for one year | $15.00 |

This well also supplies a number of farm houses.

This well is located five and one-half miles south of town.

Some oil is shown.

I found this plant in bad condition. The line was leaking at nearly every joint, and the regulator was broken and worthless. However, the company had procured and was preparing to put in a new regulator.

## GREENTOWN, HOWARD COUNTY.

*Greentown Natural Gas, Oil and Mining Company.*

| | |
|---|---|
| Capital invested | $11,000.00 |
| Number of wells | 2 |
| Number of miles of pipe line | 8 |
| Size of pipe | 1 to 4 inches. |

| | |
|---|---|
| Number of stoves supplied | 450 |
| Price for two stoves per year | $16.00 |
| Depth in Trenton limestone | 30 feet. |

The managers claim that these wells originally showed 330 pounds initial pressure.

In addition to furnishing gas for domestic use, this company furnishes fuel to one flouring mill, one elevator, one heading factory, one stave factory, one brick kiln and two saw mills.

## SHARPSVILLE, TIPTON COUNTY.

*Sharpsville Gas and Oil Company.*

| | |
|---|---|
| Capital invested | $6,000.00 |
| Number of wells | 1 |
| Number of miles of pipe line | 2½ |
| Size of pipe | 1 to 4 inches. |
| Number of stoves supplied | 200 |
| Price for two stoves per month | $1.25 |
| Depth of Trenton limestone | 975 feet. |
| Depth in Trenton | 8 feet. |

October 11, 1891, this well showed a line pressure of 260 lbs.

This well, in addition to the domestic consumption, supplies one flouring mill and one canning factory.

## CICERO, HAMILTON COUNTY.

*Cicero Gas and Oil Company.*

| | |
|---|---|
| Number of wells in use | 1 |
| Number of stoves supplied | 270 |
| Price per month, cook stoves | $0.75 |
| Price per month, heaters | 1.00 |
| Number of miles of pipe line | 6 |
| Size of pipe | 2 and 3 inches. |
| Depth to Trenton limestone | 976 feet. |
| Depth in Trenton | 18 feet. |
| Lime pressure | 250 lbs. |

The plant is in good condition.

This company made two failures. The first well flowed oil and salt water in such quantities as to render it worthless. The second well showed a very small flow of gas. This company has obtained a very large flow of gas in a fourth well, since I inspected their plant.

## RICHMOND.

### *Richmond Natural Gas Company.*

| | |
|---|---|
| Capital invested | $635,000.00 |
| Number of wells | 21 |
| Length of pipe line | 46 miles. |
| Length of mains | 30 miles. |
| Size of pipe | 3 to 8 inches. |
| Number of stoves supplied | 5,500 |
| Price per month, cook stoves, November to April | $3.33 |
| Price per month, cook stoves, April to November | 1.39 |
| Price per month, heaters | 4.16 |
| To manufactories, by meter, per 1,000 cubic feet | .10 |
| To domestic consumers, by meter, per 1,000 cubic feet | .15 |

The wells of this company are located at Chesterfield, in Madison County.

## LAPEL, MADISON COUNTY.

### *Lapel Natural Gas and Oil Company.*

| | |
|---|---|
| Capital invested | $10,000 |
| Number of wells | 1 |
| Depth to Trenton limestone | 888 feet. |
| Depth in Trenton | 24 feet. |
| Number of stoves supplied | 240 |
| Price per month, cook stoves | $0.60 |
| Price per month, heater | .80 |
| Length of pipe line | 6½ miles. |
| Size of pipe | 1 to 3-in. |

In addition to the domestic consumption, this well supplies three boilers aggregating 200 horse-power.

August 7, 1891, this well showed a line pressure of 262½ pounds.

## HARTFORD CITY.

### *Peoples Gas Company.*

| | |
|---|---|
| Capital invested | $6,500 |
| Number of wells | 2 |
| Length of pipe line | 4 miles. |
| Size of pipe | 2 to 3-in. |

One hundred and thirty franchises are supplied at $50.00 each.

### NEWCASTLE.

*Enterprise Natural Gas Company.*

| | |
|---|---|
| Capital invested | $50,000 |
| Number of wells | 5 |
| Length of pipe line | 21 miles. |
| Size of pipe | 4 to 6-in. |
| Number of stoves supplied | 1,300 |
| Prices, cook stoves, per month | $1.25 |
| Prices, heaters, per month | 1.40 |

This company obtains the greater part of its gas from five wells, eleven miles northwest. A number of wells were drilled at and near the town with poor results. Well No. 5, near the fair ground, was the best. This well measured 927 feet to Trenton limestone, and 68 feet in the rock.

### ALEXANDRIA, MADISON COUNTY.

*Alexandria Mining and Exploring Company.*

| | |
|---|---|
| Capital invested | $6,000 |
| Number of wells | 2 |
| Drift | 28 feet. |
| Original initial pressure | 325 lbs. |
| Number of stoves supplied | 600 |
| Price to cook stoves per month | $0.50 |
| Price to heaters per month | .75 |
| Length of pipe line | 5½ miles. |
| Size of pipe | 1 to 3 inches. |
| Trenton below sea level | 40 feet. |

In addition to that supplied for domestic consumption, this company furnishes gas to one stone quarry, one flouring mill, one window glass factory of ten pots capacity, and one boiler and pump station.

### FORTVILLE, HANCOCK COUNTY.

*Fortville Natural Gas and Oil Company.*

| | |
|---|---|
| Capital invested | $5,000 |
| Number of wells in Hancock County | 2 |
| Number of wells in Hamilton County | 1 |
| Length of pipe line | 3 miles. |
| Size of pipe | 2 to 4 inches. |
| Number of stoves supplied | 200 |
| Price of two stoves per year | $10.00 |
| Line pressure | 260 lbs. |
| Depth to Trenton limestone | 974 feet. |
| Depth in Trenton, Well No. 1 | 17 feet. |
| Drift | 212 feet. |

One tile kiln and three boilers are supplied by this company. The plant is in good condition.

The wells were drilled in the latter part of the year 1887.

### FORTVILLE, MADISON COUNTY.

*J. S. Merrill, Proprietor.*

| | |
|---|---|
| Number of wells in Hancock County | 1 |
| Number of wells in Madison County | 1 |
| Length of pipe line | 6 miles. |
| Size of pipe | 1½ inches. |
| Number of stoves supplied | 100 |
| Line pressure | 275 lbs. |
| Depth to Trenton rock | 950 feet. |
| Depth in Trenton rock | 33 feet. |

The wells were drilled in February, 1889.

### PENDLETON, MADISON COUNTY.

*Pendleton Natural Gas Company.*

| | |
|---|---|
| Capital invested | $6,000 |
| Number of wells | 4 |
| Number of stoves supplied | 900 |
| Prices per month to cook stoves | 70 cents. |
| Prices per month to heaters | 95 cents. |
| Depth to Trenton limestone | 835 to 876 feet. |
| Depth in Trenton. | 25 feet. |
| Initial pressure, August 6, 1891 | 298 pounds. |
| Length of mains | 40,000 feet. |
| Size of mains | 1½ to 6 inches. |

This company, in addition to that supplied for domestic use, furnishes fuel to one glass factory, one paint mill, one tile factory, the Pendleton Manufacturing Company, and one flouring mill. The plant proved to be one of the best constructed in the State. The system of mains and regulators is such as to give perfect control over the gas.

### ARCADIA, HAMILTON COUNTY.

*Arcadia Natural Gas, Oil and Mining Company.*

| | |
|---|---|
| Capital invested | $8,500 |
| Number of wells | 2 |
| Length of mains | 5 miles. |
| Size of mains | 1 to 4 inches. |
| Number of stoves supplied | 300 |
| Prices per month to cook stoves | $0 75 |
| Prices per month to heaters | 1 00 |
| Depth to Trenton limestone | 960 feet. |
| Depth in Trenton | 12 feet. |
| Line pressure | 200 pounds. |

The wells were drilled in 1887.

The plant was inspected August 8, 1891.

This company also supplies one boiler, 60-horse power, one brick kiln, one tile kiln and one elevator.

On inspection I found this plant in bad condition. The regulator did not control the pressure. I condemned it and ordered the company to place a new one on the line.

### ARLINGTON, RUSH COUNTY.

*Arlington Natural Gas Company.*

| | |
|---|---|
| Capital invested | $5,000 |
| Number of wells | 3 |
| Length of mains | 2 miles. |
| Size of mains | 2 to 4 inches. |
| Depth to Trenton limestone | 860 feet. |
| Depth in Trenton | 16 feet. |
| Depth in Trenton in well No. 1 | 24 feet. |
| Number of stoves supplied | 115 |
| Price to cook stoves, per month | $1.10 |
| Price to heaters, per month | 1.40 |

Well No. 1 has shown salt water from the first.

### GREENFIELD, HANCOCK COUNTY.

*Greenfield Gas Company.*

| | |
|---|---|
| Capital invested | $50,000 |
| Number of wells | 5 |
| Length of mains | 15 miles. |
| Size of mains | 2 to 6 in. |
| Price per stove per month | $0 50 |
| Number of stoves | 1,200 |

*Peoples' Gas Company.*

| | |
|---|---|
| Capital invested | $10,000 |
| Number of wells | 3 |
| Price of perpetual franchise | $100 |
| Depth to Trenton limestone | 975 feet. |
| Depth in Trenton | 20 feet. |
| Length of mains | 5½ miles. |
| Size of mains | 2 to 4 in. |
| Number of franchises | 225 |

### MAXWELL, HANCOCK COUNTY.

*Maxwell Natural Gas Company.*

| | |
|---|---|
| Capital invested | $3,500 |
| Number of wells | 1 |
| Length of mains | 3 miles. |
| Number of stoves | 200 |

| | |
|---|---|
| Price per month to cook stoves | $0.75 |
| Price per month to heaters | 1.00 |
| Depth to Trenton limestone | 1,002 feet. |
| Depth in Trenton | 13 feet. |
| Initial pressure when first drilled | 325 pounds |

The plant is in good condition.

This well was estimated at 4,500,000 cubic feet in twenty-four hours when first drilled, and has not as yet shown any signs of failure.

### MANILLA, RUSH COUNTY.

*Manilla Natural Gas Company.*

| | |
|---|---|
| Capital invested | $7,000 |
| Number of wells (only one in use) | 2 |
| Number of stoves supplied | 89 |
| Price per month to cook stoves | $1.25 |
| Price per month to heaters | $1.50 |
| Depth to Trenton limestone | 865 feet. |

### CARTHAGE, RUSH COUNTY.

*Carthage Natural Gas Company.*

| | |
|---|---|
| Capital invested | $9,100 |
| Number of wells | 4 |
| Depth to Trenton limestone | 800 feet. |
| Depth in Trenton | 20 to 30 feet. |
| Length of mains, miles | 5 |
| Size of pipe | 2 to 4 inches. |
| Price per month to cook stoves | $0.75 |
| Price per month to heaters | $1.00 |

Initial pressure when first drilled, 300 to 315 pounds.

These wells would reach their pressure in three minutes.

Two "dry holes" were drilled in this vicinity within one mile of good wells.

### CHARLOTTSVILLE, HANCOCK COUNTY.

*Charlottsville Natural Gas Company.*

| | |
|---|---|
| Capital invested | $5,500 |
| Number of wells | 1 |
| Number of stoves supplied | 300 |
| Price per month to cook stoves | $0.75 |
| Price per month to heaters | $1.00 |
| Line pressure October 24, 1891 | 265 pounds. |
| Length of mains | 4½ miles. |
| Size of pipe | 2 to 6 inches. |
| Volume, cubic feet | 2,500,000 |

Plant is in good condition.

## RUSHVILLE.

*Peoples Natural Gas Company.*

| | |
|---|---|
| Capital invested | $3,500 |
| Number of wells | 5 |
| Length of pipe line and mains | 18½ miles. |
| Size of pipe | 4 to 6 inches. |
| Number of stoves supplied | 675 |
| Price per month to cook stoves | $1.00 |
| Price per month to heaters | 1.50 |

Wells situated in the north part of the county, near Carthage.

## RUSHVILLE.

*Rushville Natural Gas Company.*

| | |
|---|---|
| Capital stock | $100,000 00 |
| Number of wells | 6 |
| Length of mains, miles | 22 |
| Size of pipe, steel | 2 to 8 inches. |
| Number of stoves supplied | 1,200 |
| Price per year to cook stoves | $18 00 |
| Price per year to heaters | $20 00 |

Wells situated near Carthage, ten miles distant.
Plant in excellent condition.

## WALDRON, SHELBY COUNTY.

*Waldron Gas, Oil and Water Company.*

| | |
|---|---|
| Capital invested | $7,500 00 |
| Number of wells | 3 |
| Number of stoves supplied | 100 |
| Price per month to cook stoves | $1 25 |
| Price per month to heaters | $1 50 |
| Depth to Trenton limestone | 830 feet. |
| Depth in Trenton | 30 feet. |
| Initial pressure | 275 pounds. |

No salt water and no sign of failure.
This plant is in excellent condition.

# A CATALOGUE OF THE BUTTERFLIES KNOWN TO OCCUR IN INDIANA.

BY W. S. BLATCHLEY, TERRE HAUTE, IND.

So far as can be ascertained no attempt has heretofore been made to catalogue the Diurnal Lepidoptera, or Butterflies, found in Indiana. Quite a number of persons have collected in various counties of the State, yet, as far as known, but two local lists have been published. One, "A List of the Butterflies of Decatur County, Indiana," by W. P. Shannon, was read by title before the Academy of Science, at Indianapolis, in December, 1887, and hectograph copies were afterward distributed by the author. The list contained the names of forty species, taken in the county mentioned. The other list was prepared by the present writer, and published in the *Hoosier Naturalist*, of November and December, 1886, under the title of "Some Southern Indiana Butterflies." It contained the names of, and brief notes concerning, fifty-three species taken in Monroe and Brown counties. Since 1886 the writer has collected more or less each season in various parts of the State, especially in Putnam, Wabash and Vigo counties, where a number of interesting and rare species have been taken. During my study of butterflies I have often felt the need of a catalogue of those species known to occur in the State, and believing that such a work would be of some value to future collectors, the present paper has been prepared. It comprises 108 species that have been taken within the boundaries of the State—no species being included except upon good authority. Of these, 81 are in the writer's collection, and were taken in the counties above mentioned, or in Lagrange, Kosciusko or Montgomery counties.

The remaining 27 species are in the collections of W. H. Edwards, of Coalburg, West Virginia; S. G. Evans, of Evansville, Indiana; C. E. Worthington, of Chicago, Illinois; or Geo. C. Hubbard, of Madison, Indiana. Mr. Edwards, who is one of the leading authorities upon butterflies in the United States, has received specimens from several persons in the State, chief among whom are the late Dr. G. M. Levette, of Indianapolis, and W. C. Gallager, of Ross, and he kindly furnished me a list of those in his collection from Indiana.

Mr. Evans has one of the finest private collections in the State, and has taken several species in Vanderburgh County, which have not been taken elsewhere within our limits, among them the large and beautiful *Argynnis diana*. Mr. Worthington has collected extensively in Lake County, where many rare species occur, and his list and notes have added materially to the value of the catalogue. To the above named gentlemen, as well as to a number of others from whom information was derived, which is duly acknowledged in the proper places, my especial thanks are due.

It will be seen that the counties mentioned, in addition to those of Gibson, Randolph and Fayette, from which lists have been received, represent fairly well all portions of the State; yet twenty-three additional species are given in Mr. Edward's Catalogue of the Butterflies of North America, whose range includes or approaches Indiana, but which, as far as known, have not been taken within our limits, and, therefore, are not included in the present catalogue. Moreover, the known distribution within the State of a number of the species taken is much more limited than it should be; hence additions to the catalogue, as well as information with regard to extension of range within the State, are earnestly requested and will be duly acknowledged.

To make the catalogue as valuable as possible to future collectors, not only has the known range of each species within the State been given, but also its favorite place of resort and the season at which it is most abundant, together with any other information regarding variation or habits which it was thought would be of interest. Prof. G. H. French in his manual of "The Butterflies of the Eastern United States," has treated of the habits of the larvæ of most of the species, but has said but little about the habits of the mature insects. To the student of Indiana butterflies this catalogue will perhaps serve as an accessory to French's work, and hence little or nothing is said of the larvæ.

The nomenclature adopted is that of Edward's "Revised Catalogue of the Diurnal Lepidoptera of America North of Mexico," published in the Transactions of the American Entomological Society for 1884. The number in parenthesis before each name is that of the species in the catalogue cited.

Finally, I have thought it best to include the synonymy of each of the species which is treated of in the works which the student of Indiana butterflies will be most likely to possess and to which I have had access in preparing the eatalogue. Those works are the following:

Edwards, W. H.—"Butterflies of North America." Volumes I and II.

French, G. H.—"Lepidoptera, or Butterflies and Moths," in the Seventh Report of the State Entomologist of Illinois, 1878. The Butterflies of the Eastern United States, 1886.

Harris, Dr. T. W.—A Treatise on some of the Insects Injurious to Vegetation. Third Edition, 1862. (Of the 54 species of butterflies described in this most excellent work, 51 have been found in Indiana.)

Mead, T. L.—"Report upon the Collection of Diurnal Lepidoptera," in the Report of the Wheeler Survey, V. 1875.

Morris, J. G.—Synopsis of the Described Lepidoptera of North America, 1862.

Packard, A. S.—Guide to the Study of Insects, Eighth Edition, 1883.

Riley, C. V.—Report of the Entomologist, in the United States Agricultural Report for 1883.

Scudder, Samuel H.—The Butterflies of the Eastern United States and Canada. Volumes I, II and III. 1889. (Volume III contains the plates.)

Thomas, Cyrus H.—"Cabbage Insects;" in the Ninth Report of the State Entomologist of Illinois, 1880.

Wood, J. G.—"Insects at Home," 1873.

Blatchley, W. S.—"Some Indiana Butterflies," in *Indiana Farmer*, Vols. 21 and 22.

"Some Southern Indiana Butterflies," in *Hoosier Naturalist*, November and December, 1886.

*    *    *                    *    *    *

---

# PAPILIONIDÆ.

## PAPILIONÆ.

### PAPILIO, Linnæus.

1. (1.) PAPILIO AJAX, L. Ajax Butterfly. The Zebra Swallow-tail.

*Papilio ajax*, Morris, Lep. N. A., 1862, 8, 351. (Form *walshii*, Edw.)
Edwards, But. N. A., I, 1871, pls. 1, 2, 3. (All forms.)
French, Sev. Rep. St. Ent. Ill., 1878, 135.
Id., But. E. U. S., 1886, 84. (All forms.)
Blatchley, Indiana Farmer, Oct. 9, 1886.

*Iphiclides ajax*, Scudder, But. E. U. S. and Can., 1889, II, 1264; III, pls. 15, 26, 66, 76, 85.

*Papilio marcellus*, Morris, Lep. N. A., 1862, 9. (Form *marcellus*, Bd.)

The three forms, *walshii*, Edw ; *telamonides*, Feld., and *marcellus*, Bd., are doubtless found throughout the State. All have been taken by the writer in Monroe and Vigo counties. Of the three, *marcellus* is much the more common, *walshii* being comparatively scarce, though Edwards, loc. cit. p. 9, says "that Dr. G. M. Levette has taken it abundantly in the month of April near Indianapolis." The food plant is pawpaw. The butterfly frequents open woods and winters in chrysalid.

2. (2.) PAPILIO PHILENOR, L. The Philenor Butterfly. The Blue Swallow-tail.

*Papilio philenor*, Morris, Lep. N. A., 1862, 6.
French, Seventh Rept. State Ento. of Ill., 1878, 136.
Id., But., E. U. S,, 1886, 86, figs. 11, 12, 13.
Packard, Guide to Study of Insects, 8th ed., 1883, 248.
Blatchley, Ind. Farm., Oct. 9, 1886.
*Lœrtias philenor*, Scudder, But. E. U. S. and Can , 1889, II, 1241; III, pls. 16, 26, 66, 76, 85.

Throughout the State. The larvæ are said to feed upon the different species of *Aristolochia*, or pipe vine, but the plants of that genus are rare in Indiana, whereas the butterfly is a common one, hence there must be some other food plant. Found from May 1, to September 20, in open woods and pastures. According to Riley, another food plant of the larvæ is *Asarum canadense*, or wild ginger, a common plant on rich hill-sides in Indiana.

3. (12.) PAPILIO ASTERIAS, Fab. The Asterias Butterfly. The Black Swallow-tail.

*Papilio asterias*, Morris, Lep. N. A., 1862, 5.
Harris, Insects Injur. to Veg., 3d Ed., 1862, 265, Pl. IV.
French, Seventh Rept. State Ento. of Ill., 1878, 137.
Id., But. E. U. S., 1886, 89. Figs. 14, 15, 16.
Packard, Guide. 8th Ed., 1883, 245.
Blatchley, Ind. Farm., Oct. 9, 1886.
*Papilio polyxenes*, Scudder, But. E. U. S. and Can., 1889, II, 1353; III, pls. 8, 27, 66, 76, 85.

This handsome Papilio inhabits all parts of the State, but next to *P. cresphontes* is the least common member of the genus found with us. Its larva is the well-known carrot or parsnip worm found on the various wild and cultivated species of *Umbelliferæ*.

The butterfly is most common in July and August, in open woods, especially those containing thistles. It winters in the chrysalid, the first ones appearing about May 15.

4. (13.) PAPILIO TROILUS, L. The Troilus Butterfly. The Green Clouded Swallow-tail.

*Papilio troilus*, Harris, Ins. Inj. to Veg., 1862, 3d Ed., 266.
Morris, Lep. N. A., 1862, 5
French, Sev. Rep. State Ento. of Ill., 1878, 138.
Id., But. E. U. S., 1886, 93.
Packard, Guide, 8th Ed., 1883, 247.
Blatchley, Ind. Farmer, Oct. 9, 1886.
*Euphœades troilus*, Scudder, But. E. U. S. and Can., 1889, II, 1313; III, pls. 8, 27, 66, 76, 85.

The larvæ of this species feed upon the leaves of the sassafras, *Sassafras officinale*, Nees, and the spice bush, *Lindera Benzoin*, Bl,, and the butterfly is common wherever those plants are found. There are two broods each season, and the winter is passed in the chrysalis state.

It frequents roadsides and open pastures in company with *P. philenor*, and may be taken from May 1 to Oct. 10.

Specimens are frequently taken which expand four inches, and many have the inner row of spots on upper surface of hind wings obsolete. The orange anal spot of this row is, however, always present.

5. (15.) PAPILIO TURNUS, L. The Turnus Butterfly. The Tiger Swallow-tail.

*Papilio turnus*, Harris, Ins. Inj., 1862, 268, figs. 97, 98.
Morris, Lep. N. A., 1862, 2.
French, Sev. Rep. State Ento. Ill., 1878, 139.
Id., But. E. U. S., 1886, 97, figs. 17, 18, 19.
Edwards, But. N. A., II. 1884, 7, pls. 3, 4, 5. (All forms.)
Packard, Guide, 8th Ed., 1883, 247.
Blatchley, Ind. Farmer, Oct. 9, 1886.
*Jasoniades glaucus*, Scudder, But. E. U. S. and Can., 1889, II, 1288; III, pls. 8, 13, 26, 66, 76, 85.
*Papilio glaucus*, Morris, Lep. N. A., 1862, 2.
(Dimor. form *glaucus*, L.)

Frequent in all parts of the State from May 15 till October. In May and June it is often seen in the vicinity of streams and along the borders of thickets; later on it is more abundant about thistle patches in open woods. The larvæ feed upon a number of plants, chief among which are: ash, tulip or poplar, cherry, apple, and the various species of *Cratægus* or hawthorne. The dimorphic female form, *glaucus*, L., is southern in its range, but has been taken in the State as far north as Kosciusko County. It is usually rare where found, no more than one or two specimens having been seen or taken in any one locality, except in the vicinity of Evansville, Vanderburgh County. Of its distribution there Mr. Evans says: "It is quite common, and presents many curious examples of black and yellow blended and mixed in the same insect. I took one in which the left wing and half body were yellow, and the right, black. I saw another last season that seemed to be equally black and yellow, the two colors being almost evenly distributed over the whole insect. There are about half as many *glaucus* as *turnus* in the county." In Indiana *turnus* is double brooded and winters in the chrysalis.

6. (20.) PAPILIO CRESPHONTES, Cram. The Cresphontes Butterfly. The Giant Swallow-tail.

*Papilio cresphontes*, French, Sev. Rep. St. Ent. Ill., 1878, 139.
Id., But. E. U. S., 1886, 101, figs. 20, 21, 22.
*Heraclides cresphontes*, Scudder, But. E. U. S. and Can., 1889, II, 1334; III, pls. 14, 27, 66, 76, 85.
*Papilio thoas*, Morris, Lep. N. A., 1862, 7.

This is our largest and rarest Papilio. Its range, as given by Edwards, is "Southern and Western States, but moving east and north" It is reported as rare by most of the persons who have sent in lists. During the six years which the writer has collected in the State he has seen but two living specimens, one in Montgomery, the other in Wabash County. The food plants of the larvæ, *Ptelea trifoliata*, L., and *Xanthoxylum Americanum*, Mill (Hop tree and Prickly Ash), are not rare in Monroe and Vigo Counties, yet the butterfly has not been seen in either, although a constant outlook has been kept for it. Where found it is usually near streams, and flies swiftly and high in air, thus rendering its capture difficult.

## PIERINÆ.

### PIERIS, Schrank

7. (35.) PIERIS PROTODICE, Bd.-Lec. The Southern Cabbage Butterfly. The Chequered White.

*Pieris protodice*, Morris, Lep. N. A., 1862, 17, 317.
Packard, Ninth Rep. U. S. Geol. and Geog. Survey, 1877, 750.
Id., Guide, 8th Ed., 1883, 249.
French, Sev. Rep. St. Ent. Ill., 1878, 141, figs. 32, 33.
Id., But. E. U. S., 1886, 107, figs. 23, 24, 25.
Thomas, Ninth Rep. St. Ent. Ill., 1880, 25, 33.
Riley, U. S. Agr. Rep., 1883, 114, pl. X, figs. 2, 3, 4.

Blatchley, Ind. Farmer, Oct. 9, 1886.
Id., Hoos. Nat. II, Nov., 1886, 42.
*Pontia protodice*, Scudder, But. E. U. S. and Can., 1889, II, 1163; III, pls. 7, 16, 26, 65, 76, 84.

The two forms of this species, *protodice*, Bd.-Lec. and *vernalis*, Edw., are found all over the State, but they are much less common than *P. rapæ*, L. It has almost the same habits as the latter, but is more often found at a distance from cultivated grounds. It winters in the pupa state, first appearing as imago about April 15, and may be taken as late as November 1. Food, plants, cabbage, turnip and sweet alyssum. There are three broods each season, and in Vigo County, in the spring of 1891, large numbers of the first brood were seen mating on April 18.

8. (36.) Pieris napi oleracea-aestiva, Harris. The Turnip Butterfly. The Gray Veined White.

*Pontia oleracea*, Harris, Ins. Inj., 1862, 270, fig. 99.
*Pieris oleracea*, Harris, Morris, Lep. N. A., 1862, 19.
Scudder, Morris, loc. cit., 315.
French, Sev. Rep. State Ento. Ill., 1878, 143.
Thomas, Ninth Rept. State Ento. Ill., 1880, 26.
Packard, Guide, 8th Ed., 1883, 249, fig. 182.
Riley, U. S. Agr. Rept., 1883, 115, pl. X, fig. 5.
Scudder, But. E. U. S. and Can., 1889, II, 1191; III, pls. 7, 13, 26, 65, 76, 84.
*Pieris napi oleracea-aestiva*, French, But. E. U. S., 112.

This species of many names is represented sparingly in the northern part of the State by the above named variety, the range of which is given by Edwards as New York to Michigan.

Specimens in the writer's collection were taken by Mr. A. B. Ulrey in Kosciusko County, in the summer of 1890. Food plants—cabbage, turnip, radish, etc.

9. (38.) Pieris rapæ, L. The Cabbage Butterfly.

*Pieris rapæ*, Packard, Ninth. Rept. U. S. Geol. and Geog. Survey of the Terr., 1877, 746, fig. 18.
French, Sev. Rept. State Ento. Ill., 1878, 144.
Id., But. E. U. S., 1886, 114, figs. 28, 29, 30.
Thomas, Ninth Rept. State Ento. Ill,, 1880, 8, 31, figs. 1, 2.
Riley, U. S. Agr. Rept., 1883, 108, pl. I.
Blatchley, Ind. Farmer, Oct. 9, 1886.
Scudder, But. E. U. S. and Can., 1889, II, 1205; III, pls. 7, 16, 65, 76, 84.

Found in large numbers throughout the State, and is our most injurious butterfly, the larvæ literally destroying the cabbage crop in many localities. It winters in the pupa state and the first ones appear about April 1, from which date until heavy frosts it may be taken. It is most abundant in Central Indiana, about July 1, when the second brood appears. In the southern part of the State a third brood appears about September 10, the pupæ of which survive the winter. In this country *P. rapæ* is preyed upon by one dipterous parasite, *Exoriste hirsuta;* and by two hymenopterous parasites, *Pteromalus puparum* and *Apanteles glomeratus*. Sometimes as many as one hundred eggs of one of these parasites are deposited within the body of a single caterpillar, and the number of larvæ of *P. rapæ* which they prevent from reaching the perfect state, during a single season, is an enormous one.

### NATHALIS, Boisduval.

10. (39.) NATHALIS IOLE, Bd.

*Nathalis iole*, Morris, Lep. N. A., 1862, 22.
Mead, Rep. Wheeler Exp., V. 1875, 747.
French, But. E. U. S., 1886, 116, fig. 31.
Scudder, But. E. U. S. and Can., 1889, III, 1842.
*Nathalis irene*, (Fitch), Morris, Lep. N. A., 1862, 22, 351.

This butterfly has been taken only in Jefferson, Lake and Vanderburgh counties. In the latter Mr. Evans reports it as found only one season in November. Its range as given by Edwards is "Illinois, Missouri and westward." Food plant of larva unknown.

### ANTHOCHARIS, Boisduval.

11. (43.) ANTHOCHARIS OLYMPIA, Edw.

*Anthocharis olympia*, Edw. But. N. A., II, 1884, 77, pl. 16.
French, But. E. U. S., 1886, 117.
*Synchloe olympia*, Scudder. But. E. U. S. and Can., 1889, III, 1844.

Occurs in small numbers about Whitings, Lake County, during the first half of May, where it has been taken by Mr. Chas. E. Worthington, of Chicago. It frequents cultivated grounds, gardens and meadows. Food plant, unknown.

12. (53.) ANTHOCHARIS GENUTIA, Fab. The Falcate Orange-tip.

*Anthocharis genutia*, Morris, Lep. N. A., 1862, 20.
Edwards, But. N. A., II, 1884, 83, pl. 17.
French, But. E. U. S., 1886, 118.
Scudder, But. E. U. S. and Can., 1889, II, 1147; III, pls. 15, 26, 65, 76, 84.

Vanderburgh County, by Evans. "This pretty species is single brooded and flies in spring. The eggs are laid upon the species of *Cardamine* and other *Cruciferæ*, but the life history of the larvæ is not well known. It flies low and swiftly, with a peculiar tremulous motion, and is readily distinguished from other Pierids by its flight as well as by the conspicuous coloring of the male." EDWARDS, loc. cit.

## CALLIDRYAS, Boisduval.

13. (54.) CALLIDRYAS EUBULE, Linn. The Danewort Butterfly. The Cloudless Sulphur.

*Callidryas eubule*, Morris, Lep N. A., 1862, 25.
French, Sev. Rep. St. Ento. Ill., 1878, 147.
Id., But. E. U. S., 1886, 119.
Scudder, But. E. U S. and Can., 1889, II, 1053; III, pls. 15, 25, 65, 76, 84.

A beautiful butterfly, whose range is southern, and which is reported only from Vanderburgh County, where Mr. Evans takes from one to a half dozen almost every season, in open woods during July and August. Food plant, the different species of *Cassia* or Wild Senna.

14. (56.) CALLIDRYAS PHILEA, L.

*Callidryas philea*, Morris, Lep. N. A., 1862, 350.
(Note by W. H. Edwards.)
French, But. E. U. S., 1886, 124.
Scudder, But. E. U. S. and Can., 1889, III, 1833.

A single specimen of the above species has been taken in Jefferson County by Mr. Hubbard. It has been reported heretofore only from Texas, Illinois and Wisconsin.

## COLIAS, Fabricius.

15. (62.) COLIAS CAESONIA, Stoll. Dog's Head Butterfly.

*Colias caesonia*, Morris, Lep. N. A., 1862, 27.
French, But. E. U. S., 1886, 127, fig. 32.
*Zerene caesonia*, Scudder, But. E. U. S. and Can., 1889, III, 1836.

This beautiful Colias has been taken only along the western border of the State. It is reported as frequent in Vanderburgh and Lake counties. In Vigo County, in the latter half of October, 1887, three or four specimens were taken from the vicinity of ponds in the Wabash River bottoms, but it has not been seen since. The larvæ feed upon clover, and false indigo, *Amorpha fruticosa L.*

The females, which are on the wing in late autumn, have the under side of the hind wings much more deeply suffused with red than do those which fly earlier in the season.

16. (66.) COLIAS EURYTHEME, Bd. The Eurytheme Butterfly. The Orange Sulphur.

*Colias eurytheme*, Morris, Lep. N. A., 1862, 29.
Edwards, But. N. A., I, 1869, 45, pl. 14.
Id., But. N. A., II, 1884, 103, pl. 21. (All forms.)
Mead, Rep, Wheeler Exp., v. 1875, 748.
French, Sev. Rep. St. Ento. Ill, 1878, 147.
Id., But. E. U. S., 1886, 128. (All forms.)
Blatchley, Ind. Farmer, Oct. 9, 1886.
*Eurymus eurytheme*, Scudder, But. E. U. S. and Can., 1889, II, 1126; III, pls. 15, 25, 65, 76, 84.
*Colias keewaydin*, Edw., But. N. A., I, 1869, 49, pl. 15.
*Colias amphidusa*, Morris, Lep. N. A., 1862, 29.
*Colias edusa*, Id., loc. cit., 27.
*Colias chrysotheme*, Id., loc. cit., 28.

The two forms, *eurytheme*, Bd., and *keewaydin*, Edw., occur occasionally in various parts of the State, but are nowhere common. *Keewaydin* was taken by the writer in Monroe County, in 1887, and *eurytheme* in Putnam County in 1890.

It winters, according to Edwards, in both imago and pupa stage, frequents meadows and roadsides, and is most common in July. Food plant, white and buffalo clover.

17. (68.) COLIAS PHILODIGE, Godt. The Sulphur Yellow Butterfly.

*Colias philodice*, Harris, Ins. Inj. to Veg., 1862, 272, figs. 100–102.
Morris, Lep. N. A., 1862, 29.
French, Sev. Rept. State Ento., Ill., 1878, 147.
Id., But. E. U. S., 1886, 133.
Packard, Guide, 8th Ed., 1883, 250.
Edwards, But. N. A., II, 1884, 93, pls. 19, 20.
Blatchley, Ind. Farmer, 1886, Oct. 9.
*Eurymus philodice*, Scudder, But. E. U. S. and Can., 1889, II, 1111; III, pls. 7, 13, 25, 65, 76, 84.

This is, without doubt, the most common butterfly in the State, being found in abundance from April 10 to November. In May and June they frequent fields of clover, upon which plant the larvæ feed, but later on they congregate by hundreds about muddy places in the roads, and along streams. The white female form is often seen, but is much less common than the yellow.

The species varies greatly, and that young collectors may not look upon some of its forms as distinct species, I quote the following, slightly modified, from Edwards, loc. cit., p. 97: "They vary in size from an expanse of 1.3 to 2.6 inches; in color, from pale sulphur to lemon and bright yellow; in the breadth of the black border from .1 to .3 inches; in the size and shape of discal spot on primaries and secondaries; in the color of the under surface, and in the row of extra discal spots beneath, from a complete series across both wings to none at all." Hibernates usually as pupa, but sometimes as larva. There are three broods each season, the first of which, in Central Indiana, appears about April 25, the other two in the latter half of June and August, respectively. A few individuals have been seen on the wing, in Vigo County, as late as November 5.

## TERIAS, Swainson.

18. (86.) TERIAS NICIPPE, Cram. The Nicippus Butterfly. The Black-bordered Yellow.

*Terias nicippe*, Morris, Lep. N. A., 1862, 33.
French, Sev. Rept. State Ent. Ill., 1878, 148.
Id., But. E. U. S., 1886, 136, fig. 33.
*Xanthidia nicippe*, Scudder, But. E. U. S. and Can., 1889, II, 1066; III, pls. 15, 26, 65, 76, 84.

Throughout the southern half of the State, but not seen by the writer, nor reported farther north than Vigo and Fayette counties. Quite frequent where found, and especially so in October along sandy banks where the food plants of the larva, the various species of *Cassia*, or Wild Senna, are abundant. Specimens on the wing have been seen in the city of Terre Haute as late as November 18, and it probably hibernates as a butterfly.

19. (90.) TERIAS LISA, Bd.-Lec. The Lisa Butterfly. The Little Sulphur.

*Terias lisa*, Morris, Lep. N. A., 1862, 34.
French, Sev. Rep. State Ento. Ill., 1878, 148.
Id., But. E. U. S., 1886, 139.
*Eurema lisa*, Scudder, But. E. U. S. and Can., 1889, II, 1087; III, pls. 7, 15, 26, 65, 76, 84.

Although this little Terias is said by French, in the Seventh Ill. Report, loc. cit., to be "one of the most common butterflies that flits along roads and over moist places during the summer and fall in Southern Illinois," yet in Indiana it has been noted only in Decatur, Lake and Vanderburgh counties, in the latter of which Mr. Evans takes "a few each season." Food plant, clover and *Cassia*.

# NYMPHALIDÆ.

## DANAINÆ.

### DANAIS, Latreille.

20. (94.) Danais archippus, Fab. The Milkweed Butterfly. The Monarch.

*Danais archippus*, Harris, Ins. Inj., 1862, 280.
Morris, Lep. N. A., 1862, 38.
French, Sev. Rep. State Ent. Ill., 1878, 149.
Id., But. E. U. S., 1886, 144, figs. 36–39.
Packard, Guide, 8th Ed., 1883, 251.
Blatchley, Ind. Farm., 1886, Oct. 30.
*Anosia plexippus*, Scudder, But. E. U. S. and Can., 1889, I, 720; III, pls. 1, 16, 18, 64, 74, 83, 87.

One of the largest and most common butterflies throughout the State. Most abundant about June 1 and September 10, when the two broods of the season, respectively, come forth. A few faded individuals may be seen in April as the imago hibernates. This is one of the few species the members of which flock together at certain periods, usually about September 20. These swarms seem to be composed almost wholly of males, and in Indiana gather about the leaves and branches of beech trees. The reasons for these gatherings are, up to the present, unknown. Food plants of larvæ, the various species of milkweed (*Asclepias*).

## NYMPHALINÆ.

### AGRAULIS, Boisduval and LeConte.

21. (100.) Agraulis vanillæ, Linn.

*Agraulis vanillæ*, Morris, Lep. N. A., 1862, 40.
French, But. E. U. S., 1886, 148.
Scudder, But. E. U. S. and Can., 1889, III, 1814.

A handsome species, which inhabits the Southern States, and has been taken in Indiana only in Vanderburgh County.

The food plant of larvæ is the beautiful Southern Passion Flower, *Passiflora incarnata*, L. Those found in this State doubtless fed upon the allied species, *Passiflora lutea*, L.

## ARGYNNIS, Fabricius.

22. (101.) Argynnis idalia, Drury. The Idalia Butterfly. The Regal Fritillary.

*Argynnis idalia*, Harris, Ins. Inj., 1862, 285, fig. 110.
Morris, Lep. N. A., 1862, 41.
French, Sev. Rep. St. Ento. Ill., 1878, 149.
Id., But. E. U. S., 1886, 150.
Blatchley, Ind. Farmer, 1886, Nov. 6.

*Speyeria idalia*, Scudder, But. E. U. S. and Can., 1889, I, 535; III, pls. 4, 12, 21, 64, 75, 84.

This fine species is known to occur in but four counties in the State, viz., Monroe, Vanderburgh, Fayette and Lake.

It emerges from the chrysalid formed by the hibernating larva about July 1, and frequents meadows and low grounds near streams. Its larvæ, as well as the larvæ of all other members of the genus, feed upon the different species of wild and cultivated violets.

23. (102.) Argynnis diana, Cram. The Diana Butterfly.

*Argynnis diana*, Morris, Lep. N. A., 1862, 42. (Male only.)
Edwards, But. N. A., I, 1868, 63, pl. 20.
Id., But. N. A., II, 1884, 148, pl. 29. (Preparatory stages.)
French, Sev. Rep. State Ento. Ill., 1878, 149.
Id., But. E. U. S., 1886, 153.

*Semnopsyche diana*, Scudder, But. E. U. S. and Can., 1889, III, 1799.

This large and beautiful Argynnis is a southern species, ranging from West Virginia through Kentucky and Tennessee to Arkansas, but is nowhere common. Mr. S. G. Evans, of Evansville, Ind., has, however, collected them in the vicinity of that city every season for ten or twelve years. He takes them from the middle of June to the middle of August, from upland meadows and borders of woods. This is, as far as known, the most northern station at which the species has been found, and is its only record in the State. Like the other members of its genus, it is single brooded, the larvæ feeding on violets and hibernating.

24. (107.) Argynnis cybele, Fab. The Cybele Butterfly. The Great Spangled Fritillary.

*Argynnis cybele*, Morris, Lep. N. A., 1862, 42.
Edwards, But. N. A., I, 1868, 67, pl. 21.
French, Sev. Rept. State Ent. Ill., 1878, 150.
Id., But. E. U. S., 1886, 155.
Blatchley, Ind. Farm., 1886, Nov. 6.
Scudder, But. E. U. S. and Can., 1889, I, 554; III, pls. 4, 21, 64, 75, 84.

Next to *Colias philodice*, Godt., this is the most common butterfly in Indiana from May 20 until September. In any clover field in June vast numbers may be seen gathering honey and chasing one another from bloom to bloom. In July and August they are to be found wherever there are thistles and ironweeds. During the latter month the eggs are laid, and by the middle of September the butterfly has almost wholly disappeared. The larvæ pass the winter beneath sticks and pieces of bark in the vicinity of the food plant.

25. (108.) ARGYNNIS APHRODITE, Fab. Aphrodite Butterfly. The Silver Spot Fritillary.

*Argynnis aphrodite*, Harris, Ins. Inj., 1862, 285, fig. 111.
Morris, Lep. N. A., 1862, 43.
Edwards, But. N. A., I, 1868, 71, pl. 22.
French, Sev. Rep. St. Ento. Ill., 1878, 150.
Id., But. E. U. S., 1886, 157, fig. 40.
Packard, Guide, 8th Ed., 1883, 253, fig. 183.
Scudder, But. E. U. S., 1889, I, 563; III, pls. 4, 12, 21, 64, 72, 84.

*A. aphrodite* has been noted in but five counties, but probably occurs throughout the State, being confounded with *cybele*, which it closely resembles. It may, however, be easily told from that species by the following characters:

Smaller size; less brown on the bases of the upper side of wings; narrower pale band near outer margin of under side of hind wings; narrower space between black bands on outer margin of fore wings above; and deeper tint of ground color, approaching a red. It frequents the same localities as *A. Cybele*, and is most abundant, where found, from June 25 till August.

26. (109.) ARGYNNIS ALCESTIS, Edw. Alcestis Butterfly.

*Argynnis alcestis*, French, Sev. Rep. St. Ento. Ill., 1878, 150.
Id., But. E. U. S., 1886, 158.
Blatchley, Ind. Farm., Nov. 6, 1886.
Id., Hoos. Nat, II., Nov. 1886, 42.
Scudder, But. E. U. S. and Can., III, p. 1802.

In Indiana this species has been collected in but two counties—Lake, where Worthington reports it as common; and *Monroe*, where a single specimen was taken from a meadow July 1, 1886. From above it closely resembles *A. cybele*, but on the under side the hinder wings are dark cinnamon brown, without a submarginal yellow band.

It is probably quite common on the prairies in the northern part of the State, and has been overlooked heretofore.

27. (112.) Argynnis atlantis, Edw. The Mountain Silver-spot.

*Argynnis atlantis*, Edwards, But. N. A., I, 1868, 75, pl. 24.
Mead, Rep. Wheeler Exp., V. 1875, 754.
French, But. E. U. S., 1886, 160, fig. 41.
Packard, Guide, 8th Ed., 1883, 262. (Larvæ and pupæ described.)
Scudder, But. E. U. S. and Can., 1889, I, 571; III, pls. 4, 21, 61, 84.

This species has been taken in the two widely separated counties of Vanderburgh (Evans) and Lake, but nowhere else in the State. As to its distinguishing characters, I quote the following from Edwards, loc. cit.: "Atlantis is readily distinguished from Aphrodite by its smaller size, duller color, broad black margins, confluent median band of secondaries and color of same wings below; also, by the longer and narrower fore wings. It is rarely to be seen in the open country where Aphrodite abounds, but frequents narrow passes in the mountains and the grass fields which skirt the forests. It is readily attracted by any decaying animal matter, and a piece of meat or a dead bird or snake has irresistible charms for it."

28. (141.) Argynnis myrina, Cram. Myrina Butterfly. The Silver-Bordered Fritillary.

*Argynnis myrina*, Harris, Ins. Inj., 1862, 286, fig. 112.
Morris, Lep. N. A., 1862, 45.
Packard, Guide, 8th Ed., 1883, 253.
French, But. E. U. S., 1886, 161, fig. 42.
*Brenthis myrina*, Scudder, But. E. U. S. and Can., 1889, I, 593; III, pls. 4, 12, 22, 64, 75, 84.

Vanderburgh County, by Evans. Otherwise only from the northern half of the State, where it is quite frequent in meadows and prairies from June 15 to September. Food plant, violets.

29. (152.) Argynnis bellona, Fab. Bellona Butterfly. The Meadow Fritillary.

*Argynnis bellona*, Harris, Ins. Inj., 1862, 287, figs. 113, 114.
Morris, Lep., N. A., 1862, 45.
Mead, Rep. Wheeler Exp., 1875, 756.
Packard, Guide, 1883, 253.
French, But. E. U. S., 1886, 164.
*Brenthis bellona*, Scudder, But. E. U. S. and Can., 1889, I, 608; III, pls. 5, 12, 22, 64, 75, 84.

This, the smallest member of the genus, is found throughout the eastern and northern parts of the State, but is very rare if it occurs at all in the Lower Wabash Valley. It is quite common, where found, during July and August, in low meadows and prairies, especially those containing many flowers.

## EUPTOIETA, Doubleday.

30. (154.) EUPTOIETA CLAUDIA, Cram. The Claudia Butterfly.
*Euptoieta claudia*, Mead, Rep. Wheeler Exp., V. 1875, 750.
French, Sev. Rep. State Ent. Ill., 1878, 150.
Id., But. E. U. S., 1886, 165, fig. 43.
Blatchley, Ind. Farm., 1886, Nov. 6.
Scudder, But. E. U. S. and Can., 1889, I, 519; III, pls. 14, 21, 64, 75, 84.
*Argynnis columbina*, Morris, Lep. N. A., 1862, 44.

In the southern half of the State, but not seen or reported in the northern although it should occur there. Given as rare in most of the lists which mention it. Frequents meadows and borders of thickets from July 15 to October 15, a single specimen having been taken by the writer on the latter date in Vigo County. Food plants, violets, May apples, sedum and portulaca.

## MELITÆA, Fabricius.

31. (156.) MELITÆA PHÆTON, Drury. Phæton Butterfly. The Baltimore.
*Melitæa phæton*, Harris, Ins. Inj., 1862, 288, fig. 115.
Morris, Lep. N. A., 1862, 50.
Packard, Guide, 8th Ed., 1883, 255, figs. 184–186.
Edwards, But. N. A. II, 1884, 151, pl. 30.
French, But. E. U. S., 1886, 168, figs. 44–47.
Blatchley, Ind. Farmer, 1886, November 6.
*Euphydryas phæton*, Scudder, But. E. U. S., I, 690; III, pls. 5, 12, 22, 64, 75, 84.

An uncommon species, noted in but four counties, viz.: Decatur, Vanderburgh, Vigo and Monroe, but probably found throughout the State. This is the only butterfly in Indiana whose larvæ live in colonies in webs of their own construction. These webs are woven on the food plants, which are snake-head or turtle-head (*Chelone glabra*), and the two monkey flowers (*Mimulus*). The larvæ form the webs about the last of July and, after feeding until they have moulted the third time, they pass the winter in a state of lethargy within them. With the first appearance of the food plant in spring they begin feeding again, after which is formed the chrysalis from which the butterfly emerges about June 1. It frequents low, open fields and marshes where the food plants abound, and flits with an irregular and nervous flight close to the earth.

## PHYCIODES, Doubleday.

32. (186.) PHYCIODES NYCTEIS, Doubl-Hew. The Peppermint Butterfly. The Silver Crescent.

*Melitæa nycteis*, Morris, Lep. N. A., 1862, 325, 351.
Packard, Guide, 8th Ed., 1883, 257.
*Phyciodes nycteis*, Mead, Rep. Wheeler Exp., V. 1875, 762.
French, But. E. U. S., 1886, 172, fig. 50.
Blatchley, Ind. Farmer, 1886, Nov. 6.
*Charidryas nycteis*, Scudder, But. E. U. S. and Can., 1889, I, 658; III, pls. 5, 22, 64, 75, 84.

Common all over the State, but less so than the next species, which it closely resembles. Found in the vicinity of streams, and during July and August frequents, by hundreds, the flowers of peppermint, *Mentha piperita*, and allied species. Food plants, asters, wild sunflowers and *Actinomeris*. The larvæ pass the winter, when partly grown, beneath the shelter of objects on the ground, and the imago has been taken in Western Indiana as early as May 17.

33. (190.) PHYCIODES THAROS, Drury. The Tharos Butterfly. The Pearl Crescent.

*Melitæa tharos*, Morris, Lep. N. A., 1862, 51 (*morpheus*).
*Phyciodes tharos*, Mead, Rep. Wheeler Exp., V. 1875, 763.
French, Sev. Rep. State Ent. Ill., 1878, 151.
Id., But. E. U. S., 1886, 177.
Edwards, But. N. A., II, 1884, 161, pl. 31, 32.
Packard, Guide, 8th Ed., 1883, 256.
Blatchley, Ind. Farm., 1886, Nov. 6.
Scudder, But. E. U. S. and Can., 1889, I, 629; III, pls. 5, 12, 22, 64, 75, 84.
*Melitæa pharos*, Harris, Ins. Inj., 1862, 289, figs. 116, 117.

The two forms of this species, *marcia*, Ewd., and *morpheus*, Fab., are both very abundant, especially the latter. Three or four broods are produced each season, the first one (*marcia*) from hibernating larvæ, appearing about the tenth of May, and the others at intervals of six or eight weeks thereafter. In company with *Colias philodice*, they flock about muddy places in the roads and the damp, sandy margins of streams. Food plant, asters.

## GRAPTA, Kirby.

34. (207.) GRAPTA INTERROGATIONIS, Fab. The Semicolon Butterfly. The Violet Tip.

*Vanessa interrogationis*, Harris, Ins. Inj., 1862, 298, fig. 124 (*fabricii*, text-*umbrosa*).

*Grapta interrogationis*, Morris, Lep. N. A., 1862, 53 (*umbrosa*).
Edwards, But. N. A., I, 1872, p. 111, pls. 38, 39.
French, Sev. Rep. State Ent. Ill., 1878, 151.
Id., But. E. U. S., 1886, 182, fig. 51.
Packard, Guide, 8th Ed., 1883, 259.
Blatchley, Ind. Farmer, 1886, Nov. 20.
*Polygonia interrogationis*, Scudder, But. E. U. S., I, 319; III, pls. 3, 11, 20, 64, 74, 83.

Throughout the State. Of the two forms recognized by Edwards, the paler one, *fabricii*, is much the more common, especially the members of the brood which emerge about September 10, the individuals of which hibernate. This form is also quite variable, the silver spot on the under surface of the hind wings being often unbroken, and in many specimens the larger and hindmost of the black spots between the cell and hind margin of the fore wings above is double, the additional spot being larger than either of those in the cell. It frequents roadsides, borders of thickets and the vicinity of gardens where hops are cultivated.

35. (208.) GRAPTA COMMA, Harr. The Comma Butterfly. The Hop Merchant.

*Vanessa comma*, Harris, Ins. Inj., 1862, 300, pl. 4, fig. 1 (*harrisii*).
*Grapta comma*, Morris, Lep. N. A., 1862, 54.
Edwards, But. N. A., I. 1871, 101, pl. 36 (*harrisii*).
French, Sev. Rep. S. Ento. Ill., 1878, 152.
Id., But. E. U. S., 1886, 185.
Packard, Guide, 1883, 260.
Blatchley, Ind. Farmer, 1886, Nov. 20.
*Polygonia comma*, Scudder, But. E. U. S. and Can., I, 332; III, pls. 3, 20, 64, 74, 83.
*Grapta dryas*, Edwards, But. N. A., I, 1871, 109, pl. 37 (form *dryas*).

A common species in most parts of the State, but not reported in all the lists. Food plants—hop, elm, and nettles. Like *G. interrogationis*, the members of the late brood of this species seek some sheltered place, such as a crevice in a rock or a hole in a tree, where they pass the winter in a dormant state, from which they are aroused by the first warm breezes of spring. Specimens have been taken on the wing as late as November 22, and as early as March 4. During the summer three or four may usually be found in company in damp places, alongside of streams or in shaded ravines.

36 (217.) GRAPTA PROGNE, Cram. The Progne Butterfly.

*Vanessa progne*, Harris, Ins. Inj., 1862, 301.
Morris, Lep. N. A., 1862, 56.
*Grapta progne*, French, But. E. U. S., 1886, 190, fig. 53.
Blatchley, Ind. Farmer, 1886, Nov. 20.
*Polygonia progne*, Scudder, But. E. U. S. and Can., 1889, I, 362; III, pls. 3, 16, 19, 64, 74, 83.
*Grapta c-argenteum*, Packard, Guide, 1883, 260, fig. 188.

This small Grapta has been taken in six counties in different portions of the State, but is scarce wherever found. In midsummer it frequents rocky ledges and shaded ravines, but in autumn it is more often found along the margins of dense woods. When disturbed it, as well as the two preceding members of the genus, has the habit of making a short circuit and flying back to the self-same spot from whence it was started.

Food plants—gooseberry, currant, blackberry and elm.

37. (218.) GRAPTA J-ALBUM, Bd.-Lec. The White J. Butterfly.

*Vanessa j album*, Harris, Ins. Inj., 1862, 298.
Morris, Lep. N. A., 1862, 56.
*Grapta j-album*, French, But. E. U. S., 1886, 192.
*Eugonia j-album*, Scudder, But. E. U. S. and Can., 1889, I, 379; III, pls. 3, 20, 83.

Vanderburgh, Decatur and Lake. Rare in the three counties. Borders of thickets and along streams during July and August. Hibernates as imago. Food plant unknown. Vanderburgh County is, up to the present, the most southern station at which *j-album* has been taken.

## VANESSA, Fabricius.

38. (219.) VANESSA ANTIOPA, Linn. The Camberwell Beauty. The Mourning Cloak. The Antiopa Butterfly.

*Vanessa antiopa*, Harris, Ins. Inj., 1862, 296, fig. 121, 123.
Morris, Lep. N. A., 1862, 57.
Wood, Insects at Home, 1873, 396.
French, Sev. Rep. State Ento. Ill., 1878, 153.
Id, But. E. U. S., 1886, 193.
Packard, Guide, 8th Ed., 1883, 258.
Blatchley, Ind. Farmer, 1886, Nov. 20.
*Euranessa antiopa*, Scudder, But. E. U. S. and Can., 1889, I, 397; III, pls. 2, 11, 20, 64, 74, 83.

A common and handsome species often seen in spring as early if not earlier than *Grapta comma*, as it also winters in the perfect state. It is, however, much more abundant than that species for about a month, after which it disappears, and none are seen till the first of June, when it again becomes common, the first brood of the season having emerged from chrysalid. A second brood appears about the middle of September. In England, where it is rare and considered a great prize by the collectors, it is known as the Camberwell Beauty. The larvæ feed upon the leaves of willow, elm and poplar.

39. (221.) VANESSA MILBERTII, Godt. Milbert's Butterfly. The American Tortoise-shell.

*Vanessa milbertii*, Harris, Ins. Inj., 1862, 302, fig. 125.
Morris, Lep. N. A., 1862, 56.
Mead, Rep. Wheeler Exp., V. 1875, 769.
Packard, Guide, 8th Ed., 1883, 259.
French, But. E. U. S., 1886, 195.
*Aglais milberti*, Scudder, But. E. U. S. and Can., 1889, I, 420; III, pls. 2, 12, 20, 64, 74, 83.

This brilliantly colored Vanessa has a wide distribution, but appears to be nowhere as common as *Antiopa*, with which species it agrees essentially in habits.

In Indiana it has been taken only in Lake and Vanderburgh counties, from both of which it is reported as rare. Food plant, nettle. Vanderburgh County is, as far as known, the most southern station at which it has been taken.

"The butterfly is found most abundant by the roadside, especially among the hills, and by the margin of forests. It is always found in sunny exposures; is fond of resting on dry leaves scattered over the ground in spring, and, like many other early butterflies, is attracted by the blossoms of the lilac."—SCUDDER.

## PYRAMEIS, Doubleday.

40. (222.) PYRAMEIS ATALANTA, Linn. The Red Admiral. The Atalanta Butterfly.

*Cynthia atalanta*, Harris, Ins. Inj., 1862, 294, fig. 120.
*Pyrameis atalanta*, Morris. Lep. N. A., 1862, 58.
French, Sev. Rep. St. Ento., Ill., 1878, 153.
Id., But. E. U. S., 1886, 196, fig. 55.
Packard, Guide, 1883, 261.
Blatchley, Ind. Farmer, 1887, April 23.
*Vanessa atalanta*, Wood, Insects at Home, 1873, 399, pl. 13.
Scudder, But. E. U. S. and Can., 1889, I, 441; III, pls. 2, 12, 20, 64, 74, 83.

A common and showy butterfly, which also hibernates as imago, and comes forth from its winter quarters on the first warm days of March and April. It is most abundant, however, about June 10 and September 20, when the two broods of the season respectively emerge. It flies everywhere, but especially abounds about clumps of willows, on the trunks of which it delights to rest and enjoy the sunshine, and when disturbed flits away but a short distance and soon returns to the same or an adjacent tree. According to Harris, *atalanta* was probably introduced with its food plant, the common nettle, into this country from Europe, where it is also abundant, and known as the Red Admiral Butterfly.

41. (223.) PYRAMEIS HUNTERA, Fab. Hunter's Butterfly. The Painted Beauty.

*Cynthia huntera*, Harris, Ins. Inj., 1862, 292, fig. 119.
*Pyrameis huntera*, Morris, Lep. N. A., 1862, 60.
French, Sev. Rep. St. Ento. Ill., 1878, 153.
Id., But. E. U. S., 1886, 198.
Mead, Rep. Wheeler Exp., V. 1875, 769.
Blatchley, Ind. Farmer, 1887, April 23.
*Vanessa huntera*, Scudder, But. E. U. S. and Can., 1889, I, 457; III, pls. 2, 12, 20. 74, 83.

Much less common than the preceding, but found throughout the State. The larvæ feed upon everlasting (*Gnaphalium polycephalum*), and the various species of *Artemisia*. The butterfly is most often met with in August and September, in fields containing golden rods and wild asters. There are two broods each season; the butterflies and occasionally the chrysalids of the autumn brood hibernating.

42. (224.) PYRAMEIS CARDUI, Linn. Thistle Butterfly. The Painted Lady.

*Cynthia cardui*, Harris, Ins. Inj. 1862, 291, fig. 118.
*Pyrameis cardui*, Morris, Lep. N. A., 1862, 59.
Mead, Rep. Wheeler Exp., V. 1875, 770.
French, Sev. Rep. St. Ento. Ill., 1878, 154.
Id., But. E. U. S., 1886, 199.
Blatchley, Ind. Farmer, 1887, April 23.
*Vanessa cardui*, Wood, Ins. at Home, 1873, 401, pl. 13.
Scudder, But. E. U. S. and Can., 1889, I, 469; III, pls. 2, 12, 21, 64, 74, 83.

The Thistle Butterfly is a rather common species from mid-June until after heavy frosts. During the summer months it is usually found in open pastures where there are thistle patches, but on sunny days in autumn it is often seen in orchards sipping the juices from a bruised or rotten apple. In England, where it is common, it is known as the "Painted Lady," on account of the variety and beauty of its colors. The larvæ feed upon thistles, burdock and wild sunflowers, and are therefore more beneficial than otherwise. It passes the winter as imago, and in Vigo County has been taken on the wing as early as April 10.

### JUNONIA, Doubleday.

43. (226.) JUNONIA COENIA, Hub. The Coenia Butterfly. The Buckeye.

*Junonia coenia,* Morris, Lep. N. A., 1862, 61.
Packard, Guide, 1883, 261.
French, But. E. U. S., 1886, 200, fig. 56.
Scudder, But. E. U. S. and Can., 1889, I, 494; III, pls. 14, 21, 64, 74, 83.
*Cynthia lavinia,* Harris, Ins. Inj , 1862, 293.
*Junonia lavinia,* French, Sev. Rep St. Ent. Ill., 1878, 154.

A showy insect, abundant in the Southern States, and rarely found as far north as Lake County, Indiana, where it has been taken by Worthington. Single specimens have also been secured in Jefferson and Vigo counties, and a few in Vanderburgh.

It flies from June to November in open fields and low meadows where flowers are abundant. Food plants, plantain, gerardia and snapdragon.

### LIMENITIS, Fabricius.

44. (236.) LIMENITIS URSULA, Fab. The Ursula Butterfly. The Red-spotted Purple.

*Nymphalis ursula,* Morris, Lep. N. A., 1862, 64.
*Limenitis ursula,* French, Sev. Rep. St. Ent. Ill., 1878, 154.
Id., But. E. U. S., 1886, 206, fig. 58.
Packard, Guide, 1883, 262.
Blatchley, Ind. Farmer, 1887, April 23.
*Basilarchia astyanax,* Scudder, But. E. U. S. and Can., 1889, I, 280; III, pls. 2, 19, 64, 74, 83.
*Nymphalis ephestion,* Harris, Ins. Inj., 1862, 283.
*Limenitis ephestion,* Packard, Guide, 1883, 262.

Common in the central and southern half of the State, less so in the north. Its usual resorts are the vicinity of streams and about muddy places in roads, although it is often seen in orchards and gardens. It winters in the larva state and is most common as imago in June and the latter half of August. The food plants of the larvæ are willow, wild cherry, apple, plum, oak and ironwood.

45. (237.) LIMENITIS ARTHEMIS, Drury. The Banded Purple Butterfly.

*Nymphalis arthemis,* Harris, Ins. Inj., 1862, 283, pl. I, fig. 7.
Morris, Lep. N. A., 1862, 65.
*Limenitis arthemis,* Edwards, But. N. A., II, 1884.
Packard, Guide, 1883, 262.
French, But. E. U. S., 1886, 208.

*Basilarchia arthemis*, Scudder, But. E. U. S. and Can., 1889, I, 294; III, pls. 2, 19, 54, 74, 81, 83.
*Limenitis proserpina*, Edwards, But. N. A., I, 1868, 127, pl. 48. (Form *proserpina.*)
Id., Canadian Entomologist, March, 1891, 49.
*Basilarchia proserpina*, Scudder, But. E. U. S. and Can., 1889, I, 289; III, pls. 2, 19. (Form *proserpina.*)

This handsome butterfly is a northern species which has been taken in Lake County, by Worthington. It is found from June to September frequenting the same localities as *L. ursula.* The larvæ feed upon willow, aspen, basswood, and probably thorn.

Mr. S. H. Scudder, in his But. E. U. S., p. 289, regards the form *proserpina* as a hybrid between *L. ursula* and *L. arthemis.* Mr. Edwards in the Canadian Entomologist, loc. cit., controverts this view, and gives in full his reasons for considering it a dimorphic form of *arthemis.*

46. (239.) LIMENITIS DISIPPUS, Godt. The Disippus Butterfly. The Viceroy.

*Nymphalis disippus*, Harris, Ins. Inj., 1862, 281, fig. 109.
Morris, Lep. N. A., 1862, 65.
*Limenitis disippus*, French, Sev. Rep. St. Ento. Ill., 1878, 154.
Id., But. E. U. S., 1886, 210, figs. 59–62.
Edwards, But. N. A., II, 1884, 227. (Descrip. of larvæ.)
Blatchley, Ind. Farmer, 1887, April 23.
*Limenitis misippus*, Packard, Guide, 1883, 262, fig. 189.
*Basilarchia archippus*, Scudder, But. E. U. S. and Can., 1889, I, 267; III, pls. 1, 11, 19, 64, 74, 83.

A rather common species in all parts of the State, but by casual observers usually confounded with *Danais archippus*, Fab., which it closely resembles in color and markings, but from which it may be readily known by the presence of a narrow, curved, black band across the center of the hind wings. There are two broods each season, the larvæ of the second brood constructing from a leaf a tube-shaped retreat into which they enter, head first, and pass the winter. Their dwellings are formed by first fastening, by means of silk, a leaf to the twig upon which it grew. Notches are then cut in the leaf and the edges are bent together and fastened by a silken thread. In the words of Edwards, loc. cit.: "Some caterpillars cover themselves in a web, or bind two leaves together loosely; more conceal themselves under wood or stone, or in the sod; but here is one who has turned tailor, weaver and house builder. It knows just what sort of leaf to choose for its purpose, takes its measurement, cuts out the pattern on a system peculiar but effective;

sews it up; upholsters the interior with silken threads, and takes possession, even having provided against the ingress of water by a flap, shaped when the pattern is cut out." It is an interesting fact that only the second brood of larvæ exhibits an instinct for thus forming homes. The butterfly is most frequent in July, and is usually found in low grounds, about clumps of willows, upon the leaves of which the larvæ feed. Additional foot plants are poplar, plum and oak.

## APATURA, Fabricius.

47. (244.) APATURA CELTIS, Bd.-Lec. The Eyed Emperor. The Hackberry Butterfly.

*Apatura celtis*, Morris, Lep. N. A., 1862, 68.
French, Sev. Rep. St. Ento. Ill., 1878, 155.
Id., But. E. U. S., 1886, 215, figs. 63, 64.
Edwards, But. N. A., II, 1884, 231, pl. 38.
Blatchley, Ind. Farmer, 1887, May 11.
*Chlorippe celtis*, Scudder, But. E. U. S. and Can., 1889, III, 1788.

This species is found in the southern half of the State and as far north as Wabash County, where it has been taken by the writer, but it is nowhere abundant. It flies during July and August in low, open woods, especially those where the food plant of the larva, *Celtis occidentalis*, or the hackberry tree, grows. *Celtis* has a swift flight and darts rapidly from one object to another as if actuated by curiosity, often alighting upon the body of the person pursuing it or upon the net, where it opens and closes its wings rapidly for a few seconds, and then starts out on a short circuit soon to return again. The larvæ pass the winter hidden among the ridges in the bark of the hackberry and may be found feeding on the buds as soon as the latter appear in spring.

48. (248.) APATURA CLYTON, Bd.-Lec. The Tawny Emperor.

*Apatura clyton*, Morris, Lep. N. A., 1862, 68.
French, Sev. Rep. St. Ent. Ill., 1878, 155.
Id., But. E. U. S., 1886, 218, figs. 65, 66.
Edwards, But. N. A., II, 1884, 245, pl. 39.
Blatchley, Ind. Farmer, 1887, May 11.
*Chlorippe clyton*, Scudder, But. E. U. S. and Can., 1889, I, 241; III, pls. 16, 19, 64, 74, 83.

The range of this species in the State coincides with that of *A. celtis*, the food plant being the same. It is, however, much less common than the latter, having been taken in but five counties, whereas *celtis* is reported in all the lists but two. Neither species is found in the northwestern corner of the State. Of the two forms of clyton, *ocellata*, Edw., is the more common. There is but one brood each season, the butterfly emerging about June 15. It frequents the vicinity of streams, but is sometimes seen in company with *A. celtis* about dwellings and orchards, especially towards the close of its season. A single specimen was taken in the heart of the city of Wabash, Ind., August 11, 1890.

## PAPHIA, Westwood.

49. (251.) PAPHIA TROGLODYTA, Fab. The Goat Weed Butterfly.
*Paphia troglodyta*, French, But. E. U. S., 1886, 226, figs. 67–69.
*Paphia glycerium*, Morris, Lep. N. A., 1862, 67.
Edwards, But. N. A., I, 1871, 137, pl. 46.
*Paphia andria*, French, Sev. Rep. St. Ent., Ill., 1878, 156.
*Anœa andria*, Scudder, But. E. U. S. and Can., III, 1794.

A southwestern species, the habitat of which is given by Edwards as Illinois to Texas. Very rare in Indiana, a single specimen having been taken in Vigo County, by Prof. B. W. Evermann, on April 24, 1890, and "one or two in three different seasons," in Vanderburgh County, by Evans. The larvæ feed upon species of Croton, and the imago hibernates, there being but one brood each season.

"The butterfly is often seen in orchards resting on the sunny side of the trees, at other times on the road or upon the fences. It is shy and difficult to capture, although it seldom leaves a favorite locality, but continues to fly about until danger has passed."—EDWARDS, loc. cit.

## SATYRINÆ.

## DEBIS, Westwood.

50. (253.) DEBIS PORTLANDIA, Fab. The Woodland Butterfly. The Pearly Eye.
*Debis portlandia*, Morris, Lep. N. A., 1862, 79.
French, But. E U. S., 1886, 229, fig. 70.
Blatchley, Ind. Farmer, 1887, May 11.
*Enodia portlandia*, Scudder, But. E. U. S. and Can., 1889, I, 180; III, pls. 1, 18, 64, 74, 83.
*Debis andromacha*, Morris, Lep. N. A., 1862, 78, 351.

The Woodland Butterfly has been taken in six counties in as many different portions of the State, but is nowhere common. Its favorite resorts are dense, damp woods and thickets, where, during July and August, it may be found resting on the stump or trunk of a tree in the immediate vicinity of the coarse grasses, which are the food plants of the larvæ. In this State it is single brooded and the larvæ hibernate.

## NEONYMPHA, Westwood.

51. (254.) NEONYMPHA CANTHUS, Bd.-Lec. The Canthus Butterfly. The Eyed Brown.

*Neonympha canthus*, Morris, Lep. N. A., 1862, 74.
French, But. E. U. S., 1886, 232.
*Hipparchia boisduvalli*, Harris, Ins. Inj., 1862, 305, fig. 128.
*Satyrodes eurydice*, Scudder, But. E. U. S. and Can., 1889, I, 193; III, pls. 1, 11, 18, 64, 74, 83.

Noted only in Lake County, where it is common, but should be found throughout the northern half of the State. It is on the wing during June and July, and is found in low open woods and meadows. The larvæ feed upon various kinds of grass and hibernate after the fourth moult.

52. (258.) NEONYMPHA EURYTRIS, Fab. The Wood Nymph Butterfly.

*Hipparchia eurytris*, Harris, Ins. Inj., 1862, 306, fig. 129.
*Neonympha eurytris*. Morris, Lep. N. A., 1862, 73.
French, Sev. Rep. St. Ent. Ill., 1878, 156.
Id., But. E. U. S., 1886, 238.
Packard, Guide, 1883, 264.
Blatchley, Ind. Farmer, 1887, May 11.
*Cissia eurytus*, Scudder, But. E. U. S. and Can., 1889, I, 214; III, pls. 1, 11, 18, 64, 74, 83.

This little wood-brown butterfly is rather common throughout the State from May 15 until August. It frequents woods, fence rows, and shady roadsides and flies close to the ground with a queer, jerky flight, often alighting on the grass, or on a log or chip, seldom on a flower or shrub. The larvæ feed upon grass, and the second brood of the season hibernate.

## SATYRUS, Westwood.

53. (283.) SATYRUS ALOPE, Fab. The Alope Butterfly. The Blue-eyed Grayling.

*Hipparchia alope*, Harris, Ins. Inj., 1862, 305, fig. 127. (Form *alope*, Fab.)
*Satyrus alope*, Morris, Lep. N. A., 1862, 76.
French, Sev. Rep. St. Ent. Ill., 1878, 156.
Id., But. E. U. S., 1886, 243, fig. 71. (All forms.)
Packard, Guide, 8th Ed., 1883, 263.
Edwards, But. N. A., II, 1884, 261, pls. 41, 42. (All forms.)

*Cercyonis alope*, Scudder, But. E. U. S. and Can., 1889, I, 163; III, pls. 1, 11, 18, 67, 74. (Form *alope*.)

*Erebia nephele*, Morris, Lep. N. A., 1862, 76. (Form *nephele*, Kirby.)

*Satyrus nephele*, Mead, Rep. Wheeler Exp., V. 1875, 773.
Packard, Guide, 1883, 263.

*Hipparchia nephele*, Harris, Ins. Inj. 1862, fig. 130. (No text.)

*Cercyonis nephele*, Scudder, But. E. U. S. and Can., 1889, I, 171; III, pls. 1, 11, 18, 64, 83. (Form *nephele*.)

Three forms of this handsome butterfly, viz., *alope*, Fab., *nephele*, Kirby, and *olympus*, Edwards, are found in the northern part of the State. It ranges as far south as the southern border of White and Wabash Counties. *Olympus* has been noted only in Lake County. All the forms are on the wing during July and August, and frequent open woods, meadows and prairies. The larvæ feed upon the various species of wild grasses and hibernate.

## LIBYTHEINÆ.

### LIBYTHEA, Fabricius.

54. (309.) Libythea bachmani, Kirtland. Bachman's Butterfly.

*Libythea bachmani*, Morris, Lep. N. A., 1862, 63.
French, Sev. Rep. St. Ent. Ill., 1878, 157.
Id., But. E. U. S., 1886, 250.
Packard, Guide, 8th Ed., 1883, 264.
Edwards, But. N. A., II, 1884, 289, pl. 46.
Blatchley, Ind. Farmer, 1887, May 11.

*Hypatus bachmanii*, Scudder, But. E. U. S. and Can., 1889, I, 760; III, pls. 4, 21, 64, 75, 84.

This curious little fly, with its long, beak-like palpi and angled fore wings, once seen will ever after be recognized at first sight. It doubtless inhabits all parts of the State, having been taken in six widely separated counties, yet but few are found each season in any one locality. It frequents low grounds and the vicinity of streams, and flies from June to September. Food plant, hackberry.

# LYCÆNIDÆ.

## LYCÆNINÆ.

### THECLA, Fabricius.

This large genus is represented in Indiana, so far as known, by ten species, but one of which may be said to be common. All are comparatively small in size, of a blue, smoky brown or black color, and have wings of a delicate texture. The habits of all are essentially the same. They mostly pass the winter in the pupa stage, and the imagoes are to be found from May 15 until frost. They are seldom seen except along fence rows and the borders of woods and thickets, where they flit rapidly to and fro with a restless, jerking flight, pausing every few moments on leaf of brier or shrub to bask in the sunlight, and then as suddenly starting onward again.

55. (326.) THECLA HALESUS, Cram. Great Purple Hair-streak.
*Thecla halesus*, Morris, Lep. N. A., 1862, 91.
Mead, Rep. Wheeler Exp., V, 1875, 777.
French, But. E. U. S., 1886, 255.
*Atlides halesus*, Scudder, But. E. U. S. and Can., 1889, III, 1827.

A western and southern species, not before reported east of Illinois. Found in small numbers in Lake County by Worthington. Food plant, oak.

56. (327.) THECLA M-ALBUM, Bd.-Lec. The Black-banded Hair-streak.
*Thecla m-album*, Morris, Lep. N. A., 1862, 92.
French, But. E. U. S., 1886, 256.
*Eupsyche m-album*, Scudder, But. E. U. S. and Can., 1889, III, 1824.
*Thecla psyche*, Morris, Lep. N. A., 1862, 93.

An eastern Thecla, not before reported west of Ohio. Rare in Jefferson and Decatur counties. Food plant, oak.

57. (331.) THECLA HUMULI, Harr. The Hopvine Thecla. The Gray Hair-streak.
*Thecla humuli*, Harris, Ins. Inj., 1862, 276, pl. IV, fig. 3.
French, Sev. Rep. St. Ent., Ill., 1878, 157.
Id., But. E. U. S., 1886, 259.
Packard, Guide, 1883, 265.
*Thecla favonius*, Morris, Lep. N. A., 1862, 95.

*Thecla hyperici*, Morris, Lep. N. A., 1862, 94.
*Uranotes melinus*, Scudder, But. E. U. S. and Can., 1889, II, 850; III, pls. 6, 14, 23, 65, 75, 84.

Throughout the State, but rather scarce. The larvæ feed upon the hop, bean and thorn, and the butterfly frequents the vicinity of these plants from May to September.

58. (339.) THECLA EDWARDSII, Saunders. Edward's Thecla.
*Thecla edwardsii*, French, But. E. U. S., 1886, 261.
Scudder, But. E. U. S. and Can., 1889, II, 892; III, pls. 6, 24, 65, 75, 84.
*Thecla falacer*, Harris, Ins. Inj., 1862, 276.

Found up to the present only in the northern part of, but probably exists throughout the State. Scarce. Food plant, hawthorne and oak.

59. (341.) THECLA CALANUS, Hub. The Oak Thecla. The Banded Hair-streak.
*Thecla calanus*, French, But. E. U. S., 1886, 263, fig. 73.
Blatchley, Hoos. Nat., II, 1886, 62.
Scudder, But. E. U. S. and Can., 1889, II, 885; III, pls. 6, 14, 24, 65, 75, 84.
*Thecla falacer*, Morris, Lep. N. A., 1862, 95.

This is our most common Thecla and is found in all parts of the State. The larvæ feed upon the various species of oak, and hibernate, the imago emerging from chrysalid in June and July.

60. (343.) THECLA STRIGOSA, Harr. The Streaked Thecla. The Striped Hair-streak.
*Thecla strigosa*, Harris, Ins. Inj., 1862, 276.
Morris, Lep. N. A., 1862, 101.
Edwards, But. N. A., I, 1869, 146, pl. 48.
French, Sev. Rep. St. Ent. Ill., 1878, 157.
Id., But. E. U. S., 1886, 266, fig. 74.
Packard, Guide, 1883, 267.
Blatchley, Hoos. Nat., II, 1886, 62.
*Thecla liparops*, Scudder, But. E. U. S. and Can., 1889, II, 877; III, pls. 6, 24, 65, 75, 84.

All over the State, but found only in small numbers in the counties in which it has been taken. Food plants, oak, apple and willow. There is but one brood each season, the butterflies appearing about July 10.

61. (355.) THECLA SMILACIS, Bd.-Lec. The Auburn Thecla. The Olive Hair-streak.
*Thecla smilacis*, Morris, Lep. N. A., 1862, 98.
French, But. E. U. S., 1886, 268.

*Thecla auburniana*, Harris, Ins. Inj. 1862, 277
*Thecla aubumiana*, Morris, Lep. N. A., 1862, 101.
*Mitura damon*, Scudder, But. E. U. S. and Can., 1889, II, 861; III, pls. 6, 23, 65, 75, 84.

Lake County. Rare. (Worthington.) Food plant, the red cedar, *Juniperus Virginiana*, Linn., about which the imago is almost always found. There are two broods each season which appear in May and August, respectively.

62. (357.) THECLA POEAS, Hub. The Least Purple Hair-streak.
*Thecla poeas*, Morris, Lep N. A., 1862, 103.
French, But. E. U. S., 1886, 270.
Blatchley, Hoos. Nat. II, 1886, 62.
*Calycopis cecrops*, Scudder, But E U. S. and Can., 1889, III, 1821.

This, one of the prettiest of the Theclas, is southern in its range and rare in our State. A single specimen was taken by the writer from an oleander bush, in Monroe County, August 17, 1890. Mr. Edwards has also received it from Indiana, but is unable to give the locality. Food plant, unknown, but probably one of the species of huckleberry, *Vaccinium*, of which two or three kinds grow in Monroe County.

63. (367.) THECLA HENRICII, Gr.-Rob. The Plum Thecla. The Hoary Elfin.
*Thecla henricii*, French, But. E. U. S., 1886, 273.
*Incisalia irus*, Scudder, But. E. U. S. and Can., 1889, II, 835; III, pls. 6, 23, 65, 75, 85.

This species, which, according to Edwards, has been previously recorded only from West Virginia and Maine, has been taken in Jefferson County by Mr. Hubbard. The larvæ feed upon wild plum, and the perfect insects, appearing about May 1, frequent the flowers of the red bud, *Cercis Canadensis*, Linn., and the borders of sandy roads.

64. (376.) THECLA TITUS, Fab. The Wild Cherry Thecla. The Coral Hair-streak.
*Thecla titus*, French, But. E. U. S., 1886, 278.
Blatchley, Hoos. Nat., II, 1886, 62.
*Strymon titus*, Scudder, But. E. U. S. and Can., 1889, II, 809; III, pls. 6, 23, 65, 75, 84.
*Thecla mopsus*, Harris, Ins. Inj., 1862, 278.
Morris, Lep. N. A., 1862, 102.
Mead, Rep. Wheeler Exp., V., 1875, 779.
Packard, Guide, 1883, 266.

In all parts of the State, but scarce where found. It is one of the handsomest and largest members of the genus. Food plant, wild cherry. It passes the winter in the egg state, and flies as imago during July and August, frequenting the flower of golden rod, milkweed and thistle.

## FENISECA, Grote.

65. (377.) FENISECA TARQUINIUS, Fab. The Wanderer.
*Feniseca tarquinius*, French, But. E. U. S., 1886, 279.
Scudder, But. E. U. S. and Can., 1889, II, 1016; III, pls. 5, 25, 34. 43, 65, 84.
*Polyommatus cratægi*, Morris, Lep. N. A., 1862, 85.

Taken only in Jefferson County, where it is rare, but should occur all over the State. The larvæ are remarkable for their carnivorous habits, as they feed only upon plant lice or aphids, and are especially fond of the species of these insects which frequent the common alder, *Alnus incana*, Willd. Hence the butterfly is most often found in the vicinity of streams, along the banks of which the alder grows. It is on the wing at intervals from May 15 to mid-September, as there are three broods each season.

## CHRYSOPHANUS, Doubleday.

66. (385.) CHRYSOPHANUS THOE, Bd.-Lec. The Thoe Butterfly. The Bronze Copper.
*Polyommatus thoe*, Morris, Lep. N. A., 1862, 84.
*Chrysophanus thoe*, French, Sev. Rep. St. Ent. Ill., 1878, 158.
Id., But. E. U. S., 1886, 281.
Packard, Guide, 8th Ed., 1883, 264.
Blatchley, Hoos. Nat., II, 1886, 62.
Scudder, But. E. U. S. and Can., 1889, II, 977; III, pls. 5, 25, 65, 84.

This handsome species is rare where found, and has been taken in four widely separated counties. There are two broods each season which emerge in June and August. The butterfly is to be found in low meadows and about the borders of ponds. The food plant is curled dock, *Rumex crispus*.

67. (391.) CHRYSOPHANUS EPIXANTHE, Bd.-Lec. The Epixanthe Butterfly. The Purple Disk.
*Lycaena epixanthe*, Harris, Ins. Inj., 1862, 274.
*Polyommatus epixanthe*, Morris, Lep. N. A., 1862, 85.
*Chrysophanus epixanthe*, French, But. E. U. S., 1886, 282.
*Epidemia epixanthe*, Scudder, But. E. U. S., and Can., 1889, II, 985; III, Pls. 5, 25, 65, 79.

Lake County. Rare. Probably throughout the northern half of the State. It is single brooded, the butterflies emerging in June and July, when they are found only in the vicinity of cranberry bogs and peaty meadows.

68. (392.) CHRYSOPHANUS HYPOPHLEAS, Bd. The American Copper Butterfly.

*Polyommatus hypophleas,* Morris, Lep. N. A., 1862, 84.
*Chrysophanus hypophleas,* French But E. U. S., 1886, 283, figs. 75–77.
Blatchley, Hoos. Nat., II, 1886, 62.
*Heodes hypophlæas,* Scudder, But. E. U. S. and Can., 1889, II, 998; III, pls. 5, 13, 25, 65, 75, 84.
*Lycæna americana,* Harris, Ins. Inj., 1862, 273; fig. 104.
*Polyommatus americana,* Morris, Lep. N. A., 1862, 91.
*Chrysophanus americana,* French, Sev. Rep. St. Ent. Ill., 1878, 158.
Packard, Guide, 1883, 264.
*Polyommatus phlæas,* Morris, Lep. N. A., 1862, 84.

Quite common in the Lower Wabash Valley, but rare in the northern and eastern parts of the State. It flies from May 1st to October, and is most often met with in lowland meadows or along sandy roadsides, where in small parties of two to four it flits close to the ground, stopping ever and anon to rest upon a blade of grass or to sip the moisture from the margin of a puddle left by some recent rain. The larvæ feed upon a small dock, known as sheep sorrel, *Rumex acetosella.*

## LYCÆNA, Fabricius.

69. (432.) LYCÆNA PSEUDARGIOLUS, Bd.-Lec. The Azure Blue Butterfly.

*Polyommatus pseudargiolus,* Harris, Ins. Inj., 1862, 274, text. (*neglecta,* Edw.).
*Argus pseudargiolus,* Morris, Lep. N. A., 1862, 82 (*pseudargiolus,* Bd.).
*Lycæna pseudargiolus,* Edw., But. N. A., I, 1869, 153, pl. 50 (*pseudargiolus*).
Id., But. N. A., II, 1884, 315, pls. 50, 51. (All forms.)
Mead, Rep. Wheeler Exp., V. 1875, 785 (*violacea,* Edw.).
French, Sev. Rep. St. Ent. Ill., 1878, 158.
Id., But. E. U. S., 1886, 286, figs. 78–80. (All forms.)
Blatchley, Hoos. Nat., II, 1886, 62.
*Cyaniris pseudargiolus,* Scudder, But. E. U. S., II, 927; III, pls. 6, 13, 24, 65, 75, 84.

| | |
|---|---|
| *Lycæna neglecta,* | Edwards, But. N. A., I, 1869, 155, pl. 50 (*neglecta*). |
| | Packard, Guide, 1883, 265. |
| | Mead, Rep Wheeler Exp., V. 1875, 786. |
| *Lycæna violacea,* | Edw., But. N. A., I, 1868, 149, pl. 49. |
| *Lycæna lucia,* | Harris, Ins. Inj., 1862, 275, fig. 106 (*lucia*, Kirby). |
| *Polyommatus lucia,* | Morris, Lep. N. A., 1862, 90. |

Four forms of this variable and much described species are found in Indiana, three of which, viz., *pseudargiolus*, Bd.-Lec., *neglecta*, Edw., and *violacea*, Edw., are found throughout the State, while *lucia*, Kirby, has been taken only in Lake County. Of the four, *violacea*, which flies in early spring, and *neglecta*, in late summer, are the most common.

The black male, var. *nigra* of *violacea*, has been taken by the writer in Wabash County, but is not reported elsewhere. *Pseudargiolus* is said by Worthington not to occur in Lake County, and when found in other parts of the State is comparatively rare.

All these forms have essentially the same habits, and are seldom found except in low, shady places, and especially in the vicinity of small streams. *Violacea* winters in the pupa state, and Mr. Edwards has given a pleasing description of its habits, as follows: "By the 3d or 4th of April we usually have one or two very warm days, the mercury at 80°, and then these little butterflies swarm along the sunny sides of creeks, gathering in clusters as close as they can stand, in favorite spots, motionless, with wings erect and closed, wholly intent in extracting from the sand some fluid, no doubt delightful. These are all males, for the females do not appear until some days after, or about the 10th. By this time the peach trees are in full bloom and the females are especially attracted to them. But, as a general thing, this species is not partial to flowers." The larvæ feed upon various plants, chief among which are *Actinomeris*, *Cornus* or dogwood, and *Cimicifuga*, or black snake root.

70. (434.) LYCÆNA COMYNTAS, Godt. The Comyntas Butterfly. The Tailed Blue.

| | |
|---|---|
| *Polyommatus comyntas,* | Harris, Ins. Inj., 1862, 275. |
| | Morris, Lep. N. A., 1862, 83. |
| *Lycæna comyntas,* | Mead, Rep. Wheeler Exp., V. 1875, 783. |
| | French, Sev. Rep. St. Ent. Ill., 1878, 158. |
| | Id., But. E. U. S., 1886, 292, fig. 81 |
| | Packard, Guide, 1883, 265. |
| | Blatchley, Hoos. Nat., II, 1886, 62. |
| *Everes comyntas,* | Scudder, But. E. U. S. and Can., 1889, II, 911; III, pls. 6, 14, 24, 65, 75, 84. |

Very common from June to September, collecting with *Colias philodice* and the two species of *Phyciodes* about muddy spots in the roads. Also, often found in fields of clover, upon which plant the larvæ feed, or along dry hillsides, where grow the other food plants, species of *Desmodium* and *Lespedeza.*

## HESPERIDÆ.

### ANCYLOXYPHA, Felder.

71. (448.) ANCYLOXYPHA NUMITOR, Fab. The Bordered Skipper. The Least Skipper.

*Pamphila numitor*, Morris, Lep. N. A., 1862, 120.
*Ancyloxypha numitor*, French, But. E. U. S., 1886, 301.
Blatchley, Hoos. Nat., II, Dec., 1886, 62.
Scudder, But. E. U. S. and Can., 1889, II, 1558; III, pls. 10, 13, 29, 66, 73.
*Heteropterus marginatus*, Harris, Ins. Inj., 1862, 308, fig. 131.

This, the smallest species of *Hesperidæ*, is a very common butterfly from mid-June until October. It is found hovering among the tall grasses and sedges which grow along the margins of ditches and ponds. There are three broods each season, and chrysalids from the last one hibernate.

### THYMELICUS, Speyer.

72. (455.) THYMELICUS POWESHIEK, Park.

*Thymelicus poweshiek*, French, But. E. U. S., 1886, 301.
*Oarisma poweshiek*, Scudder, But. E. U. S. and Can., 1889, III, 1859.

A Western species, not before recorded east of Illinois. It occurs in small numbers about Whitings, Lake County.

### PAMPHILA, Fabricius.

This genus of butterflies, which outranks all others in point of numbers, is represented in Indiana by twenty-two known species, the majority of which occur throughout the State.

Many species are usually overlooked by tyro collectors, as they are small in size, dull in color, and are usually seen at rest rather than in active motion. When disturbed, they fly low and but a short distance at a time, moving with a peculiar jerking flight similar to that of the *Neonymphas.* In repose the hind wings, instead of being folded above the body, are spread horizontally and meet the fore ones, which are also held in a peculiar position, so as to form a right angle.

But few are to be found before June 1, but about that time certain species become common among the tall, rank grasses and sedges which grow in damp places and upon which most of the larvæ feed. Others are found abundantly in clover fields, and later on the flowers of thistles, ironweeds, marigolds, and other showy *Compositæ* attract them in large numbers.

73. (456.) PAMPHILA MASSASOIT, Scudd. The Mulberry Wing.
*Pamphila massasoit*, French, But. E. U. S., 1886, 302.
*Poanes massasoit*, Scudder, But. E. U. S. and Can., 1889, 1597; III, pls. 10, 29, 37.

Ranges from New England to Nebraska, but noted in Indiana only in Lake County, where it is rare.

74. (457.) PAMPHILA ZABULON, Bd.-Lec. The Zabulon Skipper. The Mormon.
*Pamphila zabulon*, Morris, Lep. N. A., 1862, 116.
French, But. E. U. S., 1886, 303, figs 82, 83.
Blatchley, Hoos. Nat., II, December, 1886, 62.
*Atrytone zabulon*, Scudder, But. E. U. S. and Can., II, 1617; III, pls. 10, 13, 30, 66, 77. (All forms.)

74. (a.) PAMPHILA ZABULON HOBOMOK, Harris. Hobomok Skipper.
*Hesperia hobomok*, Harris, Ins. Inj., 1862, 313, fig. 137.
Morris, Lep. N. A., 1862, 110.
Packard, Guide, 1883, 269.
*Pamphila zabulon hobomok*, French, But. E. U. S., 1886, 303.

74. (b.) PAMPHILA ZABULON QUADRAQUINA, Scudder.
*Pamphila zabulon quadraquina*, French, But. E. U. S., 1886, 304.
Blatchley, Hoos Nat., II, December, 1886, 62.

A variable and common species. The three varieties, whose synonymy is given above, are found in Indiana. Of these *zabulon* is by far the most common. Var. *hobomok* has been taken only in Decatur County. This is the first Pamphila to be seen in spring in Central Indiana, numerous specimens of *zabulon* having been taken from the flowers of violets on May 15, 1891. The female form *quadraquina* was seen a week later.

75. (466.) PAMPHILA SASSACUS, Harris. The Sassacus Skipper.
*Hesperia sassacus*, Harris, Ins. Inj., 1862, 315.
Morris, Lep. N. A., 1862, 110.
*Pamphila sassacus*, French, Sev. Rep. St. Ent. Ill., 1878, 159.
Id., But. E. U. S., 1886, 305.
*Erynnis sassacus*, Scudder, But. E. U. S. and Can., 1889, II, 1641; III, pls. 10, 30, 66, 73.

A common species in the northern part of the State, but not found as yet in the southern. The larvæ feed upon crab grass, *Panicum sanguinale*, and the butterfly may be taken during June and the first half of July.

76. (491.) PAMPHILA HURON, Edw. The Huron Skipper. The Sachem.

*Pamphila huron*, French, Sev. Rep. St. Ent. Ill., 1878, 159.
Id., But. E. U. S., 1886, 312.
Blatchley, Hoos. Nat., II, December, 1886, 62.
*Atalopedes huron*, Scudder, But. E. U. S., II, 1661; III, pls. 17, 31, 77, 85.

A fairly common Pamphila throughout the State. On October 28, 1890, a large number were taken by the fingers from the heads of thistles. They seemed to be in a comatose condition, although the day was quite warm and pleasant. It is triple brooded, the imagoes appearing in May, July and September.

77. (493.) PAMPHILA PHYLÆUS. Drury. The Fiery Skipper.

*P. phylæus*, Morris, Lep. N. A., 1862, 118.
French, But. E. U. S., 1886, 313.
*Hylephila phylæus*, Scudder, But. E. U. S. and Can., 1889, II, 1630; III. pls. 17, 30, 77, 85.

A southern species, which in Indiana has been taken only in Jefferson County.

78. (499.) PAMPHILA OTHO EGEREMET, Scudd. The Otho Skipper.

*Pamphila otho*, French, Sev. Rep. St. Ent. Ill., 1878, 160.
*Pamphila otho egeremet*, French, But. E. U. S., 1886, 316.
Blatchley, Hoos. Nat., II, Dec. 1886, 62.
*Thymelicus ætna*, Scudder, But. E. U. S. and Can., 1889, II, 1696; III, pls. 10, 31, 77, 85.

In all parts of the State, but scarce and variable.

With us it flies from June 20 till mid-September, and frequents low, open meadows and roadsides.

79. (500.) PAMPHILA PECKIUS, Kirby. Peck's Skipper. The Yellow Spot.

*Hesperia peckius*, Harris, Ins. Inj., 1862, 315, fig. 139.
*Pamphila peckius*, French, Sev. Rep. St. Ent. Ill., 1878, 160.
Id., But. E. U. S., 1886, 317; fig. 84.
Blatchley, Hoos. Nat., II., Dec. 1886, 62.
*Polites peckius*, Scudder, But. E. U. S., 1889, II, 1683; III, pls. 10, 13, 31, 66, 80.
*Pamphila peckii*, Morris, Lep. N. A., 1862, 120.
*Hesperia wamustta*, Harris, Ins. Inj., 1862, 318, fig. 141.
Morris, Lep. N. A., 1862, 111.
Packard, Guide, 1883, 270.

The most common species of *Pamphila* throughout the State, and the one most frequently found in upland woods on the flowers of *Compositæ*. It flies from June till October, and winters as chrysalis or mature larva.

80. (504.) PAMPHILA CERNES, Bd.-Lec. The Cernes Skipper.
*Pamphila cernes*, French, Sev. Rep. St. Ent. Ill., 1878, 160.
Id., But. E. U. S., 1886, 320.
Blatchley, Hoos. Nat., II, 1886, 62.
*Hesperia ahaton*, Harris, Ins. Inj., 1862, 317, fig. 140.
Morris, Lep. N. A., 1862, 111.
*Pamphila origenes*, Morris, Lep. N. A., 1862, 117.
*Pamphila thaumas*, Morris, Lep. N. A., 1862, 119.
*Pamphila arogos*, Morris, loc. cit., 1862, 118.
*Limochores taumas*, Scudder, But. E. U. S., 1889, II, 1725; III, pls. 10, 13, 32, 66, 77, 85.

Next to the preceding in abundance, and one of the prettiest of the genus. In this State it is on the wing from May 25 until October, and frequents open woods where flowers abound.

81. (505.) PAMPHILA MANATAAQUA, Scudd. The Cross Line Skipper.
*Pamphila manataaqua*, French, Sev. Rep. St. Ent. Ill., 1878, 160.
Id., But. E. U. S., 1886, 323.
*Limochores manataaqua*, Scudder, But. E. U. S. and Can., II, 1720; III, pls. 10, 32, 66, 73.
*Hesperia cernes*, Harris, Ins. Inj., 1862, 316.

Very common in the northern part of the State, but much less so in the southern, where it has been taken only in Vigo County.

82. (506.) PAMPHILA VERNA, Edw. The Vernal Skipper. The Little Glass Wing.
*Pamphila verna*, French, But. E. U. S., 1886, 324.
*Euphyes verna*, Scudder, But. E. U. S. and Can., II, 1742; III, pls. 10, 31, 66, 77.

Edwards records this species from Indiana, but gives no locality. It has been taken by Worthington in Lake County. Otherwise unknown in the State.

83. (507.) PAMPHILA VESTRIS, Bd.
*Hesperia vestris*, Morris, Lep. N. A., 1862, 109.
*Pamphila vestris*, French, But. E. U. S., 1886, 325.

Two males of this species are in the writer's collection, one of which was taken in Monroe, the other in Putnam County, both in the month of August, from the flowers of ironweed. One was sent to Edwards for verification, as it had been taken before only in California, Colorado and Florida.

84 (508.) PAMPHILA METACOMET, Harris. The Metacomet Skipper.
*Hesperia metacomet*, Harris, Ins. Inj., 1862, 317.
Morris, Lep. N. A., 1862, 111.
*Pamphila metacomet*, French, Sev. Rep. St. Ent. Ill., 1878, 161.
Id., But. E. U. S., 1886, 326.
Blatchley, Hoos. Nat., II, Dec., 1886, 62.
*Euphyes metacomet*, Scudder, But. E. U. S. and Can., II, 1739; III, pls. 10, 31, 66.

Taken occasionally in all parts of the State, but scarce where found. The spots on the under side of the hind wing are wanting more often than they are present.

85. (510.) PAMPHILA ACCIUS, Sm.-Abb. The Accius Skipper. The Clouded Skipper.
*Pamphila accius*, French, But, E. U. S., 1886, 327.
Blatchley. Hoos. Nat., II, December, 1886, 62.
*Lerema accius*, Scudder, But. E. U. S. and Can., II, 1768; III, pls. 17, 32, 66, 77, 85.

This is a species of southern range. It was taken by the writer in Monroe County on July 3, 1886, two worn specimens being secured.

86. (517.) PAMPHILA OCOLA, Edw. The Ocola Skipper.
*Pamphila ocola*, French, But. E. U. S., 1886, 332.
*Prenes ocola*, Scudder, But. E. U. S. and Can., 1889, III, p. 1866.

Recorded by Edwards as occurring at Whitings, Lake County, where Worthington has found it in small numbers.

87. (523) PAMPHILA BIMACULA, Gr.-Rob. The Bright Rayed Skipper.
*Pamphila bimacula*, French, But. E. U. S. 1886, 334.
*Limochores bimacula*, Scudder, But. E. U. S. and Can., II, 1718; III, pls. 10, 32.

Rather common in the northern part of the State, but not known to occur in the southern half. The butterflies may be taken on the wing during July and August, and are most frequently found in low, damp meadows.

88. (524.) PAMPHILA PONTIAC, Edw. The Pontiac Skipper. The Black Dash.
*Pamphila pontiac*, French, But. E. U. S., 1886, 335.
*Limochores pontiac*, Scudder, But. E. U. S. and Can., II, 1732; III, pls. 17, 32.

Taken in Jefferson and Lake counties, and, therefore, probably found throughout the State. It has a northern range, and Jefferson County is the most southern station at which it has been taken.

89. (525.) PAMPHILA DION, Edw. The Dion Skipper.

*Pamphila dion*, French, But. E. U. S., 1886, 337.

*Limochores palatka*, Scudder, But. E. U. S. and Can., 1889, III, p. 1863.

A northern butterfly recorded by Edwards, from Lake County, where it has been collected by Worthington.

90. (530.) PAMPHILA DELAWARE, Edw. The Delaware Skipper.

*Pamphila delaware*, French, But. E. U. S., 1886, 342.

*Atrytone logan*, Scudder, But. E. U. S. and Can., 1889, II, 1614; III, pls. 17, 30.

Noted in three widely separated counties, and probably it is to be found all over the State. Scarce.

91. (534.) PAMPHILA OSYKA, Edw. The Osyka Skipper.

*Pamphila osyka*, French, But. E. U. S., 1886, 345.

*Euphyes osyka*, Scudder, But E. U. S. and Can., 1889, III, p. 1865.

Recorded by Edwards, from Whitings, Lake County. Locality verified by Worthington, who reports it rare.

92. (538.) PAMPHILA FUSCA, Gr.-Rob. The Dusky Skipper.

*Pamphila fusca*, French, But. E. U. S , 1886, 346.

A single specimen taken by the writer, in Monroe County, was referred to this species, and the identification was verified by Mr. Edwards, to whom it was sent. It has hitherto been collected only in the Gulf States.

93. (540.) PAMPHILA HIANNA, Scudd. The Hianna Skipper. The Dusted Skipper.

*Pamphila hianna*, French, But. E. U. S., 1886, 347.

*Lerema hianna*, Scudder, But. E. U. S. and Can., 1889, II, 1771; III, pls. 17, 32, 66, 77, 85.

Lake County, Lagrange County. Rare. Not taken south.

94. (541.) PAMPHILA VIATOR, Edw. The Viator Skipper. The Broad-winged Skipper.

*Pamphila viator*, French, But. E. U. S., 1886, 347.

*Phycanassa viator*, Scudder, But. E. U. S. and Can., 1889, II, 1604; III, pls. 17, 30, 59.

Taken in Putnam and Lake Counties, but not elsewhere. Scarce. The habits and food plants are unknown.

## AMBLYSCIRTES, Speyer.

95. (542.) AMBLYSCIRTES VIALIS, Edw. The Roadside Skipper.
*Amblyscirtes vialis*, French, Sev. Rep. St. Ent. Ill., 1878, 161.
Id., But. E. U. S., 1886, 348.
Blatchley, Hoos. Nat., II, Dec., 1886, 62.
Scudder, But. E. U. S., 1889, II, 1582; III, pls. 10, 29, 66, 77, 85.

This neat little butterfly is frequent in the southern part of the State, but seems to be unknown in the northern. It is found from May 10 till September, along shady roads and fence rows, and is especially attracted by the flowers of ground ivy, *Nepeta glechoma*. The larvæ feed upon grass. There are often four anteapical dots on fore wings, instead of three, the number given in the descriptions cited above.

## PYRGUS, Westwood.

96. (554.) PYRGUS TESSELLATA, Scud. The Tessellated Skipper.
*Pyrgus tessellata*, French, Sev. Rep. St. Ent. Ill., 1878, 161.
Id., But. E. U. S., 1886, 352, fig. 86.
*Syrichthus oilus*, Morris, Lep. N. A., 1862, 121.
*Hesperia montivago*, Scudder, But. E. U. S. and Can., 1889, II, 1536; III, pls. 15, 29, 77, 85.

This species should occur throughout the State, but has been taken only in Vigo and Jefferson Counties in the southern half. It appears most common in late fall, when it is found about the borders of streams and thickets. The food plants are different species of the *Malvaceæ*, as hollyhock and Indian mallow, and the winter is supposed to be passed in chrysalis.

## NISONIADES, Speyer.

97. (561.) NISONIADES BRIZO, Bd.-Lec. The Brizo Skipper.
*Thanaos brizo*, Harris, Ins. Inj., 1862, 309, fig. 132.
Scudder, But. E. U. S. and Can., II, 1500; III, pls. 9, 13, 28, 77, 85.
*Nisoniades brizo*, Morris, Lep. N. A., 1862, 114.
French, But. E. U. S., 1886, 354.

Vigo and Lake counties. Probably throughout the State, but rare. Most commonly met with in midsummer and early fall in low ground meadows. The larvæ, according to Harris, feed upon leguminous plants, such as *Lathyrus*, or vetchling, and the ground nut, *Apios tuberosa*.

98. (562.) Nisoniades icelus, Lintn. The Dreamy Dusky Wing.
*Nisoniades icelus*, French, But. E. U. S., 1886, 355.
*Thanaos icelus*, Scudder, But. E. U. S. and Can., II, 1507; III, pls. 9, 28, 77, 85.

Frequent in the northern half of the State, but not yet taken in the southern. Habits same as preceding. Food plants, aspen, *Populus tremuloides*, and willow. It is single brooded and hibernates as a full fed larva in a nest which it forms from a leaf and lines with silk.

99. (564.) Nisoniades lucilius, Lintn. Lucilius's Dusky Wing.
*Thanaos lucilius*, French, Sev. Rep. St. Ent. Ill., 1878, 161.
Scudder, But. E. U. S. and Can., 1889, II, 1458; III, pls. 9, 28, 77, 82.
*Nisoniades lucilius*, French, But. E. U. S., 1886, 357.

Putnam and Lake counties. Scarce. Probably elsewhere as its food plant, *Aquilegia canadensis*, or wild columbine, is found in all parts of the State. It winters as larva and the imago may be taken from May to September.

100. (565.) Nisoniades persius, Scudd. Persius's Dusky Wing.
*Nisoniades persius*, Mead, Rep. Wheeler Exp., V, 1875, 786.
French, But. E. U. S., 1886, 359.
*Thanaos persius*, Scudder, But. E. U. S. and Can., 1889, II, 1468; III, pls. 9, 28, 66, 77, 85.

Known to occur only in Lake County, but is probably present throughout. Food plants, willow and poplar.

"The butterfly is fond of alighting on wet sand, and may most frequently be found by shady roadsides, near woods. It flies with a strong, rapid movement, especially when disturbed, and seldom passes from one spot to an adjacent one without describing several irregular, rapid circles. At such a time it rarely rises more than two or three inches above the ground."—Scudder.

101. (569.) Nisoniades martialis, Scud. Martial's Dusky Wing.
*Nisoniades martialis*, French, But. E. U. S, 1886, 362.
*Thanaos martialis*, Scudder, But. E. U. S. and Can., 1889, II, 1493; III, pls. 9, 28, 66, 77, 85.

A rather frequent species in most parts of the State. It may be taken in June and July, in high, open woods and copses.

102. (570.) Nisoniades juvenalis, Fab. Juvenal's Skipper.
*Thanaos juvenalis*, Harris, Ins. Inj., 1862, 309.
French, Sev. Rep. St. Ent. Ill., 1878, 162.
Scudder, But. E. U. S. and Can., II, 1476; III, pls. 9, 28, 77, 85.

*Nisoniades juvenalis*, Morris, Lep. N. A., 1862, 114.
French, But. E. U. S., 1886, 363.
Blatchley, Hoos. Nat., II, Dec. 1886, 62.

This seems to be the most common species of the genus within our limits, having been taken in all parts of the State. Its habits, and food plants, with the addition of oak, are essentially the same as those of *N. brizo*. It winters as larva, and there are two broods each season.

## PHOLISORA, Speyer.

103. (580.) PHOLISORA CATULLUS, Fab. The Sooty Wing.
*Nisoniades catullus*, Morris, Lep. N. A., 1862, 115.
*Pholisora catullus*, Mead, Rep. Wheeler Exp., V. 1875, 787.
French, Sev. Rep. St. Ent. Ill., 1878, 162.
Id., But. E. U. S., 1886, 367, fig. 87.
Blatchley, Hoos. Nat., II, Dec., 1886, 62.
Scudder, But. E. U. S. and Can., 1889, II, 1519; III, pls. 9, 29, 66, 77, 85.

Very common in the southern counties, but less so north. Its favorite resorts are the damp, sandy places along streams where it may be taken in numbers from May to September.

The number, position, and size of the white spots on the fore wings vary exceedingly. The larvæ feed upon the various species of *Monarda*, *Chenopodium* and *Ambrosia*, and those of the second brood of the season hibernate in nests which they form of a folded leaf.

104. (583.) PHOLISORA HAYHURSTII, Edw. The Southern Sooty-wing.
*Pholisora hayhurstii*, French, But. E. U. S., 1886, 367.
Scudder, But. E. U. S. and Can., 1889, III, 1857.

Most common in southern counties, but found in small numbers throughout. Its habits are the same as those of the preceding. Food plant, unknown, but probably pigweed, *Chenopodium album*.

## EUDAMUS, Swainson.

105. (588.) EUDAMUS PYLADES, Scud. The Northern Cloudy-wing.
*Eudamus pylades*, French, But. E. U. S., 1886, 368, fig. 88.
*Thorybes pylades*, Scudder, But. E. U. S. and Can., 1889, II, 1436; III, pls. 9, 13, 27, 66, 76, 85.
*Eudamus bathyllus*, Harris, Ins. Inj., 1862, 312, fig. 132.

Rather rare, but has been taken in four counties. It flies during June and July in meadows and along the edges of woods. Food plants are clover, ground-nut, etc.

106. (590). EUDAMUS BATHYLLUS, Sm.-Abb. The Southern Cloudy-wing.

*Hesperia bathyllus*, Morris, Lep. N. A., 1862, 106.
*Eudamus bathyllus*, French, Sev. Rep. St. Ent. Ill., 1878, 162.
Id., But. E. U. S., 1886, 369.
Packard, Guide, 1883, 269.
Blatchley, Hoos. Nat., II, 1886, 62.
*Thorybes bathyllus*, Scudder, But. E. U. S. and Can., 1889, II, 1432; III, pls. 17, 27, 66, 76, 85.

Also a rare species, but probably found throughout. It frequents fence rows and thickets from May 15 to September, and has been taken in Monroe, Randolph and Lake counties. The larvæ feed upon different species of *Leguminosæ*.

107. (595.) EUDAMUS LYCIDAS, Sm.-Abb. The Hoary Edge.

*Hesperia lycidas*, Morris, Lep. N. A., 1862, 106.
*Eudamus lycidas*, French, Sev. Rep. St. Ent. Ill., 1878, 162.
Id., But. E. U. S., 1886, 370.
Blatchley, Hoos. Nat., II, December, 1886, 63.
*Achalarus lycidas*, Scudder, But. E. U. S. and Can., 1889, II, 1418; III, pls. 9, 27, 66, 76, 85.

Rather frequent throughout. Most common in brier patches and along the border of woods. May to September. The larvæ feed upon *Desmodium* and allied plants, and the winter is passed in chrysalis.

108. (599.) EUDAMUS TITYRUS, Fab. The Tityrus Skipper. The Silver Spot.

*Eudamus tityrus*, Harris, Ins. Inj., 1862, 310, figs. 133, 134, pl. V, fig. 1.
French, Sev. Rep. St. Ent. Ill., 1878, 163.
Id., But. E. U. S., 1886, 374, figs. 89, 90.
Packard, Guide, 1883, 269.
Blatchley, Hoos. Nat., II, Dec. 1886, 62.
*Goniloba tityrus*, Morris, Lep, N. A., 1862, 112.
*Epargyreus tityrus*, Scudder, But. E. U. S. and Can., 1889, II, 1399; III, pls. 9, 15, 27, 76, 82, 85.

Common in all parts of the State. The larvæ feed upon the leaves of many leguminous plants, chief among which is the common locust, and the butterfly may usually be found near those trees, or hovering over some bright colored flower in yard or garden. Another favorite resort is a clump of blackberry bushes, about which it will flit for hours on a hot day in midsummer. In Indiana it is single brooded, and hibernates in the chrysalis. In the spring of 1891 the first specimen was taken May

10, and from that date onward it was frequently seen, even in the streets of the city of Terre Haute.

***

Collectors should be on the lookout for the following species whose range, according to Edwards, includes Indiana or territory adjacent to Indiana, but which have not as yet been taken within the State:

1. *Terias mexicana*, Bd. Taken in Iowa and Illinois.
2. *Melitœa harrisii*, Scudd. New England to Wisconsin.
3. *Phyciodes batesii*, Peak. Ohio.
4. *Phyciodes carlota*, Peak. Southern and Western States. W. Va.
5. *Grapta faunus*, Edw. Atlantic to Pacific. (Northern range.)
6. *Limenitis dissippus floridensis*, Str. Illinois.
7. *Neonympha sosybius*, Fab. Mississippi Valley.
8. *Calephelis borealis*, Gr.-Rob. New York to Illinois.
9. *Thecla acadica*, Edw. Northern States.
10. *Thecla irus*, Godt. Atlantic and Western States.
11. *Thecla niphon*, Hub. Atlantic and Western States.
12. *Thecla lœta*, Edw. Atlantic and Western States.
13. *Lycœna lygdamas*, Doubl. Michigan, Wisconsin to Georgia.
14. *Lycœna scudderii*, Edw. New York to Wisconsin.
15. *Lycœna striata*, Edw. Texas to Wisconsin.
16. *Carterocephalas omaha*, Edw. West Virginia to Colorado.
17. *Pamphila metea*, Scudd. New York to Colorado.
18. *Pamphila uncas*, Edw. Delaware to Dakota.
19. *Pamphila seminole*, Scudd. New York to Iowa.
20. *Pamphila leonardus*, Harr. New England to Kansas.
21. *Pamphila mystic*, Scudd. Wisconsin, Illinois and Michigan.
22. *Amblyscirtes samoset*, Scudd. Mississippi Valley.
23. *Pyrgus centaureœ*, Ramb. New York to Colorado.

JUNE 25, 1891.

# THE

# BATRACHIANS AND REPTILES

OF THE

# STATE OF INDIANA.

BY

OLIVER PERRY HAY, A. M., Ph. D.

# LETTER OF TRANSMITTAL.

IRVINGTON, IND., September 1, 1892.

PROF. S. S. GORBY, *State Geologist of Indiana.*

DEAR SIR—I herewith present to you my report on the Batrachia and Reptilia of the State of Indiana. In the body of this work I have endeavored to include all the species known to inhabit the State, and to exclude all that are not known to occur within our limits. Since, however, there are several species which are, judging from their geographical distribution, likely hereafter to be taken within the State, I have added their names in an appendix.

Of all the species mentioned in this report I have given as accurate descriptions as I have been able to prepare; and I have endeavored to state also the most important facts known regarding their habits. It is to be hoped that this endeavor will incite others to study our lower vertebrates with respect to their manner of life, since too little is known about even the commonest species.

I am indebted to many friends for aid in preparing this report, so many that I can not here mention all their names. Under each species I have tried to give due credit for specimens and notes. I must here, however, acknowledge the liberality of Dr. Leonhard Stejneger, Curator of Reptiles in the National Museum, Washington, D. C., in giving me free access to the large collections there; also the kindness of Prof. B. W. Evermann, who allowed me to examine a considerable collection made by himself, mostly in the vicinity of Terre Haute. This collection is the property of the State Normal School. To yourself I owe the opportunity to examine the specimens in the State Museum. Some years ago I had occasion to study a collection made at New Harmony by the late Mr. James Sampson, of that place. For the opportunity of doing this I am indebted to Prof. John Collett. The writings of Agassiz, Cope and other naturalists have been consulted in the earnest desire to obtain a correct idea of our batrachian and reptilian fauna. Nevertheless, I have at times doubtless fallen into error.

The following is a summary of the species of each group known to occur in Indiana:

| | | |
|---|---|---|
| Tailed Batrachians | 18 species. | |
| Tailless Batrachians | 12 species. | |
| Total Batrachians | | 30 species. |
| Snakes | 28 species. | |
| Lizards | 5 species. | |
| Turtles | 18 species. | |
| Total Reptiles | | 51 species. |
| Total of both classes | | 81 species. |

Thanking you for your many kindnesses, I am,

Yours sincerely,

O. P. HAY.

# THE BATRACHIANS AND THE REPTILES OF INDIANA.

On the part of people who have not made a scientific study of animals no distinction is made between the group of creatures here called *Batrachians* and that group called *Reptiles*. The amphiuma and the snakes, the salamanders and the lizards, the common toad and the turtles are all called "reptiles." Nor is this strange when we consider how closely members of both groups resemble one another in outward form and in habits. It is indeed only recently that zoölogists, who endeavor to found their systems on more important differences than appear on the outside, have agreed to regard the frogs, salamanders, and newts, as fundamentally different from the lizards, turtles, and snakes. In reality, the batrachians are more closely related to the fishes than to the reptiles, while the latter are more nearly akin to the birds. The batrachians form a class standing intermediate between the class of fishes and the class of reptiles.

Nevertheless, since zoölogists have almost universally associated the two classes in their works, and since people do not usually distinguish the one kind of animals from the other, they are here described together.

The batrachians differ from the reptiles in several important respects. The skin of the former is usually smooth and moist, sometimes raised up into warts, as in the toads, but never disposed in overlapping scales or regular plates. Scales and plates, such as are seen in the lizards and snakes, and tortoises, are almost universal among the reptiles. No Indiana reptile is without such a covering, except our soft-shelled turtles. The life-history of the members of the two groups is also widely different. The batrachians almost always lay their eggs in the water, and the young pass their early days there as tadpoles. They respire by means of gills until the time of their metamorphosis approaches, when lungs are developed, the gills are absorbed, and the animal leaves the water and lives to a greater or less extent on the land. Reptiles, on the contrary, lay their eggs on land, the young are hatched with the form of the adults, and they never have gills. A few batrachians retain their gills life-long, breathing both by means of these and their lungs. Other differences exist, but since their determination would require dissections, they are not thought suitable for consideration in a work of this kind.

Since the animals herein described are a source of discomfort and alarm to many people, it may be well to say here that of all the batrachians and reptiles known to inhabit Indiana, but four, the yellow-banded rattlesnake, the prairie rattlesnake, the coral snake, and the copperhead, are poisonous. It is possible that the poisonous southern moccasin, or cottonmouth, may yet be found in the southwestern part of the State; if so, we shall have five poisonous species, and five only.

### Key to the Classes.

A. Skin usually smooth and soft, sometimes rough and warty, never forming scales that overlap or are arranged in regular rows; eggs usually laid in the water and giving origin to tadpoles. (Water-dogs, salamanders, frogs and toads.) *Batrachia*, p. 413.

AA. Skin usually having epidermal scales or large regular plates; these usually arranged in a regular manner, often overlapping. Eggs laid on land. Young with form of adults. (Snakes, lizards, turtles, alligators, etc.) *Reptilia*, p. 481.

## BATRACHIA.

The Batrachia include a great variety of animals that are found living in all except the coldest parts of the earth and the salt water. As already stated, they are, with rare exceptions, hatched in the water, where they spend at least a portion of their lives. A few forms retain their gills throughout life, and seldom or never leave the water. In a few cases the eggs are laid on the land, under sticks and stones; the young from such eggs may have very rudimentary gills and consequently never enter the water. Such species closely approach, in their habits, the reptiles. The gills may be either internal or external; usually they are of the latter kind. The external gills are attached to processes of the skin, and not to the branchial arches. The internal gills of the tadpoles or frogs grow out from the branchial arches, as in fishes.

The skin of the batrachians is richly provided with glands. These secrete a milky fluid, which is often acrid, and sometimes poisonous to the enemies of the species producing it. It thus serves as a means of defense to these animals, which are otherwise almost helpless. Often the glands are collected into groups, as in the case of those on the back of the head of the common toad. In some species the skin forms a fin on the upper and lower sides of the tail; but in such fins there are no rays, such as are found in the fins of fishes.

When limbs are present they have the same skeletal elements as the limbs of reptiles and mammals. Some batrachians are devoid of limbs. All of our species have the anterior limbs present; most of them have also the posterior pair. The anterior limbs never have more than four fingers; the posterior may have five toes.

Not much can be said here regarding the skeleton. The vertebræ are usually either amphicœlous or opisthocœlous. Ribs are often absent; when present they do not connect with a sternum below. In the lower forms as many as four branchial arches may be present; in the higher species the number is reduced. There may be teeth on the maxillaries, premaxillaries, vomers, and dentaries; more rarely on the palatines, the pterygoids and the splenials. A band of teeth may be found in some cases supported by the parasphenoid. The teeth are almost always very simple in structure, pointed, and grown fast to the supporting bones.

Breathing is effected in the adult by drawing the air into the mouth through the nostrils, then closing these, contracting the cavity of the mouth, and thus forcing the air into the lungs. Hence, a frog may be suffocated by holding its mouth open.

For additional information on the anatomy of the Batrachia the student should consult Prof. Huxley's article, "*Amphibia,*" in the Encyclopedia Britanica; also for the Urodela, Dr. R. Wiedersheim's work, "*Kopfskelet der Urodelen.*"

The living species of Batrachia have been divided by Prof. E. D. Cope (*51*, 13) into four orders, viz: Proteida (*Necturus*), Urodela, Trachystomata (*Siren*), and Salientia. I prefer here to retain the genera *Necturus*, *Proteus* and *Siren* under the Urodela.

### Key to the Orders of *Batrachia*.

A. Limbs present or absent; when present, the hinder pair not much more strongly developed than the anterior. Tail developed or not; present in all our species. Animals fitted for creeping on or burrowing in the earth or for swimming in the water. *Urodela*, p. 414.

AA. All four limbs present and the hinder pair greatly developed. Tail wholly absent in the adult. Animal, when on land, usually progressing by leaping. *Salientia*, p. 456.

## Order URODELA.

Batrachia having a lizard-like, eel-like, or serpent-like form. All limbs, as well as the supporting girdles, absent in the extralimital *Cœcilidæ*. At least the fore limbs and the shoulder girdle present in all our forms; and usually also the hinder limbs. Posterior limbs never conspicuously larger than the anterior. Proximal elements of the tarsus not elongated. Vertebræ numerous, at least 14 in front of the sacrum; these either amphicœlous or opisthocœlous Ribs present, short. Maxilla present in all except *Necturus* and *Siren*. Teeth present on maxillaries, vomero-palatines, and on the dentaries, except in *Siren*. No tympanic cavities or eustachian tubes. Cloaca opening externally by a longitudinal slit.

The Urodela include about 133 species, distributed principally north of the equator. North America furnishes 54 species, 18 of which, at least, are found in Indiana.

The order as here defined contains 10 families. Of these, two, the Cœcilidæ and the Thoriidæ, are not natives of North America.

### KEY TO THE N. A. FAMILIES OF *Urodela*.

A. Maxillary bone wanting. External gills present at all times of life.

- a. Body eel-like. No posterior limbs. *Sirenidæ*, p. 416.
- aa. Body lizard-lke. Two pairs of limbs. *Proteidæ*, p. 418.

AA. Maxillary bone present. No gills in the adult state. All four limbs present.

- a. Body extremely elongated. Both pairs of limbs very rudimentary. *Amphiumidæ*, p. 420.
- aa. Body lizard-like. Anterior and posterior limbs well developed.
  - b. A branchial slit on each side of the neck. Vomero-palatine teeth close to and parallel with those of the premaxillaries and maxillaries. *Cryptobranchidæ*, p. 423.
  - bb. No branchial slits on the side of the neck. Vomero-palatine teeth considerably behind the premaxillary teeth.
    - c. Parasphenoidal teeth present, forming two brush-like bands along the roof of the mouth. *Plethodontidæ*, p. 439.
    - cc. No parasphenoidal teeth.
      - e. Vomero-palatine teeth in a transverse row between, or just behind, the choanæ. *Ambystomatidæ*, p. 425.
      - ee. Vomero-palatines in two longitudinal rows along roof of the mouth, on two prolongations backward of the vomers. *Salamandridæ*, p. 452.

## Family I. SIRENIDÆ.

Body elongated, eel-like. Posterior limbs wanting; the anterior moderately developed, with three or four fingers. External gills present during whole of life. One to three branchial slits on each side of the neck. Premaxillaries and dentaries without teeth, and covered with a horny sheath. Teeth on the splenials. Vomers provided with teeth, which form two converging patches on the roof of the mouth. No maxillaries present. Contains two genera, each embracing a single species, both confined to North America.

### KEY TO THE GENERA OF *Sirenidæ*.

A. Fingers four; branchial slits usually three. *Siren*, p. 416.
AA. Fingers three; branchial slit one. *Pseudobranchus*.

*Pseudobranchus* has not been found north of Georgia and Florida.

### Genus SIREN, Linnæus.

*Siren*, Linnæus, 1765, *95*; i, 311; Boulenger, 1882, *28*, 86; Cope, 1889, *51*, 225.

Hand with four fingers. Jaws with horny sheath. Vomerine patches of teeth broad. Tongue broad, free in front. External gills and branchial slits, three. Eyes distinct, but without lids.

### **Siren lacertina**, Linn.

*Mud-eel. Siren.*

*Siren lacertina*, Linnæus, 1765, *95*, i, 311; Holbrook, 1842, *54*, v. 101, pl. 34; Boulenger, G. A., 1882, *28*, 87; Cope, E. D., 1889, *51*, 226; Barton, B. S., 1821, *40*.

Body long, slender, nearly cylindrical; about twelve times as long as the head is broad. Head flat above, sides tapering to the blunt snout, which overhangs the mouth. Gill slits three. External gills three pairs; but these appear to be abortive in the young up to six inches in length. Eyes small, without eyelids. Premaxillaries distinct, toothless, covered with a black horny sheath. Vomers and palatines distinct, each with several rows of small teeth. Dentaries also toothless, and covered with a black horny sharp-edged sheath. Teeth on splenials (just below hinder ends of dentary sheath). Tongue free on sides and in front.

Anterior limbs well developed, short, furnished with four digits each. No trace of hinder limbs. Body and tail crossed by numerous furrows; about thirty of these from fore legs to vent. Tail compressed, with a fin above and below; its length somewhat more than one-third the total length, terminating in a sharp point.

Color a bluish black, paler below. Sides of head sometimes with a yellow band from muzzle to gills.

The length attained may be as great as thirty to forty inches.

Distribution from North Carolina west to Mexico, and up the Mississippi Valley to Alton, Ill., and Lafayette, Ind.

Indiana localities: New Harmony (Sampson's coll.); Mt. Carmel, (Nat. Mus. coll.); Terre Haute (B. W. Evermann); Lafayette (S. Coulter); Washington, Daviess County (C. H. Gilbert).

Habits.—One of the earliest and best accounts that we have of the habits of this curious animal was given by Dr. B. S. Barton, of Philadelphia, in a letter addressed to John Gottlob Schneider, the author of "Historia Amphibiorum." Schneider and some other authors supposed that the *Siren* was only the larva of some yet undiscovered salamander. Barton argues against this notion with ability. He states that the favorite resorts of the *Siren* are the rice ponds and the adjacent muddy grounds. It sometimes attains a length of 20, 30, or even 40 inches. Where it abounds it is, according to Barton, called "Alligator" and "Water-lizard." He kept one for almost a year, and experimented with it. During this time, it underwent little or no change in either size or condition of its branchiæ. While in the water, the gills are incessantly in motion. The animal appears to depend only partially on its gills for oxygen, since various observers have noted its coming frequently to the surface for air. Barton says that in warm weather it comes to the surface every five minutes, while in colder weather it comes up about every fifteen minutes. It has the power to remain under water for more than an hour at least. It appears to spend a good portion of its time burrowing in the mud of swamps. Barton thinks that it sometimes travels overland, although its movements on land are slow. An earlier observer, Garden, who corresponded with Linnæus, declares that the *Siren* may crawl up on the trunks and limbs of fallen trees, likewise that it sings with a querulous voice similar to that of a young duck. This idea gave origin to the name *Siren*. It possibly emits a shrill, somewhat hissing tone like that of the Amphiuma. Barton appears to think that the *Siren* can take water into the mouth through the nostrils; an interesting observation in view of the fact that some salamanders do the same as a means of breathing. Cope (*51*, 224) has recorded his observation that in small specimens the branchiæ are rudimentary and apparently functionless, and that it is only in the adult individuals that the gills are fully developed.

Linnæus affirms that the *Siren* lives on serpents which it catches and holds with its strong teeth. Barton doubts this, but considering the great voracity of the Batrachia in general, and the large size reached by some of the *Sirens*, it appears quite reasonable. Their teeth, however, are not "strong." Barton fed his specimen on angleworms, pieces of meat, etc. It takes its food with "inconceivable rapidity." It can endure hunger for long periods. The one kept by Barton was exposed for several days in water at a temperature of 33° or 34° F., and for a few hours was "locked up, as it were, in the ice."

Holbrook (*54*, v. 101) says that this animal lives chiefly in the mud, but this they sometimes leave and take to the water, in which they swim with great swiftness. He says too that they are sometimes found on the land, but he did not know why they go there.

So far as I am aware, nothing is known concerning the breeding habits of this species. It is so rare in our State that few opportunities are likely to be offered to any observer to study such habits. This will have to be done in the South, where it abounds. I have not seen mention made of specimens having been found of less than three inches in length. Specimens of this size are very desirable.

## Family II. PROTEIDÆ.

Body lizard-like in form; limbs, four; external gills, three pairs, present during whole of life; maxillaries, absent; teeth on premaxillaries, vomers, palato-pterygoids, and dentaries.

Only the genus *Necturus* is found in North America. *Proteus* is an inhabitant of the subterranean waters of Austria.

### Genus NECTURUS, Rafinesque.

Rafinesque, 1819, *97*, 417; Boulenger, 1882, *28*, 84; Cope, 1889, *51*, 23.

Fingers 4; toes 4; permanent branchial slits 2 pairs; eyes exposed; tongue large; vomero-palatine teeth strong, in a single row; tail broad and compressed.

Premaxillary teeth 11–15; vomerines 12–16; spotted. *maculatus*, p. 418.

Premaxillary teeth 6–8; vomerines 8–9; no spots. N. C., S. C. *punctatus*.

### **Necturus maculatus**, Raf.

*Water-Dog; Gilled Salamander.*

*Necturus maculatus*, Rafinesque, 1819, *97*, 417; Boulenger, 1892, *28*, 84; Cope, E. D., 1889, *51*, 23, with figures.

*Triton lateralis*, Say, 1823, *14*, 5.

*Menobranchus lateralis*, Harlan, 1825, *62*, i, 221; Holbrook, 1842, *54*, 115, pl. 38.

*Necturus lateralis*, Wagler, 1830, *75*, 210.

Body moderately elongated, thick, cylindrical or moderately depressed, and with a distinct dorsal groove. Head broad and flat. Snout rounded. Labial folds well developed. A distinct gular fold. Eyes small. The two series of teeth in the upper jaw near to, and parallel with, one another. Premaxillary series short; the vomero-palatine series extending back to the corner of the mouth. The mouth is large and extends backward to under the eyes. Nostrils in the edge of the lips. Head contained in the distance to the vent about five times; three-fourths as wide as long. Costal folds usually 14. Tail broad and compressed, one-third the total length. Limbs well developed. Digits 4–4.

Skin smooth and furnished with numerous follicles.

Color ashy brown, palest below, and more or less mottled and spotted with blackish, especially above. Young specimens with a lateral dark band from the snout to the tail. Gills bushy, and in life bright red.

Prof. Cope (*51*, 26) mentions specimens from Ontario which were entirely black.

This species reaches a length of 24 inches or more.

This is a widely distributed animal in Eastern North America, and in places it is very abundant. It is recorded from the territory extending from Montreal to Alabama, west to Wisconsin, Kansas, W. Arkansas, and Louisiana.

It will no doubt be found in all parts of Indiana, but it is very common in the numerous lakes of the northern portion of the State. I have record of it from Lafayette (S. Coulter); Mt. Carmel, Ill. (National Museum); New Harmony (Sampson's coll.); Monroe County (Ind. Unv. coll.); Franklin County (Hughes). I have found it common at Lake Maxinkuckee, Marshall County. Prof. Blatchley reports it as very common at Terre Haute. Of 19 specimens sent me by Prof. Evermann more than half had the gills very short or almost wholly gone.

HABITS.—This species appears to be wholly aquatic, although it does not depend on its gills entirely for the oxygen that it consumes. It has been observed to come to the surface for air; and its gills are sometimes missing, as though nibbled off. In such cases breathing must be accomplished by other means. They have quite well developed lungs, which some observers have artificially inflated. The animal has seldom been observed to go on land. (*54*, *loc. cit.*) In the water they progress either by creeping along on the bottom or by swimming. The swimming is accomplished mainly by strokes of the large flat tail, and their progress is rapid. They are, for the most part, nocturnal in their habits.

The food of the Water-dog consists of insects, crustaceans, worms and mollusks. They are frequently taken on the hooks of fishermen. They will, no doubt, be found to be willing to eat almost anything that can serve as food. They are not acceptable game to the fishermen, since the latter regard them as very poisonous, and dislike to handle the creatures. This notion is an erroneous one; but a nip by their sharp and strong teeth would no doubt be somewhat painful. Drs. Wilder and Barnard (*22*, 8,

438) cooked and ate one, and reported it as excellent. The animal might, therefore, possibly be made useful, if people could overcome their prejudices.

The Water-dog has the power of enduring long periods of cold and hunger. Kneeland reports having specimens for three months in water that froze more or less every night.

Dr. C. O. Whitman states that the egg of *Necturus* is about the size of a pea, and, unlike the eggs of most batrachians, it has no pigment to obscure the processes of development. It forms an admirable object for the study of batrachian development.

Large numbers of the *Necturus* are found in the streams emptying into Lake Michigan and along the shores of the lake. At Ecorse, Michigan, 2,000 were taken in a minnow seine at one haul. It is stated that some of these were so gorged with white fish spawn that when they were thrown on shore the spawn flew out of their mouths. Another man, according to Professor J. W. Milner (Report of the United States Fish Commission, 1872–3, p. 62), had out, at Evanston, Illinois, 900 fish-hooks, and from these, in one day, he took 500 of the "lizards." Milner states that they make no more attempt to bite than does a frog. A full series was collected from the Detroit River of specimens ranging from an inch and a half to full grown. About the middle of July eggs were taken.

## Family III. AMPHIUMIDÆ.

Body elongated and eel-like. Limbs two pairs, feebly developed. No external gills in adult stage. Tail well developed. Skull long and narrow. Maxillaries large, directed backward, toothed. Premaxillaries united. Vomero-palatines narrow, directed backward nearly parallel with axis of head. No true ethmoid.

A family containing a single genus.

### Genus AMPHIUMA, Garden.

*Amphiuma*, Garden, 1821, *98*, i, 599; Boulenger, 1882, *28*, 82; Cope, 1889, *51*, 215.

Limbs very feebly developed; digits two or three on each. A single branchial slit on each side the neck. Teeth of maxillary and vomero-palatine in two parallel, backwardly directed series along each upper jaw. Premaxillaries united; developed from a single center; sending back two strong processes, one in roof of mouth, the other between nasals and frontals on the upper surface of the snout.

Contains but a single species, confined to North America.

**Amphiuma Means,** Garden.

*Amphiuma; Congo-Snake.*

Garden, *loc. cit.* Holbrook, 1842, *54*, 5, 89, pl. 30; Boulenger, 1882, *28*, 83; Cope, 1889, *51*, 216, with figures.

Body long and eel-like. Head narrower and more pointed than is usual among the batrachians. A single gill-slit on each side. Eyes extremely small, barely seen through the skin. Maxillary and vomero-palatine teeth forming four nearly parallel rows in the roof of the mouth. No external gills in the adults. Fore and hind limbs present, extremely feeble in development. Digits on each somewhat variable, usually two or three. Length of head (snout to gill-cleft), in length from snout to vent about ten times. Tail about one-fourth the total length, compressed, slender and pointed. Skin everywhere smooth.

Color dark slaty or reddish brown, paler below. Lower jaw and edge of upper lip yellowish.

The amphiuma may reach a length of three feet. It is found from the Carolinas west to Louisiana. The author has taken it at Little Rock, Arkansas, and has seen a specimen in the National Museum at Washington which was taken at Jeffersonville, Indiana, by Mr. George Spangler. The specimen is fifteen inches long and was received at the Museum March 25, 1880. Careful observations along the Ohio and Wabash Rivers will no doubt result in bringing additional specimens of this interesting animal to light.

This, like the Siren, appears to be a mud-loving species. Its whole structure appears to adapt it to burrowing about in the mud at the bottoms of creeks and rivers and ditches. Its head is long and pointed, and the bones of the skull firmly bound together, as if to render the head the point of a drill. The first instinct of the animal, when put into any vessel, seems to be to burrow out of sight. This habit of burrowing in mud has been observed ever since the discovery of the creature. Harlan (*39*, 86) speaks of them as "burrowing in the mud in swamps, or in the vicinity of streams, where it searches for its food and hibernates, occasionally visiting the dry land." Other specimens are spoken of as having been found several feet beneath the recent alluvial deposit, under the decayed trunk of a tree. The same author (*39*, 188) states that he had been informed that "they are sometimes discovered two or three feet under mud of the consistency of mortar, in which they burrow like worms, as was instanced in digging near a street in Pensacola, when great numbers were thrown up during the winter season."

The food of this animal consists of a variety of aquatic animals. Harlan says that in the stomach of some were found small fishes and beetles. Holbrook adds to their diet small mollusks.

Both Harlan and Holbrook note the habit possessed by this animal of leaving the water occasionally, but the purpose of so doing was not known. No doubt it passes from one water to another in this way, since in can creep readily and does not depend on the water for respiration.

The writer has had the opportunity of studying the breeding habits of the Amphiuma. At Little Rock, Ark., on the first of September, a female was found lying in a small excavation underneath a fallen tree trunk in a cypress swamp. The tree was at a considerable distance from any water. Her body was disposed in a coil, in the midst of which was a mass of eggs. In these eggs were young so far advanced that they would soon doubtless have been excluded. The young, which constituted the whole contents of the eggs, were surrounded by a transparent capsule about as thick as writing paper. The eggs were a little more than a third of an inch in diameter, and were connected by a cord of substance similar to that of the capsule itself. This cord varied in length from a fifth to a half inch. There appeared to be two strings in the mass, but of this I was not certain. The whole mass of eggs resembled closely a string of large beads. Of the eggs there were probably about 150.

Within the eggs the young were coiled in a spiral. Their length is something less than two inches. Each had three pairs of conspicuous gills, and, since they were evidently nearly ready to hatch, it is probable that they would retain the gills for awhile after entering the water. The gills consisted of a main stem, from which were given off eight or ten branches. Three gill-slits remained open. The eyes appeared to better advantage than they do in the adults. Though the gill slits are probably present in the just hatched animal, they certainly do not remain long, since Harlan mentions (*39*, 189) having received specimens of only three inches in length that did not exhibit the least appearance of gills.

Not only does the amphiuma exhibit to a remarkable degree, for so low a creature, the maternal instinct, but it is an animal of a good measure of spirit. Dr. Shufeldt (*50*, 2, 163,) experimented somewhat with the living animal. Into the vessel containing the amphiuma he threw a dead snake. This the amphiuma seized quickly with its jaws and extending itself, began to whirl around rapidly in the water. After the snake had been released, it was again thrown to the amphiuma, and the movements were repeated. When the dead ophidian was presented to the amphiuma the third time no attention was given it. While the female that I captured was still alive, I placed her on a floor and poked her a little with a stick. This she seized, and springing from the floor, she whirled round and round in a spiral form and turned the stick in my hand unless I held it tightly.

These animals are remarkable for the size of their blood corpuscles, the largest furnished by any vertebrated animal, since they can be seen by the naked eye. The number of their vertebræ is also worthy of remark, there being altogether about 110, of which sixty-five lie in front of the sacrum.

## Family IV. CRYPTOBRANCHIDÆ.

Form salamandrine. Head broad and depressed, mouth wide. Limbs four, well developed. Tail broad and compressed. Teeth on the anterior edge of vomers, concentric with those of premaxillaries and maxillaries, but not extending so far back as latter. No teeth on parasphenoids.

Contains two living genera, *Megalobatrachus* of Japan, three feet long, and the following:

### Genus CRYPTOBRANCHUS, Leuckart.

*Cryptobranchus*, Leuckart, 1821, *77*, 260; Boulenger, 1882, *28*, 81; Cope, 1889, *51*, 37; *Menopoma*, Harlan, 1825, *62*, 221.

Tongue large, free in front. One gill-slit on each side. Four branchial arches. Maxillary row of teeth extending back to angle of mouth; the vomerine to choanæ; the two series lying close together.

Tongue free in front; its upper surface with folds. *alleghaniensis*, p. 423.

Tongue not free; its upper surface with large papillæ. Tenn. *fuscus*.

### Cryptobranchus alleghaniensis, (Daudin.)

*Alleghany Salamander; Hellbender.*

*Salamandra alleghaniensis*, Daudin, 1803, *69*, viii. 231; *Cryp. salamandroides*, Leuck., l. c.; *Menopoma alleg.*, Harlan, l. c., with figures; Holbrook, 1842, *54*, v. 95, pl. 32; *Cryp. alleg.*, Van der Hoeven, *104*, iv. 384; Boulenger, *28*, 81; Cope, 1889, *51*, 38, with figures.

Size large, body heavy and depressed. Head broad and flat and snout rounded. Tail broad and much compressed, and with a fin along its upper edge; its length equal to half the remainder of the animal. Skin richly provided with mucous follicles, especially about the head. Sides with a conspicuous, corrugated cutaneous fold, which extends from the angle of the mouth to the middle of the tail.

Mouth large, the gape extending to behind the eyes. Nostrils small, close to the edge of the lips. Eyes small, with no evident lids. Limbs short and stout, bordered externally by a fold of membrane, which extends down to the outer toe. Hinder limb stoutest, and bordered behind by a second fold, which, near the foot, passes into the external fold. Digits 4–5.

The distance from the snout to the gill-slit is equal to about one-sixth the total length.

Color grayish to black, usually dark slate; sometimes mottled and spotted.

A total length of two feet may be reached, though usually smaller.

Known to occur from Pennsylvania west to Iowa, south to South Carolina and Louisiana. Not yet known from Florida or Texas.

Indiana localities are: Evansville (Nat. Mus.); Whitewater R. at Brookville (E. R. Quick); Ohio R. at Vevay and Madison (Hay.); New Harmony (Max. von Wied, *103*, xxii. 136).

It appears strange that the occurrence of this animal has not yet been reported from any part of the State except immediately along the Ohio River, since its extra limital distribution indicates plainly that it must be found in all the larger lakes and streams of the State.

The "Hellbender" is a great coarse, sprawling, repulsive looking creature. In the Ohio and its tributaries it is a common animal, and is cordially despised by the fishermen, whose hooks are too often burdened with it instead of fish, and who regard it as also poisonous. The latter idea is erroneous; nevertheless, its bite might be painful. They appear to be exclusively aquatic, and yet are capable of living for a long time out of the water. Mr. Charles H. Townsend (*22*, 16, 139), says that in Loyalhana Creek, Westmoreland County, Pa., shoals of them may be seen in early spring moving sluggishly over the bottom. In August they appear to hide away under rocks, but will come out after a bait of dead fish. They are very tenacious of life. Mr. Townsend carried some of them in a bag, on horseback, for five miles through a blazing sun, then put them into a tub of water for five weeks without food, and they survived and were vigorous. Mr. Wm. Frear, of Lewisburg University, in corroborating Mr. Townsend's account of their tenacity of life, states that a specimen eighteen inches long had lain in the sun forty-eight hours, then in a museum a day longer, before it was placed in alcohol. After being submerged in this twenty-four hours it was taken out and was alive and vigorous. On making cuts, in the attempt to sever the cervical vertebræ, it showed no anger or discomfort; but if only the tip of the tail was touched, the animal would viciously snap its jaws and strike with its tail.

Two females of Mr. Townsend's specimens spawned while in the tub where he put them. The spawn is reported as similar to that of frogs, but without the dark colors of the latter. The ova were exuded in strings, and were farther apart than the eggs of frogs. The eggs were of a yellowish color and surrounded with gelatinous matter, which swelled greatly on coming in contact with the water. Professor Cope states that the eggs are rather large and are attached by two strong suspensors at opposite poles. They must resemble somewhat the eggs of the Amphiuma, but with soft gelatinous covering.

The very young have not yet been seen, so that it is not known whether or not they possess gills. If gills are present on hatching, they must be very transient, at most.

Maximillian, Prinz von Wied (*103* xxii, 136), states that he found the young of this species at New Harmony. They were about three inches long, had two gill-slits yet open, and remains of external gills. These gills were afterward gradually absorbed. It is possible, however, that these were the young of some *Ambystoma*, as Professor Cope has suggested to me.

The Hellbender is said to eat worms, crustaceans and fishes. It will probably eat almost anything that presents itself.

Grote states that he has seen these animals with the shed skin rolled up in their mouths, as if in the act of swallowing it. They were observed during July and August to have a swaying motion of the body, but the purpose of this was not discovered. The statement is also made that during the time of pairing of the sexes the tail becomes broader and the lateral folds undergo some changes. The eggs seem to be deposited in the water during the month of August.

Professor S. P. Gage and wife have made the observation that this animal at times draws in water by pharyngeal movements and expels it through the gill-slits.

## Family IV. AMBYSTOMATIDÆ.

No persistent gills or gill-slits. Limbs four; digits four to five. Vomers broad, with the teeth on the posterior edge, the vomero-palatine teeth forming a nearly straight row across the roof of the mouth, in a line just behind the choanæ. No parasphenoidal teeth. Tongue large, with a narrow anterior and lateral free edge. Carpus and tarsus ossified.

Of the *Ambystomatidæ*, as here defined, all the species belong to North America, except a single one, and that occurs in Siam. Of the N. A. forms Professor Cope recognizes four genera. Since these genera are founded on peculiarities of structure of the hyoid apparatus, and these require minute dissections, and since all known Indiana species belong to the genus *Ambystoma*, the others are not defined. The genera recognized by Professor Cope are *Amblystoma*, *Chondrotus*, *Linguælapsus* and *Dicamptodon*.

### Genus AMBYSTOMA, Tschudi.

*Figure* 1, *Plate* 1.

*Ambystoma*, Tschudi, 1838, *29*, 92; *Amblystoma*, Agassiz, 1848, *100*.
Larval forms.
*Siredon*, Wagler, 1830, *75*, 209.

*Axolotes*, Owen, 1844, *101*, xiv, 23.

Vomero-palatine teeth in a nearly straight, sometimes interrupted, row behind the choanæ. Tongue broad, free margin narrow, the upper surface with numerous narrow folds. Tail usually somewhat compressed.

As formerly defined, this genus would comprise about eighteen species. As defined by Professor Cope, it will contain still about thirteen species. Of these we certainly have in Indiana six, and possibly more.

The Ambystomas are familiarly known as "Mud-puppies," and are frequently met with in the operations of plowing, digging ditches and cleaning out cellars. They are often not distinguished from lizards, but the latter are very active, while the former are extremely slow in most of their movements. The Ambystomas, like all similar animals, are regarded as venomous and are usually destroyed on sight. On the contrary, they are the most innocent animals imaginable. They can not be provoked to bite; and if they should do so, they have no poison glands connected with their teeth, and the teeth are so very short that they could scarcely penetrate the skin.

The species appear to be mostly nocturnal in their habits. Their food in the adult stage consists of insects, small mollusks, and more especially of earthworms. Their winters seem to be spent near the borders of ponds, and in these, as soon as the ice is broken up in the spring, their eggs are deposited. These are surrounded by a mass of gelatine, by means of which they cling to one another and to grass and sticks. The tadpoles are slenderer than are those of toads and frogs, and they have branching external gills. They look a good deal like small catfishes. In due time these tadpoles lose their gills and betake themselves to the land. The larvæ of some of the species attain a large size before undergoing their metamorphosis, and one species has been known to breed while still possessing gills.

### Key to the N. A. Species of *Ambystoma*.*

A. Tongue with a median crease from which the papillary folds diverge in a pinnate manner. Palatine teeth not extending beyond the choanæ. *microstomum*, p. 427.

AA. Tongue with the papillary folds radiating from a point at the back of the tongue. Palatine teeth extending laterally beyond the choanæ.

*In determining the species of Ambystoma great care should be exercised. Too much reliance must not be placed on this key, but the descriptions must be appealed to, and the animal in hand carefully compared with them. Those costal grooves are to be counted which plainly lie between the fore and the hind legs. The number of these, in any species, may occasionally be one more or less than here given. Examine both sides of the body. The color and character of the spots may vary within limits.

a. Costal grooves 12.

b. A single indistinct plantar tubercle or none. Black on sides, with a yellow stripe along the back. Head broad. Idaho. *epixanthum.*

Leaden brown, with a grayish-brown dorsal stripe. Wyoming to Pacific coast. *macrodactylum.*

Lead color to black, sometimes with whitish specks along the sides. *jeffersonianum*, p. 430.

bb. Two distinct plantar tubercles.

Lower jaw projecting beyond the upper. *xiphias.* Appendix.

Lower jaw not projecting perceptibly beyond the upper. Sides with vertical yellow spots. N. Mexico. *trisruptum.*

Lower jaw not projecting. Spotted irregularly with yellow. *tigrinum*, p. 431.

aa. Costal grooves 11.

c. Two distinct plantar tubercles.

Dark brown above, brownish yellow below. Tail equal to rest of body. *copeianum*, p 434.

Dark above, with large, irregular yellow spots. Yellow below. *bicolor.*

cc. No plantar tubercle, or one indistinct.

Lead color. Tail equal to distance from vent to gular fold. Size small. Pennsylvania to Georgia. *conspersum.*

Dark above, with a row of yellow spots of size of eye on each side of back. *punctatum*, p. 435.

Black above, with cross bands of gray. *opacum*, p. 437.

aaa. Costal grooves 10.

Brown, with sprinklings of gray. *talpoideum.* Appendix.

### **Ambystoma microstomum**, (Cope.)*

*Small-Mouthed Salamander.*

*Figure* 1, *Pl.* 1.

*Amblystoma microstomum*, Cope, 1867, *1*, 206; Boulenger, 1882, *28*, 50; *Chondrotus microstomus*, Cope, 1887, *22*, 88; 1889, *51*, 101, with figures.

Body longest and slenderest of all the species of *Ambystoma*, the distance from the snout to the axilla being contained twice in the distance from the axilla to the groin. Head small and short; contained in length

*Although Prof. Cope has assigned this species to his recently proposed genus *Chondrotus*, I retain it in *Ambystoma*; since a careful examination of the tongue structures has shown that there is no essential difference between these and those of other species of *Ambystoma*. The otoglossal is identical with that of *A. opacum*.

to the groin 6 or 7 times. Snout rounded. Lower jaw slightly projecting beyond the upper. Mouth small. Tongue of moderate size, oval, the papillary folds arranged pinnately on each side of a conspicuous median groove. Palatine teeth extending little, if any, beyond the choanæ; forming a nearly straight line across the palate, or with an obtuse angle pointing forward.

Body with 14 costal grooves, and a slight dorsal furrow. Tail a little longer than the distance from the fore to the hind limbs; nearly cylindrical at the base, becoming flattened toward the obtuse tip. Limbs short and weak, failing much of meeting when laid along the side.

Skin smooth and slippery, and with numerous minute mucous pores.

The color above is a dark brown or black, paler below. In alcohol there is sometimes a tinge of red. All over the body, but especially along the sides, there are numerous mildew-like specks of gray.

The extreme length may become as much as six inches.

This species has been found inhabiting the country from Ohio to South Carolina, and west to E. Kansas and Louisiana. It has also been brought from about Hudson Bay.

In some parts of Indiana it is an extremely abundant species. It is the commonest species of Urodele about Irvington. I saw it in Mr. Sampson's collection at New Harmony. Dr. Ridgway collected it in numbers at Wheatland. It has been taken at Terre Haute by Profs. Evermann and Blatchley, and at Brookville by Mr. A. W. Butler. One specimen in the Terre Haute Normal School collection from Howard County.

I have been enabled to study this species with some care, and I shall detail its habits somewhat, since they will illustrate the habits of other species of the genus.

The Small-mouthed Salamander spends the winter months in and about the borders of stagnant ponds. I have had it taken in midwinter from under ice over which boys were skating. It was captured under such circumstances on January 6, 1886, and again February 6, 1889. These winters were rather mild, and the ice not thick. As soon as the ice is melted they begin to lay their eggs, and it is no unusual thing to have the ponds frozen solidly again after some eggs have been deposited. Some specimens in captivity laid their eggs in the middle of January. Ovoposition more commonly occurs during the month of March. It may continue for a space of at least three weeks.

The eggs proper are quite small, being about one-twelfth of an inch in diameter. Each egg is surrounded with a capsule of gelatine, which on coming in contact with the water swells up and becomes about as large as a hazel-nut. By means of this gelatinous mass the eggs are cemented to one another and to leaves of grass, sticks, and other objects in the water. The eggs may be deposited singly, but more commonly they occur in masses of from two to a dozen, and even more. This gelatine no doubt serves to protect the eggs and the young. I do not believe that any animal will eat the gelatine.

Segmentation of the eggs begins immediately, and soon the young salamander may be seen within the gelatine looking like a dark worm. The development of some of the eggs appears to progress more rapidly than that of others. The young escape into the water from the first of April to the tenth. They are then about two-fifths of an inch long, are of a bright olive color, with some squarish blotches along the back. Three little gills stand out on each side of the neck, and on these may be seen rudiments of lateral filaments. The fore-legs are seen as the merest rudiments. I do not think that at this stage they have any mouth. The body is covered with cilia. From the time of hatching there is a club-shaped organ attached just behind each corner of the mouth. These are the "balancers." By means of these the little animal manages to hang fast to the sides of the vessel, or to objects in the water. They are lost before the tadpole becomes an inch long.

When the larva has become a half inch long, its gills have developed two rows of filaments on each stalk. Through these the blood may be seen circulating. Water enters the mouth through the nostrils and passes out through the gill-slits, thus bathing the gills.

Larvæ two-thirds of an inch in length had their intestines filled with the remains of small animals. These consisted principally of entomostracous crustaceans. The stagnant waters where the salamanders lay their eggs swarm with minute animal life, and the tadpoles have sharp appetites and the ability to provide for themselves. Later on they seize on small mollusks and insects.

When they have become an inch long, they may be seen to come to the surface after air. This happens more and more frequently as the size increases. When they have attained a size of nearly two inches, the gills begin to show signs of undergoing absorption. They seek the surface oftener, and are inclined to float on the water. They will even leave the water if allowed to do so. The time of completing their change into the adult form is about the first of June. The gills are lost; the tail loses its fin-like border; the legs have become well developed; and soon the only difference between the animal and its parents is in size. They betake themselves to the banks, where they are soon concealed among grass roots and earth.

About the ponds the adults may often be found concealing themselves under sticks and pieces of wood which lie partly in and partly out of the water. Here they can get an abundance of their favorite food, the earthworms. After their eggs have been disposed of, they appear to leave the vicinity of the water, and scatter out, so that they are only occasionally found under logs and in the soil. At this period they do not seem to be able to remain a great length of time in the water, and when left there they have sometimes drowned.

I have often been surprised at the ability for climbing shown by these animals. I have seen them climb up the corners of a zinc box six inches high, and make their escape. Indeed, it is extremely difficult to keep them imprisoned.

The salamander will soon learn to take food when it is offered. They seize and swallow earthworms with great greediness. A worm several inches long will be swallowed by installments.

This species of *Ambystoma*, even in its adult stage, enjoys a sort of aquatic respiration. I have observed them, while under the water, to draw in streams of water through the nostrils and to expel it at intervals through the mouth. These expulsions of water by the mouth occur every eight to twelve seconds. The animal will remain under the water breathing thus for perhaps fifteen minutes. It will then appear to become uneasy, bubbles of air escape from its mouth, and soon it comes to the surface after air. In all probability oxygen is absorbed from the water by the lining of the mouth, and thus the blood is partially purified. In this way we may account for the long time that these animals can remain in water under the ice.

This salamander appears to enjoy having its back tickled with a straw. It will often lift its tail high in the air and wave it to and fro in a ludicrous way. It seems at times to make a low piping sound, and at other times produces a clucking noise.

It is of interest to us that this species was first described by Dr. E. Hallowell (*1*, 1856, 8) as *Ambystoma porphyriticum* from specimens sent him from Indiana.

### **Ambystoma jeffersonianum,** (Green.)

*Jefferson's Salamander.*

*Salamandra jeffersoniana*, Green, 1827, *102*, 4; Holbrook, 1842, *54*, 5, 51, pl. 14; *Ambystoma jeffersoniana*, Baird, 1849, *2*, 283; *Amblystoma jeffersonianum*, Cope, 1867, *1*, 195; Boulenger, 1882, *28*, 46, pl. II, fig. 2; Cope, 1889, *51*, 101, with figures.

A species with an elongated body and head. The distance from the snout to the axilla considerably less than the distance from axilla to groin. Tail equal to distance from snout to vent. There are twelve costal grooves and a dorsal furrow. Skin smooth, but under the lens showing numerous mucous pores. A line of these internal to the orbits. Head rather broad and depressed; its width contained in length to groin from four to five times. Cleft of mouth extending back more than half way to gular fold. Eyes large and set far back. Gular fold prominent, but not meeting above. Tongue large and with the papillary folds radiating from behind. Choanæ apart same distance as the nostrils. Series of palatine teeth interrupted in the median line and behind each choana, thus making four patches.

Limbs long and slender; in some specimens overlapping when laid along the side; in others not quite meeting. Toes long and slender. Tail compressed, narrower above, but without a crest. The tarsal tubercles are lacking, or there may be one indistinct.

The body varies above from lead color to brown and black, paler below. On the sides of body and tail, sometimes also on belly, there may be distinct or faint blotches of bluish, but often these are wholly wanting.

A length of five to six inches may be reached by full grown adults.

Of this species Prof. Cope recognizes three varieties, or subspecies, viz.:

Head broad; its width in length to groin 4 to 4.5 times; lead colored to brown, sometimes with whitish-spots. *jeffersonianum.*

Head (as above) 5 times; black, with numerous white spots on sides, belly and tail. *laterale.*

Head (as above) 5 times; uniform lead color. *platineum.*

A widely distributed species, but most common toward the north. Hudson's Bay south to Virginia and Southern Illinois. Indiana localities: Hanover (Hallowell); Irvington (Hay); Franklin County (A. W. Butler); Wabash County (A. B. Ulrey); Monroe County (Ind. Univ. coll.); Terre Haute (Blatchley); Lake Maxincuckee, Marshall County (the variety *laterale*). The latter variety with black skin, relieved by numerous bluish white spots on sides of body and tail and on the belly, and with narrow head, may be expected throughout northern Indiana. It may be distinguished from *Plethodon glutinosus* by the lack of parasphenoidal teeth.

The special habits of this species have not, so far as I know, been studied. These, however, we may be sure, resemble much those of the other *Ambystomas;* but we may be as certain that they will present some interesting peculiarities.

### **Ambystoma tigrinum,** (Green.)

*Tiger Salamander.*

*Salamandra tigrina*, Green, 1825, *2*, v, 116; *Triton tigrinus*, Holbrook, 1842, *54*, v, 79, pl. 26; *Ambystoma tigrina*, Baird, 1849, *2*, 284; *Ambystoma mavortia*, Baird, 1849, *2*, 284; *Amblystoma tigrinum*, Cope, 4867, *1*, 179; 1889, *51*, 68, with figures; Boulenger, 1882, *28*, 43.

This species, as now recognized, is one of the most widely distributed of North American urodeles, being known from Maine to Florida, west to California, and southwest to Mexica. In this wide extent of territory the species has been subjected to a great variety of conditions, and the result has been the production of numerous forms, which differ so much that they have been described as distinct species under many names. The discovery of intermediate specimens has resulted in bringing all the forms under the earliest name, *tigrinum*. I describe the species as represented in Indiana.

A large, heavily built species, with long tail, stout limbs and a dark color, varied with numerous yellow spots.

Head about as wide as the body, or somewhat narrower in large individuals; the width in the length to the groin about four times. Paratoid region much swollen. Gular fold prominent, overlapping, rising on the sides of the neck. A groove running back from the orbit to the gular fold. Mouth large, reaching back half way or more to the gular fold. Tongue large, with the papillary folds radiating from behind. Vomero-palatine teeth in a straight or slightly curving series across the roof of the mouth, just behind the choanæ; occasionally the series projects forward in an angle between the choanæ.

The body is usually thick and depressed, and looks as if swollen. The distance from the snout to the axilla is contained in the distance from snout to groin two and a half times. There are twelve well marked costal furrows. The tail is commonly equal to the distance from snout to the groin, but specimens are often found in which it is considerably longer. It is flattened and the extremity has sharp edges above and below.

The limbs are stout. There are two distinct tubercles on the sole of the hind foot.

The ground color is a livid blue-black, brown, or black on the upper side. Scattered over the body, limbs and tail are numerous spots of bright yellow, which vary greatly in size, shape and arrangement. The spots may enlarge and become confluent, so as almost to cover the upper surface, or they may be almost obsolete. They are not limited to the upper part of the back, as they are in *A. punctatum*. The belly is of the same color as the upper surface, but it is usually wholly overlaid with sulphur yellow, so as to obscure the ground color. Through this wash of yellow may be seen the still brighter yellow of the spots. The chin and throat are often almost wholly yellow, yet this does not conceal the still brighter yellow spots. Prof. W. S. Blatchley has shown me a very large specimen from Terre Haute which is mostly yellow, but has on body and tail rather broad anastomosing dark bands. It suggests Cope's *A. xiphias*, but lacks the projecting lower jaw and the very long tail.

This species is the largest of the genus, individuals sometimes reaching a length of a foot. It is not uncommon to find them from six to nine inches long.

Distribution from Maine to Florida, California and Mexico. Indiana localities: Irvington and Indianapolis, rather common; Terre Haute

(Evermann, Blatchley), Crawfordsville (Beachler), Lafayette, very common (F. C. Test); in vicinity of Lake Maxincuckee; Wabash County (Ulrey). Probably to be found throughout the State. The specimens that I have seen from the northern portion of the State have the upper surface less spotted with yellow than usual.

This species has probably been more extensively studied than any other of the genus, and this especially on account of the fact that the gills and other larval structures are sometimes retained until the animal has reached the full adult size and even is capable of breeding. Dr. Elliott Coues (*9*, 4, 290), in speaking of specimens taken in North Dakota, says: "In all the specimens observed, the metamorphosis from the *Siredon* stage was completed at a length of four to five inches. In other regions I have procured the same species, still in the *Siredon* stage, but nearly twice as large." Some interesting observations have been made on the larvæ of this species by Dr. R. W. Shufeldt (*50*, 1885, 263; *51*, 453.)

Dr. P. R. Hoy (*22*, v. 578) states that the Tiger Salamander, early in spring, about April 1, in Wisconsin, repairs to the water for the purpose of depositing its eggs. These are laid in packets of from twenty to fifty, on blades of grass. The eggs, including the gelatine, are a half inch in diameter, the yelk one-eighth. The tadpole emerges in twenty-five days, and has at that time a length of one-half inch. On each side of the mouth is a short "holder." By May 5 the "holders" are lost, the fore legs have made their appearance, and the larva feeds voraciously on aquatic insects. By the middle of August the gills have been absorbed. Thus about 100 days are occupied in attaining the adult condition. Dr. Hoy further says that when the feet and legs have been amputated, as they may be by water insects, they are reproduced, and the digits in the same order as originally.

Though I have frequently taken this species about Indianapolis, I have never been able to obtain its eggs nor to recognize the very young. In Indiana the metamorphosis is undergone when the tadpole is about four inches in length. I have seen many specimens taken at Irvington, and these will illustrate the peculiarities of the young at a time just preceding the metamorphosis. The entire length is 4.37 inches. There are present three external gills, each with numerous flat filaments arranged in two rows along the main axis. Three gill-slits are yet open, and these are guarded by gill-rakers similar to those of fishes. The teeth of the vomers and those of the palatines form separate patches, and in a series parallel with those of the maxillaries and premaxillaries. The tongue as yet shows no folds. The limbs are well developed. The tail has a broad, fin-like membrane above and below. The upper membrane extends forward well toward the head. The upper surface is extensively mottled and blotched with dusky. The color below is white.

On the back are three or four faint cross-bands of dusky. No indications are present of the future yellow spots so conspicuous in the adult.

In Indiana this species appears to pass the winter hiding about the margins of ponds, or, in some cases, away from the water, under logs and such places. I have received specimens taken under the ice, in company with *A. microstomum*, in January and February. Like the latter species, it mostly leaves the water as soon as ovoposition is completed. They may then be found burrowing in the earth, when they can be found at all. However, this species, unlike *A. microstomum*, appears to be capable of remaining indefinitely in the water during the summer months and of enjoying its existence there. On the other hand, I have been told of a specimen that was taken in a dry corn-field on a hot day in August. A large specimen that was kept by me for several weeks seemed, during the warmer months, to prefer remaining covered up in a box of sand that was provided. At intervals it betook itself to the water. It was observed that this specimen shed its cuticle about every ten days. Before this exuviation occurred it entered the water and remained there for some time after the skin had been cast. During the colder months it preferred to remain constantly beneath the water, only coming up at intervals of fifteen minutes to take in air. Observations showed that this species, like *A. microstomum* and *A. punctatum*, enjoys an aquatic respiration. Water is steadily inhaled by the nostrils for five or six seconds, and then expelled by the mouth.

This species is a voracious eater, and will readily learn to take food from the hand. One was kept for weeks without manifesting any disposition to eat anything, but on being put into a cage along with an *Acris* and a large caterpillar, these mysteriously disappeared. One morning the salamander was caught holding a good-sized *Hyla versicolor* by one foot. Next morning the tree-toad was gone, while the salamander had an unusually bloated appearance. He would eat pieces of meat, angle-worms, and one day attempted to swallow a dead mouse.

Like all other animals of the kind, this one is regarded by many people as dangerously poison. It is, however, entirely harmless.

### Ambystoma copeianum, Hay.

*Cope's Salamander.*

*Amblystoma copeianum*, Hay, 1885, *3*, 209, pl. 14; Cope, 1889, *51*, 63, with figures.

Head broad, body short, tail long and compressed.

The width of the head is a little less than the distance to the gular fold, and is contained in the distance from the snout to the groin 3.6 times. Distance to gular fold in distance to groin 3.2 times. Upper jaw projecting beyond the lower. Tongue like that of *A. tigrinum.*

Vomero-palatine teeth in four distinct series, made so by interruptions in the middle line and immediately inside the choanæ. The latter openings more widely separated than the outer. The body is short and depressed. The distance from the snout to the axilla is just equal to that from the axilla to the groin. There are eleven distinct costal furrows and a dorsal groove. The tail is equal to the distance from the snout to the beginning of the vent. It has a well developed crest and is compressed. Hind foot with two distinct tubercles.

The limbs are well developed, the posterior being a little longer, somewhat stouter, and the foot broader than the same parts in a specimen of *A. tigrinum* of the same size.

The color above is dark brown, almost black; below, brownish yellow. Between the fore and the hind legs the yellow color mounts up on the sides of the body to a level with the upper surfaces of the limbs. Head above like the back, below like the belly, with indications of a brighter yellow spot behind the symphysis.

This description is founded on the only known specimen, which was captured at Irvington, near Indianapolis. Nothing whatever is known concerning its habits.

### **Ambystoma punctatum,** (Linn).

*Spotted Salamander.*

*Lacerta punctata*, Linnæus, 1766, *64*, i. 370; *Salamandra venenosa*, Holbrook, 1842, *54*, v. 67, pl. 22; *Ambystoma punctata*, Baird, 1850, *2*, 283; *Amblystoma punctatum*, Cope, 1867, *1*, 175; 1889, *51*, 56, with figures.

A species with broad head, stout body, black ground-color, and yellow spots.

Head depressed; widest at the swollen paratoid region. The greatest width is contained in the distance to the groin from 4 to 4.6 times. From the snout to the gular fold in distance from snout to groin 3.5 to 4 times. Gular fold not prominent, but rising high on the neck. Another fold from the angle of jaw running back to gular fold. Eyes of moderate size. Mouth large. Tongue moderate, with the papillary folds radiating from behind. Teeth of vomero-palatines in three portions, the extremities of the series being separated from the median portion by interruptions just behind the choanæ. The latter openings considerably further apart than the external nostrils.

Body plump, with a dorsal groove and 11 (occasionally 10) costal furrows. The distance from the snout to the axilla in distance from snout to groin 2.5 times. Limbs moderately developed; when placed along the side, just meeting or not quite. Toes rather short and depressed;

the plantar tubercles indistinct. Tail thick at the base, becoming compressed toward the tip, not high, and without a keel; a well-marked depression along each side; usually shorter than remainder of the animal. Skin smooth, but well furnished with mucous pores. A row of enlarged pores along the upper jaw, another inside the orbit, and another on each side of the upper edge of the tail.

The general color varies from slate-blue to deep black. There is an irregular row of spots along each side of the back and tail. Similar spots are found also on the head. From head to tail there may be from 10 to 20 of these spots. In alcoholic specimens these spots are white, but in life they are bright yellow. Those on the head are often bright orange, at least in spring. The spots are usually the size of the orbit. Under side of animal paler than above. May attain a length of seven or eight inches.

It is distributed from Halifax, N. S., to Wisconsin and south to Georgia and West Texas.

Indiana localities: Wabash County (Ulrey); New Harmony (Sampson's coll.); Wheatland (Ridgway); Franklin County (Hughes); Wayne County (Butler); Shelby County (G. H. Clark); Monroe County (Ind. Univ. coll.); Irvington; Terre Haute (Evermann and Blatchley). No doubt, exists throughout the State.

This species differs from *A. tigrinum* in having but eleven costal grooves, but a single series of yellow spots on the upper surface, in the fading of these spots to white in alcohol and in having no plantar tubercles, or but a single indistinct one.

Like its kindred, this species resorts in early spring to stagnant ponds for the purpose of depositing its spawn. They have been found about Irvington about the middle of March, hiding under pieces of fallen wood, which lie partly in the water. Later they disperse and may occasionally be found under logs. Dr. S. F. Clarke (*122*, 1880, No. 2) has studied the development of this species. The eggs are laid in masses of from 300 to 400. Each egg is covered with a thin coat of jelly, which swells up when brought in contact with the water. This is supposed to protect the eggs from fishes, but it probably protects them from many other enemies, animal and vegetable. This mass of jelly is much more solid than that of any other species of *Ambystoma* that I am acquainted with. While depositing her eggs, the female lies with her fore limbs extended laterally and her hind limbs curved around the opening of the cloaca, as if to assist in holding the eggs together. The male deposits the sperm on the eggs and thus fertilizes them. The egg has a light and a dark colored pole of equal size. Segmentation is most rapid in the light-colored pole. In due time the balancers appear, and are again lost on the thirtieth day. The larva has three pairs of gills, a tail with a fin-like membrane, and soon develops fore and hind limbs. Its transformation to the adult form occurs when a length of about two inches has been reached. (Cope, *51*, 49.)

Like the related species, this salamander swims readily by vigorous strokes of its flat tail, while the limbs are held appressed to the sides. They are often found floating on the water of the aquarium. When disturbed they immediately plunge to the bottom and seek to hide. Their food-habits are closely like those of *A. tigrinum*. They devour with great greediness the angleworms that one offers them. The worms are swallowed by a succession of gulps. One was observed to swallow three inches of worm in five minutes. Prof. S. W. Garman has observed that the tail is prehensile and employed to prevent the animal from falling. I have observed the same thing.

This species, like *A. tigrinum* and *A. microstomum*, when under the water draws this in through the nostrils and at intervals expels it by the mouth. In this way they are enabled to remain for considerable periods under the water away from the air.

### **Ambystoma opacum,** (Gravenhorst).

*Marbled Salamander.*

*Salamandra opaca*, Gravenhorst, 1807, *105*, 431; *Salamandra fasciata*, Holbrook, 1842, *54*, v. 71, pl. 23; *Ambystoma opaca*, Baird, 1849, *2*, 283; *Amblystoma opacum*, Cope, 1867, *1*, 173; *51*, 54 with figures; Boulenger, 1882, *28*, 40.

A species with a short, stout, swollen body, short tail, and weak limbs; the color dark, with light colored cross-bands.

The greatest width of the head is about three-fourths of the distance from the snout to the gular fold. The neck is distinct; the mouth extends half way to the gular fold. Tongue extensively free at the sides, and with the papillary folds radiating from behind. The vomero-palatine teeth consist of two lateral and a median series, the interruptions occurring just behind the choanæ.

The body has a swollen appearance. The length to the axilla is contained in the distance to the groin two and one-third times. There are eleven costal folds, and but slight indications of a dorsal groove. The limbs are but moderately developed. The animal has the appearance of being clumsy and weak. The tail is short and stout, its length equaling only two-thirds the distance from the snout to the groin. The plantar tubercle is wanting. The skin is everywhere pitted with minute pores.

The color is a dark brown or black. Across the back and upper side of the tail are a dozen light gray, or silvery white bands. These are broadest on the body. They usually fork on the sides and run together.

An irregular splotch on the head and nape of the same color. The limbs and belly may be uniform in color, but may be sprinkled with white dots.

Length of large specimens, 4.5 inches.

Distribution from Long Island and Florida, west to Wisconsin and Louisiana.

The following localities in Indiana have furnished specimens of this species: New Harmony (Sampson's coll.), Wheatland (Ridgway), Terre Haute (Blatchley). There seems to be no reason why a careful search should not be rewarded by finding this species anywhere in the State.

The habits of this salamander have been most carefully studied by Col. Nicholas Pike, with specimens taken on Long Island. He states (*48*, i, 209) that eggs and young were taken soon after the ice had left the ponds toward the latter part of March. The eggs were enveloped in a glairy mass similar to that of *A. punctatum*. The young emerged in fifteen days, but remained close about the glairy mass which they had escaped. Mr. Pike supposed that this furnished them food; this is, however, improbable. At first they are of a dingy brown color, with two rows of pale dots along the sides. When a month old, they were excessively active. Some which were dissected had in their stomachs the larvæ of insects, etc. At the age of two months, they would eat small mollusks. When an inch long the gills are fringed, the tail-fin is edged with black, the rows of white spots are more prominent, and the head broader and more prominent. The gills appear to be absorbed, and the fin membrane to disappear, when the length is about two inches. The whole body is described as being then sprinkled with white dots, as if flour had been thrown upon the animal. As soon as the branchiæ are absorbed, the larvæ become restless, seek to escape from the water, and if confined in it, many of them die. If permitted they crawl into moss and leaves, and curl up there in contentment. The metamorphosis occurs about the 5th of May. It is, however, not until the last of July that they assume the colors of the adult. From the time when the eggs are laid until the young have taken the complete adult form and color, there elapse about four and a half months, and the animal is then two and a half inches long.

Col. Pike regards the *A. opacum* as being strictly a terrestrial animal, entering the water only for the purpose of depositing its eggs. In confinement they refuse food for some time, and lie curled up, head to tail. At last they are willing to accept such mollusks as are offered them. It is entirely probable their food habits are similar to those of their relatives; and that they will eat almost any animal substance that they can swallow. Col. Pike states that this species hibernates late, hiding under leaves and burrowing in the ground. He says it has been known to burrow in soft ground to the depth of three feet.

## Family V. PLETHODONTIDÆ.

(*Includes Prof. Cope's families Plethodontidæ, Desmognathidæ, and Thoriidæ,** *51*, 33).

Body salamandrine in form. No persistent gills or gill-slits. Vertebræ amphicœlous or opisthocœlous. Teeth on posterior edge of vomers. Parasphenoidal teeth present. Tongue extensively free on sides or all round. Carpus and tarsus cartilaginous.

### Key to the Subfamilies of *Plethodontidæ*.*

A. Vertebræ amphicœlous. *Plethodontinæ*, p. 439.

AA. Vertebræ opisthocœlous.

- a. Carpus and tarsus cartilaginous. *Desmognathinæ*, p. 450.
- aa. Carpus and tarsus osseous. Extralimital. *Thoriinæ*.

### Subfamily PLETHODONTINÆ.

Vertebræ amphicœlian. Carpus and tarsus cartilaginous.

### Key to the N. A. Genera of *Plethodontinæ*.

A. Tongue free along the sides, but not in front.

- a. Posterior digits 4.
  - b. Costal grooves 18–31; Pacific States. *Batrachoseps*.
  - bb. Costal grooves 13. *Hemidactylium*, p. 440.
- aa. Posterior digits 5.
  - b. Mandibular teeth small, numerous, terete.
    - c. Premaxillaries not ankylosed; costal grooves 10 to 19. *Plethodon*, p. 441.
    - cc. Premaxillaries ankylosed; costal grooves 17; color, pale yellow. Georgia. *Stereochilus*.
  - bb. Mandibular teeth, few, small, knife-shaped. Pacific States. *Autodax*.

*The three subfamilies of Plethodontidæ are founded on internal characters, and require some dissections. These, however, are not difficult to make. By making a short incision along the back of the specimen in hand, dressing away the muscular tissue down to the vertebral column, and then sharply bending the back so that two of the vertebra separate, it may be seen whether the anterior rounded head of the vertebræ is made of cartilage or bone. If it is of cartilage, the vertebræ are amphicœlous; if of bone, opisthocœlous. In either case, the posterior end of the vertebral centrum is concave. In like manner, the wrist and ankle may be dissected and the determination made whether the nodules found in them are composed wholly of cartilage or are bony. Since, however, we have no species of *Thoriinæ*, this examination is not necessary. It may facilitate the determination to recollect that the species of *Desmognathus* resemble in easily observed characters the species of *Plethodon* only, and the descriptions of these should be carefully scanned.

AA. Tongue extensively free all round and standing on a central stalk.
a. Posterior digits 4. Southern States. *Manculus.*
aa. Posterior digits 5.
b. Premaxillaries not ankylosed. *Gyrinophilus.* Appendix.
bb. Premaxillaries ankylosed. *Spelerpes*, p. 445.

### Genus HEMIDACTYLIUM, Tschudi.

*Hemidactylium*, Tschudi, 1838, *99*, 54; Cope, 1889, *51*, 130.

No fontanelle between the parietals. Premaxillaries distinct. Tongue free along the sides, attached in the middle line in front. Limbs feeble; digits, 4–4.

### **Hemidactylium scutatum,** (Schlegel).

*Scaly Salamander; Four-toed Salamander.*

*Salamandra scutata*, *Schlegel*, 1837, *106*, 119; *Hemidactylium scutatum*, Tschudi, 1838, *99*, 94; Cope, 1889, *51*, 130, with figures; *Batrachoseps scutatus*, Boulenger, 1882, *28*, 59.

Head flattened above, broadest just behind the eyes. Snout short, truncate. Width of head in the length to the groin about six times. Gular fold rising above nearly to middle line. Vomero-palatine teeth in two short series just behind the choanæ. The parasphenoidal patches not in contact. Body cylindrical; the distance from snout to axilla in the distance from snout to groin three times. There is a dorsal furrow which runs forward to the head, and, there forking, sends a branch to each eye. Costal furrows 13 or 14. On each side of the back is a fainter longitudinal groove. Above this the costal furrows run forward and meet in the middle line at an acute angle. Base of the tail with a decided constriction, beyond which the tail again swells out and then tapers to a sharp point. Both upper and lower edges of the tail with an evident ridge for the greater part of the length. Skin of the whole upper surface granulated.

Limbs feebly developed; outstretched arms and legs about equal, and contained in the distance from the snout to the groin not quite twice. Fingers and toes 4, short, almost rudimentary.

Color above brown, chestnut, or purplish, mingled with pale spots and specks; snout, shoulders, limbs and upper surface of tail clay-colored. Below, the color is bluish-white, with many specks and small spots of black. The central line of the belly is spotted or not.

This species is distributed from Massachusetts and Canada westward at least as far as Illinois and south to Georgia. It is regarded as a rare animal, although it appears to be pretty abundant in places. Prof. Verrill has reported it to be common at New Haven, Conn. The Indiana localities from which it has been reported are: Brookville (Hughes), Terre Haute (Blatchley), Irvington (W. P. Hay), Wabash County at North Manchester (A. B. Ulrey). Mr. Hughes states that it was found in the moss at the roots of trees which stood near ponds. In this moss were also found the eggs. One of Mr. Hughes' pupils found about forty specimens, but did not secure them. The eggs are said to resemble those of that eminently terrestrial species *Plethodon cinereus*. Since the eggs were found near the water, it is possible that the larvæ spend a portion of their lives in that element. Prof. Cope says that the gills are absorbed at an early period of life, and he thinks that the animal never enter the water. The food is said to consist principally of worms and insects.

When this species has been dropped on its back, it will often lie for a time perfectly quiet, as if feigning death. I have heard it give a faint squeak like the scratching of a quill toothpick against paper. It can readily climb a perpendicular surface, and it can suspend itself by its tail. When thrown into water, it may hide for awhile at the bottom, but it soon endeavors to get out. The smallest specimen that I have seen is one from North Manchester, the total length of which is a little less than an inch and a half.

### Genus PLETHODON, Tschudi.

*Plethodon*, Tschudi, 1838, *99*, 59; Boulenger, 1882, *28*, 53; Cope, 1889, *51*, 132.

Vomero-palatine teeth in two more or less oblique series which lie behind the choanæ. Parasphenoidal teeth present. Premaxillaries separated. Digits 4–5. Tongue free laterally, but attached medially in front.

Species belonging to North America seven. Of these, four occur on the Pacific Coast.

#### Key to the Eastern United States Species of *Plethodon*.

Costal grooves 16 to 19. Color above ashy, or with a red dorsal band.
*cinereus*. p. 441.

Costal grooves 14. Color above black, with small white dots.
*glutinosus*. p. 444.

Costal grooves 13. Color above black, with large yellow spots.
*æneus*. Appendix.

### Plethodon cinereus, (Green).

*Ashy Salamander; Red-backed Salamander.*

*Salamandra cinerea*, Green, 1818, *2*, 356; *Plethodon cinerus*, Tschudi, 1838, *99*, 92; Cope, 1889, *51*, 133; *Salamandra erythronota*, Green, 1818, *2*, 356; *Plethodon erythronotus*, Baird, 1849, *2*, 285; Boulenger, 1882, *28*, 57.

Form elongated and slender, with weak limbs. The length to the axilla in the length to the groin from 3 to 3.5 times.

The head is small and short, its width in the length to the groin seven times. The snout is short and rounded. Eyes large and prominent. Gular fold distinct, rising high on the sides of the neck. A distinct groove runs back from the corner of the eye to the gular fold, and is met by a groove rising from the corner of the mouth. The neck is distinct. Mouth large, the upper jaw slightly projecting. Tongue large, oval, free at the sides and slightly free behind. The vomero-palatine teeth in two short, arched, backwardly converging rows, which do not extend beyond the choanæ. The parasphenoidal teeth in two patches lying close together.

The body is cylindrical, without dorsal furrow, and with from 16 to 19 costal furrows, not inclnding the one in the axilla, but including the inguinal. The limbs are short and weak, the outstretched hind legs scarcely equal to half the distance from the snout to the groin. The digits are short, the inner ones rudimentary. Tail equal to, or longer than head and body. Total length 3.5 to 4 inches.

Prof. Cope recognizes three varieties of this species, and these are based principally on differences of coloration. In all three forms the color below is whitish or yellowish, finely marbled with brown. On the sides the brown predominates, until it covers the surface, leaving only whitish specks. The middle of the back is variable.

Middle of back without a red stripe, ashy to black. *cinereus.*

Middle of back with a red or chestnut stripe, its borders parallel. *erythronotus.*

Middle of back with dorsal stripe having dentate borders. *dorsalis.*

When the reddish or chestnut stripe is present it is somewhat broader than the inter-orbital space. Its central portion is usually finely marbled with brown. It may extend on the tail to its tip. In the form *dorsalis*, the stripe has deep indentations along its edges; these sometimes come opposite in pairs, when the band alternately expands and contracts. In other cases the indentations alternate, and then the band has a zigzag appearance. The variety *dorsalis* is furthermore said to have a shorter body than the others, the length to the axilla being contained in the length to the groin only 3 times, instead of 3.3 or 3.5 as in the other varieties. The number of costal folds is given by Prof. Cope as 16 instead of 18, as the others have. The variety *dorsalis* has been described from specimens collected at Louisville. I have two good specimens taken at Wyandotte Cave, not far from Louisville, which have the broad zigzag dorsal band and seventeen costal furrows, counting them as Prof. Cope counts them. In one the distance to axilla in distance to groin is 3; in the other 3 3. I think, therefore, that the form is hardly constant enough in its characters to be regarded as a variety. Mr. A. W. Butler reports this form from Bloomington.

The value of the *cinereus* and *erythronotus* forms is difficult to determine. They have been regarded as distinct species. Prof. Cope says that as varieties they are very permanent ones. He has found all of the young of the same brood or set of eggs, whether in the eggs or just escaped from them, uniformly with either dark backs or red ones. He has found red-backed specimens watching eggs with red-backed embryos, and brown-backed adults in charge of brown-backed embryos. He states also that there is some differences in the geographical distribution of the two forms. In general, however, the two are found in the same region, and it is no unusual thing to find both kinds under the same log. Further accurate observations are needed in order to settle this question. Blatchley (*94*, '91, 25), reports finding them in equal numbers at Terre Haute. This species is found in the territory extending from Maine, Ontario and Wisconsin south to Mississippi and Georgia.

In Indiana, specimens have been reported from New Harmony (*cinereus*, Hay); Franklin County (Butler); Monroe County (Ind. Univ. col.); Terre Haute (Evermann and Blatchley); Brookville (*cinereus* and *erythronotus*, *51*, 135 and 137); Crawfordsville (Beachler); Wyandotte Cave (*dorsalis*, Hay); Lake Maxinkuckee (*cinereus* and *erythronotus*, Dr. Vernon Gould); North Manchester, Wabash County, both forms (A. B. Ulrey). Some of the specimens from the last named locality have the dorsal streak of a more brilliant red than any others that I have ever seen.

The habits of this species appear to be wholly terrestrial. The eggs are laid in May, in damp situations, under stones, logs and leaves. The young are at first provided with branchiæ, but these are soon absorbed, and are probably not of much use to them at any time. The young are solicitously watched by one or the other of the adults. Smith (*18*, 725), states that he found specimens in the neighborhood of Vassar College, on the 6th of April. He adds that when it is disturbed it runs swiftly away, unless it is accompanied by the young, in which case neither these nor the adult attempt to escape. He thinks the adults feed the young. The eggs, the same author says, are laid in packets of from 6 to 11, and sometimes as late as June, while in the White Mountains the period of ovoposition may be delayed as late as August. The food consists of insects and small snails. In one specimen collected, near Wyandotte Cave, I found a small shell allied to *Helix*, while in the stomach of another were the bodies of numerous ants. The species is quite active, running away when molested and hiding under the leaves. It can climb glass by applying the feet and abdomen closely to the surface.

**Plethodon glutinosus,** (Green).

*Slimy Salamander.*

*Figure* 2, *Pl.* 1.

*Salamandra glutinosa*, Green, 1818, *2*, 357; Holbrook, 1842, *54*, v. 39, pl. 10; *Plethodon glutinosus*, Tschudi, 1818, *99*, 92; Boulenger, 1882, *28*, 56; Cope, 1889, *51*, 139, with figures.

The body of this species is rather heavy for the genus. It is cylindrical or somewhat depressed, and with a very shallow groove along the back, but not extending upon the tail. Skin smooth and shining, pitted with numerous minute pores, which secrete a white sticky fluid. The length of the snout to the axilla in the distance from snout to the groin 2.75 times. Costal grooves 14.

Head of moderate width, its width in the distance to the groin six times. Snout rounded or truncate, the upper jaw projecting beyond the lower. Gular fold not overlapping; met by a groove from the eye. The latter organs large and protruding. Tongue large, the posterior fourth and the sides free; the papillary folds radiating from behind. Vomero-palatine teeth in two short, separated, anteriorly convex arches, which laterally pass a little beyond the choanæ. Parasphenoidal bands in close contact throughout and anteriorly removed from the vomero-palatines. The length of the parasphenoidal bands equal in length to the distance between the pupils. Choanæ as widely separated as the external nostrils.

Tail equal to or a little longer than the remainder of the animal; cylindrical in section and tapering to a point. Limbs moderately developed, the tips of the outstretched hind legs being contained in the distance from head to groin 1.5 times. The digits are short and depressed; the inner on fore and hind legs are small, but distinct.

The color above is black or blue-black. Along the sides are numerous whitish blotches about the size of the eye, and these are sometimes more or less confluent. On the back and upper head the spots are usually smaller and less bright. Under surface of the head and neck paler; of the belly bluish, with minute dots of white, which are not always the mouths of the mucous pores. Sometimes the posterior half of the tail is of a reddish brown color. In some specimens, when living, there are numerous spots of a brassy hue on the belly and under surface of the head, the tail with rounded dots of yellowish. Rarely there are no white spots anywhere on the body.

The largest specimens of this species that I have seen are 7 inches long.

The species is distributed from Maine to Wisconsin, and south to Texas and South Carolina. Indiana localities are: Brookville (Cope, *51*, 143, specimens sent to Nat. Mus. by Dr. R. Haymond); Terre Haute (Evermann and Blatchley); Monroe County (C. H. Bollman); Crawfordsville (specimens shown me by Mr. Chas. Beachler).

This species resembles the variety *laterale* of *Ambystoma jeffersonianum*, and to a lesser extent *Ambystoma microstomum*. It may be distinguished from both by the possession of parasphenoidal teeth.

This species, like its relative, *P. cinereus*, appears to be wholly terrestrial. It probably never enters the water, even for the purpose of laying its eggs, although Smith (*18*, 726) states that in Georgia it enters the water in April for the purpose of breeding. If the young ever have gills they are lost at a very early age. The species spends its life hiding under logs and stones, whence at night it comes forth to seek its prey. This consists of insects, and probably any other small animals that may fall within its reach. It is quite active while moving over the ground, although it can not run so rapidly as *Spelerpes longicaudus* and *Desmognathus fusca*. It moves with a sort of leaping and wriggling motion. It is especially remarkable for the development of prehensile powers in its tail. It will wrap its tail around one's finger and hang there for an almost indefinite time. Although given to living on land it shows no aversion to entering the water.

Prof. Cope (*51*, 142) says that it is found more abundantly in mountaneous districts, and haunts rocky localities as well as forest mold and fallen logs. He thinks that it prefers a cool climate. It appears, however, to be abundant in Southern Illinois, and I found numerous and large specimens in the low lands of Eastern Mississippi.

### Genus SPELERPES, Rafinesque.

*Spelerpes*, Rafinesque, 1832, *107*, i, 22.

Vomero-palatine teeth in two series, which either converge backward without reaching the parasphenoids, or run transversely to the anteriorly prolonged parasphenoidal patches. These patches either separated or joined along the middle line. Tongue small, supported on a central stalk, mushroom-like. Premaxillaries ankylosed, their spines enclosing a fontanelle. Limbs moderately well developed; digits 4–5.

This genus, as limited by Cope, contains ten species, three of which belong to Mexico, the remainder to the United States. *S. multiplicatus*, being found only in the Southwestern United States, is not here described.

#### Key to the North American Species of *Spelerpes*.

A. With 21 costal furrows; color, dark. *multiplicatus*.

AA. With 15 costal furrows; body stout; color, red, with black spots; vomero-palatines meeting the prolonged parasphenoids. *ruber*. Appendix.

AAA. With 13 to 14 costal grooves; body slender; vomero-palatines not meeting the parasphenoidal patches.

a. Tail considerably longer than rest of animal.

b. Yellow, with black spots; tail with black cross-bars. *longicaudus*, p. 446.

bb. Red, with black spots on body and on tail. *maculicaudus*, p. 447.

bbb. Yellow, with a broad dorsal band and another each side of back. *guttolineatus*. Appendix.

aa. Tail not much, if any, longer than rest of animal, back with a median row of dots, and on each side a dusky line or band. Ground-color yellowish, above and below. *bislineatus*, p. 448.

### Spelerpes longicaudus, (Green).

*Long-tailed Triton.*

*Figure* 3, *Pl.* 1.

*Salamandra longicauda*, Green, 1818, *2*, 351; Holbrook, 1842, *54*, v, 61, pl. 19; *Spelerpes longicauda*, Baird, 1849, *2*, i, 287; Boulenger, 1882, *28*, 64; *S. longicaudus*, Cope, 1889, *51*, 168, with figures.

Body elongated and slender, with well developed limbs. Tail considerably longer than the rest of the animal.

Head flat, tapering gently backward, more rapidly forward to the rounded and projecting snout. Width of head in length to the groin 6 to 6.5 times. Eyes moderately large and prominent. Gular fold prominent, on the sides of the neck projecting backwards. Tongue boletoid and capable of protrusion. Vomero-palatine teeth in two short, curved series, which approach but do not meet each other backward; neither do they reach to the parasphenoidal patches. Externally they do not reach forward to the hinder borders of the choanæ. The parasphenoidals in two distinct bands, approaching in front, but diverging posteriorly.

Body somewhat flattened, with a dorsal groove and thirteen costal furrows. Distance from the snout to the axilla in the distance to the groin 2.6 times. The tail is low and flattened, about 1.5 times the length of the remainder of the animal, sometimes nearly twice as long, running out to a sharp point.

Outstretched hind limbs contained in the length to the groin about 1.3 times; toes and fingers short.

The color is usually a bright lemon yellow, sometimes increasing in depth to an orange. Below, the tint is paler and without spots. Above and on the sides there are numerous jet black spots varying in size from specks to spots as large as the eye. The largest of these may form a row running back from each eye to the pelvis, forming an interrupted band along the side. On the tail the spots are usually confluent into vertical bars.

The length of adult specimens is usually about five inches. I have a specimen from Pennsylvania that is 6.5 inches long.

This species ranges from Maine and Wisconsin south to Florida and Louisiana. In Indiana it has been taken at Waveland, Montgomery County (A. W. Butler); in Monroe County (Ind. Univ. coll.); "Caves of Southern Indiana" (D. S. Jordan); Harrison County (Prof. Hallett, with specimens). It is possible that the reports of this species from Monroe County and "Caves of Southern Indiana" refer to the *Spelerpes maculicaudus*, which is found there.

This is one of the most beautiful and interesting of our batrachians. Its brilliant colors, its graceful form, and its innocent habits demand for it attention and kindly protection. It appears to prefer for its haunts rocky ground and the fissures of caves. Prof. Cope says that he has never seen it in the water. Others regard it as to a great extent aquatic.

Harlan (*39*, 96) states that it inhabits the swamps of New Jersey. It undoubtedly enters the water in order to deposit its spawn. I have been able to learn nothing about its food or about its breeding habits.

### Spelerpes maculicaudus, (Cope).

*Hoosier Salamander.*

*Figure* 4, *Pl.* 1.

*Gyrinophilus maculicaudus*, Cope, 1890, *22*, xxiv, 966, with figures; *Spelerpes maculicaudus*, Hay, 1891, *22*, 1133.

A species resembling closely *S. longicaudus*, but differing in form, arrangement of vomero-palatine teeth, and color. Head broader and flatter than in *longicaudus*, contained in distance to groin 5 to 5.5 times. The distance from snout to axilla in distance to groin 3.5 times against 4 times in *longicaudus*. Tail long and compressed, containing head and body 1.5 times. Costal grooves 13 or 14, one more than in *longicaudus*. Arrangement of vomero-palatine teeth different from that in *longicaudus*. In this latter, the series runs forward toward the choana and then turns outward behind it, not reaching as far forward as its hinder border. In *maculicaudus*, the series runs forward to a point in advance of the hinder border of the choana, or even to its anterior border, and then turns abruptly outward and backward, so as to produce the form of a hook.

The ground-color varies from orange to vermillion red. That of *longicaudus* being usually lemon yellow, sometimes becoming reddish brown or orange. The head and body are irregulary spotted with black dots about the size of the pupil, or larger. The tail is similarly spotted, but the spots do not incline to form vertical bars, as in *longicaudus*. The lower surface is uniform.

In a specimen that I have from Brookville, there is on each dorso-lateral region a row of black spots, one on each costal space. This row begins over the arm and runs back on the tail. In the middle of the back there is an irregular row of spots. In a specimen from Bloomington, the spots are more irregular.

Total length of large specimens, 6 inches; head and body 2.5 inches.

This species was originally described from specimens sent to Prof. Cope from Brookville, Ind. It was first taken there by Mr. E. R. Quick. Mr. Edward Hughes has reported the occurrence of the species in Decatur County. I have also seen specimens from the neighborhood of Bloomington, Indiana, some of which were contained in the collection of the State Normal School at Terre Haute. During the summer of 1891 Mr. W. P. Hay found one of these salamanders in May's Cave, near Bloomington, and another in Kern's Cave, about a mile southwest of Bedford, in Lawrence County. Both these specimens were found clinging to the walls of the caves about four feet from the water, and the one in the last mentioned cave was about a quarter of a mile from the entrance. They made no effort to escape, and both were detected by the gleaming of their eyes in the candle light. During the present summer Mr. Hay took a specimen of the species in a small cave near Wyandotte Cave. Dr. Stejneger, of the National Museum, has shown me a specimen of the same species, which has been sent to him from Barry County, in southwestern Missouri. This extends greatly the range of the salamander.

These salamanders are said to be more aquatic than is *S. longicaudus*. I kept two of them for some time in an aquarium, and they seemed to spend a considerable portion of the time out of the water. They have the power of climbing up a perpendicular glass, and they will remain sticking in such places for a long time. When the glass, to which they are adhering, is turned horizontal, they can remain sticking to the under side. They are extremely active, and when pursued, escape with great rapidity.

### **Spelerpes bislineatus,** (Green).

*Two-lined Triton.*

*Salamandra bislineata*, Green, 1818, *2*, i. 352; *S bilineata*, Holbrook, 1842, 54, v. 55, pl. 16; *Spelerpes bilineata*, Baird, 1849, *2*, 9, 287; *S. bilineatus*, Boulenger, 1882, *28*, 66; Cope, 1889, *51*, 163, with figures.

A small species, seldom exceeding 3.5 inches long, and with the tail varying from a little less to a little more than the remainder of the total length.

The head is rather narrow, being usually contained in the length to the groin about seven times, occasionally only five times. The snout is short and rounded, sometimes abruptly so. The eyes are prominent.

The tongue is free all round, as is the case with all of the genus, and can be thrust far out of the mouth. The vomero-palatine teeth consists of two short, curved series, which backwardly approach each other without meeting, and which do not reach the parasphenoidal patches. The latter are separated from each other by a narrow space.

The body is elongated and slightly depressed. The distance from the snout to the axilla in distance to the groin nearly three times. There are nearly always fourteen costal furrows, occasionally but thirteen, rarely fifteen. There is a well-defined dorsal furrow. The limbs are rather feebly developed, the outstretched hind limbs are contained in the distance from the snout to the groin about 1.5 times. The tail may be a little shorter than the head and body, or a little longer. It is compressed, keeled above, rounded below, and ends in a sharp point.

The color above is clear yellow, or yellowish-brown, sometimes merely yellowish-gray; below pale yellow, without spots. Along the middle of the back there is a row of small dark spots, and these may even become confluent into a narrow line. Beginning at the eye, there is a dark-brown line which runs backward on the body and tail. The lower border of this line may be continued down on the side, gradually fading out, however, so that the whole side may appear to be occupied by a broad dusky band. Just below the darkest upper edge of the band, in the intercostal spaces, there may be spots of the ground color.

Size, usually about 3.5 inches, although a length of 4 inches may be attained.

This species is very widely distributed, being known from Maine to Florida, and west to Wisconsin, and possibly Louisiana.

Indiana localities are: Brookville (Hughes and Butler); Monroe County (Ind. Univ. coll.); Waveland, Montgomery County (Butler); Marion County, abundant at places along Fall Creek, (W. P. Hay); Terre Haute (Blatchley); Vigo County (Nor. Sch. coll.). Some specimens from Vigo County have the ground-color, above, a gray merely tinged with yellowish. The snouts of these specimens were also unusually blunt. Similar specimens have been taken in Marion County. Mr. C. S. Beachler reports the species from Waldron, Shelby County.

Like a number of other species, this seems to delight in living in close proximity to the water without spending the whole of its time in that element It is found hiding away under sticks and stones and among dead leaves about shallow streams and rivulets issuing from springs. It is very active and very slippery, so that when it starts away it is extremely difficult to catch it. A number of adults and larvæ were taken June 1, by W. P. Hay, near Fall Creek, in Marion County. The adults were concealed among the dead leaves on the borders of a spring, while the larvæ were found in a little pool not far away. The adults were extremely active, and ran rapidly by a kind of combination of wriggling and jumping. The young, which had attained a length of one inch and a half, had all the markings of the adults, except that the color was less yellow The limbs were developed as in the adults. There were three pairs of gills, which the little animals held erect in the water. The tail also had a broad membranous fin. When the young were disturbed, they would dart through the water with a velocity that was surprising. I was not able to determine what they eat. One of the adults, when captured, had in its mouth the white larva of some dipterous insect The young show a decided disposition to leave the water long before the gills are lost Both old and young have the ability to climb up perpendicular surfaces. Some young were kept in a fruit jar in some water, and it was found that they were dying All the water was poured out, except a very little, after which they fared better. One was found to have crawled half-way up the side of the jar, and was resting there in apparent content.

I have not been able to ascertain the character of the eggs of this salamander, nor how they are disposed of. They must be laid in the early spring.

### Subfamily DESMOGNATHINÆ.

Vertebræ opisthocœlian. Carpus and tarsus cartilaginous.

This subfamily contains only a single genus, *Desmognathus*, belonging to which there are three species, only one of which is likely to be found in Indiana.

### Genus DESMOGNATHUS, Baird.

*Desmognathus*, Baird, 1849, *2*, 285; Boulenger, 1882, *28*, 77; Cope, 1889, *51*, 194.

Vemero-palatine teeth in a short curved series behind the choanæ; feebly developed or entirely wanting. Parasphenoidal patches present. Premaxillaries ankylosed. Tongue extensively free laterally and behind, little free in front. Digits 4–5. Vertebræ opisthocœlian.*

Externally this genus has the characters of *Plethodon*. It is, however, distinguished from the latter by its vertebræ being convex in front, and by the coalescence of the premaxillaries into one piece.

A. With 14 costal grooves.
- a. Abdomen of uniform pale color. N. Y. and Pa. *ochrophæa.*
- aa. Abdomen marbled with light and dark. *fusca*, p. 451.

AA. With 12 costal grooves.
- Color black above and below. Va. to Ga. *nigra.*

*See foot-note page 439; p. 31 of author's edition.

**Desmognathus fusca,** (Rafinesque).

*Brown Triton.*

*Figure* 5, *Pl.* 1.

*Triturus fuscus*, Rafin., 1820, *108*, March; *Salamandra quadrimaculata*, Holbrook, 1842, *54*, 49, pl. 12; *Desmognathus fuscus*, Baird, 1849, *2*, 285; Cope, 1869, *1*, 115; Cope, 1889, *51*, 194, with figures; Boulenger, 1882, *28*, 77.

Body rather heavily built and somewhat depressed. The distance from the snout to the axilla in distance from snout to groin three times, or nearly so. There are usually 14, rarely 13 or 15, costal grooves. A dorsal furrow commencing at the nape and ending over the vent.

Head flat and the snout rounded. The gular fold prominent, rising on the sides of the neck and the turning forward towards the eyes. Another fold, starting on the under jaw, crosses the corner of the mouth and rises on the side of the head. This furrow is crossed by one which starts behind the eye and runs back to the gular fold. The eyes are very prominent. Tongue moderate in size, free at sides and behind, little free in front. Vomero-palatine teeth not strongly developed, sometimes entirely missing. When present they form only a short series on each side. Parasphenoidal teeth in two patches which diverge backwardly. Lower mandible somewhat undulate, especially in the males; toothed to near the angle of the mouth. Width of head in distance to the groin about five times. The limbs are feebly developed, the fore and the hind limbs, when stretched along the side, not meeting by about four interspaces. Fingers 4, toes 5, joined at the bases by a narrow membrane. Tail about as long as the remainder of the animal, tapering gradually to a sharp point; its section at the base circular becoming flattened further back on the upper edge into a narrow fin.

The color of this species is quite variable. The adults of full size are usually dark above, with the belly paler, and with mottlings of brown. Along with the brown of the upper surface are shades of gray and pink; the young, and sometimes the half-grown, with ochreous spots along each side of the back, and these bordered more or less with black. In some specimens the whole middle line of the back is yellow or somewhat orange, brightest along the outer border, and divided along the middle line by a row of black spots. Such specimens resemble *Plethodon cinereus erythronotus*. These bright colors are sometimes retained by the full-grown specimens.

A variety of this species, *auriculata*, which has not been recognized in Indiana, is distinguished by having a series of small red spots along the sides, and often a red spot from the eye to the corner of the mouth. Has been taken near Cincinnati, Ohio.

The habitat of this salamander includes the territory extending from Maine to Indiana, Georgia, Mississippi, and southwestern Arkansas.

In Indiana it has been taken, up to this time, only at Brookville (Haymond, Butler, Hughes), and in Monroe County (C. H. Bollman); Richmond (F. C. Test); Decatur County (W. P. Shannon).

Where found at all, this species appears to be one of the commonest. It is to a very great extent aquatic. Prof. Cope says that "it lives chiefly among the stones in the many shallow rivulets and springs of the hilly and mountainous regions of the country. It prefers the rapid and shallow streamlets. Here it may be found under every stone, or its delicate larvæ may be observed darting rapidly from place to place, seeking concealment among mud and leaves." My experience with them is that, while in confinement, they do not, at least during the summer months, remain wholly in the water, but prefer to lie hidden in their tunnels in moss, with the head sticking out, so as to observe what is going on. When they are lying thus, if an insect is presented to them on the forceps they spring swiftly forward and seize and swallow it. I have had them to take flies and small spiders. One attempted to swallow a nearly whole red-legged grasshopper. They are extremely active and vigorous, and as slippery as eels, and it is with the greatest difficulty that they can be retained in the hands. When one is put on the floor, it escapes rapidly by a sort of combination of leaping and running. When held on the hand they will leap from it in the endeavor to escape. The tail is to some extent prehensile, and may be employed to keep the animal from falling.

Prof. Baird originally observed that this salamander lays its eggs in a string, and this is wrapped several times around the body of one of the pair, which then retires to a spot of concealment while the eggs develop. This curious habit, about which more needs to be known, has been confirmed by Prof. Cope. How long the care for the eggs continues is not known. The larvæ retain the gills for a varying period, but usually until the animal is half-grown.

## Family VI. SALAMANDRIDÆ.

Body salamandrine in form. No persistent gills or gill-slits. Vertebræ opisthocœlous. Vomers each with a long palatine process reaching backward over the parasphenoid, bearing along its inner edge a single series of teeth. No parasphenoidal teeth. Carpus and tarsus ossified. Our single species red or olive above, with a series of red spots on each side of the back.

As here defined, including Professor Cope's families *Salamandridæ* and *Pleurodelidæ*. It embraces from six to nine genera, of which we have only the following:

### Genus DIEMYCTYLUS, Raf.

*Diemyctylus*, Rafinesque, 1820, *108*, 5; Cope, 1889, *51*, 202; *Molge*, Merrem, 1820, *96*, 1885; Boulenger, 1882, *28*, 6.

Vomero-palatine teeth on inner margin of long backwardly projecting palatine processes of vomers. No parasphenoidal teeth. Tongue small, free only a little at the sides. An arch of bone connecting the squamosal and frontal bones. Digits 4–5.

### **Diemyctylus viridescens,** Rafinesque.

*Green Triton;* Newt.

*Figure* 6, *Pl.* 1.

*Triturus* (*D.*) *viridescens*, Rafinesque, 1820, *108*, No. 22; *Salamandra symmetrica*, Holbrook, 1842, *54*, v, 57, pl. 17; *Diemyctylus viridescens*, Cope, 1889, *51*, 207, with figures; *Molge viridescens*, Boulenger, 1882, *28*, 21; *D. viridescens*, Gage, 1891, *22*, 1103, with plate and complete synonomy.

Body usually rounded and full, without a dorsal crest, but with a distinct sharp vertebral ridge. Distance from the snout to the axilla in distance to groin 2.5 times. Head longer than broad, its width in distance to the groin about 3.5 times. Outlines of head converging in front of the eyes to the rounded snout. Skull flat above, with four ridges enclosing three grooves; the outer ridge formed by the fronto-squamosal arch. Sides of the head perpendicular. A row of three or four enlarged pores behind the eye; these sometimes wanting. No gular fold. Tongue small and fleshy, free a little at the sides Vomero-palatine teeth in two rows, which meet between the choanæ; then, diverging gradually, run backward along the roof of the mouth to the back of the skull. Tail constituting about one-half the entire length of the animal, more or less compressed, and tapering to a point; in the breeding season furnished above and below with a membrane-like fin.

Anterior limbs slender, the inner finger rudimentary. Hinder limbs stout, the inner and the outer toes small. In the breeding season, black callosities appear, in the case of the mature males, on the inner side of the hinder limbs, on the bottoms of the feet, and at the tips of the toes, those above forming transverse ridges.

The coloration of this species is so different at different periods of its life that a specimen seen while immature and again when full-grown would with difficulty be recognized as belonging to the same species. The gilled larvæ are olive of various shades, with black specks above; below, the color is almost uniform whitish. The metamorphosed, but still immature specimens are, on the other hand, of an orange color, varying to vermillion. The belly is somewhat paler. There may or may not be small black specks on the upper surface; while there are on each side of the back about half a dozen crimson spots of the size of the pupil, each surrounded by a black ring. Such young specimens are terrestrial in their habits. The sexually mature individuals are generally of some shade of olive, often having a reddish or yellowish tinge. The lower surface is generally of a bright yellow. Both above and below are to be seen numerous dots of black. In the breeding males some of these spots, especially those on the tail, may enlarge and become more or less ocellated. On each side of the back are the red spots surrounded by a black ring. The red, immature specimens are generally quite rough above and often below through the development, all over the skin, of small, pointed papillæ.

The distribution of this species is from Maine to Hudson's Bay, Wisconsin, Texas, and Georgia. Indiana localities are as follows: New Harmony (Sampson's Coll.), Brookville, where it is common (Hughes), Mt. Carmel (L. M. Turner), Monroe County (Ind. Univ. Coll.), Terre Haute (Evermann, Blatchley), Rochester, Fulton County (Dr. Vernon Gould), Lake Maxinkuckee, Marshall County (Hay.)

The habits of this beautiful and interesting creature have been studied by many naturalists, among them Dr. Hallowell, Prof. S. F. Baird, Prof. E. D. Cope, Dr. Howard Kelly, Sarah P. Monks, Col. Nicholas Pike, and Prof. S. P. Gage. The red form is so different from the sexually mature, "viridescent" form that it was originally described as a distinct species under the name *miniatus*, and indeed was put by Rafinesque in a different subgenus. Prof. Baird placed the forms in the same genus as distinct species, but he recognized the close similarity existing between the two. Prof. Cope as early as 1859 (*1*, '59, 122–128), expressed the opinion that *miniatus* is only a state of *viridescens*; yet in his check list of 1875 he gives the two forms as subspecies. Later (*51*, 207) he regards them as "seasonal forms, which may be by reason of the environment rendered permanent for a longer or shorter time." Dr. Howard Kelly kept a number of the red *miniatus* in a dark box filled with wet moss and saw them transform into the olive state characteristic of *viridescens*. Sarah P. Monks observed the same change. Col. Nicholas Pike kept a number of the red ones where they could enter the water. After some time they did this, and after about three months they lost the bright red color, and in less than a year had the olive hue of *viridescens*. He, in common with many others, believed that the *viridescens* form might change back into the *miniatus* form.

Prof. S. P. Gage and wife of Cornell University have studied the species most carefully. They have seen the eggs deposited, watched the hatching of the larvæ, their transformation into the red, immature, *miniatus*, and the change of other specimens of these into the *viridescens*.

They believe that the terrestrial life continues until the autumn of the third or the spring of the fourth year after hatching, and that when they have once entered the water they do not again leave it unless the pool dries up or there is a scarcity of food.

The eggs are fertilized internally, and, when laid, are glued to the leaves of aquatic plants. Prof. Gage's observations seem to show that only about six or eight eggs are laid after each pairing of the sexes. After some days another batch may be laid. The time of deposition of the eggs extends from the first week of April until at least the middle of June. Gage's statements to the effect that the eggs are attached singly to the leaves of plants is confirmed by the observations of Cope and Monks. Prof. Verrill, of Yale College, and Col. Pike, on the other hand, state that the eggs are laid in masses containing from 25 to 150. The larvæ are active and timid. Their heads are not so broad as those of the larvœ of the Ambystomas, with which they may be associated. Their food consists of minute crustaceans, larval insects, and small snails. In color and form they closely resemble the full-grown individuals, except that they have three plumose gills, and the broad tail-fin extends forward to the back of the head. The gills begin to be absorbed during the last half of the August after hatching, the tail-fin is absorbed, and the larvæ then often comes to the surface to obtain air. About September 1 the now transformed young leave the water, hide away in the dirt and among leaves, and acquire the yellow or red color. During the metamorphosis the body appears to shrink considerably in size. I have seen, in the National Museum, a number of specimens, 2.25 and 2.75 inches long, with remains of gills, while red specimens, 1.75 inches long, entirely without any trace of gills are common. Prof. Gage, however, finds that the larvæ are usually only about an inch and a half long at the time of their change.

Where found in abundance, the adult newts may be taken during all the warmer months of the year; and it is probable that they are active during the whole year, unless the cold is too intense. They have been seen swimming under ice an inch thick. They delight most in pools which are fed by perennial springs. Their habits are not so nocturnal as those of many of their kindred. They may be seen at all times of day swimming about, climbing on aquatic plants, floating on the surface of the water, and basking in the sunshine. The food of the adults consists of insects, tadpoles, worms and mollusks. In confinement they become quite tame, and will take pieces of beef or insects from a wire, opening the mouth slowly, protruding the tongue, and gently pulling off the morsel. One has been known to swallow a piece of earthworm twice its own length, and to use its hands in holding its prey.

During the breeding season the colors are most intense, and the sexes are at their best. The spots along the sides become flame-color, the belly orange, while the male acquires a broad spotted crest along both edges of the tail. At the same time the black callosities appear on the hind legs. In their courtship the males are very active and very ostentatious. When success is won, they seize the female around the body and remain thus for an hour or more. Prof. Gage finds that the sexes pair in the fall as well as in the spring.

The outer skin is frequently shed. It is pushed back from the head by rubbing against objects; sometimes the hands are employed to effect this purpose. The process of moulting occupies about an hour and a half. Samuel Lookwood (*22*, x, 11) has seen it free itself of the cuticle while under the water; immediately the little thing turned around and swallowed the whole skin. Prof. Gage has seen the terrestrial form pull the exuvium off the end of the tail and swallow it. It is also interesting that the Newt can utter a faint shrill cry. The tail is extremely prehensile, and may be employed to suspend the animal for some time. It has been observed by Prof. Gage that during the aquatic stages the epithelium of the mouth is of the non-ciliated variety, while during the *miniatus* stage the epithelium is ciliated. Furthermore, the adults, while living in the water enjoy a form of aquatic respiration, water being regularly taken into the mouth and again expelled.

## Order SALIENTIA.

Batrachia having a frog-like, or toad-like form. All four limbs present, the hinder greatly developed and fitted for leaping. Proximal elements of tarsus elongated, so as to form an additional limb segment. Vertebræ in front of the sacrum not exceeding nine. Ribs rarely present. No tail in the adult state. A tympanic cavity present.

This order includes the frogs and toads. With rare exceptions, the eggs are laid, fertilized, and hatched in the water. The young are familiar to all as tadpoles. These breathe for a short period by means of external gills, and for a longer time by internal gills. The intestines are long, the mouth furnished with horny sheaths, and the lips with several rows of horny teeth. By means of these, the little tadpoles are enabled to support themselves by scraping off the minute vegetable matter which covers objects in the water. As growth progresses, the limbs develop; the fore limbs, however, are for a long time concealed beneath the skin, and when they break through, they appear to be produced suddenly. As the period of metamorphosis approaches, the horny jaws and denticles are shed, the mouth enlarges, the tongue appears, the intestine shortens, the tail is absorbed, respiration by the lungs prevails, the gills disappear, and the tadpole leaves the water and becomes a frog.

All regions of the world, except the very coldest and the very driest, furnish representatives of this Order. Altogether there are about 800 species described. All our species come under Prof. Cope's suborders *Arcifera* and *Firmisternia*. Of the first, we have representatives of two families; of the second, one family.

KEY TO THE FAMILIES OF *Salientia*.

A. Clavicles* and coracoids of each side connected by an arched cartilage; that of the one side overlapping that of the other. (*Arcifera.*)
 a. Upper jaw without teeth; digits without disks. *Bufonidæ*, p. 457.
 aa. Upper jaw furnished with teeth.
  b. Form frog-like; toes and fingers with disks. *Hylidæ*, p. 460.
  bb. Form toad-like; digits without disks. *Scaphiopodidæ*.
AA. Clavicles and coracoids of the one side firmly connected with those of the other side by means of a narrow median cartilage. (*Firmisternia.*)
 a. Upper jaw with teeth. *Ranidæ*, p. 472.
 aa. No teeth on upper jaw. *Engystomatidæ*.

## Family VII. BUFONIDÆ.

Both upper and lower jaws destitute of teeth. Vomerine teeth usually absent. The diapophysis of the sacral vertebræ more or less expanded. Vertebræ procœlous. Ribs none.

A widely distributed family, containing, according to Cope, fourteen genera, of which we possess only one, *Bufo*.

Certain characters are very commonly possessed by the *Bufonidæ*. Among these are a heavy squat form, short limbs, a rough, warty skin, and a collection of integumentary glands lying behinh the head, and known as the paratoids.

### GENUS BUFO, Laurenti.

Laurenti, 1768, *109*, 25; Boulenger, 1882, *27*, 281; Cope, 1889, *51*, 260.

No vomerine teeth. Tympanum distinct or hidden. Toes webbed; fingers free. Sacral diapophysis more or less dilated. Outer metatarsals united.

---

*In order to understand the arrangements of the shoulder girdle on which the division of the Salientia into *Arcifera* and *Firmisternia* is based, the student ought to dissect this portion of the common Toad, as a representative of the *Arcifera*, and the same portion of the Leopard Frog, as an example of the *Firmisternia*. The accompanying figures, 7 and 8, pl. 2, will assist.

**Bufo lentiginosus,** Shaw.

*Toad.*

*Bufu lentiginosus*, Shaw, 1803, *71*, iii, 173; Boulenger, 1882, *27*, 308; Cope, 1889, *51*, 277 and 289, with figures. *B. musicus*, Holbrook, 1842, *54*, v. 7, pl. 1.

Var. *americanus*. *Bufo americanus*, LeConte, 1838, *53*, i, 75, pl. 9; 1842, *54*, v., 17, pl. 4; *B. lentiginosus*, var. *americanus*, Boulenger, 1882, *27*, 309; Cope, 1889, *51*, 284, with figures.

Var. *fowleri*, *B. lentiginosus fowleri*, Putnam, 1889, *51*, 279, with figures.

Form of body heavy and awkward. Head furnished above with more or less conspicuous bony crests. Of these, two, the fronto-parietal, run backward from the snout to the back of the head and embrace between them a furrow. Immediately behind the orbits each of these is met at right angles by a crest, the postorbital, which runs outward and downward behind the eye. From the lower end of the postorbital, a ridge, the supra-tympanic, may pass backward over the tympanic disk.

Snout short and blunt, the outline in front of the nostrils perpendicular. Tympanic disk distinct, oval, smaller than the eye. Upper jaw notched in the middle line. Paratoids elliptical, about as long as the distance from the nostril to the postorbital crest. Heel reaching to the eye or less. Toes half-webbed. Two metatarsal tubercles; the outer small, the inner large and with a cutting edge.

Skin on the upper surface everywhere provided with large and small pointed warts; below rough with crowded, pointed granulations.

Color variable; usually olive to brown, with irregular blotches and spots of dark brown; middle of the back with a light streak; below dirty yellow. The upper surface is sometimes almost a uniform black; at other times ash-gray, showing the dusky spots with great distinctness. Occasionally a specimen is found with the tubercles, and even considerable portions of the skin of a beautiful pink color. Other specimens may be of a uniform brick-color above, pink below.

Males provided with a large vocal sac, which communicates with the mouth by a slit on each side of the tongue. The toad may reach a length of as much as five inches, including head and body. Females larger than the males.

Four varieties, or subspecies, of this animal are recognized by Prof. Cope, three of which may be looked for within our borders. They may be distinguished as follows:

Fronto-parietal crests lying closely together, parallel, posteriorily passing little if any beyond the postorbitals. No supra-tympanic crest; a preorbital ridge. Heel reaching beyond the muzzle. Size rather small. Color grayish-olive; vertebral line yellow. *fowleri.*

Fronto-parietal crests diverging toward back of head, and passing somewhat beyond the postorbitals. The latter crests short; preorbital not strong; no supra-tympanic. Heel reaching the front of the orbit. Our common form. *americanus.*

Fronto-parietals diverging toward back of head, passing beyond the postorbitals and expanding into a pair of knobs; supra-tympanic well developed. Head from snout to ends of crests contained in length to vent 3.5 to 4 times. Southern. *lentiginosus.*

The common toad in its various forms has an extremely wide distribution, being known to occupy the whole of eastern North America, west to Montana, Arizona, and Mexico. In Indiana the variety *americanus* is everywhere distributed. The variety *lentiginosus* has not been reported from any locality within the State, but may be looked for in the extreme southern portion. The variety *fowleri* is known principally from specimens found at Danvers, Mass., but Prof. Cope reports a specimen from New Harmony. (See *51*, 279.)

The toad is with us an extremely common animal. It is almost a synonym for ugliness, but its mild and inoffensive disposition has gained for it some degree of toleration. Nevertheless, it still suffers much persecution, chiefly at the hands of untaught and thoughtless or cruel boys.

The toad appears in the spring when the warm days have fully come, and it is seen until the approach of the cool days of the autumn. Soon after emerging from its winter retreat, it repairs to the water for the purpose of depositing its eggs. These are laid, not as those of the common frog, in a shapeless mass, but in a long string, consisting of a double series of eggs enveloped in a tube of gelatinous materials. Mr. E. E. Crosby (*22*, vii, 574) says that the eggs of two specimens numbered respectively 8,840 and 2,200. Prof. Cope states that the young hatch early and are of a darker hue than is usual with other Salientia, but it is difficult to see how they can be blacker than the larvæ of *Rana pipiens*. The length of the young mature toads is about one-half inch; the color grayish, with small dark-colored spots. The metamorphosis occurs about July 10. The notes of the male toad are heard principally during the breeding season. They may be represented by the syllables ur-r-r-r-r.

The habits of the toad are mostly noctural, although it is not uncommon to see a toad hopping about in the daylight. Usually, however, they hide away during the day in holes and obscure corners, and come forth at evening to seek their food. This consists mainly of insects, and of these enormous numbers are devoured. It is related (*34*, '73, 23) that one old toad ate at one time twenty-three squash bugs, and on the top of these, ninety-four caterpillars. On account of this propensity for devouring insects, intelligent gardeners and farmers seek to induce toads to take up their residence on their grounds. No boy should be permitted to destroy this harmless animal. The prey is taken by suddenly projecting the tongue from the mouth, and then withdrawing it with the insect sticking to it. Besides insects, toads will eat earthworms, and small crustaceans, while it is said that one attempted to swallow a wounded humming bird. When the prey is large and difficult to swallow, the toad is said sometimes to push it against the ground or a stone. One is described as pressing its hand against its stomach, in order to hold down an earth worm that threatened to escape. The toad is stated never to make leaps after its prey, but to await until it has approached near enough to be reached by the tongue.

The warty skin of the toad is full of large glands, which secrete a thick whitish fluid. This has very acrid properties, and doubtless serves to render the animal unpalatable to most of its enemies. It does not seem, however, to protect it from snakes. It is said that this secretion will make the mouth of dogs sore, and even to cause some inflammation of the human skin. This last is doubtful. The skin of the frog is shed at intervals, and the statement has been made that this skin is immediately swallowed. During the winter the toad hibernates in holes and in the mud.

Dr. J. A. Allen, of Cambridge, Mass., tells of some toads that were taken in a torpid condition from the mud at the bottom of an old well. Some of them were buried in the mud two feet deep, and he supposed that they had been there ten or fifteen years, and probably longer. On being taken out, they soon revived and hopped away.

## Family VIII. HYLIDÆ.

Upper jaw with teeth. Fingers and toes furnished with disks; these supported by the claw-like, terminal phalangeal bone. Transverse process of sacrum expanded. Vertebræ procœlous.

According to Prof. E. D. Cope, this family contains 183 species, and these he includes in 18 genera. They are distributed in all the great faunal regions. Of these genera, we have only three.

### Key to the Genera of *Hylidæ* found in Indiana.

Fingers without a web. Toes fully webbed. Digital disks small. *Acris*, p. 461.

Fingers webbed or not. Toes fully webbed. Digital disks larger. *Hyla*, p. 463.

Fingers not webbed. Toes with little or no web. Disks small. *Chorophilus*, p. 469.

### Genus ACRIS, Dum. & Bib.

*Acris*, Dumeril & Bibron, 1841, *74*, viii, 506; Boulenger, 1882, *27*, 336; Cope, 1889, *51*, 324

Fingers free; toes fully webbed, the tips of the digits with small disks. Vomerine teeth present. Tongue with a notch behind. Tympanum indistinct. Sacral process little expanded.* Closely allied to *Hyla*.

This genus contains but a single species, and this is abundant everywhere with us.

### **Acris gryllus,** (LeConte).

*Cricket Frog.*

*Rana gryllus*, LeConte, 1825, *62*, i, 282; *Acris gryllus*, Dum. & Bib., *74*, 507; Boulenger, 1882, *27*, 336; Cope, 1889, *51*, 324, with figures; *Hylodes gryllus*, Holbrook, 1842, *54*, iv. 131, pl. 33.

Variety *crepitans*.

*Acris crepitans*, Baird, 1855, *1*, 59; Boulenger, l. c.; Cope, l. c., 326, with figures.

Form frog-like. Length of head, measured to hinder edge of tympanic disk, in the length of body to vent three times. Snout pointed, its length in length of body six times; projecting beyond the lower lip. Vomerine teeth in two patches between the choanæ. Tongue broad, ovate, with or without a notch behind. Males with a large gular sac, which opens beneath the tongue. Tympanic disk seen with difficulty. Skin of the back smooth, or with small or large tubercles. Belly and thighs granulated; throat smooth. Legs long, the heel passing near to or beyond the snout Two large metatarsal tubercles. Subarticular tubercles well developed. Fingers without web; toes webbed to near the tips.

Color variable and subject to rapid changes. Usually the upper surface is ashy-gray or brown. Occasionally green predominates, or there is considerable of reddish, especially along the middle of the back. Between the eyes there is a triangular spot of dusky, bordered with green in life. The middle line is usually pale. The upper lip is spotted with black. There is a blotch of dusky from the eye to the shoulder, and a stripe of the same above and behind the fore legs. Legs crossbarred Color below, white; under jaw often dusky. The length of large specimens is a little over one inch.

---

*Foot-note.—This character may easily be observed by making a transverse incision in the skin of the back at the point where the iliac bones are connected with the vertebral column; that is, where the frog's back bends abruptly. The transverse process cleaned of tissue, may then be compared with the same structure in the Common Tree-frog, *Hyla versicolor*.

Two varieties, or subspecies, of this frog are recognized, as follows:

Skin of back nearly smooth; hind foot from metatarsal tubercles longer than half the length of head and body. *gryllus.*

Skin of back considerably tuberculated. Hind foot, from the metatarsel tubercles, shorter than one-half the length of head and body. *crepitans.*

The habitat of this species extends from New York to Florida, and west to Nebraska and Texas. The variety *gryllus* is, for the most part, Southern in its range, while *crepitans* is more Northern. In Indiana the *crepitans* is found everywhere. The variety *gryllus* is in the National Museum from Mt. Carmel, on the Wabash, and I have specimens taken at Lake Maxinkuckee which correspond well to the descriptions of that variety.

This little frog is one of our commonest batrachians. During the summer season it may be seen in numbers along all of our streams. I doubt if it is often seen about the ponds or pools far from running water. It is not thoroughly aquatic, but delights to spend its time amid the vegetation about the border of the water. When alarmed it will leap into the water, but it often appears to become alarmed at its rashness and hastens to reach the land again. When followed up, however, it will go to the bottom and seek to conceal itself for awhile. Though belonging to the "tree frogs" it never ascends trees, and probably climbs only the shorter grasses and water plants. It is a cheerful little creature, and on warm days may constantly be heard executing its noisy song. This resembles closely the striking together rapidly of two pebbles, and often, when their singing has been interrupted by the passer-by, it may be started again by clicking two stones sharply together.

This little chatterer appears very early in the spring, and it is my observation that it is to be found at all times during the summer. Numerous specimens were found at Irvington on the 8th of March. The eggs are probably laid about this time, although I do not know anything about them. On the 16th of August I found numerous specimens of the tadpoles of this species. They were found hiding in the vegetation at the bottom of a small stream. They were in very different stages of development, some with both the fore and the hind legs visible, others with only short hind legs. The arrangement of the horny denticles about the mouth of the larvæ I found to be different from that of specimens of *Chorophilus triseriatus.* In both species there are two rows of horny denticles on the upper lip. On the lower lip, there are in the *Chorophilus* three rows of denticles, but in *Acris* only two. Furthermore, in *Chorophilus* the denticles are finely serrated at their tips; in *Acris* this is not the case. The teeth of the latter genus are less numerous than in the former. The transformations occurred about September 1.

Dr. Holbrook states that the Cricket frog feeds on various kinds of insects, and makes immense leaps to secure its prey and to escape pursuers. He says that it can be easily domesticated, and takes its food readily from the hand. He kept several of them for months in a glass globe on a few sprigs of purslane, feeding them occasionally with flies; their chirp was at times incessant, and sprinkling them with water never failed to render them more lively and noisy.

Dr. C. C. Abbott (*22*, xvi, 707) has studied the habits of this species in New Jersey. He found them extremely abundant along ditches through meadows in the early spring, and very noisy. The eggs were deposited in little masses about May 1, and attached to blades of coarse grass. After the eggs were laid the number of frogs rapidly diminished, and by June 10 all were gone. Dr. Abbott believes that all die, and that those which appear later come from the transformation of the tadpoles. This occurs late in August. The frogs seem to be moderately abundant about the middle of September, but they are then found along rapidly flowing brooks. He also thinks that the frogs do not eat during the autumn, while in the early spring they are extremely voracious.

In this region I have found them during the whole summer, notably in August before the tadpoles of the year have transformed.

### Genus HYLA, Laurenti.

*Hyla*, Laurenti, 1768, *109*, 32; Boulenger, 1882, *27*, 337; Cope, 1889, *51*, 349.

Fingers wholly, partially, or not at all webbed. Toes more or less webbed. The digits all provided with disks of larger or smaller size. Vomerine teeth present. Tongue entire or notched behind. Tympanum usually distinct, sometimes hidden. Sacral vertebræ, with its transverse processes more or less expanded.

The essential difference between this genus and *Acris* lies in the amount of expansion of the sacral diapophysis.

A large and widely distributed genus. North America possesses nine of the species. Of these seven occur in the Eastern United States.

### Key to the E. U. S. Species of *Hyla*.

A. Fingers one-third or one-fourth webbed.

Gray, olive, or green above; a V-like mark between eyes and a large, dark blotch on the back. Thighs yellow inside, and with dark mottling. Form stout. *versicolor*, p. 464.

Brownish or green above, without spots. A white line on upper lip and along the sides. Thighs not mottled or spotted behind. Form slender. *carolinensis*, Appendix.

B. Fingers webbed not at all, or only the outer with a narrow web.

a. Fingers entirely free.

Olive-brown above, green in life; a stripe from eye along the side to femur. Toes two-thirds webbed. Tympanum one-third the eye. Rare. N. J. and S. C. *andersonii.*

Olive or green above, with small, irregular dark spots. A V-shaped mark between the eyes. Toes one-half webbed. Tympanum one-half the eye. *squirella*, p. 466.

Gray or olive above, with a X-shaped cross on the back. Thighs not spotted behind. Tympanum one-half the eye. Toes one-half webbed. *pickeringii*, p. 466.

b. Outer fingers with a narrow web.

Resembles *H. versicolor*, but with a web between the outer fingers and with the thighs behind dusky and with yellow spots. S. C. to Fla. *femoralis.*

Purplish ash above, with numerous irregular dark spots. Limbs barred; thighs behind yellow, unspotted. Toes webbed to penultimate phalanx. Tympanum one-half to two-thirds the eye. Ga. to Fla. *gratiosa.*

### Hyla versicolor, LeConte.

*Chameleon Tree-Frog.*

*Hyla versicolor*, LeConte, 1825, *62*, i, 281; Holbrook, 1842, *54*, iv, 115, pl. 28; Boulenger, 1882, *27*, 372; Cope, 1889, *51*, 373, with figures.

Form heavy and almost toad-like. Head considerably broader than long; the snout rounded; the space in front of the eye concave. Eyes large and protruding. Tympanic disk about two-thirds the diameter of the eye. Tongue large, circular, notched behind. Vomerine teeth in two closely approximated patches lying between, or a little behind, the chonæ. Chest crossed by a broad fold of skin. Fingers and toes with disks nearly as large as the tympanum. Fingers with an evident membrane uniting them. Toes webbed to near the tips. The first finger opposed to the rest. On extending the hind leg along the side the heel attains the back of the orbit.

Upper surface with numerous smooth warts; belly and under surface of thighs granulated. Males furnished with a large gular sac which opens on each side under the tongue.

The color in life varies from olive to dark gray and green, varying with the surroundings of the animal. Between the eyes there is a V pointing backwards. On the back there is a large, somewhat cruciform blotch of dark color, and behind it another smaller blotch on each side. The limbs are marked with broad bars of brown. The groin and the front and back of the thighs are bright yellow, over which is a network of brown lines. The gular sac of the males is often brown.

The length of a large specimen, head and body, is sometimes two inches.

This species occurs from Maine to Minnesota, and south to the Gulf and Texas. It is not necessary to specify localities in our own State.

Prof. Cope has recorded a variety of this species from Mt. Carmel, Ill., under the name of *phœocrypta.* "The color is a dark brown, with three rows of large approximated darker brown spots." Thighs yellowish brown, with little darker brown.

HABITS.—This species is by far our commonest representative of the *Hylidæ.* Although not often seen, it is heard by all, especially during the early spring. The time of appearance in the spring varies with the latitude and the weather. About Indianapolis I have heard them as early as the middle of April, and they may come from their winter quarters even earlier. Their breeding habits have been described by Mary H. Hinckley, as they are displayed in Massachusetts (*43*, xxi, 104 and 309; *22*, xvi, 636). The adults emerge from their places of concealment from May 1 to 10. The eggs begin to be deposited immediately, and this proceeds until July 4. The eggs are attached singly or in small groups to the grasses growing in the water near the shores. These eggs have extremely little gelatinous matter around them. The development of the tadpoles goes on with great rapidity, being accomplished within forty-eight hours. When hatched, the tadpoles are a quarter of an inch long, and of a pale yellow color, dotted on the head and sides with olive. Later the olive hue prevails, and there are markings of gold. The external gills appear and are resorbed during the first week. The "holders' disappear within the first ten days. The tadpoles do not huddle together.' The hind legs appear at the age of three weeks. At that time the belly is iridescent, the back metallic, and the tail may be of a bright red. Soon, however, the color changes to a greenish, and by the time the metamorphosis has been completed, the color is a bright green. The arms appear during the eighth week. At this time they eat little food. They abandon the water from the 19th to the 24th of July, and their size is small. They betake themselves immediately to shrubbery and ascend it. They were seen to catch small spiders and to eat plant-lice. Some that were kept in a fernery gave evidence that they are nocturnal. Their green color is retained for about three months, when the frogs become gray. The black markings are not developed until after the young have forsaken the water.

The Tree-Frog has a loud voice and may be heard during damp weather. It passes its time on trees, fences, and among vines, and it has the power of adapting its colors to the objects among which it lives.

The changes are said to occur slowly. These changes of color enable it to escape the notice of its enemies. These frogs appear to hibernate sometimes in the earth and sometimes in crevices in trees.

### Hyla squirella, Bosc.

*Squirrel Tree-Frog.*

*Hyla squirella*, Bosc, 1802, *57*, ii, 181; Holbrook, 1842, *54*, iv, 123, pl. 30; Boulenger, 1882, *27*, 398; Cope, 1889, *51*, 363, with figures.

A species of small size, the length seldom exceeding an inch and a quarter. The body and limbs slenderer than in either *H. versicolor* or *H. pickeringii*. The snout is somewhat pointed; eyes prominent; tympanum about one-half the diameter of the eye. Vomerine teeth between the choanæ. Head broader than long. Fingers without web; toes half-webbed. Heel reaching in front of the eye. Skin of the upper surface smooth; of the belly, thighs, and sometimes of the chin and throat, granulated.

Color above in life said to be green; below, white. In spirits, light brown or purplish. There is a V-shaped mark joining the eyes and several scattered spots of the size of the tympanum on the back. A dark band from the snout to the eye, thence through the ear to the shoulder. Below this there is a narrow light line. Limbs indistinctly barred.

The snout of this species is less projecting than in *H. pickeringii;* the tympanum larger and more distinct.

Until recently this species has been known only from South Carolina and west to Louisiana. Recently, however, a specimen was sent to Professor Cope by Mr. Amos W. Butler, from Brookville, Indiana. This gives a remarkable extension to the range of the species.

Of this frog Holbrook says that it is found on trees, often seeking shelter under the bark of such as are decayed. It frequently chooses old logs for the place of its hibernation. He had often seen them about old houses and under logs and boards.

### Hyla pickeringii, (Storer).

*Pickering's Tree-Frog.*

*Hylodes pickeringii*. Storer, 1839, *58*, 240; Holbrook, 1842, *54*, iv, 135, pl. 34; *Hyla pickeringii*, LeConte, 1854, *1*, 429, pl. 7; Boulenger, 1882, *27*, 399; Cope, 1889, *51*, 352, with figures.

Head a little longer than broad; snout rather pointed; the canthus rostralis distinct; the loral region concave. Interorbital space wider than the eyelid. Tympanum distinct, about half the diameter of the eye. Tongue free behind, rounded and slightly notched. Vomerine teeth in two patches, a little behind the choanæ. Males furnished with a large gular sac, which opens into the mouth by a slit each side of the tongue. Fold of skin on the breast conspicuous or not. Fingers and toes with well-developed discs. Fingers entirely without webs. Toes half webbed. Hinder limb, when pressed to side, bringing the heel to the eye. Two distinct tubercles on the heel; subarticular tubercles present. Skin nearly smooth above, granulated on the chest, belly and the under surface of the thigh.

Color above varying from ash to brown and reddish. On the back is an X of narrow dusky lines, these beginning at the eyes and terminating on the sides just before the insertion of the thighs. On each side of the body, opposite the intersection of the lines of the X, begins another dusky line, which runs parallel with the corresponding line of the X. Between the eyes is a very open V. A dusky band runs from the snout to the eye, and seems to be continued over the tympanum and the fore leg, and fades out along the side. Edge of the upper lip pale, but mottled with dusky. Some specks of brown on the breast and throat. Gular sac of male brown, at least in the spring. Fore legs of the color of the body, and with indistinct bars. Thighs mottled, tibiæ barred, feet mottled. The young frogs, with bodies three-fourths of an inch in length, are of a fine straw color, with the usual brown markings.

Length a little over one inch.

Known to occur from Maine (*18*, 707) to Manitoba and south to South Carolina and Indiana. Specimens of this frog have been taken in the vicinity of Bloomington by the late Charles H. Bollman. Professor Blatchley reports having taken four specimens at Terre Haute, and there was a specimen from there in the Normal School collection. I have it also at the hands of Mr. A. B. Ulrey, from North Manchester, Wabash County. I have also received a specimen from Brookville, at the hands of Mr. Ed. Hughes. It will, no doubt, be found ultimately in all portions of the State.

Prof. Cope states that this is our most abundant species of Hyla, but that it is more generally known by its voice than by its appearance. "After the rattling of the *Acris gryllus* in the marshes and river banks is fairly under way, during the first bright days of spring, the shrill cry or whistle of this little creature begins to enliven the colder swamps and meadows of the hill country. Different individuals answer each other with differently toned voices of a single note. This is exceedingly shrill and loud; the muscular force employed in expelling the air from the lungs seems to collapse the animal's sides till they nearly meet, while the gular sac is distended with each expulsion to half the size of the head and body together. They are chiefly noisy in the end of the afternoon, but in shady situations or on dark days may be heard through the morning and noon. When the breeding season is over they may still be found, but with difficulty, among fallen leaves in low places, where their color admirably adapts them for concealment, or in cellars, or on the ground in the woods. Not till the near approach of autumn do we have evidence of their ascent into the trees. Then, when the wind is casting the first frosted leaves to the ground, a whistle, weaker than the spring cry, is heard, repeated at intervals during the day, from one part of the forest to another, bearing considerable resemblance to the note of the purple finch, uttered as it is while flying. These voices are heard during the same season, that of the *Hyla* being distinguishable as slightly coarser, or more like a squeak. Both are associated with the weak chirp of the late *Dendrœca coronata* as it gleans its insect food on its southern flight. These are the latest sounds of autumn, and soon disappear before the steady advance of the ice king." (Cope, *51*, 354.)

DeKay (*30*, 69) says that this species is abundant in the neighborhood of New York, and that they are often to be seen on Indian corn and grape vines, and in greenhouses, under the leaves of plants during the heat of summer. He says that they feed on small flies; but it is not probable that they restrict themselves to such small creatures. Mr. S. P. Fowler sent the editors of the American Naturalist a beautiful fawn-colored specimen, which he had found imbedded in a heap of grass in his garden on November 25.

The eggs are laid in bunches of from 4 to 10, and are about one-twelfth of an inch in diameter. The eggs and larvæ in various stages of development are figured by Prof. Baird in Cope's "Batrachia of N. A." He states that the eggs are laid May 15. Smith says (*18*, 707,) that in Maine the eggs are deposited in April. According to Prof. Baird's statements, the young are able to swim within four days. For further details on breeding habits see Miss Hinckley's paper in Mem. Bost. Loc. Nat. Hist., vol. v, pp. 311–318.

Some larvæ of *pickeringii* which I have examined in the National Museum, at Washington, and which had the tail of full size, were a little less than an inch in length. Other young which had just transformed were only seven-sixteenths inch long. Prof. Blatchley reports finding this frog at Terre Haute, April 8, at the margin of a pond, to which they had evidently resorted in order to deposit their eggs. Two were kept in captivity several weeks, and regularly at 8 P. M. they began their piping notes, and kept them up about an hour. After this they were silent until the next evening. The gular sac would be inflated until it was two-thirds as large as the animal itself, when the air would be forced out, producing the notes. (*94*, '91, 27.)

### Genus CHOROPHILUS, Baird.

*Chorophilus*, Baird, 1854, *1*, 59; Boulenger, 1882, *27*, 332; Cope, 1889, *51*, 331; *Helœcetes*, Baird, *1*, 1854, 59.

Fingers free from web. Toes with little or no web. Digital disks all small, but the phalanx with a strong claw. Vomerine teeth present. Tongue round or oval, slightly notched behind. Tympanic disk distinct. Sacral vertebra with its transverse process slightly expanded.

This genus contains some six species, all except one belonging to North America.

KEY TO THE NORTH AMERICAN SPECIES OF *Chorophilus*

A. Upper jaw projecting beyond the rounded lower; profile pointed.
- Width of head in length of head and body 2.5 to 2.66 times; nostrils half way from tip of snout to eye. Texas. *ornatus*.
- Width of head in length 3 to 3.5 times; nostrils nearer tip of snout than orbit; no subarticular tubercles. Georgia to Texas. *occidentalis*.
- Width of head in length 2.8 to 3.66 times; subarticular tubercles well developed; upper surface usually with 3 to 5 dark stripes or rows of spots; nostrils nearer tip of snout than orbit. Eastern United States. *nigritus*, p. 469.

B. Upper jaw not projecting beyond the almost V-shaped lower; profile truncated; length two-thirds inch. South Carolina. *ocularis*.

### Chorophilus nigritus, LeConte.

*Striped Tree-Frog.*

Variety, *nigritus*. *Rana nigrita*, Leconte, 1825, *62*, 282; *Cystignathus nigritus*, Holbrook, 1842, *54*, iv, 107, pl. 26; *Chorophilus nigritus*, Baird, 1854, *1*, 60; Boulenger, 1882, *27*, 333; Cope, 1889, *51*, 337, with figures.

Variety, *feriarum*. *Helœcetes feriarum*, Baird, 1854, *1*, 59; *Chorophilus feriarum*, Cope, 1889, *51*, 339, with figures.

Variety, *triseriatus*. *Hyla triseriata*, Wied, 1839, *63*, 249; *Chorophilus triseriatus*, Cope, 1875, *12*, 30; 1889, *51*, 342; *C. septentrionalis*, Boulenger, 1882, *27*, 335, pl. 23, fig. 1.

Length of head and body seldom exceeding an inch and a quarter. Head having its length equal to its breadth or greater. Tympanum distinct, about one-half the diameter of the eye. Tongue emarginate behind. Vomerine teeth between, or slightly behind the choanæ. Males furnished with a conspicuous gular sac, which is capable of considerable inflation, and opening into mouth by a slit each side the base of the tongue. A conspicuous fold of skin across the breast. Fingers with, at most, a rudiment of a web. Toes with a slight web at their basal joints. Disks of all the digits small. Limbs of quite variable length, the heel reaching only to the tympanic disk, or to the nostril. Skin almost everywhere granulated, finely on the back, more coarsely on the lower surface.

General color, varying from light ash to fawn and purplish-brown; below, cream color. On the back and sides there may, in nearly all specimens, be seen five dark stripes or rows of spots. One beginning on the head, runs along the back, often forking on the urostyle. On the head, this stripe may expand so as to involve the eyelids, or there may be spots on the lids distinct from the median stripe. On each side of this dorsal stripe is another, which begins behind the eye and ceases just in front of the thigh. Another stripe begins on the snout, runs through the eye, over the tympanic disk and the shoulder, and fades out along the side. A whitish line runs along the upper lip to the shoulder. Sometimes the median and the lateral bands next it may be broken up into distinct spots, or these bands may be obsolete. The limbs are more or less barred or spotted with dusky.

Under the name *nigritus* I have included forms which are assigned by Prof. Cope to three distinct species, *nigritus*, *feriarum*, *triseriatus*. I do so because, at the present time, I do not think that the distinctions are sufficiently constant to characterize species. That the student may recognize the forms and accord them specific value, if he so desires, I state the differences.

Snout acuminate; width of head in length of head and body 2.8 to 3 times; heel reaching in front of orbit; size larger; color leaden or fawn, with three rows of dark spots above; these sometimes united into continuous bands. South Carolina to Mississippi. *nigritus*.

Snout shorter; width of head in the length 3 to 3.25 times; heel reaching to front of orbit; length of body in total length of hind leg, from 1.40 to 1.70; color ash or brownish, eyelids involved in median stripe, three parallel stripes above, seldom interrupted. Eastern United States to Illinois. *feriarum*.

Snout drawn out; width of head in length 3.5 to 3.6 times; heel reaching only to tympanic disk; length of body in total length of hind leg, 1.24 to 1.50 times; color ash to brown, with three parallel dark stripes, the median often forking behind; a distinct spot on each eyelid. New Jersey to New Mexico and Idaho. *triseriatus*.

*C. nigritus* is chiefly or wholly southern, *feriarum* eastern, and *triseriatus*, the short-legged and peaked-nosed form, mainly western, in distribution. All that I know of from Indiana belong to the variety *feriarum*. These have been taken at Brookville (Ed. Hughes), Brooklyn, Morgan County (W. P. Hay), Wheatland (Nat. Mus. coll.); Irvington; Terre

Haute (Blatchley), New Harmony and Mt. Vernon (Max. von Wied, *103*, xxii, 118); Wabash and Kosciusko counties (A. B. Ulrey).

This species appears to be rather rare in Indiana, but its rarity may be more apparent than real, since many of these animals have the faculty of effectually concealing themselves from the eye of the collector. In Indiana the variety *feriarum* lays its eggs about the 20th of March. The writer has described the life history of this little frog (*22*, xxiii, 770, with plate). Its eggs were found in a small pool on the 22d of March. They were attached to twigs in small and large bunches. Each egg was one-third inch in diameter, including the usual coating of jelly. In the egg the larva has a strong dorsal flexure, and has the tail thrown over the back. The tadpoles were set free on April 5. They are slenderer than the larvæ of the Leopard Frog, and not so dark in color. They are dark gray, rather than black. The external gills are small and quickly absorbed. They spend much of their time sticking to objects by means of their "holders," but very soon these organs disappear, and they then anchor themselves by means of their sucker-like mouths. The rudiments of the hinder limbs appear about the 20th of April. At the same time two rows of horny teeth appear on each lip, and a few days later an additional row on the lower lip. These teeth are minutely deticulated at their tips, and they form an admirable apparatus for scraping off the layer of nutritious slime that covers all objects in the water. There are from 55 to 95 of these teeth in each row.

As the tadpoles grow older the body becomes broader and the tail acquires a broad fin. By April 20 the length has become one half inch, and by May 4 about three-quarters. The body is of a dark color, adorned with numerous blotches of gold. The belly is nearly covered with a shimmer of gold and coppery. When three-fourths inch long the young were observed to come to the surface and to take in air.

By the 20th of May the young have attained the total length of a little over an inch. Many of them about this time succeed in releasing their forelegs from the skin which has held them down. Now the tadpoles grow smaller instead of larger. This is largely due to the shortening of the intestine at this period of transformation. These four-legged tadpoles are very lively and very timid. They show a great inclination to get out of the water and to hop about. They soon lose their skill in swimming, and if confined to the water too long will drown. The disks are seen on their fore feet as soon as these feet appear. The tails are rapidly absorbed, and by the 12th of June all have become little frogs like the adults, except in size. At the time of transformation the length of the head and body is less than one-half inch.

This species, though called a tree-frog, probably never climbs trees. They seem to live on the ground among the fallen forest leaves and in the grass. Prof. Cope states that it will leap into the water when alarmed, but will not stay there long. He also describes the note of *triseriatus*, which I have not heard. It is said to resemble that of the Cricket Frog, although not so loud. It may be imitated by drawing a point strongly across a coarse comb, holding them at the bottom of a jar and bringing them rapidly to the top. The same authority says that the note is uttered in the hottest part of the day.

## Family IX. RANIDÆ.

Upper jaw furnished with teeth. Vomerine teeth present or absent. Transverse process of sacral vertebra little or not all expanded. Vertebræ procœolus. Ribs none. A large family, of some 20 genera and about 250 species. They belong chiefly to the Old World. Our species belong to the

### Genus RANA, Linnæus.

*Rana*, Linnæus, 1758, *64*, ed. x, 354; Boulenger, 1882, *27*, 6; Cope, 1889, *51*, 393.

Teeth on upper jaw and on vomers. Tongue free behind and notched. Tympanum usually distinct, sometimes hidden. Fingers free. Toes webbed. Outer metatarsals separated by a web.

Contains more than a hundred species, living in all countries except southern parts of South America and New Zealand. Cope assigns thirteen species to North America.

### KEY TO THE E. U. S. SPECIES OF *Rana*.

A. Without a black ear patch.

Dorso-lateral dermal folds present; heel reaching nearly to the muzzle or beyond it; back with well defined dark brown, pale edged oval or round spots. *pipiens*, p. 473.

Dorso-lateral dermal folds large, with smaller ones between; heel to front of orbit; tympanum one-half the diameter of eye; brown spots so large as to reduce ground color to a net-work of narrow lines; three phalanges of fourth toe without web. *areolata circulosa*, p. 476.

Dorso-lateral dermal folds four; the *quadrate* spots of back in rows; two phalanges of fourth toe free of web; heel to front of orbit, or sometimes to muzzle. *palustris*, p. 475.

Dorso-lateral dermal folds present; tympanum one-half size of eye, or even larger than eye; hind foot longer than tibia or femur; large dark spots on back. *septentrionalis*. Appendix.

Dorso-dermal folds present; skin of back rough; tympanum nearly as large as eye, or larger; toes webbed nearly to tips; heel not reaching muzzle; dark blotches on back; size moderate. *clamata*, p. 477.

No dorso-dermal folds; tympanum usually as large as eye, or larger; toes webbed to tips; usually some blotches above; size large.

*catesbiana*, p. 478.

B. Side of head with a black patch.

Head in distance from snout to vent 3.5 times; tympanum one-half the eye; skin of middle of back smooth; heel to middle of orbit.

*cantabrigensis*

Head in length 3 times; tympanum two-thirds the diameter of eye; skin of middle of back rough; heel to muzzle or more.

*sylvatica*, p. 479.

### Rana pipiens, Gmel.

*Leopard Frog.*

*Rana pipiens*, Gmelin, 1788, *123*, 1052; *Rana virescens*, Cope, 1889, *51*, 397, with figures; *Rana halecina*, Schreber, 1782, *66*, 185; Holbrook, 1842, *54*, iv, 91, pl. 22; Boulenger, 1882, *27*, 41.

A very common, widely distributed and variable frog. Head varying in relative length, being contained in the length of head and body from 2.5 to 3.5 times. Vomerine teeth in two slightly oblique patches between the choanæ. Tympanum about as large as the eye. Heel reaching to the muzzle or a little beyond. A pair of prominent dorso-lateral folds starting behind the eyes and running to the end of the body. Between these may be two or more thinner folds. None of these folds are as broad as those of *R. palustris*. Another glandular fold runs from the corner of the mouth to the shoulder. No, or an inconspicuous, branch meeting this from the dorsal-lateral fold behind the tympanum.

Ground color ashy, olive or bright green above; below uniform white or yellowish. The upper surface with a number of rounded or oval brown spots of small to medium size, and these usually bordered with yellowish. The spots between the dorso-lateral folds are larger, and may be arranged in two or three rows, or may be irregularly placed. Outside these folds are two or three rows of smaller spots. The upper surfaces of the limbs are more or less conspicuously barred or spotted. Length of head and body of full grown specimens three to four inches.

Most of the males of this species have vocal sacs, which open by a small slit near the angle of the mouth. These sacs appear to be protruded through the slits, and serve to render the voice more powerful. Of this species Prof. Cope recognizes four subspecies, three of which may occur in our region. It must, however, be understood that forms intermediate are likely to be found.

Head long, contained in the length to vent 2.5 to 3 times; snout long and pointed; males with external vocal vesicles; heel reaching beyond tip of snout; web of foot leaving three phalanges of fourth toe free; spots of small size, scarcely bordered with pale; no longitudinal band on the front of femur. Mostly in Southern States. *sphenocephala.*

Head of medium length, contained in length 3 times; snout pointed; males with vocal vesicles; heel reaching tip of snout; web of foot leaving two phalanges of fourth toe free; spots of medium size, bordered with pale color; femur with a longitudinal band; tibial bars divided into two rows of spots. Maine to Mexico, but mostly in E. U. S. *pipiens.*

Head short, contained in the length 3.5 times; snout obtuse; vocal vesicles rudimentary; web of foot leaving nearly three phalanges free; spots larger and widely bordered with yellow; cross bars of tibia complete; no longitudinal bar or femur. Maine to Oregon and Mexico, but mostly Western U. S. *brachycephala.*

This species, as represented by its different varieties, is distributed all over the eastern portion of the United States and west to Oregon, Nevada and Mexico. The variety *sphenocephala* is chiefly southern in its range, *pipiens* (*virescens* of Cope) eastern and northern, and *brachycephala* western. Neither is confined, however, to these limits. With us the common form is *pipiens*, and it is everywhere abundant. *Sphenocephala* is in the National Museum from Wheatland, Ind., and to this I refer one specimen from Lake Maxinkuckee, which I find in the collection of the State Normal School. One specimen in the same collection and taken at Camden, Carroll County, had some of the characteristics of *brachycephala.* The head is contained nearly 3.5 times in the total length. Three specimens brought from Wabash County have the length of the head in length of head and body only 2.66 times. These might be referred to *sphenocephala.*

The Leopard Frog is our commonest, best known, and most beautiful frog. It is likewise the one that first makes its appearance when in the early spring the ice has relaxed its hold on the waters of our ponds and streams. Its cry is one of the earliest of the vernal notes. Indeed, it is no unusual thing, during an open winter, to hear its croak during the warmer days of midwinter. Its notes are of a varied kind. Prof. Cope says that its voice may be imitated by the syllables chock, chock, chock; but at times it has a cry that sounds like derisive laughter, and again, a sort of low, querrulous tone. Dr. Garnier (*22*, '83, 949) speaks of its "lugubrious and dismal love notes." Soon after it leaves its winter quarters, it proceeds to lay and fertilize the eggs. These are extremely numerous, and are laid in great masses, consisting of the small eggs enveloped in a large quantity of jelly. One pole of the egg is white, the other black. I have record of the deposition of the eggs at Irvington on March 18, and of the escape of the larvæ by April 1. The latter are five-sixteenths inch long; of this one-half is the broad tail. The numbers of these to be seen sometimes in ponds is astonishing. These tadpoles grow rapidly and transform during the first summer of their lives.

This frog is exceedingly active, and is capable of making leaps of 8 to 10 feet. They frequent ponds and streams, but they also leave these and travel to considerable distances in the search of suitable food. When thus traveling about they are much exposed to the attacks of snakes. Their intense green color must serve them well as a means of concealment from their enemies. Like other frogs they pass the winter buried in the mud at the bottoms of ponds and streams.

### **Rana palustris,** LeConte.

*Swamp Frog.*

*Rana palustris*, LeConte, 1825, *62*, i, 282; Holbrook, 1842, *54*, iv, 95, pl. 23; Boulenger, 1882, *27*, 42; Cope, 1889, *51*, 406, with figures.

This species is very closely related to *Rana pipiens*, and especially resembles the variety *brachycephala*. The head is relatively longer than in the variety last named, being contained in the length of head and body 3 times. The snout is usually obtuse, although not always so. Vomerine teeth in two nearly transverse patches between the choanæ. The tympanum is about two-thirds the diameter of the eye. The males have no external vocal vesicles, although Boulenger says that they have internal vesicles. The glandular folds of the back are especially well developed, being unusually broad. Of these the dorso-lateral are most conspicuous. They begin at the upper eyelid and run back to the hinder end of the body. Nearer the middle line and just behind the eyes two other folds begin, but appear to die out near the pelvic hump. Their places are there taken by two folds which lie close to the urostyle. All these folds are breader than in specimens of *Rana pipiens*. Above the tympanum the dorso-lateral fold gives off a branch which curves down behind the tympanum and meets another fold starting at the mouth and terminating at the shoulder.

The hind leg contains the length of the body 1.66 times. When the leg is pressed to the side the heel reaches the snout, or somewhat less. The web is deeply scalloped, and on the fourth toe leaves three phalanges free. The tubercles of the palm and of the sole are greatly developed.

The ground color is a pale brown or ashy above; below, yellowish white. Nearly the whole of the upper surface is covered with *squarish* spots of dark brown. The dorso-lateral folds are of the ground color. Within these there are two quite regular rows of the quadrate spots; the interspaces of these are much narrower than the diameter of the spots. Sometimes two or more of these spots coalesce so as to make a band. There is a spot on the snout and another on each eyelid. Outside of the dorso-lateral folds on each side is a row of spots like those of the back, but somewhat smaller. Lower down on the side is still another row of smaller and more irregular spots. On the upper jaw is a white streak from the snout to the shoulder. Upper and lower lips are mottled. The arms are spotted. The hind limbs are conspicuously barred from the groin to the toes. The posterior surface of the thighs is bright yellow, spotted with brown.

This species is found from New Brunswick west to Iowa, and south to Louisiana. It has been reported to me as occurring at Brookville (Hughes), and at Bloomington (Bollman). I have not seen the specimens from either of these places. In the State Normal School collection are two specimens that were taken at Lake Maxinkuckee. I have two specimens taken at Irvington, which I refer to this species with some doubt.

I have been able to learn little about the special habits of this frog. Prof. Cope tells us that it is a more solitary frog than *R. pipiens*; that it prefers cold springs, and that it is seen in the grass more frequently than any others of our frogs. Its note is likewise said to be a low prolonged croak, somewhat resembling the sound of tearing some coarse material. Some authors tell us that it has a strong, disagreeable smell.

### **Rana areolata circulosa**, R. and D.

*Hoosier Frog.*

*Rana circulosa*, Rice and Davis, 1878, *67*, ed. ii, 355; Cope, 1889, *51*, 413, with figures.

*Rana areolata*, as defined by Prof. Cope, is made up of four subspecies. Of these three belong to the Southern States, the fourth, *circulosa*, was originally described from specimens taken in Benton County, Ind. The species is characterized by a large, broad head, a short leg, imperfect palmation, and its peculiar coloration. The length of the head is one-third or more of the length, and its breadth is equal to, or greater than, its length. The leg, when pressed to the side, brings the heel only to the eye. The web is deeply scalloped and leaves three phalanges of the fourth toe free. Above, on each side, is a strong glandular fold, and between these there are several thin folds.

In *circulosa* the head is one-third of the length to the vent, and quite flat. The tympanic disk is oval or circular and only one-half the diameter of the eye. Between the dorso-lateral folds are six to eight narrow folds, and these may disappear in alcohol.

The striking thing about these frogs is their coloration. The spots found on the upper surfaces of their relatives, *R. pipiens* and *palustris*, have here become so expanded that they cover nearly the whole area. The ground color of yellowish is reduced to a network of narrow lines, or circles. Posteriorly in large specimens the lines of the net-work are broader and browner, and have a border of a lighter color. The spots themselves are of a reddish brown color. No light streaks about the head. Upper lip marbled with brown and yellow. Fore limbs mottled. Hind leg, including thigh, tibia, and foot, with wide bars of dusky and very narrow interspaces. Below, the color is uniform yellowish.

Found in northern portions of Indiana and Illinois. Described originally from a specimen which was found in Benton County, Indiana, by E. F. Shipman. About the size of *R pipiens*, but one specimen in the National Museum is nearly five inches long from snout to vent.

### **Rana clamata,** Daudin.

*Green Frog.*

*Rana clameta*, Daudin, 1803, *69*, 104; Boulenger, 1882, *27*, 36; Cope, 1889, *51*, 419, with figures; *Rana clamatans*, Holbrook, 1842, *54*, iv, 85, pl. 20.

Head broad and flattened, contained in the length of head and body about three times. Snout rounded. Eyes large and protruding. Vomerine teeth in two patches, the posterior edges of which project behind the line joining the hinder borders of the choanæ. Tympanic disk usually as large as the eye, sometimes larger; occasionally, especially in the females, somewhat smaller than the eye. A groove passes from the back of the eye over the tympanic disk and downward behind it, and terminates in front of the arm. There are present two dorso-lateral glandular folds. These start at the upper eyelids and run back to the pelvic region. Over the tympanic disk a branch is given off which passes down behind the disk and terminates over the arm. The groove described above lies between the disk and the branch. The skin of the back and sides is more or less rough. This roughness is produced by minute, sharp-pointed, wart-like elevations, those along the sides largest.

Hind limb, when pressed to the side, bringing the heel between the eye and snout. Third toe longer than the fifth. Toes webbed nearly to the tips. Subarticular and one metatarsal tubercles moderately developed.

Color above varying from greenish olive to brown; in life often bright green toward the head. On the back there are usually numerous small nearly circular blotches of dark brown, and larger ones on the sides. These are not spots, light bordered and definite, as those of *R. pipiens*, but look as if the color had run into the surrounding skin. The hind legs are crossed by narrow bars or rows of spots. The hinder surface of the thighs is granulated and of a yellow color, with spots and mottlings of black. The lower jaw and throat are marbled with brown, otherwise pale below. This species may be distinguished from *R. catesbiana* by the presence of the two dorsal folds. The length of head and body may be greater than three inches.

Distributed over the Eastern United States at least to the plains. Found all over Indiana in abundance.

This frog is thoroughly aquatic and lives along streams, in pools and in cold springs. It probably never leaves the water to travel any considerable distance. It is rather solitary, never collecting in such numbers as do the individuals of *R. pipiens.* They are timid, and when surprised by the stroller they leap, with a cry, into the water. Its voice may be represented by the syllable "chung." DeKay states that its note is more sonorous and in a lower key than that of the Bull-frog. The tadpoles of this species require two years for their development. Before the tail has been absorbed this species may be distinguished from larvæ of the Bull-frog by the presence of the dorsal glandular folds. When the fore limbs have appeared, the total length of the tadpole is about two and a half inches. The larvæ are stated to live on soft vegetable substances and never to be carnivorous.

### **Rana catesbiana,** Shaw.

*Bull-Frog.*

*Rana catesbiana*, Shaw, 1802, *71*, iii, 106, pl. 27; Boulenger, 1882, *27*, 36; Cope, 1889, *51*, 424, with figures; *Rana pipiens*, Harlan, 1825, *47*, 62; Holbrook, 1842, *54*, iv, 77, pl. 18 (not of Gmelin).

Attaining the largest size of any of our frogs, the body becoming in some cases 8 inches long, and the length of head, body and legs 18 inches. Head contained in the length 3 times or less; usually somewhat broader than long; sides of head sloping outward; snout rounded. Vomerine teeth projecting little behind the choanæ. Tympanic disk the size of the eye or even larger. Skin of the back smooth or minutely rough. Heel reaching to the front of the eye. Fourth finger slightly longer than the first. Third toe longer than the fifth. Toes webbed to the tips. There are no dorso-lateral glandular folds. A glandular fold begins at the upper eyelid, runs over and behind the tympanic disk, and in front of the arm, ending on the breast. Between it and the tympanic disk is a sharp groove.

The color of the upper surfaces in alcohol varies from reddish to olive and brown. In life the color may be pale yellow, green, brownish, or even deep brown. Below, the general color is white or yellowish. On the upper surface spots of brown may occasionally be almost entirely missing, but generally there are blotches of brown varying in size and number, sometimes running together. Their outlines are not well marked. The sides usually with distinct marblings of brown. The thighs may be spotted as well as the rest of the leg and foot. The lower surfaces may be almost devoid of any brown markings, or they may be conspicuously present on throat, breast, belly and legs. The hinder part of the thighs is usually mottled and blotched.

Distribution, Eastern North America to the Rocky Mountains. Everywhere in Indiana.

This species lives in the waters of our brooks, rivers and lakes. It probably never strays away from the vicinity of the water in the search of food. Its loud voice has given it its popular name of "Bull-frog." Prof. Cope says that its notes may be imitated by uttering a bass "br'wum" several times in a hoarse voice in front of an empty cask. Dr. J. H. Gardnier (*22*, 1883, 954) says that he has heard the Bull-frog at a distance of 5 or 8 miles. Authors tell us that when this frog is whipped it will cry much like a child; and Dr. Gardnier says that he has known the Bull-frog to hold its mouth open and scream for more than a minute, like a child in distress. These frogs are very voracious, and seem to catch and swallow almost any living thing that they can possibly devour. They have been known to eat cray-fishes, small fish, insects, worms, snails, mice, and even their own species. One was observed to be trying to swallow another of about half its size. Prof. J. A. Allen tells us that one seized and swallowed a cedar bird which he had shot, although the wings and tail continued to protrude out of the frog's mouth. Dr. Jos. Jones, of Georgia, reports having found in the stomach of one that he dissected a "grass-snake" three feet long. Other cases of the latter kind are on record.

The tadpoles of these frogs, like those of *R. clamata*, require two years for their complete development. It is possible that in some cases a greater number of years is passed in the larval state. A larva of this species was found to have a total length of 4.5 inches, of which 2.8 was tail. The general color above was dark olive green, below yellowish white.

This species is the one that is most relished as an article of diet. The frogs are often caught with hooks baited with red flannel.

### **Rana sylvatica**, LeConte.

*Wood Frog.*

*Rana sylvatica*, LeConte, 1825, *62*, 282; Holbrook, 1842, *54*, iv, 99, pl. 24; Boulenger, 1882, *27*, 47; Cope, 1889, *51*, 447, with figures.

A rather slender and graceful frog, with a broad head and long legs. Length of head contained in the length of head and body from 3 to 3.5 times; its width greater than its length and contained in body and head

2.5 to 2.75 times. Snout rather pointed, the *canthus rostrales* distinct. Eyes prominent. Tympanic disk about two-thirds the diameter of the eye. A dorso-lateral glandular fold starts at the corner of the eye and continues along the side to near the vent. Over the tympanic disk it gives off a rather indistinct branch, which bends down behind the disk and terminates over the arm. There are no folds between the dorso-laterals. Another glandular fold begins at the corner of the mouth and stops just over the arm. The skin of the back, the sides, and upper surfaces of the legs is provided with numerous minute sharp points, which produce a slight roughness to the sight and touch. The hinder surface of the thighs somewhat granulated. Other surfaces smooth. Legs long, the heel reaching to the muzzle or beyond. Tibia longer than the femur. One metatarsal present. The subarticular tubercles feebly developed. Web leaving two phalanges of longest toe, and one of the others, free. Length of head and body may be about 3 or 4 inches.

In alcoholic specimens the color of the upper surfaces of body and limbs varies from pale reddish-brown to ashy or dark gray; the sides may be pale yellow or brown; beneath whitish. There may be a few indistinct spots on the pelvic region of the back, while the sides may be somewhat mottled with dusky. Lower surfaces occasionally indistinctly marbled. Limbs distinctly or indistinctly barred with brown. A dark stripe at the base of the humerus in front. A black stripe from the snout to the eye. A triangular brown ear patch. A white stripe from the snout and along the upper lip to the arm. Upper and lower lips marbled with brown and whitish. One specimen in my possession, captured at Irvington, has a light streak from snout to vent, reminding one of *R. catabrigensis*. In life the colors are variable. One was gray above, the back with a tinge of green, while the hind limbs had a tinge of reddish. The dark ear-patch was overlaid with a tint of copper. Iris golden. The glandular folds were golden-yellow, the flanks yellowish-green. Another living specimen was of a reddish or pink color everywhere above. In life the color is liable to undergo rapid and considerable changes, according to the surroundings.

This species occurs from Maine to the Athabasca River and south to South Carolina and Missouri. It is doubtless to be found everywhere in Indiana. Localities which have furnished specimens are as follows: Marion and Shelby counties (Hay); Franklin County (Hughes); Monroe County (Ind. Univ. coll.); Montgomery County (A. W. Butler); Hamilton County (F. C. Test); Terre Haute (Evermann and Blatchley); Wheatland (R. Ridgway); Wabash County (A. B. Ulrey).

This, it appears to me, is our most delicate, beautiful and interesting species of *Rana*. It is far less aquatic than the others, preferring to spend its life among the fallen leaves of the forest. It is not often seen, but occasionally occurs in enormous numbers. DeKay (*30*, 64,) says that Dr. Kirtland informed him that they were so abundant in the woods of Ohio that it was almost impossible to move without stepping on them. With us, at the present day, they are far less abundant. They are extremely active, and when pursued, they escape by making great and quickly repeated leaps. They are very skillful in hiding, and the close resemblance of their colors to the dead leaves and grass surrounding them renders it extremely difficult to find them. One that I was after leaped into the water and hid along side of a stone, and although I knew almost exactly where it was, it was some time before I could recognize it.

Miss Hinckley has studied the habits of the breeding adults and of the young (*43*, xxii, 91; *22*, xviii, 151). These frogs congregate very early in the spring for the purpose of ovoposition, although they are not able to move in water below a temperature of 45° F. There may be as many as 1,380 eggs in one mass. The time of development varies greatly according to the temperature. The external gills were developed within two days after hatching, and in four more were wholly absorbed. The metamorphosis of the tadpoles was prolonged from April 12 to June 9. Tadpoles, which on May 31 measured 58 mm. in length, became reduced after the metamorphosis to 18 mm., about three-fourths of an inch. It was first observed by Prof. S. F. Baird that the tadpoles of this frog are carnivorous. He says that one way of preparing the skeleton of small animals is to put them in a vessel of water containing the living tadpoles of some of our frogs. These will devour the macerating flesh and leave the bones cleaned and hanging together by the ligaments. The larvæ of *R. sylvatica* are, he said, the most effective.

# CLASS II. REPTILIA.

Members of the Class *Reptilia* pass their lives under extremely various conditions and circumstances. Many, as the larger number of the turtles, some snakes and the crocodiles, are given to haunting the waters of the sea, or of the rivers, lakes and ponds. Others, such as most snakes, and many tortoises, and the lizards, spend their lives on the land, and some of them in the hottest and most arid situations. Their eggs, even those of the most aquatic species, are always laid on the land; and the young, though they may, immediately after they are hatched, betake themselves to the water, never have gills, and depend wholly on their lungs for the oxygen that enters their blood. Their form is from the first like that of the adults.

In nearly all cases the epidermal layer of the skin of reptiles is disposed in the form of scales or plates. These may, on the one hand, be so small as to form mere granules, or, on the other hand, they may consist of a few large plates, like those of most tortoises. The soft-shell turtles, however, furnish us with an exception to the rule given. The epidermis of these is soft and moist, and is not broken up into definite areas. When limbs are present they are made up of the same elements as those of Batrachians, Birds and Mammals. But many reptiles, such as the snakes and many lizards, are entirely devoid of limbs. The blood of reptiles is cold, the heart has only three chambers (except in the crocodiles), and the arterial blood, as it is distributed to the body, becomes more or less mixed with the venous blood. As to their reproduction, most lay eggs; others bring forth their young alive, the eggs being retained in the body until the young have reached a considerable size.

### Key to the Orders of Existing Reptiles.

A. Body covered with small, usually overlapping epidermal scales; these supported or not by bony plates of similar form and size, which also do not articulate with one another.

a. Body usually extremely elongated; bones of upper jaws loosely connected with the rest of the skull; rami of lower jaw loosely connected at symphasis by elastic tissue. Serpents. *Ophidia*, p. 483.

b. Body shorter, but sometimes considerably elongated; limbs present or absent; bones of upper jaw firmly connected with remainder of the skull; rami of lower jaw connected by suture. Lizards. *Lacertilia*, p. 539.

B. Body more or less protected by an armor of articulating bony scutes; these usually overlaid by firm epidermal plates of similar or different shape; absent, however, in some turtles.

a. Body short and broad; encased in a bony shell formed above of the expanded ribs, below of dermal bones; four limbs; jaws covered by horny beaks; no teeth. Tortoises. *Chelonia*, p. 550.

b. Body lizard-like; more or less protected by transverse series of dermal bones; limbs four; jaws provided with teeth. Crocodiles and alligators. Extralimital. *Crocodilia*.

## Order OPHIDIA.

*Snakes.*

Animals having a greatly elongated body and a tapering, pointed tail. Limbs wholly wanting, except in the rare cases where hinder limbs are believed to be represented by a pair of anal spurs. Vertebræ many and strongly articulated. Ribs movable and employed in locomotion. Brain-case consisting of a reduced number of bones, which are firmly connected and form an efficient protection to the brain. Bones concerned in the seizing and swallowing of the prey—the palato-pterygoids, maxillæ, the quadrate and the squamosal—are loosely connected with the cranium and with one another. Mandibles loosely joined in front by elastic tissues. Gape of mouth usually large. No eyelids. Skin of upper surface provided with small, usually overlapping scales; belly with larger transverse scutes. Head usually covered with a few large, regularly arranged plates. Vent a transverse slit.

The *Ophidia* form a large and important order of Reptiles. They inhabit all the great faunal regions of the globe. They are few in species in the colder portions of the globe, but swarm in the hotter and moister regions. They are divided by naturalists into a large number of families, but of these we have representatives of only the following three:

### Key to the Native Families of Ophidia.

Maxillary bones elongated, with a row of several teeth in each; none of these grooved or perforated; no poison glands or fangs present. *Colubridæ*, p. 484.

Maxillary bones each with a single erect, immovable poison fang, which is grooved in front. No pit between eye and nostrils. Body with rings of black, red, and yellow. *Elapidæ*, p. 529.

Maxillary bones much shortened, bearing each a large, erectile poison-fang, with a few supplementary fangs; these perforated and the functional fang connected with the duct of a poison gland. A pit between the eye and nostril. *Crotalidæ*, p. 530.

## Family I. COLUBRIDÆ.

*Figure* 9, *Pl.* 3.

Form elongated. Head more or less distinct from the neck. Tail tapering to a point. Head covered with large epidermal plates.* Maxillary long, furnished with a row of conical, solid teeth. No poison fangs or glands. Pupil circular. No pit in front of eye. No rattle. No anal spurs.

### Key to the Genera of the Family *Colubridæ*.

A. Anal plate divided.
  a. Dorsal scales not keeled.†
    b. Loral absent; anteorbital present. *Tantilla.*
    bb. Loral present; anteorbital absent.
      c. Nasal single, pierced by nostril.
        Rows of scales 13. *Carphophis*, p. 486.
        Rows of scales 19; two prefrontals. *Abastor*. Appendix.
        Rows of scales 19; prefrontals united. *Farancia*, p. 487.
      cc. Nasals 2, with nostril between them; rows of scales, 15 or 17. *Virginia*, p. 488.

*For plates illustrating the heads of North American species, see Volume X of the Pacific Railroad Survey Report.

†Sometimes in *Coluber* only the scales of the upper rows have keels, and occasionally all may be smooth.

bbb. Both loral and anteorbital present.

d. Nasals 2; anteorbitals usually 2.

Adult size large; pairs of subcaudal plates seldom fewer than half the number of ventral plates. *Bascanion*, p. 489.

Adult size small; pairs of subcaudal plates seldom more than one-third the number of ventral plates. *Diadophis*, p. 492.

dd. Nasal single; anteorbital single; subcaudals more than one-half the ventrals. *Cyclophis*, p. 493.

aa. Dorsal scales more or less keeled.*

e. Rostral normal; not shovel-shaped or keeled.

f. Three plates between the rostral and the eye.

Nasal single; anteorbital and loral present. *Phyllophilophis*, p. 494.

Nasals 2; anteorbital present; loral absent. *Storeria*, p. 496.

Nasals 2; anteorbital wanting; loral present. *Haldea*. Appendix.

ff. Four plates between rostral and eye (2 nasals, anteorbital, loral). Some of the outer rows of scales smooth; rows 25 to 29; ventral plates 200 to 270. *Coluber*, p. 498.

All the scales keeled; rows 19 to 33; ventrals 125 to 160. *Natrix*, p. 503.

ee. Rostral expanded and shovel-shaped, with a median keel. *Heterodon*, p. 510.

AA. Anal plate not divided.

g. Dorsal scales smooth.

h. Rostral plate normal. *Ophibolus*, p. 515.

hh. Rostral enlarged, trihedral. *Cemophora*.

gg. Dorsal scales keeled, rostral normal.

i. Postfrontals two pairs; scales in 25 to 35 rows. *Pituophis*. Appendix.

ii. Postfrontals one pair; scales in 17 to 21 rows; nasals divided. *Eutainia*. p. 520.

iii. Postfrontals a single pair; scales in 19 rows; nasals single. *Tropidoclonium*. Appendix.

*See foot note on preceding page.

### Genus CARPHOPHIS, Gervais.

*Carphophis*, Gervais, 1843, *72*, iii, 191; Garman, 1883, *13*, 99; *Celuta*, Baird and Girard, 1853, *6*, 120.

Small snakes with little heads and short tails. Head not distinct from the neck. Crown shields 7 or 9, there being in some cases but a single pair of frontals. Vertical broad. Loral present. No anteorbital. Nasals single. Scales smooth and glossy, arranged in 13 rows. Anal plates divided.

a. Color of the back descending below third row of scales. *amœna*. p. 486.

aa. Color of the back not descending below third row of scales. *vermis*. Appendix.

### Carphophis amœna, (Say).

*Ground-snake.*

*Coluber amœnus*, Say, 1825, *2*, 237; *Celuta amœna*, Baird and Girard, 1853, *6*, 129; Cooper, 1860, *20*, xii, pt. ii, 302, pl. 19, fig. 2; *Carphophis amœna*, Gervais, 1843, *72*, iii, 191; Garman, 1883, *13*, 100, pl. vii, fig. 1; *Carphophiops amœnus*, Cope, 1892, *3*, xiv, 596.

*Celuta helenæ*, Kennicott, 1859, *1*, 100; *Carphophiops helenæ*, Cope, 1875, *12*, 34; *Carphophis helenæ*, Smith, 1882, *18*, 699.

Head small, the snout moderately elongated and rounded. Vertical hexagonal. Rostral convex. Postfrontals entering into the orbits, the prefrontals small or absent. Postorbital single. Upper labials 5; eye over third and fourth. Lower labials 6. Ventral plates 112 to 131; subcaudals 24 to 36 pairs. Scales smooth and glossy, arranged in 13 rows.

Color above, rich chestnut brown, below yellow to salmon. Length not exceeding one foot. The specimens without prefrontals have been regarded as belonging to a distinct species *helenæ*. Prof. Cope has shown recently, however (*3*, 1892, 596), that this is an inconstant character, and that the forms must be united.

The species is distributed from Massachusetts to Georgia, and west to Central Arkansas. Indiana localities are: Wheatland (Ridgway); New Harmony (Sampson's coll.); Monroe County (C. H. Bollman); Brown County (Chas. Jameson); Crawford County (Hay), where in the vicinity of Wyandotte Cave several specimens were found hiding under stones and logs; Terre Haute (Blatchley). Some of the specimens from New Harmony and those from Wheatland belonged to the form with prefrontals; all the others were without prefrontals.

Little is known about the habits of this innocent little serpent. DeKay states that it is found hiding under logs and stones. Mr. Sampson, of New Harmony, told me that he found it under the dead leaves in the forests. Its movements are probably nocturnal. Holbrook adds that it lives on insects. Dr. J. A. Allen states that it is decidedly subterrestrial in its habits, and is more frequently turned up by the plow or hoe than seen crawling on the surface. It seeks to bury itself when thus exposed. Observations on the breeding habits are needed.

### Genus FARANCIA, Gray.

*Farancia*, Gray, 1842, *73*, 68; Baird and Girard, 1853, *6*, 123.

Head slightly distinct from the body. Crown-shields eight, the prefrontals being united. No anteorbital, the postfrontal and the loral entering into the orbit. Two postorbitals. Nasal single, grooved below the nostril. Scales not keeled; arranged in nineteen rows. Anal plate divided. Size large.

### **Farancia abacura**, (Holbrook).

*Horn-snake. Checkered-snake.*

*Coluber abacurus*, Holbrook, 1836, *53*, i, 119, pl. 23; *Helicops abacurus*, Holbrook, 1842, *54*, iii, 111, pl. 26; *Farancia abacurus*, Baird and Girard, 1853, *6*, 123; *Hydrops abacurus*, Dum. and Bib., 1854, *74*, atlas, pl. 65; Garman, 1883, *13*, 36, pl. 1, fig. 5.

A snake reaching a large size. Head scarcely distinct from the body. Crown-shields normal, except that the prefrontals of the opposite sides are fused into one. No anteorbital. Loral and postfrontal forming anterior border of the orbit. Rostral low. Nasal single, groove below the nostril. Postorbitals two. Upper labials 7, the eye over 3d and 4th. Lower labials 8 or 9. Scales smooth and shining; arranged in 19 rows. Ventral plates 171 to 203; subcaudals 35 to 47. Anal plate divided.

The ground color may be regarded as blue-black. The sides are marked with about sixty transverse bands or wedges of bright red, which in some cases extend nearly to the middle of the back. These bands sometimes extend downward to the middle of the belly, and either join or alternate those of the opposite side. Since the red has definite margins and contrast strongly with the black, the belly has a checkered appearance. The head above is dark blue, with the plates tinged with red on their margins. Upper labials red, with a blue spot on each.

This snake reaches a large size, contrasting in this respect with its relatives, *Carphophis* and *Virginia*. One mentioned by Mr. S. Garman is 54 inches long, of which 5.6 is tail. This species is distributed from South Carolina to Louisiana and Central Arkansas, and up the Mississippi Valley to Knox County, Indiana. It and its eggs have been sent from

Wheatland to Mr. Robert Ridgway, of the National Museum. It has also been taken in Illinois just across the Wabash River from Indiana. I have seen it at Little Rock, Arkansas, in a cypress swamp. Holbrook says of this species that it is rare and shy, and that it lives in swampy ground and in damp places. It is a beautiful snake, as beauty goes among snakes.

### Genus VIRGINIA, B. & G.

*Virginia*, Baird & Girard, 1853, *6*, 127; Garman, 1883, *13*, 96, in part.

Small, slender, and feeble snakes, with small head and short tail. Head narrow, rather high, snout pointed. Crown-shields 9. Postfrontals large, entering orbit and suppressing the anteorbitals. Loral present. Nasals 2, with the nostril in the anterior. Postorbitals 2, the lower small. Scales smooth, or feebly keeled on the posterior of body; arranged in 15 or 17 rows. Anal plate divided.

a. Scales in 17 rows. *elegans*, p. 488.
aa. Scales in 15 rows. *valeriæ*. Appendix.

### Virginia elegans, Kenn.

*Virginia's Snake.*

*Virginia elegans*, Kennicott, 1859, *1*, 99; Garman, 1883, *13*, 98.

Originally described by Kennicott from specimens obtained "in heavily timbered regions in Southern Illinois." In my possession is a small specimen that was taken by the late Charles Jameson, of Indianapolis, at some point in Brown County. The total length is 5.75 inches. From this I draw a description.

Head small, narrow, and relatively high. Snout pointed, and the sides of the head perpendicular. Vertical hexagonal, with its right and left sides parallel. Occipitals large. Prefrontals entering the orbit and with the lorals forming its anterior border. Upper labials 6, the eye over the 4th and 5th. Scales in 17 rows; smooth, except that those on the tail are feebly keeled. Ventral plates 120; subcaudals 45.

Color gray, with a tinge of purplish, especially on the head. Below yellowish white, possibly reddish in life. On the dorsal surface are to be seen, here and there, small black dots. Those on the upper surface and the sides of the head more numerous and resembling points made by a fine pen.

From Brown County, Indiana, to Indian Territory (*10*, 84).

Nothing appears to be known about the distinctive habits of this delicate little creature. It must live on the smallest insects and worm-like creatures. Its subdued colors will undoubtedly enable it to escape the notice of its enemies. Its near relative, *Virginia valeriæ*, has not yet been found in Indiana.

### Genus BASCANION, B. & G.

*Bascanion*, Baird and Girard, 1853, *6*, 93. *Bascanium*, Cope, 1875, *12*, 40.

Size large, form elongated; head distinct from the body; narrow and with sides perpendicular; tail long. Crown-shields 9. Vertical rather long and narrow. Two pairs of frontals. Loral present. Anteorbitals 2. Postorbitals 2. Nasals 2, with nostril between. Dorsal scales smooth; arranged in 15 or 17 rows. Ventral plates 170 to 210; subcaudals 80 to 150. Anal plate divided. Pairs of subcaudals seldom fewer than one-half the number of ventral plates.

### Bascanion constrictor, (Linn.).

*Black-snake. Black-racer. Blue-racer.*

*Coluber constrictor*, Linnæus, 1758, *64*, ed. x, 216; Holbrook, 1842, *54*, iii, 55, pl. 11; Garman, 1883, *13*, 41, pl. iv, fig. 3. *Bascanion constrictor*, Baird and Girard, 1853, *6*, 93.

A long, slender snake, with a distinct head and a slender, whip-like tail, which constitutes about one-fourth the entire length. Head long, pointed, high; crown flat, and with the face bent down in front of the eyes. Eye in a groove which runs forward to the nostril. Snout pointed and rather projecting. Rostral high. Upper anteorbital large, the lower very small. Upper labials 7 or 8, the large eye over the third and fourth. Lower labials 8 to 10, sixth very large. Rows of dorsal scales in 17 (rarely 15 or 19) rows; the scales very smooth, the median narrow, the outer broad. Ventral plates 171 to 190; subcaudals 80 to 110.

The color of the adults is uniform above, but varies according to age and varieties from lustrous pitch-black to lead color and yellowish olive. Length 6 feet or more. In its varieties or sub-species this species has a range from the Atlantic to the Pacific and south to Mexico.

Variety *constrictor*.

Lustrous pitch-black above, varying to lead color. Below, the color is greenish-white or slate color, with the middle line paler. There is more or less white on the chin and the lower jaw. Upper labials with some white. Specimens from the prairies of the West and Southwest are of an olive-green color, and such shade into the variety *flaviventris*.

The colors of the young Black-snake are so different from those of the adult that one would hardly suspect it to be the same species. Instead of being of a uniform color above, they are much blotched and spotted. There is a series of reddish-brown blotches with black borders along the middle of the back, but disappearing on the tail. The blotches are about three scales long, and reach down to about the fourth row of scales on each side. The sides are furnished with many specks and spots of brown. The intervals between the spots are grayish or olive. The head is mottled and specked. Below, the color is greenish-white, with three or four specks of brown on each scale. Specimens over 18 inches begin to assume the coloration of the adult.

The range of this variety is from the Mississippi River eastward. It is to be found in all portions of Indiana, and it is unnecessary to specify localities.

No species of our snakes is, probably, better known, or, at least, more talked about, than is the "Black-snake" or "Black-racer," or, as it is often called, the "Blue-racer." This is true probably because of its abundance in all localities and because of its bold, active, and aggressive disposition. It is, however, somewhat confounded with another common Black-snake, *Coluber obsoletus*, which does not appear to be nearly so active or so saucy.

The systematic name of this snake, *constrictor*, was given in allusion to its supposed habit of entwining itself about the limbs and bodies of persons whom it might see fit to attack. Gmelin, one of its early describers, speaks of it as running with great velocity, biting without poison, attacking men by entwining itself about their limbs and squeezing. This is a widely spread idea concerning these snakes at the present day, and there is no doubt some truth in it. However, their daring is greatly exaggerated, and the stories that we may hear everywhere about their squeezing people to death are without sufficient foundation. If one of these snakes were driven to bay, or were seized, there is little doubt that it would defend itself with great vigor and promptness. These serpents are not without wisdom, and it is a common reputation which they have that they will sometimes pursue persons who are retreating, but when the latter turn the snakes will seek safety in flight. They are evidently full of curiosity, and will often follow persons or objects, apparently merely to observe them. I have been told of one of these snakes which was in a meadow where a mowing machine was at work. The noise of the mower appeared to excite the reptile greatly, and it followed the machine around the meadow several times. At last it became so wrought up that it sprang over the sickle bar and was cut into pieces. It is possible that in this case the animal had young ones in the vicinity. Prof. Blatchley says (*94*, '91, 31) that they are vicious, and will hiss and strike at a trespasser when they are seeking a hiding place for the winter.

DeKay states that it is a bold, wild, and untameable animal, and that it climbs trees with great ease by twining itself around the trunk in a spiral manner. This it does in quest of eggs and the young of birds. Holbrook says that it feeds on mice, toads, and small birds. It is bold and daring, entering barns and outhouses without fear, and has been known to destroy young chickens. He also reports it as very irascible during the breeding season, and that it will attack persons who may pass it, even at a distance of several steps. Its tail quivers with rage, making a quick, vibratory motion, which among dry leaves sounds not unlike the whir of the rattlesnake. It will even descend trees in order to attack an enemy who may tease it. He never knew one to try to twine itself about the legs, as it is commonly supposed to do.

Besides eating such creatures as have been already mentioned, the black-snake sometimes attacks and devours other snakes. Mr. F. W. Cragin (*22*, xii, 820) states that he found a black-snake swallowing a striped snake, *Eutainia sirtalis*, which he had killed the day before. The black-snake was 42, the striped-snake 22 inches long. This was a case in which the reptile was driven to partaking of cold victuals. Prof. A. E. Verrill, of Yale College, writes (*22*, iii, 158) that a student of Yale caught a large black-snake, and in bringing it home alive by the neck smothered it so that it became sick and vomited up a copperhead snake two feet long and in a nearly perfect condition. Soon afterward this was followed by a good-sized frog. Prof. Verrill supposes that the black-snake caught the copperhead while it was trying to swallow the frog; but this supposition is by no means necessary. Black-snakes are known to attack and destroy rattlesnakes in open fight. The black-snake is said to circle around the rattlesnake until the latter becomes confused or thrown off his guard, and then to spring suddenly upon the poisonous reptile, encircle him in its folds, and squeeze him to death. Dr. Elliott Coues (*9*, 4, 269) speaks of the hostility existing between the black-snake and the rattlesnake. In one case reported the black-snake threw two or three coils of its tail behind the rattlesnake's head and several others further back, and then, by a powerful muscular effort, tore the rattlesnake in two. When the black-snake has thus triumphed he has a right to a full meal. They are known to eat other species of snakes (*22*, ii, 136). When one snake swallows another the head is taken into the mouth first. A snake can swallow another almost as large as itself.

H. A. Brons, writing (*22*, xvi, 566) of the habits of some western snakes, says that this species and some others have the habit of swallowing whole eggs, and that it is no unusual occurrence to find such snakes with the entire contents of quails', prairie hens', and domestic fowls' nests in their capacious stomachs. With a little trouble they may be compelled to disgorge the ingesta unbroken. Miss Hopley, in her interesting book on snakes, says that these snakes will eat eggs, and that they will drink milk and eat cream. But when people tell us that they will suck the cows we must draw the line broadly and distinctly.

In the fall, and sometimes probably also in the spring, these snakes collect together often in large numbers, and we hear occasionally of "balls" of snakes having been seen. Brons, cited above, says that the female of the "Racer" is the larger, and not so graceful in form or movements. During the season of love making she seems to toy with the male, at times darting through the grass, among stones and into crevices to avoid him. On clear, level ground she is at a disadvantage. There, if she attempts to quit him, a coil of his tail is thrown about her body and his head laid upon her neck, and if it is removed, as promptly replaced, in the evident endeavor to propitiate her. Later in the season they are solitary or live in pairs.

The eggs of the black-snake are an inch and a half long and an inch in diameter. They are covered with a thick, tough skin. Out of such an egg I took a young snake 10.5 inches long. The snout was blunt, while a little sharp tooth projected from the middle of the upper jaw, beyond the lip. (See Agassiz *4*, 1, 288; Dr. Weinland, Proc. Essex Inst. ii, 28.) This is an "egg tooth," and its purpose is to enable the young to rip open the tough egg coverings when the time for hatching has come. This tooth is shortly afterward shed. Just the time of laying the eggs and the special way in which the female disposes of them I have not been able to learn. They are in all likelihood hidden away in soft earth or in rotten wood. In one female I found nineteen eggs, of which seven were in the left oviduct.

### Genus DIADOPHIS, B. & G.

*Diadophis*, Baird & Girard, 1853, *6*, 112; Garman, 1883, *13*, 60.

Small, slender snakes, with a distinct and depressed head and a tail of moderate length. Crown-shields nine. Prefrontals two pairs. Loral present. Anteorbitals two. Postorbitals two. Nasals two, with the nostril between. Scales smooth, arranged in fifteen or seventeen rows. Anal plate divided. Ventrals 145 to 237. Subcaudals 36 to 60, seldom more than one-third the number of ventrals. Anal plate divided.

### **Diadophis punctatus,** (Linn.).

*Ring-necked Snake.*

*Coluber punctatus*, Linnæus, 1766, *64*, ed. xii, i, 376; Holbrook, 1842, *54*, iii, 81, pl. 18; *Diadophis punctatus*, Baird & Girard, 1853, *6*, 112; Garman, 1883, *13*, 72.

A snake of small size, having a head distinct from the body, and a tail about one-fourth the total length. Head flat, snout rather broad and projecting beyond the lower jaw. Rostral low and broad. The lower anteorbital small. Upper labials seven or eight, eye over third and fourth, or fourth and fifth. Lower labials eight, fifth largest. Scales smooth, arranged in fifteen rows. Ventrals 148 to 203. Subcaudals 36 to 60.

The color above varies in the subspecies, or varieties, from olive through gray to blue-black; below from yellowish white to orange and red, with more or fewer dark spots. There is usually a light ring around the neck, close to the head.

The form usually found in Indiana is the typical *punctatus.* The color above is a bluish black or a dark ash, with a wash of bronzy that extends down to the lowest rows of scales. Below, the color is orange or deep red, somewhat palest in front. On the outer ends of each of the ventrals there is a small black spot, and these are involved in the color of the dorsal scales. Near the middle line of the ventrals may be two rows of dark spots, or the spots on the ventrals may unite to form transverse bars. The ring around the neck is orange, edged with black. It is one or two scales in width. Upper labials yellow. The length may become about fifteen inches. This form is distributed from Nova Scotia to Georgia and the Mississippi Valley. Indiana localities are New Harmony (Sampson's coll.); Franklin county (Hughes); Monroe county (Bollman); Montgomery county (a specimen brought me by Mr. Beachler); Terre Haute (Blatchley); Shades of Death, Parke county.

HABITS.—Not much can be said concerning the habits of this little snake. Holbrook says that it is a very timid animal, living a great part of the time under the bark of trees, or old logs and stones. It emerges from its hiding places toward the dusk of evening, or after rain, when the insects on which it feeds have been washed from their hiding places. DeKay tells us (*30*, 39) that it is perfectly inoffensive, and that it emits a disagreeable odor. I can find nothing concerning its breeding habits.

### Genus CYCLOPHIS, Günther.

*Cyclophis*, Günther, 1858, *26*, 119; Garman, 1883, *13*, 39; *Chlorosoma*, Wagler, 1830, *75*, 185; Baird and Girard, 1853, *6*, 108.

Form moderately elongated and slender. Head distinct from body. Tail long and tapering. Crown-shields 9. Loral present, small. One anteorbital, high. Postorbitals 2. Nasal single, nostril in its center. Eyes of moderate size. Mouth-cleft long and curved. Scales smooth; disposed in 15 rows. Anal plate divided.

### Cyclophis vernalis, (DeKay).

*Smooth Green-snake.*

*Coluber vernalis*, DeKay, 1827, *2*, 361; Holbrook, 1842, *54*, iii, 79, pl. 17; *Chlorosoma vernalis*, Baird and Girard, 1853, *6*, 108; *Cyclophis vernalis*, Günther, 1858, *26*, 119; Garman, 1883, *13*, 39.

Body and tail rather long and slender, but less conspicuously so than in *Phyllophilophis æstivus*. Tail forming seldom more than one-third the total length, usually one-third or one-fourth. Head narrow and moderately high. Snout somewhat projecting beyond the lower jaw. Mouth-cleft large, curved. Upper labials 7; the eye over 3d and 4th. Lower labials 8; the 5th largest. Scales smooth; disposed in 15 rows. Ventrals 125 to 140; subcaudals 69 to 95; the latter seldom 70 per cent. of the former in number.

Color above, grass-green, fading somewhat on the lower rows of scales. Below greenish yellow. On the throat and upper labials yellowish white. The green of the upper surface often changing in alcohol to blue.

Distributed from Nova Scotia to Wyoming and southwest to New Mexico. Rare or not found in the Southern States.

In Indiana it is probably generally, but not abundantly, distributed. Known localities: New Harmony (Sampson's coll.); Brown County (collected by Chas. Jameson).

This is a beautiful and inoffensive little creature. Its color indicates plainly both that it lives among green plants and that it is little able to defend itself from the attacks of enemies. It must therefore depend on concealment for safety. It probably lives almost entirely in the grass, and rarely ascends trees and shrubbery, as does its relative, the Rough Green-snake. Holbrook says of it that "it is a very gentle animal, and can be handled with impunity; it seeks meadows of high grass, where crickets and grasshoppers abound, on which it feeds. It is found mostly on the ground, though at times I have seen it stretched on the branches of low shrubs, as the dwarf willow." DeKay (*30*, 40) says of it that it is exceedingly quick and lively in its movements; that it is most abundant in marshes, and that it is reputed to fight furiously with the Striped snake. Prof. F. W. Putnam found in Massachusetts, on August 31, its eggs under the bark of an old stump. They were just ready to hatch and one snake was already out. The eggs were an inch and a half long, and the young a little over 5 inches.

### Genus PHYLLOPHILOPHIS, Garman.

*Phyllophilophis*, Garman, 1883, *13*, 40; *Leptophis*, Bell, 1826, *110*, 328; Baird and Girard, 1853, *6*, 106.

Body and tail very long and slender, and the body somewhat compressed. Head distinct from the body. Loral present, small. One anteorbital. Postorbitals two. Nasal single, with the nostril in the center. Eye large. Mouth-cleft deep. Scales keeled, except those of the outer one or two rows; arranged in 17 rows. Anal plate divided.

This genus differs from *Cyclophis* only in having the scales keeled.

## **Phyllophilophis æstivus,** (Linn.).

*Rough Green-snake.*

*Coluber æstivus*, Linnæus, 1766, *64*, ed. xii, i, 387; *Leptophis æstivus*, Holbrook, 1842, *54*, iv, 17, pl. 3; Baird & Girard, 1853, *6*, 106; *Phyllophilophis æstivus*, Garman, 1883, *13*, 40.

Long and very slender; the tail whiplike, and constituting usually more than a third of the total length. Head separated from the body by a slender neck; narrow and high; swollen in the occipital region; the snout projecting considerably over the lower jaw. Eyes large. Scales keeled, except those of outer row and often some of the second row. Ventrals 150 to 165; subcaudals 110 to 135. The latter seldom as many as 70 per cent. of the ventrals.

Color grass-green above; below, greenish white. The green of the upper surface fades somewhat on the lower rows of scales. In alcohol the green changes to blue. The lower jaw and the upper labials are yellowish white.

Maryland to Kansas, south to Florida and Mexico. Indiana localities: New Harmony (Sampson's coll.); Vigo and Parke counties (Nor. School coll.); Dearborn county (A. W. Butler); Monroe county (Bollman); Cloverdale, Putnam county (Test).

Habits.—This snake greatly resembles in general appearance and disposition the Smooth Green snake. It may be distinguished readily from the latter by its more slender form and by its keeled scales. It is equally as harmless as the other snake, and makes no attempt to bite when taken in the hands. It is given to climbing about on trees in search of the insects and larvæ that constitute its food. I have taken it while thus moving about on the branches of small trees. Of this species Holbrook says: "Perfectly harmless and gentle, easily domesticated, and takes readily its food from the hand. I have seen it carried in the pocket or twisted around the arm or neck as a plaything, without ever evincing any disposition to mischief. In its wild state it lives among the branches of trees and shrubs, shooting with great velocity from bough to bough, in pursuit of the insects which serve as its nourishment. Its green color, similar to the leaves among which it lives, afford it protection against those birds which prey upon it."

Prof. Cope (*22*, vi, 309) says of one that he kept in confinement that it manifested no disposition to climb over the ferns and plants among which it lived, but that it lived mostly underground. It had a habit of projecting its head and two or three inches of its body above the ground and holding itself for hours rigidly in a single attitude. In this position it resembled very closely a sprout or shoot of some green succulent plant, and might readily be mistaken for such by small animals.

### Genus STORERIA, B. & G.

*Storeria*, Baird and Girard, 1853, *6*, 135; Garman, 1883, *13*, 29, in part.

Serpents of small size. Head distinct from the body. Tail only of moderate length. Crown-shields nine. No loral. One or two anteorbitals. Two or three postorbitals. Nasals two, with the nostril between. Scales keeled; arranged in fifteen or seventeen rows. Anal plate divided.

| | |
|---|---|
| Scales in seventeen rows. | *dekayi*, p. 496. |
| Scales in fifteen rows. | *occipitomaculata*, p. 497. |

### Storeria dekayi, (Holb.).

*DeKay's Snake.*

*Tropidonotus dekayi*, Holbrook, 1842, *54*, iii, 53, pl. xiv; *Storeria dekayi*, Baird and Girard, 1853, *6*, 135; Garman, 1883, *13*, 31, pl. i. fig. 1.

Head somewhat larger than the neck, flat above, and rather high. Rostral as high as wide. Snout projecting beyond the lower jaw. One anteorbital, high. No loral. Two, sometimes three, postorbitals. Upper labials seven; eye over third and fourth. Lower labials seven; fourth and fifth large. Scales distinctly keeled; in seventeen rows. Ventrals 120 to 145; subcaudals 40 to 60. Tail one-fifth the total length.

The color of the upper surface is yellowish or reddish-ash, brownish-olive, or even chestnut. The middle of the back with a paler, clay-colored, dusky-edged band, three or four scales wide. On each side of this vertebral band is a row of brown or black dots about the length of two scales apart. These sometimes extend themselves and meet across the dorsal stripe. Occasionally the dots, and sometimes the band itself, are wanting. In such cases the color above is uniform. Below the dots mentioned, other dots are occasionally seen. The color of the lower surface is whitish or yellowish in alcoholic specimens, but in life the color is often salmon or red. The ventrals with one or two dots of brown at their outer ends. Plates of the head brownish, with some minute dots. In highly colored specimens, there is a large brown spot just behind the head on each side; another spot on side of head and across the corner of the mouth, and a small blotch under the eye. The length of grown examples is from twelve to fifteen inches.

Distribution from Maine to the Mississippi Valley, and south to the Gulf and to Mexico. Probably occurring in every township in Indiana. Known localities are: Wheatland (Ridgway); Lebanon (Nat. Mus.); New Harmony (Sampson's coll.); Harrison county (specimens from

Prof. Hallett); Monroe county (Bollman); Irvington; Terre Haute (Blatchley); Denver, Miami county, (Nor. Sch. coll.); Wabash county (Ulrey); Franklin county (Butler).

The colors of this little serpent are such as harmonize well with its usual surroundings, the soil and dead grass, leaves, and slender, broken branches of trees. I have observed no evidences of its being aquatic, but some observers make such statement. DeKay reports that all that were seen by him were either in the water or in the vicinity of it. One taken by him was swimming across a bay of Long Island Sound. All that Holbrook has to say about it is that it frequents meadows and places where the grass is of luxuriant growth, and feeds on various insects, as crickets, grasshoppers, etc. They are ovoviviparous. A female, taken at Cumberland Gap, Tenn., and in midsummer, contained eleven eggs. The eggs were .37 inch by .25.

### **Storeria occipitomaculata,** (Storer).

*Storer's Snake.*

*Tropidonotus occipitomaculatus*, Storer, 1839, *76*, 230; *Storeria occipitomaculata*, Baird and Girard, 1853, *6*, 137; Garman, 1883, *13*, 30, pl. 1, fig. 2.

Averaging smaller in size than *S. dekayi*, which it resembles in proportions and in coloration. Snout short and blunt. Anteorbitals 2. Postorbitals 2. Nasals 2, with the nostril mostly in the anterior. No loral. Upper labials 5 to 6, growing larger posteriorly, the eye over third and fourth. Lower labials 6 or 7. Scales keeled; arranged in fifteen rows. Ventral scales 117 to 128; subcaudals 43 to 50.

Color olive to reddish gray or chestnut brown. Along the back there is a paler stripe about three scales wide, and this is usually edged with dusky. Bordering the pale vertebral band and situated in the dusky border in each side is a row of brown dots. The vertebral band and the dots may all be faint or entirely absent. Often there is a yellowish stripe on the lowest row of scales. Head like the body, but mottled with brown. Behind the occipital plate is a spot of yellow, salmon in life, and a similar spot on each side just behind the corner of the mouth. The fourth and fifth labials with a small spot of similar color. Below, the color is yellowish; in life salmon or brick-red. The ends of the ventrals mottled with dusky.

Length of grown specimens about one foot.

The territory occupied by this animal extends from Maine to Wisconsin and south to Georgia and Texas. In Indiana it is doubtless to be found everywhere. It has been collected at the following localities: New

Harmony (Sampson's coll.); Montgomery county (A. W. Butler); Lebanon, Boone county (S. F. Baird); Irvington, where it is less common than *S. dekayi*; Terre Haute (Blatchley).

I know little about the habits of this snake. Smith (*18*, 698) states that they are somewhat nocturnal, and live chiefly under logs and stones. They are in all probability ovoviviparous. In the stomach of a specimen taken at Irvington I found a slug.

### Genus COLUBER, Linn.

*Coluber*, Linnæus, 1758, *64*, ed. x, 216; *Scotophis*, Baird and Girard, 1853, *6*, 73; *Elaphis* Garman, 1883, *13*, 53.

Snakes attaining a large size. Head distinct from the body; rather narrow and long. Crown-shields 9. Vertical broad. Loral present. Anteorbital 1, large. Postorbitals 2. Nasals 2, with the nostril between. Mouth deeply cleft, the outline nearly straight. Dorsal scales keeled, except some of the lower rows, which may be smooth; arranged in 23 to 29 rows. Anal plate divided. Ventral plates 200 to 240. Subcaudals 63 to 95.

(In rare cases, especially specimens of *C. guttatus*, all the scales may be smooth.)

### Analysis of the Species of *Coluber*.

A. With longitudinal bands of brown. N. C. to Fla. *quadrivittatus*.

AA. Blotched above or uniform black.

- a. Scales in 25 (rarely 23 or 27) rows; with chocolate blotches. *vulpinus*, p. 498.
- aa. Scales in 25 to 29 rows.
  - Scales in 27 rows; blotches red. *guttatus*, p. 500.
  - Scales in 27 (rarely 25 or 29) rows; upper surface nearly uniform black, or grayish, with black blotches. *obsoletus*, p. 501.
  - Scales in 29 rows; color ash-gray, with about 70 blotches of brown. Kansas to Mexico. *emoryi*.

### **Coluber vulpinus,** (B. & G.).

*Fox-snake.*

*Scotophis vulpinus*, Baird and Girard, 1853, *6*, 75; Cooper, 1860, *20*, xii, pt. ii, 299, pl. 22. *Elaphis guttatus* var. *vulpinus*, Garman, 1883, *13*, 56; *Coluber vulpinus*, Cope, 1875, *12*, 39.

Form elongated and rather slender. Tail tapering, and forming about one-fifth the total length, ending in a hard, straight spine. All the cephalic plates behind the prefrontals large. Postfrontals bent down on the sides of the face. Vertical varying from narrower than long to wider than long; shorter than distance from its anterior border to snout. Upper labials 8 (rarely 7), eye over fourth and fifth; sixth and seventh largest. Lower labials 10 or 11, the sixth largest.

Dorsal scales in 25 rows (rarely 23 or 27); the carination feeble, on the outer rows and on the tail obsolete. Ventral plates 200 to 234. Subcaudals 68 to 85.

This is a distinctly spotted serpent. The ground color above varies from gray to brown and reddish, many of the scales having a broad edge of cream color. There is a dorsal series of broad blotches of a brown or chocolate color, and these are edged with black. These blotches, about 60 from head to tail, are from three to six scales long and extend down on the sides to about the sixth row of scales. They are separated on the back by two scales' length. Alternating with these blotches is another series on each side, situated on the third to the seventh rows of scales. Below these is a third series, smaller and usually less distinct. They alternate with those of the second series, and lie opposite the dorsal spots. Sometimes they lie on a level with the second series, but are smaller. The under surface is yellowish, with large squarish blotches of black. The head sometimes with a dark streak from the eye to the corner of the mouth, and another downward from the eye.

This snake may attain a total length of five feet, and even more. Its geographical range appears to be altogether northern, from Michigan to Minnesota and south to Southern Indiana. New Harmony (Sampson's coll.); Wheatland (R. Ridgway); Hamilton County (Hay). This last mentioned specimen has 85 subcaudals.

This snake appears to be the northern representative of *C. guttatus*, a species that is at home in the Southern States, but which also is found in Indiana. By some authors, as Mr. Samuel Garman, *vulpinus* is regarded as only a variety of *guttatus*. The latter may be recognized as a redder snake, with fewer blotches along the back (about 45, instead of 60), and with 27 rows of scales.

The Fox-snake appears to be moderately common in some localities. It is often known as the "Pilot-snake," and is supposed to have some mysterious connection with the rattlesnake. It is a wholly innocent snake, although, as it seems, a little inclined to be pugnacious. Dr. Suckley (*20*, xii, pt. ii, 300) states that one of these snakes was brought to him alive at Ft. Snelling, Minn. When provoked it showed its irritation by vibrating the tip of its slender tail, which, when striking a crumpled leaf or any other small object, would produce a well-marked rattling noise, very similar to that made by the rattlesnake under the same circumstances. Other observers make mention of the same habit.

Mr. Robert Ridgway, of the Smithsonian Institution, writes me that, while hunting near Mt. Carmel, Ill., he came upon a Fox-snake over six feet in length. It immediately showed a disposition to fight, and Mr. Ridgway says that it was the most viciously pugnacious snake that he had ever seen. An examination of the stomach showed that it had just swallowed a half-grown rabbit. Its disposition appears to be in strong contrast to that of *C. obsoletus*, which, so far as I have been able to learn, is very gentle.

These snakes, being wholly harmless and subsisting on vermin of various kinds, ought to receive the protection of the farmer.

### **Coluber guttatus**, Linn.

*Spotted Coluber.*

*Coluber guttatus*, Linnæus, 1766, *64*, ed. xii, i, 385; Holbrook, 1842, *54*, iii, 65, pl. 14; *Scotophis guttatus*, Baird and Girard, 1853, *6*, 78; *Elaphis guttatus*, Garman, 1883, *13*, 55, pl. iv, fig. 1.

Form elongated and somewhat compressed. Head narrow, tapering to the rounded snout. Tail about one-sixth the total length. Cephalic plates not greatly different from those of *C. vulpinus*. The dorsal scales disposed in 27 rows; rather feebly keeled, those of some of the outer rows smooth. Ventral plates 214 to 236; subcaudals 63 to 79.

The ground color is light red, fading in alcohol to brownish yellow. Along the back there is a series of about 40 blotches, or "saddles" (Cope), of dark red, each dark bordered. These blotches are somewhat irregular and variable in form. They are from 4 to 6 scales in length. Below this dorsal series on each side is another series of spots, alternately larger and smaller. Of these, the larger alternate with the dorsal series. All these send down prolongations to the belly. The lower surface is checkered with black and yellow. Head red, with a band of dark red, edged with black, running across the face, through the eyes, and to the corners of the mouth, and on the sides of the neck; another narrower band in front of this, and a third from the back of the head to the neck. The size is about that of *C. vulpinus*.

Distributed from Virginia to Illinois, and south to the Gulf of Mexico. It has been sent to the National Museum from Mt. Carmel, Illinois. This Mt. Carmel specimen has only twenty-six rows of scales. Some *Colubers* in the collection of Mr. A. W. Butler, of Brookville, I refer to this species. Another specimen, undoubtedly *C. guttatus*, is said to have been taken in Putnam county, at Greencastle. It is a large specimen, and has the characteristic head-bands. The scales are wholly smooth.

Of this serpent, Holbrook remarks that it is commonly observed about the roadsides early in the morning or at the dusk of evening;

unlike most snakes, concealing itself during the day. It is very gentle and familiar, frequenting the neighborhood of settlements, and at times entering houses. According to Catesby, it is a great robber of hen-roosts. If so, it must take the young fowls, and possibly the eggs.

### Coluber obsoletus, Say.

*Alleghany Black-snake.*

*Coluber obsoletus*, Say, 1823, *14*, i, 140; Holbrook, 1842, *54*, iii, 61, pl. 12; *Coluber alleghaniensis*, Holbrook, 1842, *54*, iii, 85, pl. 19; *Scotophis alleghaniensis*, Baird and Girard, 1853, *6*, 73; *Elaphis obsoletus*, Garman, 1883, *13*, 54, pl. iv, fig. 2; *Scotophis confinus*, Baird and Girard, 1853, *6*, 76.

A snake attaining a large size, of moderate slenderness, and with a tail that forms a fifth of the total length. Head rather broad and the snout blunt. Mouth large. Eye of medium size. Crown-shields 9; those behind the prefrontals large. Postfrontals bent down on the face. Rostral broad, and the snout projecting. Upper labials 8 (rarely 9); 6th and 7th largest. Lower labials 11; the 6th largest. Scales feebly keeled; some of the exterior rows smooth; disposed in 27 rows (in some specimens, 25 rows*). Ventral plates 230 to 250; subcaudals 53 to 86.

Color varying from gray brown to pitch-black, sometimes with a tinge of red. Often with numerous evident spots; sometimes the spots obsolete, as in our form, the typical *obsoletus*. In this, the general color is a black with a bluish tinge, or a pitch-black, most pronounced on the posterior portion of the body. The anterior half may be lighter, and show evidences of blotches. The whole of this part may have a decided tinge of red, this being due to the color of the skin between the scales; yet the red may run up on the bases of the scales. Occasionally the spots of the upper surface are of a decided red. The dorsal blotches extend down on the sides to about the 7th row of scales, counting from the lowest. They are about 6 scales long, and are separated by the length of 2 scales. Alternating with these is another series which extend from the 3d to the 7th rows of scales. These spots are all feebly indicated by the sulphur yellow of the skin between the scales; and often the color is almost uniform black. There are some scales with yellow or white edges. Lower jaw and throat white. The belly is of a slate-color or black on the hinder half; anteriorly the black is mottled with yellowish, which color becomes more and more abundant, until the throat and chin are entirely yellowish. Small, or even half-grown, individuals may have a ground color of ash-gray and numerous dark blotches.

*A specimen from Brookville, Indiana, which resembles in other respects *C. obsoletus*, has 29 rows of scales.

*Coluber obsoletus confinis* is common in the southern portion of the United States. It has the scales in twenty-five, occasionally twenty-seven, rows. The ground color is ash gray, and there are about forty-four elongated dorsal blotches of dark chocolate brown. Below these blotches are two other series of elongated spots of a similar color. The latter spots run together to form on each side, especially arteriorly, a longitudinal stripe. Ventral plates about 240. A specimen of *Coluber*, fourteen inches long, sent me from Terre Haute by Prof. Blatchley, agrees in almost every respect with Baird and Girard's description of *Scotophis confinis*. It has, however, two temporal plates, instead of one, as stated by Prof. Cope. It is undoubtedly the same form as two large specimens before me, one from Georgia, the other from Mississippi. The latter belong to *Coluber spiloides*. When the small specimen is compared with other half-grown and adult specimens of *C. obsoletus*, they appear to form an unbroken series from the very spotted young up to the adults of uniform black. I conclude that *C. spiloides* is not more than a variety of *C. obsoletus*, and *C. confinis* is probably an individual variation with respect to its temporals.

*Coluber obsoletus obsoletus* ranges from southeast New York and the eastern base of the Alleghany Mountains to the plains, and south to North Carolina and Texas. It probably occurs in all portions of our own State. It has been taken in the following localities: Wheatland (Ridgway); Franklin county, where it is common (Hughes and Butler); Monroe county (Ind. Univ. coll.); Jackson county (St. Nor. Sch. coll.); Terre Haute (St. Nor. Sch. coll. and Prof. Blatchley); Irvington (W. P. Hay). Three of the specimens examined, one taken at Irvington, another taken in Jackson county, and a third from Terre Haute, had only twenty-five rows of scales.

So far as I am aware, this is entirely a forest-inhabiting species. Our indistinctly spotted and almost jet black form is not distinguished by most people from the Black-racer, although it is a very different snake. The latter is a slenderer snake and has very smooth scales in only seventeen rows.

*Coluber obsoletus* spends its time hiding about hollow logs and in holes about standing trees. It often ascends trees in search of birds and their young. Mr. Amos W. Butler, of Brookville, says that they are the most destructive to birds of all our snakes. Besides birds, they no doubt prey on mice, rats, rabbits and other small animals. The disposition of this serpent is gentle, and it makes little resistance when surprised and seized by head and tail. It will open its mouth in an attempt to bite, but struggles little. Under such circumstances a Racer would make a lively disturbance. One put into a box with a mouse would strike at the latter whenever it showed too much familiarity, but it was not harmed. In the stomach of one individual I found a number of young mice; in another were two old and six young mice.

This species probably reaches a greater size than any other snake that we have. Dr. Robert Ridgway tells me that he killed one at Mt. Carmel, Ill. which he estimated to be over nine feet long. It made no resistance when attacked and was as easily killed as an ordinary snake two or three feet long. This species has the habit, common with many snakes, of vibrating its tail so as to make a rattling or whirring sound. This probably serves to warn the larger animals of its presence, so that they may avoid it.

Dr. G. B. Goode includes this snake among those which are said to "swallow" their young; that is, when danger threatens they open their mouths, in order to allow the young to pass down the mother's throat for safety. More observations need to be made on this subject.

I have been able to find in print no observations on the breeding habits of this snake. When and where are the eggs laid? How many of these are there? How soon do they hatch? These are a few of the things that many a farmer's boy might be able to find out for us. Two individuals were taken at Fall Creek, Marion County, while in sexual union. This was on June 19. The male was 5 ft. 3 in. long; the female was 6 ft. 3 in. The female contained sixteen eggs. They have a thick covering, and must be laid before hatching. Prof. Blatchley writes (*94*, '91, 31) that he kept one, 5 ft. 7 in. long, for sometime in confinement. It would, on being disturbed, vibrate its tail in such a way as to make a rattling sound. When the room was entered at night with a lamp the snake would hiss with a loud, gurgling noise. A large Horned Owl, kept in the same room, was attacked by the snake, tightly enveloped in its coils and so badly crushed that it soon died.

Maximilian (*103*, xxxii) has confirmed the popular notion that the snake will eat fowls' eggs. One entered his room, climbed to a vessel of eggs, and swallowed a number of them. After the eggs had passed down the throat the shells were crushed by a powerful constriction of the walls of the stomach.

### Genus NATRIX, Laurenti.

*Natrix*, Laurenti, 1768, *109*, 73; *Tropidonotus*, "Kuhl, 1826, *77*, 205"; Cope, 1875, *12*, 42; Garman, 1883, *13*, 22; *Nerodia* and *Regina*, Baird and Girard, 1853, *6*, 38, 45.

Form varying from stout to slender. Head distinct from the body. Crown-shields 9. Loral present. Anteorbitals 1 or 2. Postorbitals 2 or 3. Nasals divided with the nostril between. Scales conspicuously keeled; arranged in from 19 to 33 rows. Anal plate divided.

KEY TO THE SPECIES OF *Natrix* IN THE E. U. S., NORTH OF FLORIDA.

A. Colors arranged in lengthwise stripes; scales in 19–21 rows.
  a. With a vertebral dark vitta; another on fifth row of scales; a pale stripe along the flanks, and two dark stripes on the middle of the belly. *leberis*, p. 504.
  aa. With a vertebral light band.
    b. A dark vitta on 1st row, another on 8th; two rows of black dots on middle of the belly. *rigida*, Appendix.
    bb. Dark vittæ on 4th and 8th rows; belly uniform yellow. *grahamii*, Appendix.
    bbb. Dark vittæ on 2d and 3d, and on 5th and 6th rows; abdomen with two clouded bands on yellow ground. Texas. *clarkii*.

AA. Colors arranged in form of blotches; scales in 19 to 33 rows.
  c. Scales in 19–21 rows. *kirtlandii*, p. 505.
  cc. Scales in 23–25 rows.
    d. Anteorbitals 1; upper labials 8. *sipedon*, p. 506.
    dd. Anteorbitals 2; upper labials 9. Washington, D. C. *bisecta*.
  ccc. Scales in 27–33 rows.
    e. Scales in 27 rows; 3 alternating rows of square spots. *rhombifera*, p. 509.
    ee. Scales in 27–29 rows; a row of small plates between the eyes and the upper labials. *cyclopion*. Appendix.
  cccc. Scales in 31–33 rows. Maryland to Florida. *taxispilota*.

## **Natrix leberis**, (Linn.).

*Leather-snake.*

*Coluber leberis*, Linnæus, 1758, *64*, ed. x, 216; *Tropidonotus leberis*, Holbrook, 1842, *54*, iv, 49, pl. 13; Garman, 1883, *13*, 27, pl. 2, fig. 1; *Regina leberis*, Baird & Girard, 1853, *6*, 45; *Natrix leberis*, Cope, 1892, *3*, 668.

Head rather small, not much broader than the neck; somewhat depressed. Nasals 2, sometimes not well separated. Anteorbitals and postorbitals each 2. Upper labials 8, the 5th and 6th largest, the eye over 3d and 4th. Lower labials 10, the 5th and 6th largest. Scales disposed in 19 rows; all distinctly keeled, giving the snake a rough appearance. Ventrals 140 to 151. Pairs of subcaudals 64 to 86. Tail forming about one-fourth the total length.

The color above varies from olive brown to chestnut brown. There is a vertebral dark stripe occupying the median row of scales, and another on each side, occupying the 5th row from the outside. Along each flank there is a yellowish band lying on the upper half of the 1st and the lower half of the 2d rows of scales. Below this pale band there is a dark line occupying the outer ends of the ventral plates and the lower half of the 1st row of dorsal scales. The belly is yellow, with two brown bands which lie close together and run from the throat to the vent. Upper labials, lower jaw, and the throat yellow.

This species inhabits the United States east of the Mississippi River. In Indiana, it has been taken as follows: Franklin county (Butler and Hughes); Parke county (Butler); St. Paul, Decatur county (Hay); Terre Haute (Blatchley); Richmond (F. C. Test); Wabash county (W. O. Wallace). It may be expected to occur along all our streams.

This species seems to be wholly aquatic. When pursued, it exhibits great skill in secreting itself among the stones and other accumulations along the water's edge. Its colors are in a high degree protective. Little appears to be known concerning its special habits. Mr. A. W. Butler informs me that in Franklin County it appears as early as March 20, and is to be found still in November.

A gravid female 24 inches long, from Wabash county, contained 8 eggs, each of which had within it a young snake about 6.5 inches long, but not yet ready to be born. The eggs differ in form and length, on account of pressure. The two hindermost lie in the left oviduct. The egg coverings are very thin and delicate. The brown longitudinal stripes of the young are so distinct that the species might easily be determined. The brown ventral bands have not yet appeared.

### **Natrix kirtlandi**, (Kenn.).

*Kirtland's Snake.*

*Regina kirtlandi*, Kennicott, 1856, *1*, 95; *Tropidoclonium kirtlandi*, Cope, 1860, *1*, 340; *Tropidonotus kirtlandii*, Garman, 1883, *13*, 28, pl. 1, fig. 3; *Clonophis kirtlandii*, Cope, 1888, *3*, xi, 391.

A snake having a moderately slender body, a small head, and a tail constituting about one-fourth the entire length. Head little larger than the neck. Crown-shields nine. Snout rather short. Loral present, higher than long. Nasal divided, or only partly so. Anteorbital one, high. Postorbitals two, the upper small. Upper labials six, (five), the fifth the largest. Lower labials, seven or eight, the fifth and sixth the largest. Scales all distinctly keeled; arranged in nineteen rows. Ventrals 120 to 133. Subcaudals 50 to 65 pairs.

In life, the ground color of the upper surface is a dull red, most distinct along the middle line; all the scales dotted with brown. Along each flank, involving the outer one-fourth of the ventral plates and two or three of the lower rows of scales, is a band of silver-gray. There are on each side of the body three rows of alternating spots of dark-brown. Of these spots, those of the middle row are largest and most distinct. They lie on the second to the sixth rows of scales, are about two scales long, and are separated by one-half scale's length. There are about fifty-five of these spots from the head to the vent. Above this row is another of considerably smaller and fainter spots. The spots of the lowest row occupy the lower edge of each alternate scale of the first row. Belly deep salmon-red, each side ornamented by a row of distinct black spots, the size of the eye. They are located on the inner half of the outer fourth of the ventrals. Whole throat and lower jaw light salmon, as are the upper labials and the snout. Head brown, becoming black on the upper edges of the upper labials. The length may become about eighteen inches.

This species is distributed from New Jersey (*1*, '60, 340,) to Illinois. It is a common species about Indianapolis, almost as common as *Eutainia sirtalis*. It is found in Monroe county (D. S. Jordan); Crawfordsville (Beachler); Winchester (Engle and Wright); rare about Terre Haute, common in Putnam county (Blatchley)

This is a handsome species of snake, and one that is wholly innocent. Nevertheless, it exercises the right of the innocent, and when attacked makes a show of self-defense. It has a habit of flattening itself excessively, so that it becomes very broad and thin. It will strike vigorously, but does no harm. It appears early in the spring, and is seen late in the autumn. In a mild winter and on a sunny day, I have seen it on January 25. On the other hand, I have seen it as late as the middle of October; indeed, it appears to be more abundant late in the autumn than in the summer. About this date, several half-grown ones were found. On the 21st of March, one was dug up out of the mud on the margin of a pond. A specimen from Winchester, Indiana, contained eight eggs. These had, apparently, not begun development, and were only about .44 inch long. The species probably produces living young.

## **Natrix sipedon,** (Linn.).

*Water-Snake.*

*Coluber sipedon*, Linnæus, 1758, *64*, ed. x, 219; *Tropidonotus sipedon*, Holbrook, 1842, *54*, iv, 29, pl. 6; Garman, 1883, *13*, 25, pl. 2, fig. 3; *Nerodia sipedon*, Baird and Girard, 1853, *6*, 38; *Natrix fasciata sipedon*, Cope, 1892, *3*, 671.

Variety *fasciatus*. *Tropidonotus fasciatus*, Holbrook, 1842, *54*, iv, 25, pl. 5; *Coluber fasciatus*, Linnæus, 1766, *64*, ed. xii, i, 378; *Nerodia fasciata*, Baird and Girard, 1853, *6*, 39; *Natrix fasciata*, Cope, 1892, *3*, 670.

Variety *erythrogaster*. *Coluber erythrogaster*, Shaw, 1804, *71*, iii, 458; *Tropidonotus erythrogaster*, Holbrook, 1842, *54*, iv, 33, pl. 7; *Nerodia erythrogaster*, Baird and Girard, 1853, *6*, 40; *Natrix fasciata erythrogaster*, Cope, 1892, *3*, 673.

Variety *woodhouseii*. *Nerodia woodhouseii*, Baird and Girard, 1853, *6*, 42.

This widely distributed and variable species has been described under a great number of names, each of which has been regarded as that of a distinct species. It is doubtful if some of the above will be able to maintain their position even as recognized varieties.

*Natrix sipedon* is our most common Water-snake, and when fully grown attains a large size. The head is rather narrow, and pointed in front. Anteorbital 1, high. Postorbitals 3. Nasal sometimes divided above. Upper labials usually 8, the 6th and 7th large, the eye over 4th and 5th. Inferior labials 10. Scales strongly keeled; arranged in 23, rarely 25, rows. Ventral plates 135 to 150. Suhcaudals 60 to 75.

The ground color varies from ashy to brown. Along the back there is a series of brown spots, about 30 in number, from the head to the vent. These are about three scales long and descend on the sides to the sixth row of scales. They are separated on the back by the length of one-half scale. Along each side is another series of similarly colored square blotches. These either come opposite the dorsal blotches or alternate with them. When the three series are opposed, they unite to form continuous cross bands over the body. Spaces between the lateral blotches equal to or less than width of blotches. When they alternate, they touch at their contiguous angles. All the blotches are dark edged, while the ground color around each is paler. Occasionally the blotches unite across the back to form oblique bands. Again, the ground color is sometimes so dark that the blotches are obscured. Upper surface of the head brown. Upper labials, lower jaw, throat, and sometimes the anterior portion of the belly, yellow. The brown of the belly often takes the form of triangular spots and these are often suffused with red. On the outer ends of the ventral plates anteriorly there begin to be some mottlings of brown. Further back this increases, until the whole or nearly the whole, of the belly is brown.

In the young the contrast between the ground color and spots is greater, the spots heing nearly black.

This variety of the species *N. sipedon* is distributed over the country from the Atlantic to the Mississippi Valley, and south to the Gulf. It is the common Water-snake of Indiana and it seems to be needless to specify localities.

*Natrix sipedon fasciata*. This form of *sipedon* is characterized by having a series of dorsal blotches of brown or black, about thirty in number to the vent, and these spots run down on the sides of the animal, becoming narrower. The spaces between the blotches are occupied on the flanks by red spots, which extend down to the ventral plates. Sometimes the red spots lie just below the dark dorsal blotches, and are separated by narrow dusky bands that connect above with the dorsal blotches. Underneath the color is reddish white, and there may be some dark marbling.

This variety is abundant in the Southern States, and has been taken by Mr. Robert Ridgway at Wheatland.

*N. sipedon erythrogaster.* In this variety the upper surface is almost or entirely without dark blotches, the color being a uniform blue-black. The head and neck may be almost black. The belly, as its name implies, is more or less red in life, yellow in alcohol. Holbrook's figure of this snake represents its under surface as being of a coppery red. It, too, is found mostly in the South, but has been reported from Southern Illinois, and from Mt. Carmel, on the Wabash River. A specimen from that place is in the National Museum. It may, therefore, be regarded as an Indiana serpent. Mr. F. C. Test, of the National Museum, tells me that this snake is found in Hamilton County. Mr. Robert Ridgway says that it is very abundant at some points along the Wabash River. Mr. A. B. Ulrey, of Wabash county, has shown me a large specimen which was obsoletely blotched above, red below, with some brown mottlings. It appears to be intermediate between *sipedon* and *erythrogaster*.

*N. sipedon woodhousei.* This variety has not yet been reported from Indiana, but it is in the National Museum from St. Louis, Mo., and even from Northern Illinois. Its range is toward Texas. It is distinguished by having the scales in twenty-five rows. The lateral blotches alternate with the dorsal and are elongated downward, and are separated by spaces wider than themselves. It deserves to be sought for in our State.

*Natrix sipedon*, known as the "Water-snake," "Water Moccasin," is extremely abundant in all our streams. Under the impression that it is poisonous it is greatly feared by many people, who suppose it to be the same as the poisonous moccasin of the Southern rivers. This is a mistake, and the name moccasin ought not to be applied to our species. It has no poison fangs whatever, and its bite would produce nothing more serious than a fright and a few scratches. This snake is, however, of an ugly and sullen disposition, and when caught will struggle and strike and bite. It may be seen along the river banks, gliding from stone to stone, or swimming hastily away, to escape observation. When pursued it will dive to the bottom and conceal itself among stones and vegetation. Holbrook states that it is frequently seen resting on the low branches of trees that overhang the water. Of *fasciata*, whose habits are doubtless identical with those of our form, Holbrook says that it is a bold animal, and is one of the very few snakes that will, in confinement, devour its prey. These serpents all probably leave the water at times during the night and wander about. I have a large specimen of *erythrogaster* that, in the night, fell into a well that was being dug.

The food of this snake consists of frogs, fishes, and similar animals. There is an account in *Nature* of one which was found swallowing another. Prof. Blatchley (*94*, '91, 30) says that he found seven large Leopard Frogs in the stomach of one of these snakes. Dr. J. A. Allen tells of seeing one brought from the water with a pickerel a foot long in its mouth.

These snakes are ovoviviparious, that is, they retain the eggs in the body until they are hatched. In some cases the eggs may be laid a little before the hatching takes place. In *1*, 1887, 121, we are told of a case in which 33 young were taken from the body of one large female. Each one had attached to it a portion of an egg, from which it was absorbing nutriment. Prof. F. W. Putnam tells us of a family of 22 of the young of this snake, which were found in Massachusetts. Each one was 8 inches long. Another smaller specimen from Northern Indiana contained 16 eggs. The young in these eggs were 7.5 inches long. Each of these was provided with a well-developed egg-tooth.

While investigating the question whether or not snakes "swallow" their young, Prof. G. B. Goode found evidences that this act had been observed in the case of the Water-snake seventeen different times. This being such a common snake further observations ought to be made. If one thinks that the young have been seen to enter the mother's mouth she ought, if possible, to be caught, handled carefully, and put into a cage, to see if the young will come out again. Or, if she is killed, a careful dissection ought to be made, in order to learn whether or not the young are really in the stomach.

### **Natrix rhombifera**, (Hallowell).

*Diamond Water-snake.*

*Tropidonotus rhombifer*, Hallowell, 1852, *1*, 177; *Nerodia rhombifer*, Baird and Girard, 1853, *6*, 147; *Natrix rhombifera*, Cope, 1892, *3*, 673.

Head narrow. Anteorbital 1, sometimes 2. Postorbitals 3, the lowest nearly meeting the anteorbital under the eye. Upper labials 8, the sixth and seventh largest; the eye over third and fourth, not in contact with the fourth on account of the lowest postorbital. Lower labials 11, the fifth and sixth largest. Scales in 27 rows, all conspicuously keeled. Ventrals 136 to 141. Subcaudals 62 to 70.

Ground color above reddish gray. On the middle of the back there is a series of about 50 squarish brown blotches. Alternating with the dorsal series there is, on each side, a series of similarly colored blotches. The dorsal spots are about two scales long, and separated by the length of three scales. The lateral blotches reach down to the ventrals and even lower; while above they join the contiguous corners of the dorsal blotches. Of these blotches about 32 lie in front of the vent. Occasionally there is a little confusion in the relations of the blotches of the different series, but not much. The belly is yellowish white, with a few triangular spots of black, giving it a speckled appearance. The head is smoky brown above as far down as the upper edges of the upper labials. The lower edges of these are yellow, with a black border on the hinder edge. The lower labials are similarly yellow, with black posterior edges.

The size is about that of *Natrix sipedon*, 2 feet 8 inches or more.

This species is distributed from Michigan to Louisiana and Texas. There is a specimen of it in the National Museum from Lafayette Others have been sent there by Mr. Robert Ridgway from Wheatland. I have seen another specimen in Mr. Sampson's collection made at New Harmony. It is no doubt generally distributed throughout the State.

Of the habits of this species I know nothing, except that it is an aquatic snake.

### Genus HETERODON, Beauv.

*Heterodon*, Pal. de Beauvais, 1802, *57*, iv, 32; Holbrook, 1842, *54*, iii, 37; Baird & Girard, 1853, *6*, 51.

Body short and stout. Neck nearly as thick as the head. Tail short. Head broad, short and high. Head, neck and body capable of great flattening. Outline of mouth much curved, rising behind the eyes. Posterior teeth longer and fang-like. Snout projecting beyond the mouth, shovel shaped. The rostral with a sharp horizontal edge and a longitudinal ridge above. This followed behind by a small azygous plate. Upper labials cut off from contact with the eyes by suborbital plates. Dorsal scales keeled. Anal plate divided.

### Key to the Species of *Heterodon*.

Prefrontals separated by the azygos only. *H. platirhinos*, p. 510.

Prefrontals and sometimes postfrontals separated by a number of small plates. *H. simus*, p. 513.

### Heterodon platirhinos, Latr.

*Hog-nosed Snake; Spreading Viper.*

*Heterodon platirhinos*, Latreille, 1802, *57*, iv, 32; Holbrook, 1842, *54*, iv, 67, pl. 17; *H. platyrhinos*, Baird & Girard, 1853, *6*, 51; Garman, 1883, *13*, 75, pl. 6, fig. 5; *Heterodon niger*, Troost, 1836, *62*, iii, 186; Baird & Girard, 1853, *6*, 55.

Body stout and heavy. Tail about one-fourth the entire length, often shorter. Head rather broad and short, but quite deep. The usual nine crown-shields present. In addition, there is an azygous plate between the prefrontals. Rostral greatly developed, trihedral, pointed, and upturned. Nasals two, with the nostril between. Lorals two, these sometimes united. The anteorbitals forming a part of the row of small plates which encircle the eye. This ring is completed above by the supraoccipital. Mouth-cleft large and much curved. Upper labials eight, lower labials eleven. Eye large. Scales keeled, except those of the outer row, which are smooth; arranged in twenty-five, occasionally twenty-three, rows. Ventral plates 120 to 150. Subcaudals 45 to 60.

The color of the upper surface varies from yellowish, reddish brown, and even brick red, with dark blotches, to a uniform gray, olive-brown, blue-black, or black. When the color is not uniform there are to be seen three series of dark spots. One of these is vertebral, and consists of from twenty to thirty brown blotches, each from two to five scales long. They extend down some distance on the sides, but are likely to fade out into the ground color. On the median line, these blotches are separated by about the length of three scales. Alternating with the dorsal blotches is a series of lateral spots, circular and of a dark color. These are not developed on the tail, while the dorsal blotches form bands that extend nearly around the tail. Sometimes there are small spots on the lowest rows of scales forming a third series. All the spots are variable in size and depth of color. Head with a dark band running across from one orbit to the other, a black band from the eye to the corner of the mouth, and another across the occipital plates on to the sides of the neck. The under surface is yellow, with some mottlings of brown.

The uniformly colored individuals which were for a long time regarded as a distinct species, differ in having the color uniform gray to black above, slate color below. There are, however, all gradations in the amount of black and the distinctness of the spots to be found, and these completely connect the two supposed species.

This snake may attain the length of three feet. The body being heavy, the size then becomes conspicuous.

The distribution is from Pennsylvania to Florida and west to Minnesota and Texas. I have reports and specimens from many points in Indiana. Both spotted and uniform specimens are found at New Harmony (Sampson's coll.); also about Brookville (Hughes). I have specimens from Vernon, Jennings county (J. Cope); from Fountain county (C. H. Smith, Veedersburg); Vigo and Jackson counties (Normal School coll.); said by Mr. Beachler to occur at Crawfordsville, Montgomery county; Brown county (Chas. Jameson). Specimens sent me from Veedersburg by Mr. Smith are intermediate between the two supposed forms, and the same is true of some in the collection made by Prof. Evermann, at Terre Haute. Prof. Blatchley reports having found the two forms copulating together (*94*, 1891, 32). Mr. Quick, of Brookville, tells of a similar case.

This is a short-bodied and clumsy snake. It has a peculiar habit, when it is disturbed, of flattening out its head and anterior part of the body, so that it has quite a formidable appearance. It is said to inflate the skin of the head and neck, but it is doubtful if it really does this. When enraged it hisses loudly, and this has given origin to the name, "blowing adder." The snake has a very bad reputation among the people, as is shown by the names "adder" and "viper." Long ago a writer said of it: "When approached it becomes flat, appears of different colors, and opens its mouth hissing. Great caution is necessary not to enter the atmosphere which surrounds it. It decomposes the air, which imprudently inhaled induces languor. The person wastes away, the lungs are affected, and in the course of four months he dies of consumption." The popular notion about this snake even yet is that it is very poisonous, and that it can even spit venom. This bad reputation may be due to its resemblance to some of the poisonous snakes, and to the great show of bravery which the snake often indulges in. It is, on the contrary, regarded by herpetologists as one of the most harmless of our serpents. At the base of its upper jaws there is on each side a long tooth, which some have supposed might act as a poison fang. It has no canal or groove, is not connected with any known source of poison, and is, moreover, so far back that it is hard to see how it could be used in striking an eneny. It would be of immense advantage in swallowing frogs. A number of scientific men have reported that they have allowed themselves to be bitten by this snake and have received no harm. When attacked it spreads out its head and body, utters a hiss, and presents a threatening appearance. However, when it is tormented it will feign death, sometimes turning over on its back and remaining motionless, and will repeat this action.

Prof. W. S. Blatchley says of two, a black one and a spotted one, which he disturbed, "that they opened wide their mouths, turned on their backs and coiled and twisted about in a very rapid and curious manner for about five minutes, when they became quiet and apparently lifeless. During all these contortions they had remained on their backs, and when they became quiet and were turned over they would immediately turn on their backs again, but otherwise gave no signs of life, even at the end of an hour's time."

This species is said to prefer dry and dusty fields; but Dr. C. C. Abbott found them in spring along ditch banks looking out for Cricket-frogs, which a dissection showed that the snakes had been eating. Much appears to be unknown about the habits of this snake, as of most others. What is the use of the sharp-edged, pointed snout? Is it used in burrowing? Or is it employed in rooting up the ground in search of insects and other food? Again, what influence does cultivation of the soil have on the numbers of such sluggish serpents? Why do these survive, while rattlesnakes and copperheads so rapidly disappear? The food of these snakes is doubtless principally frogs, toads and probably mice. Rev. Samuel Lockwood tells us (*22*, 1875, 10) that he has known them to eat the heads of the common eel left on the shore by fishermen.

Some facts are known about its breeding habits. Troost dissected a specimen and found in her 25 oval eggs, each three-fourths inch long and without a calcareous covering. In a large female of the common form from Veedersburg I found in one oviduct 4 eggs, and in the other 11. The hindermost egg was an inch and a quarter long and three-quarters across. The eggs were covered with a tough membrane. I found no embryos in any of the eggs. The snake has been regarded as ovoviviparous, but such is probably not usually, if ever, the case. We have evidences that the eggs are usually laid and buried in the earth before they are ready to hatch. Prof. F. W. Cragin (*22*, xiii, 710) says that he had 22 eggs of this snake, which had been plowed up in a sandy field along Long Island Sound. One of these hatched four days afterward. Another writer (*22*, iii, 555) states that he saw one of these snakes killed, and out of a wound in its side there issued over 100 young, each about 6 or 8 inches long. This writer believed that these snakes were ovoviviparous, and that these young had really been in the stomach of the female. The number of young in this case is certainly unusual. Another author states that a "spotted spreading adder" contained 87 young, each nearly 6 inches long. These statements about such large numbers of eggs are undoubtedly erroneous. A nest of 27 eggs was brought to the National Museum August 31. The female was near the nest and attempted to defend it. In each of the eggs was an embryo well developed and about 8 inches long. The eggs did not hatch until September 7 and 8. The egg coverings were ripped open by the egg-tooth of the young snake. The young would flatten themselves when teased, and some would feign death. Dr. G. B. Goode states (*34*, 1873, 184) that the female of this species has been reported as affording its young a hiding place in her stomach.

### Heterodon simus, (Linn.).

*Sand Viper.*

*Coluber simus*, Linnæus, 1766, *64*, ed. xii, i, 216; *Heterodon simus*, Holbrook, 1842, *54*, iv, 57, pl. 15; Baird and Girard, 1853, *6*, 59; Garman, 1883, *13*, 76, pl. vi, fig. 4.

Form much that of *H. platirhinos*, but probably not attaining so large a size. Tail shorter, about a sixth or less of the total length. Head short and broad. All the crown shields short and broad. Mouth-cleft much curved. The snout upturned. Prefrontals and postfrontals separated by a number of small plates, which surround the azygos. Upper labials, 8, the sixth very high, but all excluded from contact with the eye by the suborbitals. Lower labials 9 to 11, small. Scales not conspicuously keeled, disposed in 25 or 27 rows. Ventrals 117 to 150. Suborbitals 32 to 55.

The ground color is olive or yellowish brown, with many scales partially or wholly yellowish. The upper surface is relieved by a dorsal series of brown or blackish blotches, and two lateral series on each side. The spots lowest down on each side are almost obsolete. The median series consists of about 35 somewhat irregular blotches, each 3 or 4 scales long. Alternating with these is a series of round spots about 3 scales in length. All the spots are surrounded with an edging of yellow. There is a narrow black band running across the forehead, through the eyes and to the corner of the mouth. The belly is yellow, with some cloudings of brown.

The length of this species is not so great as that of *H. platirhinos*, probably never exceeding two feet.

*Heterodon simus simus* is found from South Carolina to Mississippi, and north to Indiana. Further west it is replaced by *H. simus nasicus*, a variety with a still more prominent rostrum, about 50 spots in the dorsal series, a greater number of small scales around the azygos, 23 rows of scales, and more black on the belly.

In Indiana *simus* has been taken at very few points, but it is probably to be found throughout at least the southern portion of the State. It has been sent to the National Museum from Brookville by Dr. R. Haymond. It has been stated to occur at New Harmony, but I have not seen specimens from that place.

I find few observations that have been made on the habits of this species. The form *nasicus*, being more abundant, has been a little better observed, and its habits probably do not differ much from our variety. It is much dreaded by the settlers in the West, who call it the "Sand Viper." It is entirely harmless, and Dr. Coues states that he could not provoke it to bite. Like its relative, *platirhinos*, when it is disturbed it makes a great demonstration of hostility. One that I came upon in a prairie path in Kansas sprang out into plain sight and began such a wriggling and hissing that for a moment I supposed that it was really a rattlesnake. This was probably its purpose, and such movements would be quite likely to frighten away from it any large animal that otherwise might trample it.

One writer (*22*, xvi, 566) tells of having found this snake hanging to the foot of a box-tortoise. The foot was bleeding, and two of the toes had been digested off. These tortoises are not infrequently found with parts of the limbs missing, and this observation may account for such maimings.

### Genus OPHIBOLUS, B. & G.

*Ophibolus*, Baird and Girard, 1853, *6*, 82; Garman, 1883, *13*, 64.

Form moderately stout. Head not much broader than the neck. Crown-shields 9. Loral plates present, or only rarely absent. Anteorbital single. Postorbitals 2 or 3. Nasals divided, with the nostril between. Scales smooth and shining, disposed in 21 to 25 rows. Anal plate entire.

KEY TO THE EASTERN UNITED STATES SPECIES OF *Ophibolus*.

A. Scales in 21 (rarely 19 or 23) rows.
- a. General color red, with 22 or more triple rings of black, red, and black; or ground color reddish or gray, with 40 to 50 chocolate or brown saddle-shaped blotches. *doliatus*, p. 515.
- aa. Ground color chestnut or olive, with about 50 rhombic blotches along the back. Other blotches along the sides. Southern States, north to District of Columbia. *rhombomaculatus*.
- aaa. Ground color black, with numerous small spots of yellowish or white, these sometimes forming transverse rows of spots. *getulus*, *p*. 518.

AA. Scales in 25 rows.
- Brownish, with 40 to 60 dark blotches above. Belly blotched. *calligaster*. Appendix.

### **Ophibolus doliatus,** (Linn).

*House Snake; Milk Snake; Chicken Snake*

*Coluber doliatus*, Linnæus, 1766, *64*, ed. xii, 379; *Coronella doliata*, Holbrook, 1842, *54*, iii, 105, pl. 24; Baird and Girard, 1853, *6*, 89; Garman, 1883, *13*, 64 and 155.

Variety *triangulus*. *Coluber triangulus*, Boie, 1827, *77*, 537; *Coluber eximius*, Holbrook, 1842, *54*, iii, 69, pl. 15; Baird and Girard, 1853, *6*, 87; *Ophibolus doliatus*, var. *triangulus*, Cope, 1875, *12*, 37; Garman, 1883, *13*, 65, pl. 5, fig. 1.

Variety *syspilus*. *Ophibolus doliatus syspilus*, Cope, 1888, *3*, 384.

*Ophibilus doliatus* is an extremely variable species, and this has caused it to be described under a great number of names, the most of which have at one time or another stood for distinct species. Prof. Cope (*3*, xiv, 608), in a general view of the species, recognizes no fewer than 11 varieties or subspecies. In its distribution, the species ranges from Maine to Panama, and illustrates well the changes which a widely spread species undergoes, when traced from one region to another. The changes concern its size, squamation, its colors and the arrangement of these colors.

The head is small, little exceeding the diameter of the neck. The loral is present, with rare exceptions, but it is small. Upper labials 7; lower labials 9, occasionally 10. The eye is small and placed over the third and fourth labials. The scales are in 21 rows. In a few cases there may be only 19, and in rarer cases 21 rows. They are smooth. The ventrals range from 184 to 214. The tail forms one-sixth or one-seventh of the entire length. The ground color varies from red to reddish brown and to gray. The deeper colors appear as transverse rings, complete or incomplete, or as saddle-shaped and irregular blotches. In *O. d. coccineus*, a Southern variety, the color is red, and there are triple rings entirely encircling the body. These consist of two rings of black enclosing between them a ring of white or yellow. In other varieties the black rings of one set runs forward on the sides and joins the posterior ring of the set in front. In this way the ground color becomes divided up into a number of dorsal blotches or "saddles." At the same time the hue of both the ground color and of those which relieve it undergo change.

### Key to Indiana Varieties of *O. doliatus*.

General color red; large blotches, or saddles of ground color formed by rings of adjacent sets meeting on the ventral plates. *doliatus.*

General color red; blotches of ground color formed by the black rings of adjacent sets meeting above the ends of the ventrals; single series of black spots along middle of belly. *syspilus.*

General color brownish-red or gray, with dorsal saddles not descending to the ventral plates. *triangulus.*

*Ophibolus doliatus doliatus* is bright red above, yellowish in alcohol. Across the body there run from 20 to 30 triple rings, of which two black ones enclose one of white or yellow. The black rings do not pass entirely around the belly, but the anterior black ring of one set turns forward on the ends of the ventral plate on each side and joins the posterior black ring of the set in front. On the sides are spots alternating with the dorsal blotches, and these do not meet on the belly.

This variety probably does not attain a size greater than about two feet. It is found principally in the Southern States, but has been taken also in Indiana. I have seen specimens taken at New Harmony (Sampson's coll.); Brown county (taken by Chas. Jameson); and Jackson county (Nor. Sch. coll.). The latter specimen had 23 rows of scales, otherwise it was normal. Mr. Robt. Ridgway writes that it is not uncommon about Wheatland; Terre Haute (Blatchley); Lafayette (F. C. Test).

*Ophibolus doliatus syspilus* is a variety described in 1888 by Prof. E. D. Cope (*3*, xi, 384). It differs from the variety *doliatus* in having the dorsal blotches descend upon the ventral plates, and in having the spots which alternate with them meet on the belly and form there on the middle line a single series. "The body is scarlet, banded with 22 pairs of jet black rings, with a white ring between each pair of black. * * The belly is marked with a single series of median black spots, which are opposite the spaces between the dorsal saddles, or opposite the yellow rings." The length of the longest specimen is 30.5 in. Most of the specimens upon which this species are founded are from the Southern States, but one was taken at Wheatland, Ind., by Mr. Robert Ridgway.

*Ophibolus doliatus triangulus* is by far the commonest variety of its species that is found in Indiana. It is known to all under the familiar names of "House-snake," "Milk-snake," and "Spotted Adder." The ground color above is ashy, more or less mingled with brown, this often in life tinged with red. Above are five series of blotches and spots, a dorsal, and on each side two lateral. The spots of the dorsal row are the largest, broader than long, and extend down on the sides, but do not reach to the ventral plates. They vary in number from 40 to 60. Their color varies from grayish brown to brownish red, and are more or less distinctly bordered with black. This black sometimes becomes so conspicuous as to give the appearance of half rings on the upper surface. The dorsal blotches often coalesce with the spots of the series below. These latter are small and alternate with those of the dorsal series. They are sometimes missing. The blotches of the lowest series are located principally on the ends of the ventral plates, and usually coalesce with the spots of either the dorsal or of the middle series. They are commonly black or blue black. The anterior blotch usually extends forward on to the head and terminates variously. There is commonly a dark band across the top of the head just in front of the eyes, and this runs back through the eyes on the lower neck. Above it is a yellow band that also extends backward on the neck. At the back of the head, surrounded by the termination of the first dorsal spot, is a spot of yellow. The belly is blotched with black and creamy white, the latter in life tinged with red.

The length of this form may become as much as four feet. It is common throughout the State.

DeKay (*30*, 38) says of this snake that it is found not infrequently in outhouses and in dairies or cellars where milk is kept, which it is said to seek with avidity. It climbs well, and glides rapidly over the smoothest surfaces. He adds that its vivid colors change almost immediately after death. Holbrook states that this serpent is gentle in its habits, feeding on mice, various insects, etc. It approaches without fear the habitations of men, and is, hence, not infrequently called the House-snake. It also frequents dairies where milk is kept, and this, from a mistaken notion of its robbing the dairy-women, has given rise to another name, the Milk-snake. A number of snakes have acquired a reputation of drinking milk, and it would be interesting to have some one settle the question whether or not any of our snakes will really do so. This snake appears early in the spring. I have taken it March 20, and have seen a dead one along the road still earlier.

According to Dr. Goode's investigations this snake is oviparous and guards its nest. Moreover, when danger threatens her young, the mother finds an asylum for them down her capacious throat. (See *34*, '73, 182.) I have taken the eggs of this species in Illinois. They were buried in a pile of manure and more or less glued together. The egg is 2 inches long and a little less than 1¼ inches short diameter. The covering is parchment-like. It contained a young snake 10 inches long.

Dr. C. Hart Merriam (*78*, '78, 69) relates an instance of an individual of this species having swallowed a specimen of a Striped-snake two-thirds its own length.

### **Ophibolus getulus,** (Linn.).

*King-snake.*

*Coluber getulus*, Linnæus, 1766, *64*, ed. xii, i, 382; *Coronella getula*, Holbrook, 1842, *54*, iii, 95, pl. 21; *Ophibolus getulus*, Baird and Girard, 1853, *6*, 85; Garman, 1883, *13*, 68, pl. 5, fig. 3.

Variety *sayi*.

*Coronella sayi*, Holbrook, 1842, *54*, 99, pl 22; *Ophibolus sayi*, Baird and Girard, 1853, *6*, 84; *Ophibolus getulus* var. *sayi*, Cope, 1875, *12*, 37; Garman, 1883, *13*, 68, pl. 5, fig. 4.

*Ophibolus doliatus* var. *sayi* has a rather elongated and slender body and small head. The tail forms only about an eight of the total length. The vertical plate is triangular. Anteorbital single; postorbitals two, small. The loral is small. The snout is pointed and projecting. Upper labials 7, the eye over the 3d and 4th. Lower labials 10, the 4th and 5th largest. Ventral plates 210 to 225; subcaudals 48 to 55.

The color above is deep brown to jet black, more or fewer of the scales being ornamented each with a small spot of white or yellow. These spots usually largest on the lowest scales. Often they are scattered over the body quite regularly; at other times there are rows of these spots which form narrow lines across the back at intervals of about 5 or 6 scales. In this case there may be as many as 70 of these cross-lines. The areas between such lines may be without spots or may be spotted. Sometimes the lines fork on the sides, the branches anastomosing so as to divide the ground color into more or less distinct blotches. Each plate of the head with one or more spots of yellow. Labials bright yellow, bordered with black. Throat yellow. Belly yellowish, checkered with blue-black, the blotches following the plates. The length may be four feet or more.

This variety is distributed from Southern Indiana and Illinois south and southwest to Mexico. A specimen found in Mr. Sampson's collection at New Harmony and assigned by me to the typical *getulus* (*94*, 1887, 64) is probably more closely related to *sayi*. *Sayi* has also been taken at Mt. Carmel, Ill., on the Wabash River. Prof. Blatchley reports having found a small specimen at Terre Haute. Recently Mr. F. C. Test of the U. S. Nat. Museum has shown me a large specimen of the variety *sayi* that he took at Lafayette, Ind. This is by far the most northern locality for the State, if not for the Mississippi Valley. The cross-bands of white are very narrow, and there are few spots on the scales between the bands. Length 3ft. 2 in.

*Ophibolus getulus getulus* differs from *sayi* in having the white and yellow more definitely disposed in bands which divide up the ground color into blotches. Of these there are a dorsal and a lateral series on each side. There are about 25 to 35 of the yellow cross-bands over the back. Usually the lateral blotches alternate with the dorsal. Occasionally a specimen may have more yellow than black. The belly has various proportions of the yellow and the black. Southern in distribution, but likely to occur in Indiana.

*Ophibolus getulus niger* is a so-called variety of this species which Yarrow (*3*, v, 438) has described from specimens sent to him from Wheatland by Mr. Robert Ridgway.

It is characterized by the almost complete absence of the usual yellow spots. The head plates are entirely black, not spotted. On the body there are spots on only a few of the scales of the lower rows. The abdomen is dull black, with white blotches. One specimen taken at Wheatland was 4 feet 6 inches long. This form is reported to be common in that region. We have in the King-snake another illustration of the phenomena seen in *Heteroden platirhinos*, *Natrix sipedon*, and some others, a gradual transition from very spotted specimens to those which are of a plain black color. We can not give a distinct name to every stage in the change.

Habits.—The habits of the different varieties of this species are, in all probability, identical. It appears to be a snake of a mild and harmless disposition. It is extremely active and strong. Holbrook says of it that it is found abundantly in moist and shady places, although it never takes to water or trees. It feeds on moles, small birds, or such reptiles as lizards, salamanders, toads and the like, that fall in its way. He further says that it is commonly believed that it is the great enemy of the rattle-snake, but that there is no great evidence of this. He, however, tells of one that had as a fellow-prisoner a *Crotalophorus miliarius*, or Southern Ground Rattlesnake, and swallowed him. I found that in Mississippi this snake had the reputation of destroying rattlesnakes, and it received protection on this account. Dr. Elliott Coues (*9*, 4, 269) says that the Black-snake (*Bascanion constrictor*) and *Ophibolus getulus sayi* wage a constant warfare against rattlesnakes and moccasins. They are said to be uniformly victorious and to eat their victims. It is on account of their prowess in thus destroying poisonous serpents that they have received the name of King-snake. Mr. J. T. Humphreys, Burke County, North Carolina, gives (*22*, xv, 561) an interesting account of a conflict in a cage between a king-snake, *sayi*, and a water-moccasin. The former was 42 inches long, the latter 34, but with a considerably larger body. The moccasin was killed, its bones crushed, and, beginning at the head, the king-snake swallowed 16 inches of the moccasin's body. Chloroform was then administered and both snakes preserved. The king-snake had previously, while in captivity, eaten seven snakes. Dr. Yarrow (*22*, xii, 470) describes a specimen of *getulus* in the National Museum that has two perfect heads. One head is a little larger than the other. The two gullets unite to pass into the one stomach.

Professor Cope (*3*, xiv, 613) states that the variety *getulus* is entirely inoffensive to man, making no hostile demonstrations. His daughter, when a girl of 6 or 8 years, had several individuals as pets. They drank milk readily from a cup which she held in her hand.

### Genus EUTAINIA, B. & G.

*Eutainia*, Baird and Girard, 1853, *6*, 24; *Eutænia*, Cope, 1875, *12*, 40.

Form ranging from stout to slender. Head separated from body by an evident neck. Crown-shields 9. Loral present. Nasals divided, with the nostril between. Anteorbital 1. Postorbitals 3. Anal plate entire. Scales keeled, arranged in 19 to 21 rows.

A genus of snakes closely allied to *Natrix*, but differing in the undivided anal plate. Confined to North America, consisting of about a dozen species, all intimately related, and some of them exceedingly variable.

The general color consists of three light stripes on a darker ground, the intervals with alternating or tesselated spots. Abdomen without square spots. (Baird.)

### Key to the Indiana Species of *Eutainia*.

A. Scales in 19 rows.
  a. Lateral stripe covering two rows of scales.
    b. Lateral stripe on third and fourth rows of scales.
      c. Very slender. Tail about one-third the total length. *saurita*, p. 521.
      cc. Stouter. Tail one-fourth or less of the total. *radix*, p. 523.
    bb. Lateral stripe on second and third rows of scales. *sirtalis*, p. 525.
  aa. Lateral stripe covering three rows, second, third and fourth. *butlerii*, p. 528.
AA. Scales in twenty-one rows (sometimes). *radix*, p. 521.

### **Eutainia saurita,** (Linn.).

*Ribbon Snake.*

*Coluber saurita*, Linnæus, 1766, *64*, ed. xii, i, 385; *Leptophis sauritus*, Holbrook, 1842, *54*, iii, 21, pl. 4; *Eutainia saurita*, Baird and Girard, 1853, *6*, 24; *E. faireyi* and *E. proxima*, Baird and Girard, 1853, *6*, 25; *Tropidonotus sauritus*, Garman, 1883, *13*, 23, pl. 3. fig. 2.

An elongated species, with a slender neck, and a tail that forms from a little more to a little less than a third the total length. Crown-shields normal. Loral elongated. Nasal distinctly divided, with the nostril between them. Anteorbital 1, high. Upper labials 7 or 8. Lower labials 10, fifth and sixth large. Scales distinctly keeled, and disposed in 19 rows. Ventrals 150 to 180. Subcaudals 100 to 120.

The color above consists of a light chocolate to black ground, relieved by three stripes of greenish white or yellow. The dorsal stripe lies on the median row of scales and the adjacent half of the next row on each side. The lateral stripes lie on the third and fourth rows above the belly. The abdominal surface is greenish white, without markings or spots of any kind.

Three varieties of this species are here recognized, *saurita*, *faireyi* and *proxima*. These are still regarded by most American writers as distinct species, but I have been unable to find any characters by which the many connecting forms may be satisfactorily distributed. Prof. Cope, in his most recent publication (*3*, xiv, 646, 650), unites *faireyi* with *proxima*, and distinguishes these from *saurita* by their having 8 upper labials instead of 7. It is doubtful if this will hold good.

Variety *saurita.*

This is distinguished by having the tail, on an average, a little more than a third of the total length; ventral plates from 150 to 170; color light chocolate to deep brown, with the stripes uniform yellow. The slenderest of all the varieties. Atlantic to Mississippi Valley.

Variety *faireyi.*

Stouter in form. Tail rather less than a third the total length. Ventral plates 168 to 180; color blackish brown, with the stripes uniform greenish yellow. Wisconsin to Louisiana.

Variety *proxima.*

Stoutest in form, the tail being contained in the total length about three and a half times; color black, with the dorsal stripe brownish yellow, the lateral greenish; ventrals 170 to 180. Wisconsin to Louisiana and Texas.

Specimens sent to Professor Cope by Mr. A. W. Butler, and taken probably at Brookville, have been pronounced *Eutainia saurita.* Others of this variety have been secured at Wheatland by Mr. Robert Ridgway, and in Brown County by Mr. Charles Jameson. I have specimens from Fountain County, sent by C. H. Smith, and there is record of a specimen in the National Museum from Boone County.

Of *faireyi* I found a specimen in Mr. Sampson's collection at New Harmony. Specimens in the State Normal School collection appear to me to belong here, and these were taken at Terre Haute and at Denver, in Miami County. Others are in Mr. Smith's collection made in Fountain County. Professor Blatchley reports both *saurita* and *faireyi* at Terre Haute. Mr. W. O. Wallace, of Wabash, sends me a specimen having 21 rows of scales. The lateral stripes are on the fourth and fifth rows of scales, instead of the third and fourth, as usual. Ventrals 170; subcaudals 110.

I am not aware that the variety *proxima* has been captured in Indiana, although some have been reported. These different forms intergrade so completely that to me it appears to be useless to maintain their specific identity. It is often difficult to distinguish to which variety the specimen in hand belongs. As the species is traced from its eastern limit to the south and west it becomes stouter, the ventrals increase somewhat, and the colors deepen.

Habits.—*Eutainia saurita* has the reputation of being aquatic in its habits. This, however, can not mean that they affect the water so exclusively as do the species of *Natrix.* In fact, it leaves the water and travels considerable distances in search of food. I have taken this species frequently in the South, and I do not remember of having ever seen it in the water. However, it is found in the vicinity of streams, and no doubt often enters them. It is an active animal, as is shown by its slender and lithe form. It is wholly harmless. DeKay states that it sometimes climbs trees. He quotes Dr. J. P. Kirtland as saying that it seeks the most retired woods for its residence. Its food consists of insects, frogs, toads, and similar small animals. Of its breeding habits not much is known. In a specimen taken in Mississippi I find nine eggs with the development just begun. Professor F. W. Putnam (*22*, ii, 134) says that a female that he examined on July 13 contained nine eggs, each three-fourths inch long. In these he found embryos 2.5 inches long. On July 30 another was caught which had excluded a part of her brood, there being only four eggs left, and these were ready to be burst by the young. These eggs were 1.25 inches long, and contained young 5.5 inches. Professor G. B. Goode (*34*, '73, 182) received the following from Herman Strecker, of Reading, Pa.: "Some years ago I came across a garter snake (*Eutainia saurita*) with some young ones near her. Soon as she perceived me she hissed and the young ones jumped down her throat, and she glided beneath a stone heap. Another time I caught a snake of the same species, but, as I thought, of immense size, which I took home and put in a cage. On going to look at her, some short time afterward, I discovered a great number of young ones (about thirty, if I recollect rightly), and whilst I was still looking at the sudden increase two more crept out of the old one's mouth, and finally, after a little while, a third one did likewise." Within the body of a specimen of *fairyei*, 28 inches long, sent me from Fountain County by Mr. C. H. Smith, I find twelve eggs. Of these the hinder four are in the left oviduct. The eggs show no evidences that development had begun. The length of each is about .75 inch, the short diameter about .32 inch. The form is irregular on account of mutual pressure. In a specimen taken at Vicksburg, Miss., about July 4, I find twenty fully developed young snakes. Each is about 9 inches long.

### **Eutainia radix,** B. & G.

*Racine Garter Snake.*

*Eutainia radix,* Baird and Girard, 1853, 6, 34; *Eutænia radix,* Coues and Yarrow, 1878, *9*, iv., 277; *Eutænia radix melanotænia,* Cope, 1888, *3*, xi, 400.

A snake of moderately stout form, the tail forming from a fifth to a fourth the total length. Head distinctly marked off from the neck. Upper labials seven (rarely eight), the eye over the third and fourth. Lower labials ten, the sixth largest. Anteorbitals one, postorbitals three. The scales are in either nineteen or twenty-one rows. They are prominently keeled, so that the snake is distinctly rough in appearance. The ventral plates vary from 153 to 162; the subcaudals from 51 to 80.

Color above light or dark olive-brown, with three stripes of yellow and series of black spots. The dorsal stripe occupies the median row of scales and the adjacent half of the next row on each side. The lateral stripe lies on the third and fourth rows of scales on most of the body, but posteriorly narrows and descends to lower rows. One or two series of spots are usually to be seen below the lateral stripe, on the first and second rows. Between the lateral stripe and the dorsal may occur two series of black spots. They may be distinct or obscure. The upper surface of the head is dark olive, with the usual two minute yellow dots on the occiput. The upper labials are yellow, with an edging of black. Lower jaw and throat yellow. Abdomen greenish or olive. On the outer ends of the ventrals there is, on each side, a row of black spots, and the posterior edge may be wholly edged with the same color.

*Eutainia radix* subspecies *melanotœnia* has recently been described by Prof. E. D. Cope from a specimen furnished him by Mr. A. W. Butler, and taken in southeastern Indiana. In this variety there are 21 rows of scales. The dorsal band is nearly completely bordered on the sides with black. The space between the dorsal and the lateral stripe is nearly covered by the two rows of distinct quadrate black spots. The surface between the spots themselves is dark olive-brown. Below the lateral stripe are two rows of alternating black spots, one on each row of scales. These sometimes coincide and unite. Each of the ventrals has on each of its outer ends a black spot, and these are sometimes so large that they unite to form an interrupted stripe along the flank. Between these spots the posterior edges of the plates are black. The specimen of *Eutainia radix* reported by myself in 1881 as occurring in Indiana (*22*, xv, 738), and included in my list (*94*, '87, No. 44), proves on further examination to belong to Prof. Cope's *melanotœnia*. It differs in having 160 instead of 153 ventral plates, and 80 instead of 68 subcaudals. There is but a single row of spots below the lateral stripe, but they are large, quadrate, and lie on both the rows of scales. It was taken at Irvington.

Habits —Not much is recorded concerning the habits of this species. Drs. Coues and Yarrow found it in considerable numbers in Dakota and Montana. The were observed to stay principally about the borders of streams and pools of water, where they could catch tadpoles, young frogs, and various water insects. They are themselves preyed on by hawks. They are less active than some of the slenderer species, and when handled make little resistance. Only the larger individuals make any attempt to bite. The males and females were found pairing in September and part of October, while the greater part of the females were found to be pregnant in July and August, producing thirty or forty young. This indicates a period of gestation of nearly a year.

## Eutainia sirtalis, (Linn.).

*Garter Snake; Striped Snake.*

This is a snake which has a very wide distribution, and of which many varieties are recognized. Many of these have been by various authors regarded as distinct species.

*Eutainia sirtalis* varies in form from slender to quite stout. The head is distinctly marked off from the neck. The tail makes up from a fourth to a fifth the entire length. The head is broad behind, narrowed in front. Crown-shields 9, all well developed. Anteorbital 1. Postorbitals 3 or 4. Labials 7 or 8, the eye over third and fourth. Lower labials 10. The scales are keeled, and arranged in 19 rows. The ventral plates vary in number from 140 to 180. The subcaudals from 50 to 90 pairs. The anal plate is entire.

The ground color varies from a light olive to black. This is usually relieved by three greenish or yellow stripes, a dorsal and two lateral, and by series of dark spots, some above, some below, the lateral stripes. But of the stripes and spots some or all may be missing. The belly is greenish or slate-color, usually with a series of black dots at the outer ends of the ventral plates.

Variety *sirtalis.*

*Coluber sirtalis*, Linnæus, 1758, *64*, ed. x, 222; *Entainia sirtalis*, Baird and Girard, 1853, *6*, 30; *Tropidonotus sirtalis*, Holbrook, 1842, *54*, iv, 41, pl. 11; Garman, 1883, *13*, 24, pl. 3, fig. 3.

Dorsal stripe narrow, being encroached on by dorsal spots; lateral stripes not conspicuous; color above the faint lateral lines brown to black, this containing three series of indistinct spots, each of about 70 from head to vent; color immediately below lateral lines greenish; abdomen with a row of black blotches on the ends of the ventral plates on each side. All North America that is inhabitable by snakes.

Variety *dorsalis.*

*Eutainia dorsalis*, Baird and Girard, 1853, *6*, 30; *Eutænia sirtalis*, subsp. *dorsalis*, Cope, 1875, *12*, 41.

All three stripes broad and conspicuous; space above lateral bands bright olivaceous, and containing a series of rather large spots, 74 in number, from head to vent; abdomen greenish, with a black dot on each end of each ventral plate. Maine to Florida and Mexico.

Variety *ordinata.*

*Coluber ordinatus*, Linnæus, 1766, *64*, ed. xii, i, 379; *Eutainia ordinata*, Baird and Girard, 1853, *6*, 32; *Eutænia sirtalis* subsp. *ordinata*, Cope, 1875, *12*, 41; *Tropidonotus ordinatus*, Holbrook, 1842, *54* iv, 45, pl. 12.

Stripes all indistinct; space above the lateral bands olive, with three distinct rows of square dark spots, about 85 in number, from head to vent; abdomen like the above varieties.

Variety *parietalis.*

*Coluber parietalis,* Say, 1824, *14*, i, 186; *Eutainia parietalis,* Baird and Girard, 1853, 6, 28; *Eutœnia sirtalis* subsp. *parietalis,* Cope, 1875, *12*, 41; Coues and Yarrow, 1878, *9*, iv, 276.

Three distinct stripes, a dorsal pure yellow; the lateral a heavier yellow, tinged more or less with red; color between the stripes deep brown to black; spots, if any, indistinct; skin between the scales brick or vermillion red, this tingeing many of the scales. The red is most distinct just above the lateral stripe, but also extending down to the ventral plates. Belly whitish green, with black spots on the ends of the ventral plates. Length 3 feet. Indiana to California.

A specimen of *E. sirtalis* sent me by Mr. Chas. Beachler, of Crawfordsville, agrees well with the description given by Prof. Baird, and more especially with that given by Coues and Yarrow, as cited above, except that the red, which is so characteristic of this variety, is distinctly seen only on the anterior third of the body. Spots on ends of ventrals rather large. Specimens are frequently taken about Irvington which are referred to this variety. Prof. Blatchley states that he has taken *parietalis* at Terre Haute. Mr. A. B. Ulrey has shown me a specimen from North Manchester, Wabash county, which conforms to the description of *parietalis*, except that it has twenty-one rows of scales. The red in Indiana specimens does not extend to the posterior portion of the body, and it is more abundant and extends further back on specimens from the northern part of the State than on those taken about Indianapolis.

Variety *obscura.*

*Eutainia sirtalis obscura,* Cope, 1875, *12*, 41; Cope. 1888, *3*, xi, 399.

This is without spots, uniform brown between the bands. It is said (*3*, 11, 399) to resemble *E. saurita* at first sight. A specimen shown me by Mr. A. B. Ulrey, from North Manchester, Wabash county, appears to be referable to this variety.

*Eutainia sirtalis graminea,* Cope, 1888, *3*, xi, 399.

This interesting variety has been described by Prof. Cope from a specimen furnished him by Mr. A. W. Butler. It was taken in eastern Indiana. It is described as of a uniform light green above, yellow, clouded with green, below. There were no stripes nor spots on the body, nor any markings on the head. It resembled closely the Rough Green-snake, but it is to be distinguished from it by having 19 instead of 17 rows of scales, and by the entire anal plate, as well as by other generic characters.

Habits.—*Eutainia sirtalis* is probably the most familiar and best known of all our snakes. It is found everywhere over the country, and every country school-boy has possibly carried specimens of it in his pocket to the terror of his girl playmates, and has almost certainly killed the snakes by the dozen. This species is not so active as some others, but they are not usually so sluggish as some authors describe them. Holbrook says that it is exceedingly gentle and can be handled without fear of injury; indeed, he states that he has never known them attempt to bite. DeKay, on the other hand, says that they will bite and sometimes leave troublesome, but not dangerous, wounds. Both statements seem to exaggerate the usual disposition of the snakes. It is certain that they will at times strike and bite, but it must be rarely, indeed, that they produce anything worse than a few slight scratches.

These snakes are frequently found in moist situations, either near the water or even swimming about in it. They can not, however, be called aquatic. They are likely to be found in or near the water because there they can find abundant prey. They are often seen far away from the water in dry fields. Drs. Coues and Yarrow say of *parietalis*, that it is common in the clear, cold waters of lakes and streams of Dakota and Montana, and was often seen swimming freely in deep water at some distance from shore. This snake lives on frogs, toads, insects and small mammals. All observing persons have probably seen in this snake illustrations of the great size of prey that a serpent can swallow. The frog is often of a considerably greater diameter than the snake itself. One writer (*22*, ii, 50) relates an instance of a Garter-snake chasing and catching a mouse. Immediately the snake enveloped the mouse in its coils, crushed it boa-constrictor-like, and then swallowed it. Another writer (*22*, '84, 88) tells of seeing the Garter-snake in a pool catching small fishes. Shortly afterward in passing the pool it was dried up, and this snake was eating the dead fishes. On the other hand, the snake is preyed on by hawks, owls, hogs, ducks, and turkeys. I have seen a cat eat a Garter-snake.

These snakes, like others of the genus, are ovoviviparous. The number of young produced at a time is considerable. Prof. F. W. Putnam (*22*, ii, 134) informs us that on July 1, in a female 35 inches long, he found 42 nearly developed young, each of which was 5.5 inches long. Dr. J. Schneck, of Mt. Carmel, Ill., says (*22*, xvi, 1008) that from a female 35 inches long he took 78 young from 3 to 7 inches in length. They were pressed from the vent. The first twenty were free, the others confined within the egg-coverings. In a female 33 inches long, taken by Dr. Alex. Jameson near Indianapolis, about August 1, I find 39 young snakes not yet ready to be born. The food-yolk is not all used up. The egg-tooth is present. A female from Paris, Ill., contained 35 young, each 7 inches long. The food-yolk was all gone and the egg-tooth shed. It appears that the young are born late in the summer or early in the fall. The sexes are said to unite in September or in October, but it seems probable that this also occurs early in the spring. This is one of the snakes which has the reputation of swallowing the young when they are in peril. Col. Nicholas Pike, who is an accurate observer, assured Dr. Goode (*34*, 1873, 182) that he had seen the Garter-snake afford its young family temporary protection in its throat, from which they were soon noticed to emerge.

On the approach of cold weather these snakes seek some opening in the earth and then become dormant. In some instances they appear to collect in considerable numbers where they pass their winter slumber. We thus occasionally hear of bundles of snakes being plowed up. E. L. Ellicott relates (*22*, xiv, 206) having seen very early in the spring, in Maryland, a bundle of Garter-snakes, in which some hundreds of them could be counted. It is altogether probable that such assemblages are determined partly by the sexual impulses. The Garter-snake leaves its place of hibernation apparently as soon as the first warm days come, although they may relapse again into the dormant condition. At Irvington I have taken them as early as the 7th of March.

Like all other snakes this species at intervals sheds the outer coat of the skin. How often this occurs I do not know. Dr. Benj. Sharp (*1*, 1890, 149) observed the process of exuviation in the Garter-snake. Two specimens were kept in an aquarium. When observed one had just crawled out of the water and then shrugged and shook itself. Finding a narrow place it pressed itself in so that the skin parted along the jaws. This was pushed back behind the head. Then the snake crawled through the opening, escaping from the skin and leaving it turned inside out. The operation required less than a minute. One of the skins was without rent or loss of a scale. This occurred on April 13. Some specimens that I kept for awhile shed the skin about June 1. In case the snake can not have access to water the shedding of the skin is a more prolonged operation.

### Eutainia butlerii, (Cope).

*Eutænia butlerii*, Cope, 1888, *3*, xi, 399.

This is described as having the head little distinct, muzzle conical, a little protuberant; eye not large. There are 144 ventral plates; subcaudals 62. The ground color is olive-brown above, and there are the usual three stripes. The median has the usual width. The lateral stripes are unusually wide, covering the second, third and fourth rows of scales. They are all bordered by black. At the upper border of the lateral band there is some indication of spots. No markings on the head and labials. The abdomen is olive, with an elongated black spot at each end of each ventral plate.

The length of the only specimen known is not given in the description. Locality, Richmond, Ind.

## Family ELAPIDÆ.

Maxillary provided with an erect, immovable poison fang, which is grooved in front. Smaller teeth behind the fang or not. Head furnished with plates. Loral usually absent. Tail short and conical.

Of this family there is but a single genus known to inhabit America, namely, the

### Genus ELAPS, Schneider.

*Elaps*, Schneider, 1801, *41*, 289; Baird and Girard, 1853, *6*, 21; Garman, 1883, *13*, 104.

Body elongated and cylindrical. Head little, if any, wider than the neck; its upper surface with the nine plates usually found in the *Colubridæ.* No loral. Nasals two, with the nostril between, or mostly in the anterior. Anteorbital single, occasionally fused with the postfrontal. Eye small, the pupil round. Scales without keel, smooth and glossy; arranged in thirteen to fifteen rows. Anal plate divided, rarely entire. Subcaudals divided.

A genus with numerous species. Its members range from the Argentine Republic to the United States, where there are two or three species. One of these, the following, is found from South Carolina to Texas and Mexico. Recently it has been discovered in Southeastern Indiana.

### **Elaps fulvius,** (Linn.).

*Coral Snake.*

*Coluber fulvius*, Linnæus, 1766, *64*, 381; *Elaps fulvius*, Cuvier, 1817, *124*, ii, 84; Holbrook, 1842, *54*, iii, 49, pl. 10; Baird and Girard, 1853, *6*, 21; True, 1883, *22*, xvii, 26.

Body elongated, slender and cylindrical. Head little wider than the neck, flat above. Loral absent. Anteorbital 1; postorbitals 2. Upper labials 7, the eye over the third and fourth. Lower labials 7, the fourth large. Scales smooth, arranged in fifteen transverse rows. Ventral plates 202 to 236. Subcaudals 25 to 44 pairs.

The colors are black, bright red, and yellow. These are arranged in bands which encircle the body. The head, from the hinder end of the vertical plate to the snout and to the tip of the lower jaw, is black. The remainder of the head is encircled by a band of bright yellow. Behind this there follow, alternately, bands of black and red, about 13 to 20 of each, to the vent. Each red band is separated at each end from the contiguous black band by a narrow ring of bright yellow. The tail is alternately black and yellow, there being about four rings of each. In the red bands surrounding the body is usually found a number of scales of a brown color. There may also be one or more small blotches of black in the middle of the ventral portion of the red bands.

The Coral-snake is doubtless the most highly colored and beautiful snake that is to be found in the United States. It is moderately common in extreme Southern States, but, to our surprise, it has recently been taken in southeastern Indiana. Prof. A. J. Bigney, of Moore's Hill College, has shown me a specimen that was captured about a year ago two miles from the village of Milan, in Ripley county. The specimen is a typical *Elaps fulvius*, 22.5 inches long. It has 212 ventral plates and 45 subcaudals. It appears wholly unlikely that this specimen was accidentally introduced where it was found. That the species is really an inhabitant of that region is rendered still more probable from the fact that another specimen was taken near there, in Hamilton county, Ohio. It is preserved in the collection of the Cincinnati Society of Natural History (A. W. Butler in *94* for 1892). This occurrence of the Coral-snake in that portion of Indiana indicates that it will be found all along the southern border of the State, and thence down the Mississippi River to the Gulf.

Habits.—The Coral-snake appears to be somewhat sluggish in its disposition. It is poisonous, but it is said to bite only when provoked. In the American Naturalist for 1883, page 26, Prof. True has given us evidence of the ability of the snake to inflict dangerous bites. Several cases are reported, some of which proved fatal. However, on account of the smallness of the serpent's mouth, the shortness of its poison-fangs, and their backward position, it seems probable that dangerous wounds could be inflicted only on some such organ as the fingers or the toes. I do not know anything about the breeding habits of this genus. The Coral-snake appears to have the habit of capturing and eating other serpents. In volume xxii of the *Encyclopedia Britannica* is an illustration of one which is swallowing another snake almost as large as itself. In the alimentary canal of a specimen 21 inches long, from Florida, I have found a *Storeria* 13.5 inches long.

Persons who are living in the southern portion of the State ought to be on the watch for this strikingly colored snake, and all specimens of it should be sent where they will be preserved for study.

## Family II. CROTALIDÆ.

Form usually thick and short. Head triangular, broad behind, flat, and distinctly separated from the body by a small neck. Maxillary bone much shortened, moving freely on the lachrymal and supporting a single functional, enlarged, tubular tooth, or poison fang, which is capable of erection and of concealment under a fold of the lining of the mouth. A deep pit between the nostril and the eye, Poison glands at the sides of the head behind. Pupil oblong, perpendicular. Scales keeled. Anal plates entire. Tail short. All venomous.

This family contains both Old and New World genera, but most of them belong to North and South America. They are of great interest and have been much studied on account of their many peculiar structures, and because of the deadly effects of their venom. Those who are interested in learning more about the anatomy of these dreadful serpents may consult such works as Huxley's Anatomy of Vertebrates, the various encyclopedias, and volumes XII and XXVI of the Smithsonian Contributions to Knowledge. An interesting popular summary of the results of the studies of Drs. Mitchell and Reichert may be found in the Century Magazine for August, 1889 (vol. XVI, 503).

### Key to the U. S. Genera of *Crotalidæ*.

A. Tail not provided with a rattle. *Agkistrodon*, p. 531.

AA. Tail provided with a rattle.

- a. Upper surface of head with the usual 9 crown-shields. *Sistrurus*, p. 533.
- aa. Vertical and occipital plates replaced by small scales like those of the back. *Crotalus*, p. 536.

### Genus AGKISTRODON, Beauv.

*Agkistrodon*, Pal. de Beauvais, 1799, *36*, iv, 381; Baird and Girard, 1853, *6*, 17; *Ancistrodon*, of various authors.

Head flat, triangular, with 9 crown-shields. Loral present or absent. Scales in 23 to 25 rows, all keeled. Anal plate entire. Subcaudals not divided except some of the posterior. No rattle.

Loral present. Scales in 23 rows. *contortrix*, p. 531.

No loral. Scales in 25 rows. *piscivorus*, Appendix.

### **Agkistrodon contortrix,** (Linn.).

*Copperhead.*

*Boa contortrix*, Linnæus, 1766, *64*, ed. xii, 373; *Trigonocephalus contortrix*, Holbrook, 1842, *54*, iii. 39, pl. 8; *Agkistrodon contortrix*, Baird and Girard, 1853, *6*, 17; *Ancistrodon contortrix*, Garman, 1883, *13*, 120, pl. 8, fig. 1.

Head large, flat, triangular, and with the sides in front of the eyes perpendicular. Neck slender. Tail short, about one-eighth the total length, ending in a curved horn. Vertical plate as broad as long, pentagonal. Occipitals about the size of the supercillaries, showing a tendency to break up into smaller scales. Both pairs of frontals well developed, extending out to the edge of the upper surface of the head. A small plate sometimes lying between the vertical and the postfrontals. Two anteorbitals, the lower smaller and bounding the pit above. A loral present. Nasal divided, with the nostril present. Rostral broad and high. Upper labials 7 or 8, excluded from the orbit by a number of suborbitals, the second with a groove leading into the pit. Inferior labials 9–10. Scales in 23 rows, strongly keeled. Ventral plates about 150. Subcaudals 42 to 52, all entire except the last 8 to 18.

Spotted, with black, brown, red, reddish yellow and yellowish white. On the sides and reaching up to the middle of the back are blotches 6 scales long of hazel brown, margined with dull red. These blotches are narrow below, but run into the colors of the belly. Between these spots are larger ones of smoky brown, sometimes with a good deal of chocolate, and with dark margins and lighter centers. These widen below, but become narrower toward the middle line. On the middle of the back they either alternate with those of the other side or become confluent with them, thus forming bands across the body. The end of the tail is black above. Lower surface yellowish, more or less clouded with brown and with large black spots at the ends of the ventrals. These cover the ends of two ventrals and are separatod by the ends of three. Head above reddish or copper-colored, this color extending down on the sides to the level of the corners of the mouth and lower borders of the eyes. Below this the color is cream yellow. Lower jaw paler, but with reddish brown streak along the lower edge of the inferior labials. Length probably sometimes three feet. Terrestial.

Habitat. Massachusetts to Florida, west to Kansas and Texas. In Indiana this venomous serpent, once abundant in most localities of the southern half of the State, is now happily becoming rare; in most localities it is probably entirely exterminated. Where, however, the eountry is not thickly settled, and where there are abundant forests and rocks, it may even yet be found in considerable numbers. About New Harmony the collectors have frequently found it. It has been taken in Monroe County (Bollman). Mr. C. H. Smith reports its occasional appearance in Fountain county, and Mr. Hughes tells me that one was found, the first in many years, in 1889 in Franklin county. In the northern portion of the State it has probably always been scarcer, but still present.

The habits of this snake are tolerably well known. Unlike its equally disreputable relative of the South, it is terrestrial in its inclinations. However, its desire for water to drink and the better opportunity to obtain prey will often lead it to the neighborhood of ponds and streams. In its usual movements it is a sluggish animal, depending more for safety on the terror that it inspires and on its fangs than on flight. It appears to prefer to lurk about dark and shady situations. Its food consists of small birds, mammals, and frogs. It is itself devoured at times by other snakes, as the black-racer and the water-moccasin (*22*, iii, 158; *44*, '77, 399). In securing its prey it depends on the deadly effects of its poison. Mr. S. Garman states that they usually eat the prey as soon as it is dead, and even before it ceases to struggle. Sometimes lively mice would elude two or three strokes, and this would seem to throw the snake into an ecstacy of excitement. They would not eat fishes.

These snakes are greatly dreaded on account of their biting without giving any warning. However, some warning they do sometimes attempt to furnish. This is done by rattling on objects by quick vibrations of the tail. Many species of snakes are now known to do this. Whether their bright, dappled colors are intended to act as a warning to large animals not to tread on them, or are to protect the snakes from the observation of their prey as they lie among dead forest trees, is hard to decide. Mr. Garman says that they do not yield to good treatment. Some that he observed, though they were frequently and gently handled, remained vicious and ready to bite. These snakes are very poisonous, but the researches of Drs. Mitchell and Reichert show that their venom is less virulent than that of the rattlesnakes, but more so than the water-moccasin. While the introduction of the poison into the system produces important changes in the appearance of the skin, due to changes in the blood and blood-vessels, and though after recovery some of these appearances might recur, yet the stories that the limb becomes spotted just like the snake that did the biting, that it annually feels the bite and regains such colors, are wholly absurd.

As regards their breeding habits, the copperhead, so far as known, produces living young. The number of young produced each year is variously given. According to Professor J. A. Allen, five out of seven females caught in the latter part of July, in Massachusetts, contained slightly developed embryos, while of six females killed in September the oviducts of each contained from seven to nine young six inches long. The sexes, sometimes at least, pair in August. Other writers, principally, however, through the newspapers, put the number of young as high as 60 to 80. This is undoubtedly an error, which probably arises from confounding the copperhead with other snakes, especially with the hog-nosed snake, *Heterodon platirhinos*. This is another of the species reported to Dr. Goode (*34*, '73, 184) as furnishing to its young in times of danger a retreat down its throat.

### Genus SISTRURUS, Garman.

*Crotalophorus*, Gray, 1825, *114*, 205; *Sistrurus*, Garman, 1883, *13*, 176.

Form short and stout. Tail short. Head with nine crown-shields, as in the *Colubridæ*. Loral present. Tail furnished with a rattle.

### **Sistrurus catenatus,** (Raf.).

*Massasauga; Prairie Rattlesnake.*

*Crotalinus catenatus*, Rafinesque, 1818, *80*, iv, 41; *Crotalus tergeminus*, Say, 1823, *14*, i, 499; *Crotalophorus tergeminus*, Holbrook, 1842, *54*, iii, 29, pl. 5; *Caudisona tergemina*, Wagler, 1830, *75*, 176; *Sistrurus catenatus*, Garman, 1883, *13*, 176, pl. 9, fig. 2; *Caudisona tergemina*, Cope, 1875, *12*, 34; *Crotalophorus catenatus*, Cope, 1892, *3*, xiv, 684.

Body stout. Head short. Tail constituting from an eighth to one-eleventh the entire length. Head covered above with the nine crown-shields usually found in the non-poisonous snakes. Anteorbitals 2, the upper horizontally elongated, joining the prefrontal and excluding therefrom the small triangular loral. Lower anteorbital narrow and long, forming a part of the boundary of the pit. Supraorbitals large and overhanging the eyes. Upper labials 11 to 14, excluded from the boundary of the orbit. Lower labials 12, small. Scales in 25, rarely 23, rows, all strongly keeled, except those of the outer row. Ventral plates 136 to 153. Subcaudals 21 to 29, a few of the most posterior divided.

The ground color varies from light ashy, often with a reddish tinge, through ashy brown to deep brown and even black; below from yellowish, sprinkled with dusky, to slate blue, mingled with yellowish white and black. There are above, seven series of dark spots, which are variable in intensity of color from chestnut-brown to black. When the ground color is very dark the spots may disappear, and we see then a uniformly black snake. The outer borders of the spots are usually darker than the centers, and are surrounded with a narrow line of paler. The spots of the successive rows alternate. Those of the median, or dorsal, series are from 35 to 48 in number, and descend on each side to about the eighth row of scales. They are broader than long, and in the median line are notched in front and behind. Occasionally they may be wholly divided. Just below this series is another of much smaller spots. Further out is a series of spots which extend from the second to the sixth row of scales. The lowest series on each side lies on the outer ends of the ventral plates and the three outer rows of scales. Each side of the head with a broad, dark band from the eye back on the neck. This is bounded below by a streak of yellowish white from the pit to the corner of the mouth and on the neck. Upper labials mostly dusky. Upper surface of the head with two dark, longitudinal streaks and three paler ones. Lower jaw variegated with yellowish white and dusky. A pale transverse band from eye to eye, bordered with darker. The length may reach three feet in fully grown specimens.

Ohio and Michigan to Utah. Said by Garman to extend to Mississippi, on what authority I do not know. In Indiana it is abundant in some localities, but I have not been able to confirm its occurrence south of Indianapolis. Wabash county (D. C. Ridgley). I have seen specimens from Laporte, Hendricks, Hamilton and Montgomery counties. They appear to be abundant in the swampy grounds in the neighborhood of Lake Maxinkuckee, in Marshall county. The black specimens are frequently found in Indiana. They were once described as a distinct species, but their dark coloration is probably nothing more than an individual variation. We have a very similar case in the differently colored forms of *Heterodon platirhinos*, *Coluber obsoletus*, and *Natrix sipedon*.

HABITS.—This species is, on an average, considerably smaller than the Banded Rattlesnake, *Crotalus horridus*. It is, on that account, less to be feared than that serpent, since the fangs would naturally penetrate less deeply, and the amount of poison that is injected into the wound would be less. Indeed, Dr. Kirtland, of Ohio, is quoted as saying that its bite is scarcely worse than the sting of a hornet. But having had a good deal of experience with, and knowledge of, these snakes, I think that they are not to be tampered with. Animals that have been bitten by them, such as dogs and cows, suffer much, and have troublesome swellings. The rattle is less powerful than that of its larger relative, but may be heard at a sufficient distance. The snakes appear to prefer low, wet grounds as their habitation, but they are not aquatic. Yet they may often be found far away from water in dry fields. On the prairies of Illinois, before the country became thickly populated, these reptiles were extremely abundant, and the killing of two or three dozen of them in a season was not an unusual thing for any farmer's boy. Now, in that same region, not one is seen in years. This disappearance of these snakes has been supposed to be due to the destruction wrought among them by hogs. Yet, on those prairies, in those days, there were no roaming hogs. The extinction of the snakes may be due to the breaking up of the soil, the draining of the ponds, and the clearing away of the rank vegetation, which furnishes them protection. At the present day it is only in swamps and marshes that they are found.

It appears that these snakes shed their skins at least twice a year; and since, further, Garman has shown that the segments of the rattle represent a retained portion of the sloughed epidermal covering, it seems quite probable that two or more joints of the rattle are produced each year. In any case, the age can not be determined by the number of segments, since the terminal ones are continually being worn off and lost.

The young of this species are brought into the world alive. They are about six in number at each brood, and when born are about six inches long. They appear about the first of September. This species has been included by Goode in his list of those whose females allow the young a place of safety in the stomach. The writer has published an account of the observations made on two females of this snake by a man of credibility who had captured them and kept them until they had produced young (*22*, xxi, 216). According to these observations, the young passed freely into and out of the mother's mouth until they were a month old. After this time the mother was very attentive to the young, as I saw myself.

Genus CROTALUS, Linn.

*Crotalus*, Linnæus, 1758, *64*, ed. x, i, 214; Baird and Girard, 1853, *6*, 1; Garman, 1883, *13*, 110.

Form stout. Head triangular. Crown-shields fewer than nine, the vertical and occipitals replaced by numerous small scales. A pit in front of nostril. Anal and most of the subcaudals entire. Tail with a rattle.

### **Crotalus horridus,** Linn.

*Banded Rattlesnake.*

*Crotalus horridus*, Linnæus, 1758, *64*, ed. x, i, 214; Garman, 1883, *13*, 115, pl. 9, fig. 1; *Crotalus durissus*, Holbrook, 1842, *54*, iii, 9, pl. 1; Baird and Girard, 1853, *6*, 1.

Body elongated, tapering toward head and tail. The neck slender. Tail short, from one-eighteenth to one-eighth the total. Head broad, triangular, flattened above, concave in the interorbital region. Snout blunt. Back portion of head forward to the interorbital region covered with small keeled or tuberculated scales. Scales of the cheeks larger and smooth. Superciliaries large and overhanging the eyes. Anteorbitals 2, the lower slender and overarching the pit. Lorals 2. Nasals 2, the anterior largest. Rostral higher than broad. Prefrontals 2, postfrontals 4, in a transverse row, the inner pair sometimes replaced by small scales. Upper labials 12 to 16, separated from the orbit by three or four rows of scales. Lower labials 13 to 18. Eye small. Scales keeled, except those of the outer row; number of rows 23 or 25. Ventral plates 165 to 175. Subcaudals 19 to 25. Rattle of the adult parallelogrammic, with a median groove.

Ground color above cream yellow to yellowish brown, and even black. There are three series of dark spots, a dorsal and a lateral on each side. The dorsal blotches are large, occupying in breadth about twelve rows of scales and about four in length. These are nearly black around the borders and paler in the centers. The lateral series has the spots smaller. Posteriorly the three series coalesce, so as to form zig-zag, dark-edged, transverse bands. All the spots and bands are bordered with sulphur yellow. Tail of the adults usually black. The color below is yellow, with some mottlings and sprinklings of black. Upper lip sulphur yellow; lower lip paler.

The length of this species may become as much as six feet, possibly more.

Distributed from Massachusetts to Kansas, south to North Carolina and Texas.

It is to be found, in all probability, in nearly all the counties of Indiana, but it is in most places quite rare. I can name only two localities where it has been taken recently and record of it preserved. These are New Harmony (Sampson's coll.) and Monroe county (Ind. Univ. coll.).

HABITS.—No American snake has probably been so carefully studied as has this and its immediate relatives. This is due to the dangerous nature of this animal and to the interesting structures shown in its rattle and its arrangements for producing and instilling its poison. The results of some of these studies may be learned by consulting the works referred to on page 531.

In its free state this species appears to inhabit wooded districts, although it may probably sometimes be found on prairies. It especially delights in taking up its abode where there are rocks and debris among which it can find at short notice a safe retreat. Its movements of locomotion are rather slow. When surprised it will often seek to escape, without inflicting injury on its enemy. When, however, it is pressed, or there is no time for retreat, it delivers a blow with such rapidity that the motion can hardly be followed. The mouth is held open, the fangs directed forward, and if possible they are buried in the victim. At the same time the poison gland is squeezed by the proper muscles, so that the poison is injected deep into the wound. If the amount of poison is large it may be quickly fatal to even large animals. Small animals, as birds and mice, almost immediately succumb to the deadly influence. It is usual for the Rattlesnake to sound its rattle when it has been disturbed by some animal which it has reason to fear. The use of this alarm has been much discussed. Some have regarded it as an imitation of grasshoppers in order to allure birds within its reach. Others have thought it a sexual call. Still others think it a providential arrangement to prevent injury to innocent animals and man. It is doubtless of use to warn off animals that might do injury to the snake itself, or at least compel it to use up its store of poison and its fangs, all of which it needs to procure its food. Dr. A. R. Wallace has suggested in his recently published "Darwinism" that the creature has acquired the structure and habit in order to warn off buzzards and other snake-eaters that might pounce on it as it lies on naked rocks. It is a warning note, saying, "Look out for yourself! Your life if you injure me."

Rattlesnakes do not appear to try to injure one another by biting. Indeed, Dr. Mitchell states that the poison does not affect the snakes themselves. He says that he has over and over injected under the skin of a rattlesnake its own venom or that of a moccasin or of another rattlesnake, but he had in no case seen a death. He often kept from 10 to 35 rattlesnakes together without any of them harming the others. If a large snake were suddenly dropped on the others they would show no resentment, whereas if any other animal were thus dropped on them it would immediately get a blow. In captivity they are extremely sluggish, not moving, and refusing for long periods to accept food. Usually, after about a year without food, they will kill and eat animals. Dr. Mitchell fed his numerous specimens by putting a long funnel down their throats and pushing the food into their stomachs. They were very fond of water, and would drink large quantities of it and lie in it for hours.

They shed their skins at different times. If they did not have water the skin would come off in patches. He says nothing about the relation of the shedding of the skin and the acquisition of new segments of the rattle. It has been noted by observers that a variable number of segments of the rattle is acquired each year, although the popular idea is that one is the number. As high as four have been observed to be added in a single year. The terminal segments, too, are constantly being worn off, so that the number of segments present is no indication of the age of the snake.

On each side of the upper jaw is to be found a single fang, which is solidly attached to the maxillary. These are probably shed at intervals, and besides are liable to be torn out in use. Alongside of the functional fang there may be found a number of reserve fangs, as high as seven sometimes, the oldest of which moves into the place of the lost fang and soon becomes ankylosed to the bone. Holbrook states that Mr. Peale, of the Philadelphia Museum, kept a living female rattlesnake for fourteen years. She had eleven rattles when she came into his possession. Several were lost annually, and new ones formed. When she died there were still eleven. During this period the snake had grown four inches in length.

This snake, like all the *Crotalidæ*, brings forth its young alive. The number appears to be about nine. I found this number of eggs in a female 37 inches long, brought from Pennsylvania. The eggs were 1.5 inches long by an inch in short diameter. Of these there were four in the left oviduct. There were evidences that development had begun.

Where these snakes are numerous they are inclined to gather in considerable numbers in caverns in rocks and similar places, in order to undergo their winter sleep. Such places form the rattlesnake dens about which we hear occasionally.

## Order LACERTILIA.

*Lizards.*

Animals varying in form from stout and almost toad-like to long, slender, and snake-like. Limbs usually present, but absent in a few forms, as in our Glass-snake. Vertebræ few to many. Bones of the brain-case not so firmly united as in the snakes; those of upper and lower jaws less loosely connected than in the serpents, as a result of which the mouth is not distensible. Mandibles united at symphysis by suture. Teeth present. Skin usually provided with granular or overlapping scales. Vent a transverse slit.

A large and widely distributed order, divided by Dr. Boulenger into twenty-one families. Of these four are represented by species in Indiana.

### KEY TO THE FAMILIES OF INDIANA *Lacterilia.*

A. Whole tongue or its posterior larger portion covered with close-set papillæ, like the pile of velvet.

a. Tongue thick, little free, not or but feebly notched in front, wholly covered with villiform papillæ. Limbs present. No bony plates underlying the scales. *Iguanidæ*, p. 539.

aa. Tongue posteriorly thick and with villiform papillæ; anteriorly thin, free, deeply notched, and covered with scale-like papillæ. Scales underlaid with bony plates. *Anguidæ*, p. 542.

AA. Tongue covered with scale-like papillæ.

a. Tongue free in front, ending in two long points. No bony plates underlying the scales. *Teiidæ*, p. 544.

aa. Tongue rather long, free in front and sides; slightly notched in front. Bony plates underlying the scales. *Scincidæ*, p. 546.

### Family III. IGUANIDÆ.

Lizards varying in form from short and thick to elongated and slender. All with functional limbs. Dentition pleurodont. Tongue thick, fixed to the floor of the mouth or slightly free in front. The tip slightly or not at all notched. Plates of the upper surface of the head usually small, but well developed in our genus *Sceloporus.* No bony plates beneath the epidermal scales.

A large family, containing, according to Boulenger, 50 genera and about 300 species, with few exceptions inhabiting the New World. Only one species known in Indiana.

### Genus SCELOPORUS, Wieg.

*Sceloporus*, Wiegmann, 1828, *77*, 369; Boulenger, 1885, *29*, ii, 216.

Body depressed; tail long. Head with the plates of the upper surface well developed; the most posterior and median one (occipital) largest. No bony spines on head. Anterior teeth simple, the lateral tricuspid. Tympanum distinct, sunken. No gular folds. A series of pores (femoral) on the under side of the thigh. Scales overlapping and about equal in size. Contains about 25 species inhabiting North and Central America.

### **Sceloporus undulatus,** (Bosc.).

*Alligator Lizard; Pine Tree Lizard.*

*Agama undulata*, Bosc, 1803, *69*, iii, 384; *Tropidolepis undulatus*, Holbrook, 1842, *54*, ii, 73, pl. 9; *Sceloporus undulatus*, Fitzinger, 1843, *82*, 75; Boulenger, 1885, *29*, ii, 227.

Head broad and flat, tapering to the short and rounded snout. Neck moderate, without gular fold. Tail considerably longer than the head and body, and slender. Head with the plates of the upper surface rather large. A series of these over each eye. Back of the head with three plates, the median (occipital) larger than the lateral (parietal), and with a central translucent spot. Anterior border of the ear denticulated with three or more scales.

Hinder limb pressed to the side reaching about to the ear. Distance from the base of the fifth toe to the tip of the fourth greater than from the tip of the snout to the ear. Under side of the thigh with a row of from 13 to 17 pores. Dorsal scales conspicuously keeled, the keel running out into a sharp point. Ventral scales smaller and smooth. Scales of the sides forming rows that run upward and backward. There are from 38 to 50 scales around the body and about 35 from the occiput to the base of the tail. The tail is covered with large scales, with the keel running obliquely and ending in a point.

The color above is olive or brownish, sometimes almost black. Across the back are undulating lines of dark brown or black. On each side of the back there is a row of whitish spots. The tail is cross-lined with black. Sides mottled with black, and with some whitish spots. The male has a green or dark blue spot on each side of the throat, sometimes almost black The color is prolonged on to the arm. Each side of the abdomen is green or steel blue. The front of the thigh is dark blue or black. Middle line of the belly yellowish, with mottlings of black. The female has the throat blue, the abdomen yellowish, with black markings. Dr. C. C. Abbott says that the colors are not indicative of sex.

The length of this species becomes about 6 inches.

Distribution from New Jersey to Oregon and south to Texas. In Indiana it has been taken at Brookville (Dr. Haymond); Bloomington (Bollman); Brown county (Nor. Sch. Coll.). It is said to be rather common about Brookville, but rare in the neighborhood of Bloomington. Specimens were also seen by the author in Crawford county. One was brought from near Wyandotte Cave by W. P. Hay. Clark and Jefferson counties (Butler). I have seen a specimen said by Mr. Fletcher Noe, of Indianapolis, to have been taken by him near the city. It will probably be found to occur throughout the southern half of the State, at least in localities where there are timber and sand, and an abundance of rocks. In the South they are most abundant in the pine forests. On this account they have received the name of "Pine-tree Lizard."

These little animals are extremely active and they are able to run with great swiftness. Holbrook says that they are often found under the bark of decaying trees. It chooses also old fences as its basking places. It is given to climbing trees in search of insects and for safety from pursuers. DeKay states that when irritated in confinement they elevate their spinous scales in such a manner as to present a very formidable appearance. They are perfectly harmless, although they are often regarded as venomous. DeKay further says that they are able to alter their colors, the back assuming an azure tint.

Dr. C. C. Abbott, of New Jersey, has studied to some extent the habits of this interesting animal. They were not disposed to seek safety from pursuers in flight, but rather by concealment. They would dodge behind the trunk of a tree, and might be caught in one hand while trying to avoid the other. On being seized they do not fight and bite, but become almost instantly tame. Where they were abundant the children made pets of them and were never bitten. The lizards are extremely susceptible to changes of temperature. They are most active at about 100° F. At lower temperatures they become sluggish; at temperatures much higher they seek to escape the direct rays of the sun, and if the heat is still increased they are thrown into a state of lethargy. Their color appears to be highly protective, since they closely resemble the rough gray bark on which they so often rest. Abbott came to the conclusion that their vision is not acute, while their hearing is sharp. In endeavoring to catch flies they often missed their aim, although the insects were within easy reach. Their food consists of flies, ants, small spiders and the like. Some of Dr. Abbott's experiments tend to show that the so-called "pineal eye" is yet sensitive to the light.

The eggs are said to be laid in the sand, probably in little groups. They are deposited about June 1, and are hatched about July 10. The eggs are long and narrow, are covered with a tough coat, and are without any calcareous material. The egg weighs about 20 grains. They are abandoned to their fate, but when the young are hatched they are treated with the utmost gentleness by all the adults.

## Family IV. ANGUIDÆ.

Lizards having an elongated, slender body, sometimes extremely so. Limbs present or absent; when present they may be well developed or rudimentary. Dentition various. Tongue with the posterior portion thick and covered with villiform papillæ, the anterior portion thin, flat, notched in front, and covered with overlapping scale-like papillæ. Plates of the upper surface of the head large; an unpaired occipital plate always present. Epidermal scales of the body underlaid with bony plates.

A family containing 7 genera and about 45 species. Living for the most part in the Americas, but represented likewise in Europe and Asia. We have only the following genus:

### Genus OPHISAURUS, Daud.

*Ophisaurus*, Daudin, 1803, *69*, vii, 346; Boulenger, 1885, *29*, ii, 281; *Ophiosaurus*, Wagler, 1830, *75*, 150.

Elongated, snake-like lizards, with very rudimentary limbs or usually with none at all, the tail forming considerably more than one-half the total length. Body with a fold on each side, ending at the vent. Scales placed in straight rows longitudinally and transversely. Teeth on pterygoid, sometimes also on palatines and vomer. Teeth pointed or rounded.

This genus is represented by five species. We have only one of these.

### **Ophisaurus ventralis**, (Linn.).

*Glass-snake; Joint-snake.*

*Anguis ventralis*, Linnæus, 1766, *64*, ed. xii, 391; *Ophisaurus ventralis*, Daudin, 1803, *69*, vii, 352; Holbrook, 1842, *54*, iii, 139, pl. 20; Boulenger, 1885, *29*, ii, 281; *Opheosaurus ventralis*, Cope, 1875, *12*, 46.

Long, slender and snake-like. Head small, narrow, not separated from the body by a distinct neck. Snout long and tapering to the rounded tip. Upper surface of the head with a large vertical plate. Behind this is the interparietal, with a minute whitish spot, the "pineal eye." Behind this plate is the small occipital. Ear opening in a line with the mouth; larger than the nostril. Palatine teeth present. The pterygoid teeth in three to five longitudinal series. Teeth all conical.

On the dorsal surface, between the lateral folds, are 14 to 16 longitudinal rows of scales; between the folds across the lower surface are 10 rows; between the head and the vent are about 120 transverse rows. All the scales are smooth, except those of the median dorsal row, which are obtusely keeled. The tail is about twice as long as the head and body.

The color of the upper surface and the sides is olive, with several longitudinal narrow lines of brown. In life the lighter colors are green and yellow. There may be a dorsal dark band with a broad olive band on each side, followed on the sides by three dark lines above and two below the lateral fold; or the broad bands of olive may contain two additional narrow lines, in which case the whole upper surface and the sides are narrowly streaked with brown and yellowish or green. A specimen is occasionally found which has the upper surface black, without any lines, and the sides with rows of white ocellated spots. Again, the lines may be wholly replaced by rows of spots. The abdomen is yellow, sometimes orange, occasionally slate color. Head brownish or olive, with mottlings of darker. Lower jaw yellow.

The average length is about 18 inches, but specimens may occur as much as 3 feet.

The distribution is from Southern Virginia west to Wisconsin and south to Mexico.

In Indiana this reptile has not shown itself to be widely distributed or abundant. Professor John Collett tells me that he has seen it in Warren county. I have a specimen that was secured at Wolcott, in White county, by Mr. Charles S. Beachler. I find mention (7, 30, 122) of one being taken in Starke county. Mr. Robert Ridgway informs me that it was formerly a very common species in the Lower Wabash Valley, especially about Mt. Carmel. Since the reptile is most abundant in the Southern States, this finding of it in the most northern portion of Indiana indicates that we are likely to discover that it is a resident of the whole State.

On account of the serpent-like form of this lizard, it is almost universally regarded as a snake. It may be distinguished from the members of the order of serpents by the little distensible mouth, the firm union of the sides of the lower jaws at their symphysis, by the possession of eyelids, and by the rows of small scales covering the belly. On the lower surface of snakes there is a series of plates that pass across from one side to the other.

Wherever this lizard is found it has attracted a great amount of attention, especially on account of the facility with which the whole animal appears to break up into short pieces. Along with this knowledge of its fragility, which has given it the name of "Glass-snake," there goes the tradition that these pieces have the power of reuniting themselves, so that the reptile is thoroughly reconstructed and as sound as ever. Concerning these matters there has been a great amount of discussion in the newspapers and the scientific journals. As regards the liability of the animal to break up into pieces of different lengths on being struck or roughly handled, there is no doubt that the popular notion is correct. Two-thirds or more of the Glass-snake is tail. It is a well-known fact that many lizards on being seized drop their tails in order to free themselves or to deceive the pursuer. The tail thus lost may be reproduced. When occasion appears to demand the sacrifice, the Glass-snake sunders its tail into a number of wriggling pieces, and while the astonished observer stands viewing the wreck, the head and body hastens to a place of safety. In order that all these pieces might unite again to form a sound lizard, they would have to be fitted together in the proper order, and with the ends turned in the right direction; the half dozen or more conical muscular masses which project from the ends of the pieces would have to be interdigitated accurately; the nerves and blood vessels would need to come into juxtaposition; and then all the torn surfaces unite by "immediate union" so quickly and effectively that the animal can betake itself to its business. Hard as the possibility of accepting all this is for the naturalist, such is the popular notion, and a writer in the Scientific American, September 3, 1887, says that he seen the thing done. Before scientific men will believe the assertion it will have to be well corroborated.

The specimen of the Glass-snake which was taken in Starke county, Ind., was sent to the editor of the Popular Science Monthly (vol. xxx, p. 122,) for examination. The account of it is mixed up with the name of the Chain-snake, but the reference to the position of the vent shows plainly that it was a Glass-snake, as the editor also says it was.

This animal appears to select for its abode dry, rather than damp, situations. Holbrook states that it often is found in sweet-potato hills in time of harvest. It is entirely harmless, and can be easily tamed. It probably will not bite at all, and could do no injury if it did; but people who know little about reptiles think that all snakes and lizards, as well as all salamanders, are poisonous. It is said that the Glass-snake appears very early in the spring, even before the true snakes, and remains late in the autumn. About its breeding habits I have been able to learn nothing definite. It probably lays its eggs in the ground. Drs. Coues and Yarrow say that several individuals of this lizard were eaten by a specimen of *Ophibolus getulus sayi* that was kept in the same cage.

## Family V. TEIIDÆ.

Lizards with form varying from moderately stout to vermiform. Limbs usually present and well developed; sometimes rudimentary, and in one genus the hinder limbs are absent. Dentition various. Tongue thin, flat, ending in two long smooth points, and having its upper surface covered with overlapping scale-like papillæ. Plates of the head large or small. No bony plates underlying the epidermal scales.

A family comprising 35 genera and over 100 species; all living in the New World.

### Genus CNEMIDOPHORUS, Wagler.

*Cnemidophorus*, Wagler, 1830, *75*, 154; Boulenger, 1885, *29*, ii, 360.

Body terete, head pyramidal, tail long and slender. Limbs well developed, with five digits each. Head with large shields. The anterior nasals meeting in the middle line. Eyelids present. Tympanum exposed, sunken below the surface. Lateral teeth bicuspid or tricuspid. Scales of the upper surface of the body small; those of the abdomen large, and arranged in 8 to 12 longitudinal rows. A double fold of skin on front of neck. Femoral pores present.

About 16 species are known.

### **Cnemidophorus sex-lineatus,** (Linn.).

*Six-lined Lizard.*

*Lacerta sexlineata*, Linnæus, 1766. *64*, ed. xii, i, 364; *Ameiva sexlineata*, Holbrook, 1842, *54*, ii, 100, pl. 15; *Cnemidophorus sex-lineatus*, Boulenger 1885, *29*, ii, 364.

Long and slender. Head a four-sided pyramid. A large vertical plate, on each side of which, over the eyes, are four supraoculars. Nostril in the anterior nasal. Ear about the size of the eye. A few pterygoid teeth present. Gular folds two, the posterior with large scales in front. Upper surface of the fore limbs with large scales. Front of thigh and under surface of the lower leg with enlarged scales. Scales of the upper surface of the body small; those of the abdomen large, squarish; and arranged in 8 longitudinal, and about 33 transverse rows. Tail with large, squarish, keeled scales, the keel running somewhat obliquely. Vent with three enlarged scales in front. Appressed hind limb reaching to the ear. Tail nearly twice the length of the head and body; sometimes more.

The color of the back is olive or brownish, in life green. The sides are black, with three narrow stripes of yellow. A greenish stripe on the back of the thigh, prolonged on the sides of the tail.

Total length about 10 inches. Distributed from Maryland to Kansas, Southern California, and Mexico.

This species is included in the fauna of Indiana on the testimony of Mr. Robert Ridgway of the National Museum. He writes me that while he was collecting snakes at Monteur's Pond, near Wheatland, Knox county, he climbed a buttonbush to snare a big water-snake. While maneuvering to get his noose-rod into position he saw a specimen of what he is positive was this species (with the appearance of which he was previously very familiar) basking in the sun on a branch of the same bush. Before he could secure the lizard, it jumped off into the water and swam away. There is nothing, whatever, improbable about the occurrence of this lizard in Southern Indiana, since I have taken it in Western Illinois, at a point as far north as Logansport, Ind. Since the above was written Mr. A. W. Butler has informed me that he found this species in a small collection of reptiles sent him from Bloomington, Ind. I have not seen the specimen.

HABITS—Probably the most remarkable quality possessed by this animal is its ability to run with great swiftness. Dr. Coues in speaking of it says that the eye can scarcely follow it when it is running at its best on level ground. Dr. Yarrow also states that it is very difficult to capture, since it runs with the greatest celerity over the sand and rocks. In order to capture it Dr. Coues used fine shot in a horse-pistol. It may be taken in a butterfly net. It lives in high and dry situations, among bushes, brush heaps, logs, and the like. The naturalists named above do not regard it as at all arboreal in its habits; still it may occasionally resort to trees. Its food is principally insects. Dr. Coues states that it would come into the tents and catch flies in a quiet, furtive way, but on the least alarm it would dart out of sight. At Ft. Macon, N. C., (*1*, '76, 47,) it was seen early in April, and could be found until the cold weather in October. Notwithstanding its agility, it is one of the animals oftenest found in the stomachs of the larger snakes. Holbrook says that he has often seen the male and the female toward evening hunting in company for insects. I know nothing about its breeding habits.

## Family VI. SCINCIDÆ.

Lizards from short and stout to long and worm-like. Limbs present or absent. Dentition pleurodont; form of teeth various. Tongue thin, flat, moderately long, free, and slightly notched in front; covered with overlapping scale-like papillæ. Head with symmetrical plates. Epidermal scales supported by bony plates. Ovoviviparous.

Cosmopolitan. Contains 25 genera and about 400 species. We have 2 genera, each with a single species.

| | |
|---|---|
| Palate cleft by a single median slit. | *Lygosoma*, p. 546. |
| Palate with two slits, one from each nostril. | *Eumeces*, p. 547. |

### Genus LYGOSOMA, Gray.

*Lygosoma*, Gray, 1828, *110*, iii, 228; Boulenger, 1887, *29*, iii, 209; *Oligosoma*, Girard, 1852, *5*, 196.

Body short and stout or elongated. Limbs well developed, rudimentary or absent. Outer nostril in the nasal plate. Eyelids well developed. Tympanum distinct or hidden. Maxillary teeth conical or obtuse. Pterygoid teeth minute or absent. Palatine bones in contact, so as to leave a single median slit from the internal nostrils to opposite the middle of the eyes.

A widely distributed genus containing more than 150 species.

### Lygosoma laterale, (Say).

*Brown-backed Lizard.*

*Scincus laterale*, Say, 1823, *14*, ii, 324; *Lygosoma laterale*, Holbrook, 1842, *54*, ii, 133, pl. 19; Boulenger, 1887, *29*, iii, 263; *Oligosoma laterale*, Cope, 1875, *12*, 39.

A small lizard with a short head, elongated body, a long terete tail, and feebly developed limbs. Head flat above, the perpendicular sides tapering to the snout. Lower eyelid with a transparent disk. Ear opening the size of the opening of the eye, the tympanic disk deeply sunken. No gular folds. Limbs lacking much of meeting along the side, the appressed hind leg reaching hardly a third of the distance to the axilla. Body covered with smooth scales, not arranged in straight rows across the body. About thirty scales in oblique row around the middle of the body.

The color above is olive or brownish, with scattered brown spots, the tail often blue. Side with a brown, white margined stripe running from the eye on to the tail. Below this may be a similar but narrower stripe passing between the fore and the hind limb. Abdomen greenish white.

The total length is about 5 inches, sometimes as great as 6 or 8 inches. The tail may make up as much as two-thirds of this. The species ranges from Florida and Texas to North Carolina, Indiana and Kansas. Indiana localities from which this species has been reported are few, but it probably inhabits much of the southern portion of the State. Mr. Robert Ridgway has taken it at Wheatland, and has seen it in the "watermelon sands" district of Gibson county.

Habits.—In some portions of the Southern States this species of lizard is abundant. Holbrook says that they might, in his day, be seen by thousands in the thick forests of oak and hickory of Carolina and Georgia. They emerge from their retreats, after sunset, in search of small insects and worms, on which they live; yet they appear and disappear so rapidly that they might at first be mistaken for crickets or other insects. It is difficult to secure them alive. They conceal themselves rapidly under roots or beneath leaves. Baird and Girard (*37*, 229), say that it is always met with running on the surface of the ground in forests, among dead leaves, never ascending either trees or shrubs like many other lizards. It is said to breed in Georgia in March.

#### Genus EUMECES, Wiegmann.

*Eumeces*, Wiegmann, 1835, *83*, ii, 288; Boulenger, 1887, *29*, iii, 365.

Lizards of moderate proportions. Limbs well developed. Outer nostril in the nasal plate. Eyelids with scales. Tympanic disk distinct, deeply sunken. Maxillary teeth with conical or rounded crowns. Pterygoid teeth present. Palatine bones not meeting in the median line; palate therefore with two clefts, one from each nostril.

Of this genus 31 species are recognized. N. A., Cent. A., Asia, Africa.

### **Eumeces fasciatus**, (Linn.).

*Red-headed Lizard; Blue-tailed Skink.*

*Lacerta fasciata*, Linnæus, 1758, *64*, ed. x, i, 209; ed. xii, 369; *L. quinquelineata*, Linnæus, 1766, *64*, ed. xii, 366; *Plestiodon erythrocephalus*, Holbrook, 1842, *54*, ii, 117, pl. 16; *Scincus quinquelineatus*, Holbrook, 1842, *54*, ii, 121, pl. 17; *Scincus fasciatus*, Holbrook, 1842, *54*, ii, 127, pl. 18; *Eumeces fasciatus*, Cope, 1875, *12*, 45; *Eumeces quinquelineatus*, Boulenger, 1887, *29*, iii, 369.

Head short, broad behind, wedged-shaped in front. Snout short, obtuse. Nasal plate pierced by the nostril. Behind this is the postnasal, which joins the first labial. Behind the postnasal comes the loral, which joins the plate in the median line, the fronto-nasal. Vertical large, in contact with three anterior supraoculars. On the back of the head, in the median line, is the interparietal, in which a faint whitish spot indicates the position of the pineal eye. Ear opening smaller than the eye, the tympanic disk deeply sunken. No distinct neck nor gular fold. When the limbs are pressed to the sides they overlap. Tail longer than the head and body. Length of hind limb in the distance from the snout to the vent nearly or quite two and a half times. Scales of the back, sides and abdomen about equal in size, smooth, 28 or 32 longitudinal rows around the middle of the body. A row of enlarged scales on the under side of the tail.

Young and middle sized individuals are nearly black above, with five yellow lines running from the head to the middle of the tail. The median line forks on the head. The extremity of the tail is often bright blue. The abdomen is bluish white. As the animal grows older the stripes become obscure, the general color fades to olive or brownish, and the head becomes bright red. These older specimens were long regarded as belonging to a distinct species. Even Holbrook, who lived where the animal is abundant, described it under three names, as cited above.

The total length may be as much as 13 inches, and even more.

The species is distributed from Massachusetts to Wyoming and south. In Indiana it appears to be pretty generally and abundantly distributed in the southern half of the State. Since it has also been found in Michigan, there seems to be no reason why it should not also occur in Northern Indiana. The following are localities from which I have seen specimens:

Brookville (Hughes); New Harmony (Sampson's coll.); Monroe county (Bollman and Nor. Sch. coll.); Terre Haute (Blatchley); Marion and Crawford counties (Hay); Wabash county (A. B. Ulrey). A specimen from Bloomington is 10 inches long.

HABITS.—This is a very active species of lizard, and is found in forest regions, living about old logs and stumps, and under bark. It often ascends trees, and it would appear that the older individuals spend the greater part of their time there. Holbrook says of these older ones, called by him *P. erythrocephalus:* "They choose their residence in deep forests, and are commonly found about hollow trees, often at a height of thirty or forty feet from the ground; sometimes in a last year's nest of the woodpecker, out of which he thrusts his bright red head in a threatening manner to those who would disturb his home. He never makes his habitat on or near the ground, and, in fact, seldom descends from his elevation unless in search of food or water. Though shy and timid, he is very fierce when taken, and bites severely." The bite is not poisonous. Of the less mature individuals, Holbrook says that they live mostly on the ground, in holes of stumps, under the bark of decaying trees, and similar places. They seldom ascend trees unless they are pursued. Their food consists of insects. Smith (*18*, 651), states that this animal lays nine oval eggs at a time.

Dr. Abbott (*7*, 34, 170), thinks that the Blue-tailed Skink has a greater degree of intelligence than the Pine-tree Lizard, *Sceloporus undulatus.* The latter, on being captured, immediately submits and becomes tame. The Skink, on the other hand, is fierce, and defends itself with vigor. One that he captured and put into a case immediately buried itself and scarcely made an appearance for a week. After it came from its retreat it was suspicious of every object and sound. When it went into its retreat it never returned by the same burrow, but would stick its head out at another hole and carefully study the outlook. At length it gained sufficient confidence to eat, and in about four months it became comparatively tame. Its disposition is, in many respects, the opposite of that of the Pine-tree Lizard.

Dr. J. Schneck (*22*, 14, 55), mentions some specimens of this species which had the tail forked, as the result probably of a loss and reproduction of that appendage. When these lizards are pursued and caught by the tail, this is very liable to be dropped. The tail is afterward reproduced, and it seems that occasionally two tails take the place of the lost one. The same observer speaks of the great variations in the color of this species due to differences in age, and of the aged ones as "ruby-headed and copper-bellied specimens, 20 inches in length."

## Order CHELONIA.

*Tortoises and Turtles.*

Reptiles having the trunk relatively short and broad, with the upper and the lower walls forming two disks, which are united on the sides between the fore and hind limbs. The disks strengthened by bony deposits, which usually, but not always, involve the endo-skeleton. The bony dorsal shield (carapace) usually formed of the expanded and suturally united ribs and vertebral spinous processes. The lower shield (plastron) composed of the clavicles and a few dermal bones. No true sternum. Trunk rigid; only the neck and tail flexible. Jaws without teeth and covered with horny sheaths. Eyes with lids and a nictitating membrane. Tympanic membrane external, sometimes hidden by the skin. Tongue thick and fleshy. Limbs four; developed for walking, except in the marine turtles, in which they are formed for rapid swimming. Reproduction by means of eggs, spherical or elliptical in shape and protected by a calcareous shell.

Upper and lower disks without horny epidermal plates. A soft skin. *Trionychoidea*, p. 550.

Shell covered with large, symmetrical horny epidermal plates. *Testudinata.*

### Suborder TRIONYCHOIDEA.

The dorsal vertebræ and the expanded ribs involved in the carapace. Plastron composed of 9 bones, which enclose a fontanelle. The dorsal disk rarely strengthened by marginal bones, its border therefore flexible. The horny sheaths of the jaws hidden by fleshy lips. Fourth digit with 4 or more phalanges.

A single family living in the rivers of North America, Asia and Africa.

### Family VII. TRIONYCHIDÆ.

Body broad and much depressed; the margins of the carapace thin and leathery, in rare cases having marginal bones. No epidermic scutes. Snout much produced, leathery, with the nostrils at the tip. Ear hidden. Only the three inner digits furnished with claws. Head and neck completely retractile.

Of this family 6 genera are recognized, only one of which lives in America.

### Genus TRIONYX, Geoff.

*Trionyx*, Geoffroy, 1809, *85*, 84; Gray, 1855, *25*, 64; Boulenger, 1889, *84*, 242.

Plastron little developed behind, leaving the hinder limbs and tail completely exposed; with not more than 5 callosities. No marginal bones in the border of the carapace. Jaws strong.

A genus embracing about 15 species, residents in the rivers of North America, Asia and Africa.

A. Nostril circular, having no papilla projecting into it from the septum. (*Amyda*, Agassiz ) *T. muticus*, p. 551.

AA. Nostril crescent-shaped, having a papilla projecting into it from the septum. (*Aspidonectes*, Agassiz.)

a. Under side of feet white, not mottled with brown. *T. agassizii*, p. 552.

aa. Under side of feet mottled with white and brown. *T. spiniferus*, p. 554.

### Trionyx muticus, LeS.

*Spineless Soft-Shelled Turtle.*

*Trionyx muticus*, LeSueur, 1827, *86*, 263, pl. 7; Holbrook, 1842, *54*, ii, 19. pl. 2; Gray, 1855, *25*, i, 69; Boulenger, 1889, *84*, 260.

*Amyda mutica*, Agassiz, 1857, *4*, i, 399; *Aspidonectes muticus*, Baur, 1888, *22*, 1122.

Head long, low, and pointed in front, descending rapidly in front of the eyes. Skull, from the eyes forward, drawn out, the margins of the upper and the lower jaw being concave outwardly. The horny upper jaw with a cutting edge, which is deepest forward and bluntly toothed posteriorly. Lower jaw also with a sharp edge, and both jaws furnished with an alveolar surface, the leathery snout ending obliquely, so that the nostrils are somewhat under the tip. The nostrils are circular, there being no papilla projecting into them from the septum.

Body flat and oval. No trace of keel along the middle of the back; often a depression instead. No spines along the anterior border of the carapace, nor any tubercles anywhere. Callosities well developed on the plastron of the adults, especially of the males.

The color above is brownish, olive, or bluish-gray. In the young there are some blotches of dark brown. On the margins of the carapace, laterally and posteriorly, is a band of yellow, bordered internally with black. These bands are likely to disappear later in life. Head with a white stripe, margined with black, from the eye over the ear and then descending on the neck. Head and neck below the level of the edge of the upper lip white, without any mottling. Under surface of the feet white or bluish-gray; never mottled as in *T. spiniferus*.

The length of the carapace of fully grown adults may be a foot, sometimes probably more. The females have tails that scarcely project beyond the edge of the carapace, while that of the male is much longer. Both Agassiz and Baur have noted the fact that the males are much smaller than the females. Baur has also made the observation that the males are not so numerous as the females (*22*, 22, 1122). It is not at all improbable that such is the case; yet it may be only apparently so, due to fewer of the males being captured, on account of their smaller size, or on account of the saving only of the larger, finer specimens.

The species inhabits North America from the St. Lawrence River to Florida and west to the plains. I have note of its occurrence in the rivers of Indiana at five points: Delphi (Agassiz); Madison (Yarrow); Mt. Carmel, Ill. (R. Ridgway); and Terre Haute (Blatchley). LeSueur described the species from specimens taken at New Harmony.

HABITS.—This species, like all the soft-shelled turtles, is wholly aquatic, since they leave the water only on rare occasions. They delight to remain about the roots of trees which have fallen into the water or in drifts of timber. Here they can watch for prey and not be observed by any supposed enemy. Away from such means of concealment they are accustomed to bury themselves completely in the sand, leaving only their heads exposed. Since their heads do not differ much in color from the sand it is difficult for one to recognize them, even when the eye is directed to them. When air is required it is obtained by stretching out the neck until the pointed snout reaches the surface. The head is then again withdrawn. Like *T. spiniferus*, this species no doubt enjoys a true aquatic respiration. They subsist probably on insects, fishes, water snails, and similar small animals. Agassiz found the larvæ of neuropterous insects in their stomachs. Max. Von Wied (*103*, xxii, 53) says that LeSueur found in their stomachs worms, snails, fruits, and even hard nuts. If there are potatoes growing near the water the turtles find their way to them and devour the stems, of which they are very fond.

The eggs are spherical in form, about seven-eights of an inch in diameter, and have a thick, but brittle, calcareous shell. They are deposited in the sand on the shores of the rivers where the adults live. The young are flatter and more nearly circular than the adults. This species, like the other species of *Trionyx*, is regarded as a great delicacy.

### **Trionyx agassizii,** (Baur).

*Agassiz' Soft-Shelled Turtle.*

*Trionyx ferox*, in part, Boulenger, 1889, *84*, 259; *Platypeltis ferox*, Agassiz, 1857, *4*, i, 400, and ii, pl. vi, fig. 3 (young), pl. vii, fig. 22 (egg); *Platypeltis agassizii*, Baur, 1888, *22*, xxii, 1121.

Head with the fore part not drawn out, the margins of the jaws not concave outwardly. Snout with the nostrils at the tip; the latter crescent shaped, there being a papilla projecting into it from the septum. Body with a low, obtuse keel along the middle line. Spines present along the anterior border of the carapace, these largest in the males. Upper surface of the carapace often rough with minute tubercles. Callosities of the middle and hinder part of the plastron well developed.

Color of the upper surface olive, with blotches or spots of black. A light streak, margined with black, starts at the tip of the proboscis, divides just in front of the eyes, and sends a branch through each eye to the side of the neck. The younger individuals have a yellow border around the lateral and posterior edges of the carapace, inside of which are two or three lines of black. The spots on the carapace of the young are solid, but later in life they may become ocellated. The lower surfaces are white. The bottoms of the feet are said by Agassiz to be always free from mottlings of black. In a specimen which came from Mississippi, however, the under surfaces of these are moderately mottled with black. Agassiz states that the largest individual of this species of which he had any knowledge was 18.5 inches long from the front to the hinder end of the carapace. They are usually much smaller. The tail of the male projects beyond the edge of the carapace; that of the female does not.

This species closely resembles *T. spiniferus.* It is to be distinguished by the solid spots and the two or three black lines around the carapace (when not too large), the light line of the head dividing behind the base of the proboscis, and the uniformly colored lower surfaces of the feet.

This species belongs to the Southern States from South Carolina to Texas. A single specimen has been forwarded to the National Museum from Madison, Ind. It ought to be sought for all along the Ohio River.

Whether or not this species is more vicious than its relatives can hardly be said. But all the American species are ready to snap and bite whenever they are teased, and their biting is not to be held in contempt. The head and long neck can be thrust out with great rapidity, and the sharp-edged jaws are like scissors. Holbrook says that it will sometimes leap up and give a loud hiss. He further states that it is very voracious, feeding on fish and such reptiles as it can secure, and is so greedy that it takes the hook readily when baited with any substance whatever. Yet he had never known them to take food in captivity, even after several months. They swim with great rapidity, and often conceal themselves in the mud, buried two or three inches deep, leaving only a small breathing hole for the long neck and small head. This it occasionally thrusts out, but usually keeps it concealed so that a passer-by might think the hole the residence of some large insect. They are often seen basking in the sun on rocks and apparently asleep.

In the South they lay their eggs in May. These are about 60 in number, have a thick, smooth, brittle shell, and are larger than those of *T. muticus*, being a little less than an inch in diameter. They are hidden in the sand along the shores of streams.

Dr. Baur considers the form found in the Mississippi Valley as an entirely distinct species from the *Testudo ferox* of Schneider. Should he be correct in this judgment, as he probably is, the species above described must be known as *Trionyx* (*Platypeltis*) *agassizii.*

### **Trionyx spiniferus,** LeS.

*Spiny Soft-Shelled Turtle.*

*Trionyx spiniferus*, LeSueur, 1827, *86*, 258, pl. vi; *Trionyx spinifer*, Boulenger, 1889, *84*, 259; *Aspidonectes spinifer*, Agassiz, 1857, *4*, i, 403, and ii, pl. vi, fig. 1 (young), pl. vii, fig. 23 (egg).

Resembling much *T. agassizii.* Skull tapering gradually to the snout. Proboscis with the nostrils at the tip; these crescentic in shape, a papilla projecting into each from the septum. A low obtuse keel along the middle of the back. A series of spines on the front edge of the carapace, largest in the females. Whole upper surface of carapace often covered with minute asperities, also more prominent in the females. Tail of the male projecting considerably beyond the carapace. Callosities well developed in the middle and hinder parts of the plastron. General color above olive or light brown. In the young there are numerous ocellated spots, or rings, of black all over the carapace. These may be retained until the size has become considerable, but they finally become irregular blotches. In the young and half grown there is a yellow border around the sides and posterior edge of the carapace, and just within the yellow border is a single line of black. Head olive, with a light line, margined above and below with black, starting at the tip of the proboscis, forking at its base, and sending a branch through each eye and down on the neck. The plastron is white. Under surface of the feet much mottled with white and black.

About the size of *T. agassizii.* Agassiz states that the largest of which he had knowledge had a carapace 14 inches long.

This species is to be distinguished from *T. agassizii* by the mottled lower surfaces of the feet, the line of the head, *forking at the base of the proboscis*, and, in case the specimen is not too old, the ocellated spots of the carapace, and the single dark line around the edge of the carapace.

Habitat from Vermont to Montana and south to the Gulf. More abundant in the Northern States. In Indiana it is the most common species of soft-shelled turtle, and is so generally distributed throughout the State that it is not necessary to mention localities.

Habits.—The habits of this turtle are much like those of *T. agassizii*. It lives in similar localities, captures the same kinds of food, and deposits its eggs in the sand, just as *agassizii* does. One was found by myself on the 14th of March buried in the sand where the water was so deep that she could only with difficulty reach the surface with her proboscis. The head, colored just like the sand, was drawn entirely under as soon as she saw that she was observed. It was with a good deal of exertion that she was dislodged. She was kept until the 13th of May, during which time she could not be induced to eat anything. On being put into a ditch she immediately buried herself in the mud, and when hidden she gave her body some sidewise movements so that the mud settled over her as though nothing had disturbed it. Here she remained a day and two nights. Prof. Blatchley (*94*, '91, 34), states that he has seen them moving freely about in the water as late as December 11, and as early as March 19. When hibernating they burrow in the mud at the bottoms of ponds and streams.

This specimen will bite severely, as several observers have had opportunity to learn. DeKay mentions the fact that one bit a dog and took out a mouthful of hair. These turtles can run rapidly on the land, and when in the water they swim with great swiftness, as any one knows who has tried to catch them. Profs. S. P. and S. H. Gage have demonstrated that both this species and *T. muticus* enjoy a true aquatic respiration. They say that these animals often remain voluntarily under the water for from two to ten hours consecutively. While under the water there are about 16 movements of the hyoid apparatus each minute, and by means of these the mouth and pharynx are filled with water and again emptied. The mucous membrane of the pharynx is closely beset with filamentous processes which have the appearance of the villi of the intestines, and are abundantly supplied with blood. Analysis of the water in which a turtle was kept some hours proved that it was deprived of its oxygen and filled with carbonic acid.

The number of eggs laid by this species is probably about the same as for *T. agassizii*. The eggs are spherical, have a thick, brittle calcareous shell, and under this a very tough membrane. The eggs are a little larger than those of *T. agassizii*, an inch in diameter. LeSueur (*86*, xv, 263) says that at New Harmony the females lay their eggs in April and May in the sand along the river bank. He has found in them 50 or 60 eggs, about 20 of which were ready to be laid. The others were probably the eggs of the next season. The young appear in August. This turtle is highly prized as an article of food.

## Suborder TESTUDINATA.

Carapace usually very complete, formed by the expanded spinous processes of the vertebræ, the expanded ribs, and a series of dermal marginal bones. Plastron consisting of 8 to 11 bones; commonly united by suture with the carapace. Both carapace and plastron, with one exception, covered with large, symmetrically arranged epidermal plates. Jaws covered with horny sheaths; not hidden by fleshy lips. Fourth digit never with more than 3 phalanges.

### Key to the Families of Testudinata.

Plastron narrow, cross-shaped; bridge long and narrow; marginals 23, not including the nuchal; tail long. *Chelydridæ*, p. 556.

Plastron of small to moderate size; bridge short, but wider; marginals 23; tail short. *Kinosternidæ*, p. 560.

Plastron filling the openings of carapace, or nearly so; marginal plates 25; tail short to moderate. *Testudinidæ*, p. 563.

## Family VIII. CHELYDRIDÆ.

Body broad and depressed; the shell highest in front, serrated along its posterior border. Plastron formed of 9 bones; small and cross-shaped; the bridge narrow. Abdominal scutes separated from those of plastron by a series of inframarginals. Head large, jaws strong and hooked. Tail long, with one or more rows of compressed, horny tubercles above. Eggs spherical.

Genera two, both of which are represented in Indiana.

Shell without additional plates between the marginals and costals.
*Chelydra*, p. 556.

Shell with 3 or 4 extra plates between the marginals and costals.
*Macrocemys*, p. 559.

#### Genus CHELYDRA, Schweigg.

*Chelydra*, Schweigger, 1814, *88*, 23; Agassiz, 1857, *4*, 1, 416; Boulenger, 1889, *84*, 20.

Carapace with three tuberculated keels, which disappear more or less with advanced age. No supernumerary scutes intervening between the marginals and the costals, just above the bridge. Plastron small, with five pairs of scutes, the abdominals apparently displaced and covering the bridge. Head large, jaws hooked. Head with the skin marked off into somewhat symmetrical plates. Tail with two rows of large scales beneath.

**Chelydra serpentina,** (Linn.).

*Snapper; Snapping Turtle.*

*Testudo serpentina,* Linnæus, 1758, *64,* ed. x, 199; *Chelydra serpentina,* Schweigger, 1814, *88,* 24; Agassiz, 1857, *4,* i, 417, and ii, pl. iv, figs. 13–16, pl. vii, figs. 24–26; Boulenger, 1889, *84,* 20, with figs. *Chelonura serpentina,* Holbrook, 1842, *54,* i, 139, pl. 23.

Carapace broad and rather depressed, highest in front and notched behind. A median and two lateral, tuberculated keels, disappearing late in life. Marginal plates, exclusive of nuchal, 23. Vertebral scutes wider than long, tuberculated behind. Costal scutes tuberculated near the upper posterior angle. Plastron small, leaving the limbs exposed; covered with five pairs of scutes; the bridge very narrow. Two or three inframarginals at the outer end of the bridge.

Head large and flattened above, with rather conspicuous bony ridges; tapering, but not descending toward the snout. Eyes directed upward and outward. Feet broad and webbed to the nails. Fingers five, all with nails. Toes five, the outer one without a nail. The outer border of all the limbs with a sharp fold of skin which greatly increases the surface of the limb, as aid in swimming. Tail long and pointed, equaling the length of the plastron. Tail furnished above with a median row of large horny tubercles, supported by a bony core Each side of the tail with smaller tubercles. Under side of tail with two rows of large scales.

Skin of neck, under jaw, body, limbs and tail covered with wrinkles and large and small warts. Fore-arm and hands and feet with large, overlapping, sharp-edged scales. Color of the carapace chestnut brown to black. Plastron and soft skin whitish or yellow. Head and upper neck brown. Attains a total length, it is said, of four and a half feet, the shell two feet, usually much smaller. The weight may reach from 20 to 30 pounds.

This species has a remarkably wide distribution. It occurs from Nova Scotia to Ecuador, in South America. Westward it probably extends to the Rocky Mountains. It is found, no doubt, in every stream and pond in the State of Indiana.

HABITS.—This turtle spends the greater portion of its life in, or closely about, streams and lakes and ponds. Although found living in clear rivers, it appears to prefer muddy ponds. It is often seen far away from any water, walking along with awkward and halting gait. Its mode of locomotion has been compared with that of the alligator. When seen on the land it may be seeking some spot in which to deposit its eggs, or seeking for food, or perhaps crossing from one stream to another. In the water they do not seem to swim, but they may often be seen floating along just below the surface, with the snout and eyes only exposed. When disturbed, they immediately go to the bottom, and conceal themselves there. When traveling about they are often seen with a great amount of mud on their backs as though they had been burrowing in the earth. The Snapping-turtle is strong and courageous. When attacked they neither attempt to retreat nor retire passively into their shells, as do most turtles. The jaws are opened, the head and long neck are suddenly thrust out, and at the same moment the animal leaps forward toward its tormentor. If the aim has been correct, the jaws close on the enemy and the hold is doggedly retained. It is a curious notion held by many people that, when it has once secured a hold, it will not let loose until it has thundered. It will sometimes permit itself to be carried around by a stick which it has seized.

The Snapping-turtle is wholly carnivorous and extremely voracious. Their food consists of frogs, fishes, the smaller and younger water fowl, and crayfishes. They do not hesitate to eat any animal substance that presents itself. They have been accused of capturing young ducks. A large specimen that I dissected had in its large intestine the feathers and partially digested bones of a full grown robin. The wing and tail feathers filled up the intestines. Its excrement contained the remains of a crayfish. I have been told that they will steal the sportsman's string of fish, and use the forefoot in tearing off what they can not get into the mouth.

The eggs are laid during the month of June, and hatch in the autumn. They number from 30 to 70, and are deposited in holes excavated along the banks of streams. Agassiz says that the hole is excavated at first directly downward and then laterally, so that the eggs are deposited on one side of the mouth of the excavation. They are all deposited in one hole. After the eggs are laid the female covers them up, smooths the sand over them, and leaves them to their fate. The eggs are spherical, about an inch in diameter, and provided with a calcareous shell. The shell is not brittle, but somewhat less flexible than that of most tortoises. Occasionally an elliptical egg is found. Agassiz is authority for the statement that the young will snap before they have escaped naturally from the egg.

The flesh of the Snapping-turtle is often used for food, especially that of the younger individuals. When they grow old their flesh is likely to have a musky and disagreeable smell. Mr. True states that these turtles are regularly seen every spring in the markets of Washington ready for cooking. Storer wrote that in Massachusetts many persons saved the oil of this animal and used it to heal bruises and sprains. As a therapeutical agent it is worthy to stand alongside of goose oil, skunk oil, and rattlesnake oil.

### Genus MACROCLEMYS, Gray.

*Macroclemys*, Gray, 1855, *25*, 48; *Macrochelys*, Gray, 1855, *25*, sup., 64; *Gypochelys*, Agassiz, 1857, *4*, i, 413; *Macroclemmys*, Boulenger, 1889, *84*, 23.

Carapace with three prominent keels, which persist throughout life. A series of three or four supernumerary marginal scales on each side, between the normal marginals and the costal scutes. Plastron small, cross-like, and with five pairs of scutes. Bridge narrow. Head very large, covered with smooth, symmetrical plates. Orbits looking outward and forward. Jaws very strong and hooked. Tail with three series of tubercles above; the lower surface with small scales.

### **Macroclemys temminckii,** (Troost).

*Alligator Snapping Turtle.*

*Chelonura temminckii*, Troost, 1842, *54*, ii, 47, pl. 24; *Macroclemys temminckii*, Gray, 1855, *25*, 49; *Macroclemmys temminckii*, Boulenger, 1889, *84*, 25, with figures; *Macrochelys lacertina*, Cope, 1872, *1*, 23; *Gypochelys*, Agassiz, 1857, *4*, i, 414, and ii, pl. v, figs. 23-27.

Carapace furnished with three prominent keels which do not vanish with age. Each median scute rises posteriorly into a knob, which is largest on the hindermost vertebral scute. The lateral keel is located on the upper ends of the costal scutes. The keel rises on the hinder border of each scute into a knob, and the knobs on the hinder scutes are the highest. Posterior border of the carapace serrated. Between the lower ends of the anterior three costal scutes and the marginals occur three or four supramarginals. The plastron resembles that of *Chelydra serpentina*.

The head is of enormous size, broad behind, tapering rapidly to the acuminate beak and snout. Beak of upper jaw projecting beyond the lower, and strongly hooked, the outline of the cutting edge rising from the point of the beak, then descending to the middle, and then rising to the corner of the mouth. Lower jaw turned up into a strong hook. Head covered with large, symmetrical plates. Neck short. Tail about three-fourths the length of the carapace, furnished above with three rows of low tubercles, below with rows of small scales. Color yellowish or reddish brown to black.

This species attains a great size for a fresh-water turtle. Agassiz saw one alive that weighed about two hundred pounds. One of his correspondents speaks of a skull which measured nine inches between the eyes. A dry specimen that I examined in the National Museum had the carapace 23 inches long and 20 wide. The head was 8 inches long and 7 wide. The sternum was 16 inches long. A skull in the Indiana

Geological Museum, said to have come from Arkansas, is 9 inches wide and as many long. The length from the snout to the occipital condyle is $7\frac{1}{4}$ inches.

Its range is from western Georgia to Texas and north to Indiana. It has been taken in the Wabash River, at Grayville, Ill., as Mr. Robert Ridgway, of the National Museum, informs me. The specimen captured there was exhibited at county fairs, and was so strong that it could easily walk about with a large man on its back. Dr. Yarrow ( *10*, 30) reports two specimens of this species in the National Museum, from Northville, Mich., but an examination of the records at the Museum shows that the specimens sent from that place were not of this tortoise, but of *Necturus*.

Habits.—This is one of the most remarkable turtles occurring within our limits, if not within the United States. It is rare in collections, and persons living along the lower Wabash ought to secure all the specimens possible. It may at all times be distinguished from the common Snapping-turtle by the three extra plates above those marginals which are placed just above the bridge. Its great head and its rapidly descending snout are also good marks. It is an exceedingly strong and fierce turtle, and a large one would be hard to manage. Mr. True states that he has known a specimen of perhaps forty pounds to bite the handle of a broom quite in two when enraged. They live principally on fish, but will no doubt devour almost any animal that may be so unfortunate as to come within range of their powerful jaws. One is mentioned (*4*, i, 415) as catching a bass about fourteen inches long and holding it down on a rock with his fore feet and greedily eating it. The breeding habits are not well understood. Agassiz figures the egg. It is spherical and an inch and three-eighths in diameter.

## Family IX. KINOSTERNIDÆ.

Body rather narrow and high. The greatest height behind the middle, beyond which the outline descends rapidly. Marginal plates 23. Plastron moderately to well developed; formed of 8 bones, the entoplastron being absent. Plastral scutes 10 or 11; the gulars present and united or absent; the pectorals not meeting the marginals; abdominals cut off from marginals by two small plates on the bridge. Head large; jaws strong; snout projecting. Digits moderately developed and webbed. Five fingers and four toes with claws. Eggs elliptical.

Plastron narrow, its hinder lobe not more than one-half the width of the carapace. *Aromochelys*, p. 561.

Plastron wider, its hinder lobe considerably wider than one-half the carapace. *Kinosternon*, p. 562.

### Genus AROMOCHELYS, Gray.

*Aromochelys*, Gray, 1855, *25*, 46; *Goniochelys* and *Ozotheca*, Agassiz, 1857, *4*, i, 423, 424; *Cinosternum*, in part, Boulenger, 1889, *84*, 33.

Shell of the young with a prominent keel, which may persist in the adult or more or less disappear. Plastron lacking much of filling up the opening of the carapace, the hinder lobe not more than one-half the width of the carapace. The lobes little movable on the middle portion, and the whole length of the plastron considerably less than that of the carapace. Suture between the pectorals longer than that between the humerals.

Gular scute present; head with yellow streaks from snout.
*A. odorata*, p. 561.

No gular scute; head with dark spots, no streaks of yellow.
*A. carinata*. Appendix.

### **Aromochelys odorata**, (Bosc.).

*Musk Turtle.*

*Testudo odorata*, Bosc., 1803, *69*, 189; *Sternothœrus odoratus*, Holbrook, 1842, *54*, i, 133, pl. 22; *Aromochelys odorata*, Gray, 1855, *25*, 46; *Ozotheca odorata*, Agassiz, 1857, *4*, i, 425, and ii, pl. iv, figs. 1–6; *Cinosternum odoratum*, Boulenger, 1889, *84*, 37.

Body of the young broadly oval and with a prominent keel, toward which the shell slopes roof-like. As the animal grows older the shell becomes proportionally narrower, the middle of the back more rounded, and the keel almost disappears. The first vertebral scute is long and narrow. Plastron narrow, leaving wide gaps between it and the carapace. The anterior lobe slightly movable on the transverse hinge. It extends forward from this hinge only about two-thirds the distance to the anterior end of the carapace. A small, triangular gular scute present. Suture between the humerals not quite equal to that between the pectorals. Posterior lobe not more than one-half the width of the carapace, falling considerably short of the hinder end of the shell; notched behind. Plastral scutes of the adults separated by tracts of soft skin.

Head large, snout projecting, jaws strong, the lower hooked. Toes extensively webbed. Soft skin everywhere provided with prominent fleshy papillæ. Tail of males projecting beyond the carapace, coiled at the tip, and furnished with a small nail. Posterior borders of the thighs and lower leg with each a patch of horny, sharp-edged scales.

Color of the carapace brownish or horn-color; uniform or spotted and striped with dark brown. Upper surface of head, neck and limbs brown; the inferior surfaces paler. Head with two yellow stripes running back from the snout; one over, the other below, the eye. Plastron yellow. A specimen that was taken in May at Lake Maxinkuckee had all the soft skin suffused with red.

Length of carapace 4 or 5 inches.

Distributed from Maine to Florida and west to Louisiana and Western Missouri. It is no doubt to be found throughout the whole State of Indiana. It is reported from Brookville (Hughes), Mt. Carmel, Ill. (State coll.), lakes of Northern Indiana (Dr. G. M. Levett), Lake Maxinkuckee and Marion county (Hay).

HABITS.—This is to be regarded as essentially an aquatic tortoise. It appears to be disposed to frequent the deeper parts of ponds and small lakes, since in such places it is safer than about shores or on the land. Its disposition is timid, and it prefers to seek safety in concealment or in retreat, to defending itself actively. Nevertheless its disposition is not altogether mild, since it will, when prevented from escaping, put out its head slowly and close its jaws on its assailant with a sudden snap. Holbrook states that it will bite severely, if provoked. In their native haunts they are often seen basking in the sun on some projecting rock or on some fallen tree, from which on the slightest alarm they drop off into the water. Their food is probably mostly or altogether of animal origin. They lay their eggs on shores in holes that they have dug in the sand with their hind feet. The eggs are from three to five in number, of an elongated elliptical shape, a little more than an inch long, and have a hard, smooth shell. One kept in confinement by Agassiz laid after the middle of June.

It takes its specific name from the strong, musky odor which it emits in life

### Genus KINOSTERNON, Spix.

*Kinosternon*, Spix, 1824, *90*, 17; *Kinosternum*, LeConte, 1854, *1*, 180; *Cinosternum* and *Thyrosternum*, Agassiz, 1857, *4*, i, 426; *Cinosternum*, Boulenger, 1889, *84*, 33.

Shell with the median keel indistinct even in the young; almost or entirely disappearing in the adults. Plastron with its anterior and posterior lobes movable on the middle fixed portion. Length of plastron almost equal to the length of the carapace. The width of the posterior lobe more than one-half the width of the carapace. Suture between the pectorals considerably shorter than that between the humerals.

### **Kinosternon pennsylvanicum**, (Gmelin).

*Eastern Mud Turtle.*

*Testudo pennsylvanica*, Gmelin, 1789, *64*, ed. 13, 1042; *Kinosternon pennsylvanicum*, Holbrook, 1842, *54*, i, 127, pl. 21; *Thyrosternum pennsylvanicum*, Agassiz, 1857, *4*, i, 428, pl. iv, figs. 7–12 (y'g), and pl. v, figs. 16, 17; *Cinosternum pennsylvanicum*, Boulenger, 1889, *84*, 39.

Body oval, not much elevated. The young with three indistinct keels, a median and two lateral; these almost wholly disappearing in the adults; often a depression along the middle of the back. First and second vertebral scutes considerably longer than broad. Plastron well developed, lacking but little of filling up the opening of the carapace. The anterior lobe rounded, extending even beyond the end of the carapace, freely movable on the transverse hinge. Gular plate single, small and triangular. The humerals large, and the suture between them much longer than that between the pectorals. Hinder lobe of plastron movable on the fixed portion; notched behind. Head of moderate size; snout not greatly projecting; lower jaw hooked. Soft skin with a few or no fleshy papillæ; a pair of barbels behind the symphysis of the mandibles. Males with two patches of sharp-edged scales, one above the hollow of the knee, the other below. Tail of the males projecting beyond the shell, ending in a horny curved nail.

Color of the carapace horn-color or brown, with the sutures black. Plastron yellow or brown, with the lines of growth usually very distinct. Soft skin above brownish, with spots of yellow. A yellow stripe from the snout over the eye and back on the neck. Another from the eye to the corner of the mouth and to the angle of the jaw. Skin of the lower surfaces yellow. Size small, becoming probably not more than 5 inches from front to back of carapace.

Distributed from Canada to Florida and west to Texas and Western Kansas. In Indiana it has been taken by Mr. Robert Ridgeway, at Wheatland, in Knox county. Prof. W. S. Blatchley reports to me that he has collected a specimen at Terre Haute. Mr. Ridgway states that it is common on the borders of Monteur's Pond, in Knox county.

Habits.—This tortoise is quite similar to the musk turtle in its mode of life. It remains about ponds and muddy ditches, where it can bury itself in the mud whenever it becomes alarmed. They are more inclined to passively withdrawing into their shells when attacked than is the musk turtle, since the shell forms a more perfect protection and their jaws are not fitted for the infliction of severe wounds. Their food consists of fish, insects and similar small animals. They are said to take the hook readily, but they nibble the angler's bait so slyly that their presence is not observed for some time. Their eggs are similar to those of *A. odorata*, but rather larger. They are laid in similar situations.

## Family X. TESTUDINIDÆ.

Shell completely ossified, varying in form from broad to narrow and from high to depressed. Greatest height about the middle, whence the shell slopes in all directions, flaring at the borders. Carapace with the typical number of scutes, 4, 5, 4, with 25 marginals. Plastron large, composed of 9 bones, the entoplastron being present. Plastral scutes 11 or 12; the pectorals coming into contact with the marginals.

### Key to the Genera of *Testudinidæ*.

A. Parts of the plastron immovably sutured to one another and to the carapace.

a. Alveolar surface of the upper jaw with a median ridge parallel with the cutting edge of the jaw. *Chrysemys*, p. 564.

aa. Alveolar surface without a ridge.

b. Alveolar surface broad. Choanæ even with posterior borders of the orbits. *Malaclemys*, p. 572.

bb. Alveolar surfaces narrow. Choanæ between the eyes. *Clemmys*, p. 576.

AA. Plastron with at least its anterior lobe movable on a transverse ligamentous hinge.

c. Upper jaw not hooked. Shell two-thirds as wide as long. *Emydoidea*, p. 578.

cc. Upper jaw hooked. Shell three-fourths as wide as long. *Cistuda*, p. 579.

### Genus CHRYSEMYS, Gray.

*Chrysemys*, Gray, 1844, *91*, 27; Boulenger, 1889, *84*, 69; *Pseudemys*, Gray, 1855, *25*, 33; *Ptychemys*, *Trachemys*, and *Chrysemys*, Agassiz, 1857, *4*, i, 431, 434 and 438.

Shell moderately depressed. Bridge wide; the axillary and inguinal processes of the carapace (seen in the skeleton) well developed, the latter united to the 5th costal plate. Entoplastron lying wholly in front of the suture between the humerals and the pectoral scutes. Alveolar surfaces of the jaws broad, that of the upper with a median ridge parallel with the cutting edge of the jaw. Choanæ well toward the anterior border of the eyes. Hind legs stout, all the digits webbed beyond the bases of the claws. Skull with a bony arch bounding the eyes behind (temporal arch).

### Key to the Indiana Species of *Chrysemys*.

A. Alveolar surface of the upper jaw broad, with the median ridge tuberculated. Upper jaw slightly or not at all notched in front. (*Ptychemys*, Ag.)

a. Cutting edges of both jaws smooth or nearly so; tubercles of alveolar surface not prominent. Shell quite flat, deeply serrated behind. Plastron with its hinder border distinctly notched. Head small. *hieroglyphica*, p. 565.

aa. Cutting edge of the upper jaw smooth, of the lower serrate. Median ridge of the alveolar surface coarsely tuberculated. Shell serrate behind. Head of moderate size. { *labyrinthica*, p. 566. / *concinna*, p. 567. }

AA. Alveolar surface of upper jaw of moderate width; the alveolar ridge not tuberculated, at most slightly denticulated. Upper jaw with a median notch, but no lateral teeth. (*Trachemys*, Ag.)

a. Head rather small; posterior border of the shell very slightly serrated; plastron with a shallow notch behind. Plastral scutes each with a central blotch and a dark border. *troostii*, p. 568.

aa. Head of moderate size. Shell serrated behind. Plastron with a distinct notch behind. Plastral scutes with a central blotch, their margins not bordered with black. *elegans*, p. 569.

AAA. Alveolar surface of the upper jaw rather narrow, widest behind; the median ridge not prominent. Upper jaw with a notch in front, on each side of which there is a small tooth. (*Chrysemys.*)

a. Costal scutes alternating with the vertebrals, the transverse rows not straight.

b. Costal scutes without red or yellow bands across them. *marginata*, p. 571.

bb. Costal scutes crossed by red or yellow bands. *bellii.* Appendix.

aa. Costal scutes placed even with the vertebrals, the rows across the carapace being straight. *picta.* Appendix.

## **Chrysemys hieroglyphica**, (Holbrook).

### *Hieroglyphic Terrapin.*

*Emys hieroglyphica*, Holbrook, 1842, *54*, i, 111, pl. 17; *Ptychemys hieroglyphica*, Agassiz, 1857, *4*, 1, 434; *Chrysemys hieroglyphica*, Boulenger, 1889, *84*, 76.

Head unusually small; snout somewhat projecting; upper jaw slightly notched in front; both upper and lower jaws smooth or slightly denticulated. Shell greatly depressed, and in large specimens without trace of keel. In specimens five inches long there is a slight keel. Shell sometimes smooth, occasionally longitudinally wrinkled. At its border, especially behind the thighs, the shell flares outward excessively, in some cases producing an actual concavity in the shell above. Hinder margin deeply serrated. The bridge is narrow from front to back, the width being contained in the length of the plastron about three times or more. It rises little toward the carapace, and this contributes to the apparent flatness of the shell. Hinder border of the plastron with a deep notch. Longest suture that between the abdominals; the shortest, that between the humerals. Digits all strongly webbed. Hind feet very large and flat.

The ground color of the carapace varies from olive to dark brown. This is variegated with numerous lines and stripes of yellow. On the vertebrals the lines tend to run longitudinally. On the costals broad yellow bands divide each scute into three or four areas, inside of each of which are narrow concentric lines of the same color. The marginals are marked with yellow and brown. The plastron is yellow, with some splotches of brown on the bridge. The head, neck, feet and tail are all dark green, with numerous longitudinal bands of yellow. The length of the shell of large specimens is 12 inches.

Habitat from Georgia to Texas and north to the Wabash Valley.

Two shells of this species are in the State collection, which were sent from Mt. Carmel, Illinois, on the Wabash River. No doubt it will be found along the whole lower course of the Wabash. In the "Report of the State Geologist of Indiana" for 1875, page 499, Dr. G. M. Levette reports the occurrence of this species in the Kankakee River. Dr. Levette had given considerable attention to the study of our tortoises, and it is quite probable that he was correct in his determination of the species. I have had the opportunity of studying a number of specimens of this species in the National Museum.

Nothing appears to be known concerning the special habits of this terrapin. It is undoubtedly entirely aquatic, as are its immediate relatives.

### **Chrysemys labyrinthica**, (LeS.).

*Emys labyrinthica*, LeSueur, MSS. in *113*, 13; *Malacoclemmys geographica*, in part, Agassiz, 1857, *4*, i, 436; Boulenger, 1889, *84*, 90; *Ptychemys labyrinthica*, G. Baur, MSS.

The type of this species was taken by LeSueur in the Wabash River, probably at New Harmony, and is now in the Museum d' Histoire Naturelle, at Paris. Both Agassiz and Boulenger regarded it as belonging to *Malaclemys geographica*, but it is evidently not this species. Duméril, in his description, states that the lower jaw is denticulated and furnished with a hook which fits into a corresponding depression in the upper jaw. He correctly compares the species with *C. hieroglyphica*, but says that it differs from the latter in the less elongated oval of the carapace and the elevation of the vertebral line, the shell of *hieroglyphica* being much depressed. The species received its name, as said by Agassiz, from the numerous meandering lines upon the bridge of the sternum. Not having seen specimens, I am unable to state how it differs from *C. concinna*. Dr. G. Baur, of Chicago University, to whom I am indebted for notes regarding it, states that the skull is much different from that of all other species. He believes that Prof. H. Garman's specimen from the Wabash River, described as *concinna*, belongs to LeSueur's *labyrinthica*. The two species are closely related, and specimens should be carefully sought along the Wabash and preserved.

### **Chrysemys concinna**, (LeConte).

*The Neat Terrapin.*

*Testudo concinna*, LeConte, 1820, *62*, iii, 100; *Emys concinna*, Holbrook, 1842, *54*, i, pl. 8; *Pseudemys concinna*, Gray, 1855, *25*, 34; *Ptychemys concinna*, Agassiz, 1857, *4*, i, 432, pl. ii, figs. 4–6; *Chrysemys concinna*, Boulenger, 1889, *84*, 83.

Form of the shell somewhat variable in specimens of all ages, some having the greatest breadth at the middle, others at the hinder part; some are depressed, others more elevated. The young have a distinct keel, which is lost in half-grown specimens. The posterior border of the carapace is slightly serrated, the notches being between the scutes. Plastron with its posterior border with a distinct emargination; the hinder lobe not two-thirds the width of the carapace. Bridge wide, rising with moderate rapidity toward the carapace. Head of moderate size, the snout short and blunt. Upper jaw not at all notched in front; the cutting edge smooth; the alveolar ridge strongly tuberculated. Lower jaw with its sheath flat and rough on the outside, the cutting edge coarsely serrated, the tip with a sharp upturned point. Limbs well developed; all the digits webbed beyond the bases of the claws. Claws of the fore limbs of the males very long.

Color of the upper shell olive or brownish, with markings of yellow and dark brown. A yellow band usually runs down the middle of each costal scute. This usually sends off lateral anastomosing branches, which divide off the surface into a few large areas. Within these the yellow and brown are arranged in concentric lines. Both the upper and the lower surfaces of the marginals have eye-like spots of brown and yellow, one located across each suture. Across each scute there usually runs a yellow vertical band. Plastron almost uniform yellow, a few small spots of dusky on the anterior end, and about two on each bridge. Head, neck, legs, and tail brown, with many longitudinal stripes of yellow, or sometimes red. On the head there is a median stripe from the snout to the back of the head; another starting over the eye, widening on the back of the head; a stripe starting at hinder corner of the eye; another originating under the eye; and all, except the median stripe, running back on the neck. The lower stripe is met behind the corner of the mouth by a stripe from the middle of the lower jaw. At the tip of the jaw a stripe begins which further back divides into two, these including another yellow stripe.

The length of the shell may become as much as 16 inches.

The species ranges from North Carolina to Texas and north to Southern Indiana. Prof. Harry Garman, of Lexington, Ky., states (*61*, 1892, 185), that he received a fine, large specimen of this species from Dr. J. Schneck, of Mt. Carmel, Ills.; and he further says that several others have been observed in the same locality. The species will, therefore, be found along the lower part of the Wabash River, and possibly further north.

This species may always be readily distinguished from all others by the smooth edge of the upper jaw and the serrated edge of the lower.

HABITS.—Not much appears to be known about the habits of this terrapin. It is quite common in the waters of the more southern States. Mr. Fred. W. True, of the National Museum, states (*52* i, 155), that it seems to prefer brackish waters. Their diet consists principally of animal matter, and they are reported, in the South, to feed on certain species of worms, which they capture by inserting their claws into the worm-holes in the clay. This seems extremely doubtful. Agassiz found twelve eggs in the oviducts of one specimen. The eggs are of an elliptical form, about an inch and a half long and an inch in the shortest diameter.

### **Chrysemys troostii,** (Holb.).

*Emys troostii*, Holbrook, 1842, *54*, i, 123, pl. 20; *Trachemys troostii*, Agassiz, 1857, *4*, i, 435; *Pseudemys troostii*, Cope, 1875, *12*, 53; *Chrysemys troostii*, Boulenger, 1889, *84*, 76.

Shell only moderately depressed; said by Holbrook to be "greatly depressed." There is only a trace of the keel in the adults. Behind the bridge the shell flares outward, but not so much as in *C. hieroglyphica*. The posterior border is only slightly serrated. The upper surface is, in adult specimens, somewhat wrinkled. The plastron has a broad shallow notch behind. The bridge is wide, but does not rise much toward the carapace. The longest suture of the plastral scutes is that between the abdominals, the shortest that between the humerals. The head is relatively small, flat above, and pointed. The cutting edge of the upper jaw is convex on each side, with a slight nick in front; the alveolar ridge is low and smooth. Lower jaw ending in a turned up tip. Fore and hind limbs well developed; the digits all completely webbed; the claws of the fore foot of the males very long and curved. The tail of the males very long.

The ground color of this species may be regarded as greenish horn-color above, yellow below. The scutes of both the carapace and the plastron are bordered with dark brown. On the carapace, within the areas thus formed, there may be a little black in splotches. Or this may increase in amount until nearly the whole scute is covered. This is especially true on the hinder half of the shell. On the plastron, besides the dark margin, each scute may have a central spot of black, and this by expanding may occupy most of the surface. This is also more likely to be the case on the hinder end of the plastron. On each of the two anterior scutes there is an eyelike spot, consisting of a circle of black inclosing another of the same color. The yellow of the plastron is to a considerable extent replaced by red. The soft skin of the head and upper side of neck is olive or dusky, varied with numerous fine anastomosing lines of pale yellow. At the back of the eye a stripe begins and runs back on the neck. This stripe is bright red, not well defined along the edges, but seeming to run into the surrounding dark color. In some cases the whole of the back of the head is red. The feet, legs, tail and lower side of the neck are ornamented with broad yellow or green stripes.

The length of the shell may reach 9 inches, probably more.

Mississippi River and its tributaries from the Gulf to Northern Missouri. It has been sent to the National Museum from Wheatland, Ind., by Mr. Robert Ridgway, to whom we are indebted for knowledge of many rare reptiles of this State.

This is a very beautiful and a characteristically marked species. It may readily be distinguished from *C. elegans* by the brown borders of all the scutes, and the absence of yellow stripes on the carapace. Both have a blood-red stripe along the neck.

HABITS.—Little is known, beyond the fact that it is aquatic. It presents a good subject for study to herpetologists who live on the lower reaches of the Wabash.

### **Chrysemys elegans,** (Wied).

*Elegant Terrapin.*

*Emys elegans*, Wied, 1839, *63*, i, 213; *Trachemys elegans*, Agassiz, 1857, *4*, i, 435, pl. iii, figs. 9–11; *Pseudemys elegans*, Cope, 1875, *12*, 53; *Chrysemys scripta*, var. *elegans*, Boulenger, 1889, *84*, 78.

Shell broad and depressed, the young with a moderate keel, which disappears in the adults. Carapace serrated behind; a slight emargination in each scute and deeper ones between them. Surface of the costal scutes smooth or sometimes slightly wrinkled longitudinally. Nuchal scute very narrow. Plastron with its posterior border with a broad shallow notch; the width of the hinder lobe being hardly two-thirds the width of the carapace. Bridge wide, rising rapidly to the margin of the carapace. Longest suture of the plastron that between the abdominals, the shortest that between the humerals. Head of moderate size; snout short and rather blunt. Edge of upper jaws convex along the sides, notched in front; smooth; the alveolar surface with a low smooth ridge. Lower jaw smooth or slightly denticulated. The tip curved upward. Limbs well developed; all extensively webbed; claws of forefoot of males very long and somewhat curved. Tail of moderate length.

Color of the carapace olive, with lines and spots of yellow and black. On the vertebral scutes the lines run mostly lengthwise, on the costals transversely. Down the middle of each costal scute runs a yellow band of varying width. Parallel with it are other lines and bands of black and yellow, narrow or wide. On both the upper and the lower surfaces of the marginal scutes are sutural spots consisting of concentric circles of yellow and black. Between them a yellow band crosses each marginal. The plastron is yellow, with a black blotch on each scute, these often ocellated with yellow. The spots on the bridge usually confluent. Head with numerous narrow stripes of greenish or yellow. A broad stripe starts under the eye and runs back on the neck, being met at the angle of the jaw by a stripe from the middle of the lower jaw. Another stripe, often blood-red, starts at the posterior corner of the eye and runs back on the neck. The stripe is wanting which in *C. concinna* starts above the eye and extends on the neck. The legs and tail are striped with yellow.

Length of the shell in large specimens about 10 inches.

This species has been found inhabiting the territory from South Carolina to Mexico, and north along the tributaries of the Mississippi to the Yellowstone. In Indiana it has been taken at New Harmony (Sampson's coll.); in the Wabash River at Mt. Carmel, Ills. (L. M. Turner). The species was originally described by Max Von Wied from specimens taken near New Harmony. About July 1, 1892, I took a specimen in the Tippecanoe River at Winamac.

Dr. Boulenger, as above cited, regards this terrapin as only a variety of *C. scripta* (*Trachemys scabra*, Ag.). However, at present it appears to me that there are sufficient differences in both the young and the adults of the two forms to justify their being regarded as distinct species. Their geographical distribution is likewise different. The specimen of *C. elegans* reported by Dr. Yarrow (*10*, 33) from Oakley, S. C., is a young *C. scripta.*

Habits.—Quite as little is known about the manners of life of this species as of most of the other aquatic turtles. Agassiz figures the egg. It is elliptical in form, an inch and a half in its long and seven-eighths in its short diameter. This naturalist has also observed that this turtle has a voice, as he believed most turtles have. It is said to "emit a piping note." Dr. J. Schneck, of Mt. Carmel, Ills., kept a young *elegans* for more than two years, during which time it partook freely of food, but made no perceptible growth. Prof. F. W. Craigin (*49*, 1, 101) thinks that these and other turtles are sometimes killed by minks and other carniverous animals. To the attacks of such enemies may be due the great timidity of turtles, which seem to have so few enemies.

### Chrysemys marginata, Ag.

*Western Painted Tortoise.*

*Chrysemys marginata*, Agassiz, 1857, *4*, i, 439, pl. i, fig. 6 and pl. v, figs. 1–4; *Chrysemys cinerea*, Boulenger, 1889, *84*, 73.

Shell broad and depressed, broadest behind the middle; the shell flaring considerably posteriorly; its surface very smooth; no traces of a keel, even in the young. Scutes of the carapace arranged as usual among tortoises, the suture between the costals meeting the lateral border of the proper vertebral about its middle. Vertebrals 2 and 3 wider than long, but narrower than the costals. Anterior border of the carapace often with a few dentations; the posterior border not serrated. Plastron broad and flat, truncated before and behind; the anterior end often denticulated. Bridge wide, flat, and rising rather rapidly to the margin of the carapace. Head of moderate size; snout not much projecting. Jaws with smooth cutting edge, the front with an evident notch, on each side of which is a small tooth. Alveolar ridge feeble. Lower jaw little upturned. Limbs with moderate development; the digits webbed to the claws. Tail of moderate length, that of the males longest.

The color of the carapace is usually dark green. The hinder border of the costal and vertebral scutes is narrowly bordered with black. On the anterior border of the same scutes, and lying immediately against the black margin, are slightly wider lines of bright red (yellow in alcoholic specimens). These red or yellow lines do not join so as to form straight lines across the back. A very narrow line of red runs along the middle of the back. Upper surfaces of the marginal plates with many crescent-shaped marks of bright red. Lower surfaces of the marginals black, with large splotches of blood-red and bright yellow. Plastron bright yellow or brownish red, with a large dusky blotch occupying its central portion. Soft skin of head, legs and tail dark olive, with red stripes. On the occipital region are two large waxy yellow spots, nearly as large as the eye; these prolonged backward into two narrower pale yellow stripes. Another short yellow stripe from the upper corner of the eye; another from the lower side of the eye and running back on the neck. Two red stripes on the front of the fore legs, and similar ones on the posterior surfaces of the thighs. Besides these, there are numerous small spots of red all over the soft parts. All the red fades to yellow in alcohol.

The usual length of the shell is about 4 or 5 inches; a length of 7 inches may be attained. This species is an inhabitant of the Northern

States of the Mississippi Valley from Ohio to Kansas, and north to Lake Superior. In Indiana it is to be found everywhere. I have proofs of its occurrence at so many points that it seems unnecessary to state them.

HABITS.—This is at once our most beautiful and most common species of tortoise. It is, however, probably less well known than the Snapping-turtle, because of its strictly aquatic mode of life and its excessive timidity. It appears to prefer to abide in ponds, pools, and the sluggish parts of our streams. In such places it may be often seen lying with its fellows on some fallen tree-trunk or on some projecting stone, basking in the sunshine. The senses of sight and hearing appear to be acute, for it easily takes alarm and tumbles into the water and disappears. It is then often to be found buried in the mud close to where it entered the water. It is an entirely harmless turtle, and can hardly be provoked to bite, and its effort is then a feeble one. The food of the Western Painted Turtle probably consists of insects, tadpoles and other feeble and small animals.

Smith (*18*, 665) states that in Michigan this turtle has been found out of its winter quarters as late as October 22, and in the spring on March 31. From tortoises that have been marked, it appears that all these animals wander but short distances from where they have been hatched. According to Agassiz' figures, the eggs of this tortoise are about an inch and a quarter long and nearly seven-eighths in the shorter diameter. Many interesting things are to be found concerning the closely related *C. picta* in Agassiz' work on the Testudinata of North America (*4*).

### Genus MALACLEMYS, Gray.

*Malaclemys*, Gray, 1844, *91*, 28; 1855, *25*, 37; *Graptemys* and *Malacoclemmys*, Agassiz, 1857, *4*, i, 436, 437; Boulenger, 1889, *84*, 88.

Shell depressed, with a distinct keel. Bridge wide, with the axillary and inguinal processes well developed, the latter united to the 5th costal plate. Entoplastron lying wholly in front of the suture between the humerals and pectorals. Jaws with the alveolar surface broad to very broad and entirely without a median ridge. Choanæ behind the level of the eyes. Skull without a bony temporal arch. Digits extensively webbed.

Keel strongly tuberculated; an elongated, transverse, yellow streak behind each eye. Carapace strongly serrated behind. *pseudogeographica*, p. 573.

Keel not tuberculated; a triangular yellow spot behind each eye. Carapace feebly serrated behind. *geographica*, p. 574.

**Malaclemys pseudo-geographica**, (LeS.).

*LeSueur's Map Tortoise.*

*E. pseudogeographica*, LeSueur, MSS. in Holbrook, 1842, *54*, i, 103, pl. 15; *Graptemys lesueurii*, Agassiz, 1857, *4*, i, 436, pl. 2, figs. 10–12; *Malacoclemmys lesueurii*, True, 1875, *10*, 34; Boulenger, 1889, *84*, 91 (not *Emys lesueurii* of Gray).

Shell oval, depressed, rising roof-like to the distinct medial keel. Posterior border of some or all of the vertebral scutes with each a prominent tubercle, largest on the 2d and 3d vertebrals. Shell strongly serrated behind. Nuchal with a notch in its hinder border. Plastron with its hinder lobe not much over one-half the width of the carapace; a broad shallow notch in its hinder border. Bridge broad and flat, rising little toward the carapace. Head of the males small; that of the females rather large. Snout not at all projecting. Cutting edge of the upper jaw smooth, convex, the jaw not notched in front; the alveolar surface of moderate width, wholly separated in front by soft skin. Lower jaw with smooth, concave cutting edge, not hooked at the tip. Limbs well developed, the digits webbed to the bases of the claws. Tails of the males, as with most turtles, bringing the vent beyond the edge of the carapace.

The color of the upper surface of the carapace is olive or occasionally brownish. Usually there are no black spots on the carapace; but occasionally there is a blotch, as if made with the inked end of the finger, on each of the larger scutes and on most of the marginals. Over all the scales there is a network of greenish lines, often obscure, which divide each scute into about 4 or 5 areas. The plastron is yellow, with a little clouding or mottling of brown, or with many irregular and obscure stripes and lines of dark color. Bridge almost uniform brown or with numerous streaks of yellow and brown. Head, neck, limbs, and tail dark green, with many stripes of yellow, and many rows of small yellow spots. Behind the eye there is a very characteristic transverse streak of yellow, sometimes short, sometimes turned forward beneath the eye. When the streak is short, there is a yellow dot under the eye.

The shell of this species may reach a length of 10 inches. Adult female specimens will average 8 inches or less; males usually smaller.

This is a species belonging to the Mississippi Valley, ranging from Ohio to Kansas, south to Louisiana, north to Wisconsin. It doubtless occurs throughout the State of Indiana; nevertheless, I did not find it at Lake Maxinkuckee, and Dr. Levette does not give it in his list of turtles found in the northern part of the State. It is abundant about New Harmony (LeSueur, Max. V. Wied, and Sampson's coll.); found at Brookville (Hughes); Terre Haute, rare (Blatchley); Monroe county (Bollman).

This species is quite distinct from *M. geographica*, as shown by the much narrower alveolar surfaces of the jaws, the strongly tuberculated vertebral scutes, the more distinct keel, the transverse streak behind the eye, the coarser network of lines on the carapace, and the greater amount of brown on the plastron. Some authors, among them recently Dr. Boulenger and Prof. Harry Garman (*42*, xxii, 70) have given as distinctive characters the large head of *geographica* and the smaller head of *pseudo-geographica*. The size of the head is a sexual character in both species, the males having a small head, the females a large head. Females of the two species of the same size have heads of approximately the same width, and the same is true of the males. Of this I have satisfied myself by measurement of specimens in the National Museum and in my own collection. The head is, however, variable in relative size in different individuals of the same sex. Moreover, it will be found, I think, that the males average considerably smaller in size than do the females.

HABITS.—This is an eminently aquatic tortoise, spending its life in rivers, lakes and ponds, and coming out of the water only to bask in the sun on some rock or fallen tree, or to deposit its eggs. The food of LeSueur's Map-Turtle has hitherto been regarded as animal in nature, such as small fishes, reptiles and the like, but Prof. Garman states that the digestive canal of most of the specimens that he observed were filled with the bulbs of a sedge. In some cases, however, it was found to have eaten crayfishes. The eggs are large, being an inch and a half in the longest and an inch in the shortest diameter. According to Agassiz this species deposits its eggs earlier in the season than any others of our turtles. At Natchez, Miss., one was found to have laid her eggs as early as the first of June. It may here be stated that Agassiz concluded that our fresh-water turtles do not lay eggs before the eleventh or fourteenth year.

This species does not appear to be employed to any considerable extent as food, yet there seems to be no reason why its flesh should not be as savory as that of many species which are highly esteemed.

### **Malaclemys geographica,** (LeS.).

*Geographic Terrapin; Map Tortoise.*

*Testudo geographica*, LeSueur, 1817, *2*, 86, pl. v; *Emys geographica*, Holbrook, 1842, *54*, i, 99, pl. xiv; *Graptemys geographica*, Agassiz, 1857, *4*, i, 436, pl. ii, figs. 7–9; *Malacoclemmys geographicus*, Cope, 1875, *12*, 53; Boulenger, 1889, *84* 90; *Emys lesueurii*, Gray, 1831, *112*, 31.

Shell depressed, and keeled in small individuals, becoming more elevated, higher and more rounded in full grown adults. Keel with rudimentary tubercles, this evidence of the keel persisting even in adults.

Carapace feebly serrated posteriorly. Nuchal narrow, its hinder border notched. Carapace rounded behind in the females, more pointed in the males. Plastron with its posterior lobe about two-thirds the width of the carapace; distinctly notched behind. Bridge wide, rising little toward the carapace. Limbs well developed, scaly, the digits well provided with webs. None of the claws of the male much elongated. Head of the males small, that of the females large. Snout not at all projecting. Upper jaw with the cutting edge smooth, somewhat sinuated, not notched in front; the alveolar surface very broad, united with its fellow back nearly to the choanæ. Lower jaw flat, its alveolar surface resembling that of the upper jaw. The jaw not hooked at the tip.

Ground-color of the carapace dark olive. Over all the scutes there is a network of greenish lines, so that each of the large scutes is divided into about 8 to 10 areas. Under side of the marginals with sutural spots of dark green, which enclose irregular lines of yellow. Head, neck, limbs and tail dark green, almost black, with numerous lines and streaks of greenish yellow. Behind the eye is a somewhat triangular spot of greenish yellow, often elongated backward. Plastron yellow, with the sutures of the scutes marked with a dark line. Occupying the center of the plastron is a large lyriform blotch of brown, which looks as if the color had almost faded out.

The size of this species averages larger than that of *M. pseudo-geographica*, full grown specimens being about 10 inches long. It may become still larger

This species is distributed from Pennsylvania and New York to Michigan and Arkansas. It is found no doubt in all the streams and lakes of Indiana. Known localities are New Harmony; Brookville; North Manchester, Wabash county (A. B. Ulrey); Lake Maxinkuckee; Eel and St. Joe rivers; Terre Haute (Blatchley); Fall Creek, Marion county (W. P. Hay); Kankakee River at English Lake; Tippecanoe River at Winemac.

This turtle can be readily distinguished from any other species occurring in Indiana by the extremely expanded masticatory surface of the jaws. From *M. pseudo-geographica* it may be distinguished by the reduced keel, especially of the large females, the rudimentary tubercles of the keel, and especially by the triangular spot behind the eye. As stated in the description of *M. pseudo-geographica*, it is the head of the female that is large; that of the male is little, if any, larger than males of the same size of *pseudo-geographica*. My observation is that the females are usually much larger than are the males. Dissections made of 7 specimens taken at Lake Maxinkuckee showed that 4 were females, all with carapace more than 6 inches long; the others were not over 4 inches long, and all were males. I think that males may become somewhat larger than these, but not nearly so large as the largest females.

Habits.—The mode of life of the Map Turtle is as thoroughly aquatic as that of its relative, *M. pseudo-geographica*. It probably never, unless compelled to do so, leaves the immediate vicinity of its native stream. Holbrook states that it is bolder and more active than most other turtles, those that he had seen approaching even the snapping turtles in their disposition to bite when disturbed. The food of this species consists of animals of various kinds. Prof. Harry Garman (*42*, xxii, 70) states that an examination of the contents of the alimentary canal showed that the food consisted exclusively of mollusks, the young eating the thinner shelled species, the adults the larger and thicker shelled kinds. At Lake Maxinkuckee three persons caught about 30 specimens of this species in a few hours. Without probably an exception they were found near the shores, where there were great numbers of the water-breathing univalves. After a number had been kept for a few days in a tub there were found in it large numbers of the opercles of such mollusks; and in the intestines of one were the remains of a crayfish, some fish scales, and what appeared to be the cases of some kind of caddis-worm. Its broad masticatory surfaces are well fitted for crushing the shells of mollusks.

The eggs of this species, as figured by Agassiz, appear to be somewhat smaller than those of LeSueur's tortoises. I have found 16 eggs in a large female. DeKay states that the flesh of this tortoise is good for food. Where they are abundant they might be turned to good account.

### Genus CLEMMYS, Wagler.

*Clemmys*, Wagler, 1830, *75*, 136; *Boulenger*, 1889, *84*, 100; *Nanemys*, *Calemys*, *Glyptemys*, etc.; Agassiz, 1857, *4*, i, 442 seq.

Shell moderately to strongly depressed. Bridge wide, with strong axillary and inguinal processes of the plastron just reaching the 1st and 5th costal plates. Entoplastron crossed by the suture between the humerals and the pectorals. Alveolar surfaces of the jaws narrow and without a median ridge. Choanæ toward the front of the eyes. Skull with a bony temporal arch. Digits more or less extensively webbed.

### **Clemmys guttata,** (Schneider).

*Speckled Tortoise.*

*Testudo guttata*, Schneider, 1792, *120*, x, 264; *Emys guttata*, Holbrook, 1842, *54*, i, 81, pl. 11; *Nanemys guttata*, Agassiz, 1857, *4*, i, 442, pl. i, figs. 7–9; *Chelopus guttatus*, Cope, 1875, *12*, 53; *Clemmys guttata*, Boulenger, 1889, *84*, 109.

Shell oval, widest behind, rather depressed, no traces of keel in the adult, little trace even in the young. Nuchal scute very narrow. Plastron large; the hinder lobe about three-fourths the width of the carapace, with a shallow emarganation in the posterior border. The anterior lobe truncated, not movable on a transverse hinge. Bridge rather narrow, not more than half the width of the hinder lobe of the plastron, rising rather rapidly to the carapace. Plastron of the male concave. Head of moderate size, covered with a hard smooth skin. Snout not at all projecting. Upper jaw notched in front; the alveolar surface very narrow. Lower jaw with the sheath externally very wide; the tip upturned. Choanæ well forward, under the front of the eyes. Legs and feet all covered with scales, those of the front limbs large and overlapping. Feet not large, the claws rather short, the web not extensive. Tail long, that of the male bringing the vent beyond the carapace.

The general color of the carapace is black. Sometimes there appear to be patches of reddish brown showing through the darker. On each scute there appear from one to a dozen round spots of bright orange, each larger than the pupil. The plastron is red, orange and black, the black generally predominating. The orange usually occupies the center of the plastron and the margin. Head above black, with orange dots. Generally there is a large spot of orange just above the ear. The neck is black, with more or less red mingled therewith. The shoulders are extensively red or orange. The upper surfaces of the limbs are black, with dots of yellow and red; the lower surfaces red and orange. The tail is black, with red at the base. Length of shell 4 or 5 inches.

Distribution from New England to North Carolina, west to Indiana. In this State it appears to be found only in the northern portion among the numerous lakes, streams and swamps found there. Dr. G. M. Levette first found it in that region, reporting it as occurring "in ditches around Kendallville, and doubtless over the whole region." Two specimens were picked up one morning at Lake Maxinkuckee in May, 1891, by members of the Indiana Academy of Science. Taken also at Rochester, Fulton county, by Dr. Vernon Gould; English Lake (Dr. Baur).

HABITS.—This little turtle is less exclusively aquatic than any of those that have been described, except the snapping-turtle. It seems to delight in being in the neighborhood of swamps and sluggish streams, and it probably spends the greater part of its time in the water. Nevertheless it often leaves the water, and it may be picked up while it is making its journeys. It is a very harmless animal, and deserves protection. Holbrook says that it is timid and gentle, and can easily be domesticated. When at freedom they collect in numbers on objects above the water and enjoy the sunshine; but if any fancied enemy is seen approaching they slide off rapidly into the water and soon bury themselves in the mud. Their food is said to consist of tadpoles, young frogs and other weak animals. On land they devour earthworms, crickets and grasshoppers.

Their eggs are few in number; never, according to Agassiz, exceeding three or four. They are about an inch and a quarter long and three-quarters in the shorter diameter. The eggs are laid about the 20th of June, in a perpendicular hole dug by the use of the hind legs. After the eggs are deposited the dirt is pushed back over the opening so as to conceal it entirely.

### Genus EMYDOIDEA, Gray.

*Emys*, Duméril, 1806, *119*, 76; Agassiz, 1857, *4*, i, 441; Boulenger, 1889, *84*, 114; *Emydoidea*, Gray, 1870, *25*, Sup. 19; Baur, 1890, *22*, xxiii, 1099.

Shell moderately elevated. Bridge narrow, the plastron not sutured to the carapace, but united to it by ligament; therefore, more or less movable on it. Plastron divided by a transverse hinge at front end of bridge into two lobes, which are movable on each other. Axillary and inguinal processes of the plastron short, the latter just reaching the fifth costal plate. Entroplastron reaching but hardly intersected by the suture between the humerals and the pectorals. Alveolar surface narrow, without a median ridge. Choanæ between the eyes. Skull with a bony temporal arch. Digits webbed.

According to Dr. Baur, this genus differs from the Old World *Emys* in that the frontals enter the orbits, and the rib-heads are long, as in *Chelydra*.

### **Emydoidea blandingii,** (Holb.).

*Blanding's Tortoise.*

*Cistuda blandingii*, Holbrook, 1842, *54*, i, 39, pl. 3; *Emys meleagris*, Agassiz, 1857, *4*, i, 442, pl. iv, figs. 20–22; *Emys blandingii*, Boulenger, 1889, *84*, 114; *Emydoidea blandingii*, Gray, 1870, *25*, sup. 19; Baur, 1890, *22*, xxiii, 1099.

Shell elongated oval, widest just behind the middle; rather high, convex, and without keel. Carapace not serrated behind. Plastron large, entirely closing the shell; movable on carapace on the ligamentous hinges, the two lobes movable on each other on a transverse hinge covered by the suture between the pectorals and the abdominal scutes; the posterior lobe somewhat excavated behind. Posterior border of the entroplastron reaching the humero-pectoral suture, but not intersected by it. Bridge narrow and very short, almost obliterated Head long and wide, the eyes opening somewhat upward. Upper jaw with the cutting edge convex at the sides and notched in front. The alveolar surface narrow. Lower jaw with narrow alveolar surface and with a hooked tip.

Limbs, including the feet, scaly; the toes short and provided with a narrow web. Tail covered with scales; that of the male about two and two-thirds times in the length of the shell, that of the female shorter.

Color of the shell above, dark green to black, each scute with several round, triangular or oblong spots of yellow or orange, those of the marginals largest; all, however, sometimes wanting. Plastron yellow, with the outer posterior portion occupied by a blotch of brown. This blotch may expand so as to take in almost the whole scute. Head and neck above and along the sides dusky, with numerous yellow dots; chin, throat and under side of the neck yellow. Legs yellow, with mottlings of brown. Tail striped longitudinally with yellow and brown.

The carapace may attain a length of nine inches, but this is uncommon.

This species is wholly Northern in its distribution, being found from Massachusetts and Canada to Northern Illinois. In Indiana it occurs only in the region of lakes in the northern portion. Dr. Levette (*93*, 1875, 499) reports it as occurring "sparingly in the northern parts of Lagrange and Steuben counties." A live one was seen at Lake Maxinkuckee in May, and I have a shell of one that was taken at Rochester, Fulton county, by Dr. Vernon Gould, of that place. It does not appear to be rare in that region. It is also common at English Lake, in Starke county.

HABITS.—Not much accurate information has been gathered concerning the habits of this tortoise. It is probably somewhat less aquatic than the speckled tortoise, *Clemmys guttata*, yet it undoubtedly prefers the neighborhood of streams and ponds. I find no account of its food, but this is probably of an animal nature. Its eggs, as figured by Agassiz, are large and oval, measuring an inch and three-eighths by almost an inch. There are from seven to nine of them laid together once a year. The shell is thick, smooth and hard. According to Agassiz's figures there are no yellow or orange dots on the shell of the very young. In this respect they are in contrast with the young of *Clemmys guttata*, which are said to have the spots developed long before leaving the egg, even before the lungs are developed.

This species is to be distinguished from the box-tortoise by the more elongated, less elevated and less convex shell, the posteriorly notched plastron, and absence of anything like a hook to the upper beak.

### Genus CISTUDA, Fleming.

*Cistuda*, Fleming, 1822, *115*, ii, 270; *Cistudo*, Bonaparte, 1830, *116*, 162; Agassiz, 1857, *4*, i, 444; Boulenger, 1889, *84*, 115.

Shell high and very convex. Plastron united to the carapace by ligament and movable on it; the axillary and inguinal processes rudimentary. Plastron divided by a transverse hinge into two movable lobes, the hinge covered by the suture between the pectoral and abdominal scutes. Entoplastron cut by suture between the humerals and the pectorals. Alveolar surface of jaws narrow, without median ridge.

Upper jaw with the beak projecting downward, notched or not. Choanæ between the eyes. Skull without a bony temporal arch. Digits with short or no web.

Shell with traces of a keel, rounded above; no bridge.
*carolina*, p. 580.

Shell without traces of a keel, flat above; a distinct bridge.
*ornata*. Appendix.

**Cistuda carolina,** (Linn.).

*Box Tortoise.*

*Testudo carolina*, Linnæus, 1758, *64*, x, 198; *Cistudo carolina*, Gray, 1831, *112*, 18; Holbrook, 1842, *54*, i, 31, pl. 2; Boulenger, 1889, *84*, 115; *Cistudo virginea*, Agassiz, 1857, *4*, i, 445, pl. iv, figs. 17–19.

Shell broadly oval, sometimes four-fifths as wide as long; high and very convex; extremely solid. On at least the posterior part of the carapace are evidences of a keel; this in the young quite distinct. Margin of the carapace sloping rapidly upward from transverse hinge of the plastron. Plastron large, tightly closing the opening of the carapace, consisting of two lobes movable on each other and the carapace. The bridge entirely abolished; no axillary or inguinal scutes. The plastron rounded in front and behind. Head of moderate size, the snout not projecting; upper jaw with the cutting edge drawn down in front into a hooked beak, the hook not notched; the alveolar surface narrow. The lower jaw turned upward at the tip. Limbs and feet scaly, especially the anterior. Claws stout; the web between the digits narrow. Tail short. Scutes sometimes very smooth, sometimes showing distinctly the concentric lines of growth.

The colors of the carapace are yellow and brown or black. Sometimes the darker color predominates, sometimes the yellow. Usually the ground is brown or reddish brown, while the yellow appears as spots of various shapes; often radiating from the point of growth of the scute. The ground color may appear to be yellow, relieved with black spots. The plastron is variously ornamented with black and yellow. The young have a single yellow spot on each of the scutes of the carapace. The head, neck, limbs, and tail are brown, with numerous spots of yellow and orange. Often the scales of the fore-legs are especially bright yellow.

The length of the carapace is about 4 or 6 inches in full grown examples.

This tortoise is distributed from New England to the Gulf and westward to Texas. It inhabits the whole of Indiana, and appears to be especially abundant in the southern portion. New Harmony (Sampson's coll.); Brookville (Hughes and Butler); Monroe county (Bollman); Terre Haute (Nor. Sch. coll.); Lafayette and Westfield (F. C. Test); Jefferson, Marshall, and Marion counties (Hay); Wabash county (C. Ridgley).

HABITS.—This species is a thoroughly terrestrial animal; so much so that the statement has been made that it never goes near the water, can not endure even rain. This is a mistake, however, as I have seen the tortoise in a small, shallow rivulet which it might easily have avoided. On the other hand, it appeared to be enjoying the bath. Mr. Ed. Hughes of Brookville tells me that he too has seen them in the water; but also that he has seen them dead in deeper water, as though they had drowned. Considering the great thickness and weight of their shells it is not to be thought that they can swim readily or even at all.

These animals are entirely harmless, and when disturbed, retire within the shell and submit passively to their captor. They may be regarded as comparatively feeble animals, and in their thick, strong shells, which may be almost hermetically closed, we see a due compensation for their indifferent powers of self-defense.

The food of the box-tortoise appears to be of a mixed nature. Holbrook states that it feeds on insects, such as crickets, etc.; but he mentions LeConte's statement that they feed on fungi, such as *Clavaria*. Mr. Ed. Hughes of Brookville says that he dissected one and found in its stomach what appeared to be vegetable matter, but no insects. Max. Von Wied states (*103*, xxii, 6) that they greatly love cucumbers and lettuce, and do great injury to these plants. They are said to be very fond of mushrooms. Holbrook further says that this tortoise may be easily domesticated, and will eat whatever is offered it, as bread, potatoes, apples, etc. The notion that it will destroy mice and serpents as food he properly regards as improbable. The eggs of this species are of the usual shape, oval, about an inch and a half by three-fourths of an inch. They number from four to six, have a rather thin shell, and are laid about the latter part of June or later. During the winter these tortoises, like all others in our climate, remain buried in the earth. They appear to have been favorites for persons who attempt to secure immortality of name by engraving their names on terrapins' backs. From this practice something has been learned of their longevity. Dr. J. Schneck of Mt. Carmel, Ills., states (*22*, 20, 897,) that one at Albion, Ills., had had some initials engraved on it in 1824. It was found in the same vicinity in 1865, and marked with an additional letter. Again in 1885 it was seen within a half mile of the spot where it was liberated 20 years before. All the markings were quite distinct. Other cases of the kind prove that this tortoise lives a long time, and furthermore that it does not wander far from its early home.

# APPENDIX.

The following species seem to require description here on account of the fact that they have been found not far from the borders of Indiana, and may, therefore, yet be taken within our limits.

### **Ambystoma xiphias,** (Cope).

*Sword-tailed Salamander.*

*Amblystoma xiphias*, Cope, 1866, *1*, 192; 1889, *51*, 87, with figures; Boulenger, 1882, *28*, 45.

The only known specimen of this species is in the National Museum, and was taken at Columbus, Ohio. It is a very close relative of *A. tigrinum.* The head is narrower, the width being contained in the distance from the snout to the groin 4.5 times. The lower jaw projects prominently beyond the snout. The tail is longer than in most specimens of *A. tigrinum*, being considerably longer than the rest of the animal. The color, also, is different, yellow predominating in *A. xiphias*, dusky in *A. tigrinum.* Any specimens of apparent *tigrinum* which have peculiarities approaching those here mentioned should be carefully preserved and examined. Prof. W. S. Blatchley has shown me a specimen from Terre Haute which has the color peculiarities of *xiphias*, but it lacks the projecting jaw and the very long tail. It appears to be a true *A. tigrinum.*

### **Ambystoma talpoideum,** (Holbrook).

*Mole Salamander.*

*Salamandra talpoidea*, Holbrook, *54*, v, 73, pl. 24; *Amblystoma talpoideum*, Cope, 1889, *51*, 52, with figures; Boulenger, 1882, *28*, 40.

Most of the known specimens of this species are from the Southern States, but it has been sent to the National Museum by R. Kennicott, from about Cairo, Ill. It is, therefore, to be sought for in the southwestern portion of our own State.

It is the smallest, stoutest, and most clumsily constructed of the species of the genus. The head is described as being broad and large, the width being contained in the length to the groin 3.5 times. There are only ten costal grooves. The tail is very short, being contained in the rest of the length 1.5 times. The color is a light brown, paler below, with sprinklings and marblings of silvery or leaden gray. There are some obscue dark spots on the back and tail. The length of the animal when full grown is less than four inches. Prof. Cope states that it lives in damp places below logs and stones.

**Plethodon æneus**, Cope.

*Bronzy Salamander.*

Cope, 1881, *22*, 878; 1889, *51*, 143.

Form and proportions as in *P. glutinosus.* Vomero-palatine patches in two straight lines, which do not pass out behind and beyond the choanæ. Costal grooves 13. The color is black, but the upper surface is thickly spotted with large, yellowish-green blotches. These occupy almost the whole surface of the head. The spots on the sides are considerably smaller. The lower surface is dusted with yellow.

This species was described from a single specimen which was found by Prof. Cope at the mouth of Nickajack Cave, located at the point where the three States of Georgia, Alabama and Tennessee adjoin. Dr. L. Stejneger informs me that the species has more recently been found in Lee County, Virginia.

Genus GYRINOPHILUS, Cope.

*Gyrinophilus*, Cope, 1869, *1*, 108; 1889, *151*, 154.

Vomero-palatine teeth in two transverse series which pass out beyond the choanæ. Parasphenoidal teeth present, in two parallel bands, these meeting the vomero-palatines at a right angle. Tongue with a free edge all around and standing on a central stalk. The premaxillary bones not ankylosed. Digits 4–5.

**Gyrinophilus porphyriticus**, (Green).

*Salmon Triton.*

*Salamandra porphyritica*, Green, 1827, *102*, i, 3; Cope, 1889, *51*, 155; *Spelerpes porphyriticus*, Boulenger, 1882, *27*, 64.

The type of this genus is *G. porphyriticus* (Green). This is a native of the Alleghany Mountains from the Adirondacks to Georgia, but since it has been reported from Columbus, Ohio, it is possible that it may yet be found in Indiana. I therefore add a short description of it. For further details regarding it see Cope's "Batrachia of North America."

Body elongated, slender and depressed; there is little constriction at the neck, and the tail tapers gradually to tip. The head is flat, and the upper jaw projects beyond the lower. There is a prominent ridge running from the eye to the edge of the jaw outside the nostril. The eyes are large and prominent. There are sixteen costal grooves, not counting one immediately in the axilla. There is also a distinct dorsal groove. The limbs are rather weak and widely separated. The inner digits are rudimentary.

# APPENDIX.

The following species seem to require description here on account of the fact that they have been found not far from the borders of Indiana, and may, therefore, yet be taken within our limits.

### Ambystoma xiphias, (Cope).

*Sword-tailed Salamander.*

*Amblystoma xiphias*, Cope, 1866, *1*, 192; 1889, *51*, 87, with figures; Boulenger, 1882, *28*, 45.

The only known specimen of this species is in the National Museum, and was taken at Columbus, Ohio. It is a very close relative of *A. tigrinum*. The head is narrower, the width being contained in the distance from the snout to the groin 4.5 times. The lower jaw projects prominently beyond the snout. The tail is longer than in most specimens of *A. tigrinum*, being considerably longer than the rest of the animal. The color, also, is different, yellow predominating in *A. xiphias*, dusky in *A. tigrinum*. Any specimens of apparent *tigrinum* which have peculiarities approaching those here mentioned should be carefully preserved and examined. Prof. W. S. Blatchley has shown me a specimen from Terre Haute which has the color peculiarities of *xiphias*, but it lacks the projecting jaw and the very long tail. It appears to be a true *A. tigrinum*.

### Ambystoma talpoideum, (Holbrook).

*Mole Salamander.*

*Salamandra talpoidea*, Holbrook, *54*, v, 73, pl. 24; *Amblystoma talpoideum*, Cope, 1889, *51*, 52, with figures; Boulenger, 1882, *28*, 40.

Most of the known specimens of this species are from the Southern States, but it has been sent to the National Museum by R. Kennicott, from about Cairo, Ill. It is, therefore, to be sought for in the southwestern portion of our own State.

It is the smallest, stoutest, and most clumsily constructed of the species of the genus. The head is described as being broad and large, the width being contained in the length to the groin 3.5 times. There are only ten costal grooves. The tail is very short, being contained in the rest of the length 1.5 times. The color is a light brown, paler below, with sprinklings and marblings of silvery or leaden gray. There are some obscue dark spots on the back and tail. The length of the animal when full grown is less than four inches. Prof. Cope states that it lives in damp places below logs and stones.

### **Plethodon æneus,** Cope.

*Bronzy Salamander.*

Cope, 1881, *22*, 878; 1889, *51*, 143.

Form and proportions as in *P. glutinosus.* Vomero-palatine patches in two straight lines, which do not pass out behind and beyond the choanæ. Costal grooves 13. The color is black, but the upper surface is thickly spotted with large, yellowish-green blotches. These occupy almost the whole surface of the head. The spots on the sides are considerably smaller. The lower surface is dusted with yellow.

This species was described from a single specimen which was found by Prof. Cope at the mouth of Nickajack Cave, located at the point where the three States of Georgia, Alabama and Tennessee adjoin. Dr. L. Stejneger informs me that the species has more recently been found in Lee County, Virginia.

#### Genus GYRINOPHILUS, Cope.

*Gyrinophilus*, Cope, 1869, *1*, 108; 1889, *151*, 154.

Vomero-palatine teeth in two transverse series which pass out beyond the choanæ. Parasphenoidal teeth present, in two parallel bands, these meeting the vomero-palatines at a right angle. Tongue with a free edge all around and standing on a central stalk. The premaxillary bones not ankylosed. Digits 4–5.

### **Gyrinophilus porphyriticus,** (Green).

*Salmon Triton.*

*Salamandra porphyritica*, Green, 1827, *102*, i, 3; Cope, 1889, *51*, 155; *Spelerpes porphyriticus*, Boulenger, 1882, *27*, 64.

The type of this genus is *G. porphyriticus* (Green). This is a native of the Alleghany Mountains from the Adirondacks to Georgia, but since it has been reported from Columbus, Ohio, it is possible that it may yet be found in Indiana. I therefore add a short description of it. For further details regarding it see Cope's "Batrachia of North America."

Body elongated, slender and depressed; there is little constriction at the neck, and the tail tapers gradually to tip. The head is flat, and the upper jaw projects beyond the lower. There is a prominent ridge running from the eye to the edge of the jaw outside the nostril. The eyes are large and prominent. There are sixteen costal grooves, not counting one immediately in the axilla. There is also a distinct dorsal groove. The limbs are rather weak and widely separated. The inner digits are rudimentary.

The color above is a light brownish red; below, a pale salmon. The species closely resembles some of the varieties of *Spelerpes ruber*, and in cases of doubt it may be necessary to expose the premaxillary bone in order to determine with certainty the genus.

### **Spelerpes ruber,** (Daudin.).

*Red Triton.*

*Salamandra rubra*, Daudin, 1802, *69*, viii, 227; *Spelerpes ruber*, Boulenger, 1882, *28*, 62; Cope, 1889, *51*, 172, with figures.

This species has not at this date been found within the territory of Indiana; yet since it has been taken about Cincinnati and Columbus, Ohio, and in the region about Chicago, it undoubtedly is an inhabitant of Indiana. It is, therefore, proper that it should be here described, for the double purpose of calling attention to it and of enabling observers to identify it. Wherever it occurs it appears to be an abundant species.

This is a rather heavily built species, although the young are more slender. The width of the head is contained in the distance to the groin six times or a little less. The length of the tail two-fifths the total length. It is thick at the base, flattened toward the tip, keeled above from a short distance from the base, and below along the posterior half. The limbs are feebly developed; when the fore and hind legs are pressed to the side they lack about seven costal interspaces of meeting. Of the costal grooves there are fifteen, rarely sixteen. The tongue is boletoid. The vomerine teeth run along the hinder border of the choanæ transversely, then bend at a right angle and run backward to meet the parasphenoidal patches.

The color above varies from salmon to orange, vermillion, or brownish red. The belly is usually of some shade of red and without spots. Above there are numerous spots of black, which are distinct in the young, but in the old are more diffused, giving a brownish tinge to the whole upper surface. The total length may be six inches.

This beautiful animal is more aquatic than any others of the genus that we have with us. Prof. Cope states that its chief haunts are cold springs, but it is frequently seen in damp situations under the bark of fallen trees. It comes on the land after rains.

### **Spelerpes guttolineatus,** (Holbrook.)

*Holbrook's Triton.*

*Salamandra guttolineata*, Holbrook, 1842, *54*, v, 29, pl. 7; *Spelerpes guttolineatus*, Boulenger, 1882, *28*, 65; Cope, 1889, *51*, 170, with figures.

This is another species that may yet be found to occur in Indiana. It is most abundant in the Alleghany Mountains, but has been reported by Robert Kennicott from New Madrid, Mo.

It is of the size and general proportions and features of *Spelerpes longicaudus*. It has, however, thirteen instead of twelve costal grooves. Above, the color is brownish yellow. There are three stripes of dark brown, one in the median line, another on each side, beginning at the eyes and extending to the tip of the tail. The under surface is yellow, mottled with brown. Professor Cope says that its habits resemble those of *Plethodon cinereus*. It appears, then, to be essentially terrestrial.

### **Hyla carolinensis,** (Pennant).

*Carolina Tree-frog.*

*Calamita carolinensis*, Pennant, 1792, *59*, ii, 331; *C. cinerea*, Schneider, 1799, *41*, i, 174; *Hyla viridis*, Holbrook, 1842, *54*, iv, 119, pl. 29; *Hyla carolinensis*, Günther, 1868, *60*, 105; Boulenger, 1882, *27*, 377; Cope, 1889, *51*, 366, with figures.

This species has not been seen in Indiana up to this time. It appears to be a common frog in the Southern States from Washington, D. C. (W. P. Hay) to Texas, but it has been taken at St. Louis, Mo., by Dr. Englemann; and Prof. Harry Garman (*61*, 189) reports having found it in Union county, Illinois. It is, therefore, to be looked for in the southern portion of our State.

The size is usually greater than that of *H. versicolor*, the head and body being sometimes more than two inches. The head tapers to the rather pointed snout, and is rather longer than broad. The body is slender and the limbs long. The heel reaches in front of the eye. The fingers are distinctly webbed; the toes are webbed to the disks. The digital disks are a little smaller than the tympanum. The surface above is smooth or faintly granulated. The belly and lower parts of thighs are strongly granulated; the throat moderately so. The color above is brownish or olive-green in spirits, but grass-green in life. There are some spots of a light color; at the snout starts a streak of white which runs along the upper lip, under the ear, and over the arm to the side of the body. A similar streak runs along the hinder border of the arm, and still another along the hinder border of the tibia and foot.

### **Rana septentrionalis,** Baird.

*Northern Frog.*

*Rana septentrionalis*, Baird, 1855, *1*, 51; Garnier, 1883, *22*, 945; Boulenger, 1882, *27*, 37; Cope, 1889, *51*, 416, with figures.

*Rana septentrionalis* is a species of frog which ranges from New York to Minnesota, and which may therefore be expected to occur in Northern Indiana. It resembles closely *R. clamata*. The patches of vomerine teeth, however, are minute and do not project behind a line joining the posterior borders of the choanæ. Tympanum variable, not as large as the eye. Skin above often rough, but without pustulations. Two dorso-lateral glandular folds, as in *R. clamata,* but sometimes indistinct. Feet fully webbed; soles without tubercles. Above, the color is light or dark olive, with many narrow, irregular lines of paler. The sides and hinder half of the back with large spots of brown. The hind limbs with dark bars. The living frog is said to have a peculiar minky odor (*22*, 1883, 945).

### **Rana cantabrigensis,** Baird.

*Cambridge Frog.*

*Rana cantabrigensis,* Baird, 1854, *1*, 62; Boulenger, 1883, *27*, 45; Cope, 1889, *51*, 435, with figures.

*Rana cantabrigensis* is a near relative of *R. sylvatica,* and ranges through British America and Alaska. Not many specimens of it appear to have been taken within the United States, but in the National Museum is a specimen (*51*, 437) which is reported to have come from Clark County, Illinois. This county bounds Vigo County, Indiana, on the west, and it is probable that this frog also belongs to Indiana territory. It is more likely to be found in the northern portion of the State. Specimens of supposed *sylvatica* need to be closely scrutinized in search of *cantabrigensis.*

This species differs from *sylvatica* in having the heel reach only to the middle of the orbit, the tympanic disk only half the diameter of the orbit, the skin of the back between the glandular folds smooth, three phalanges of longest toe free from web, and with a light stripe down the middle of the back. Probably no one of these characters will be sufficient to identify this frog, but most of them must be present.

### **Carphophis vermis,** (Kenn.).

*Worm Snake.*

*Celuta vermis,* Kennicott, 1859, *1*, 99; *Carphophiops vermis,* Cope, 1875, *12*, 34; *Carphophis vermis,* Smith, 1882, *18*, 699; *Carphophis amœna* var. *vermis,* Garman, 1883, *13*, 101.

*Carphophis vermis* is found from St. Louis, Mo., to Kansas and south to Louisiana. It is to be expected in Southern Indiana. It is regarded by Garman as only a variety of *C. amœna.* There are two pairs of frontals, as in *amœna.* However, the head is smaller and the snout more pointed than in *amœna.* The color above is dark iridescent purple, almost black. This dark color descends only to the third row of dorsal scales and ceases abruptly. The upper lip is of the color of the abdomen. This is flesh color; while the tail below is red. In a specimen taken at Little Rock, Ark., there are 145 ventral plates and 25 subcaudals. The length is 10 inches. I regard this form as a good species.

### **Virginia valeriæ**, B. & G.

*Valeria's Snake.*

*Virginia valeriœ*, Baird and Girard, 1853, *6*, 127; Garman, 1883, *13*, 98, pl. vii, fig. 3.

This species is said to occupy the territory from Maryland to Georgia and Illinois. It is therefore likely to be found in Indiana. Specimens in the National Museum are reported to be from Cook county, Ill., and from "Southern Illinois."

It differs from *V. elegans* especially in having the scales in only 15 rows, instead of 17. Ventral plates 118 to 127; subcaudals 24 to 36. Length 11 inches or less. Color yellowish or grayish brown; dull yellow beneath. On the upper surface there are a few black dots; while on each scale of the back there is a faint line, which makes the body appear as if striated. Named for Miss Valeria Blaney, of Maryland.

### **Abastor erythrogrammus**, (Daudin).

*Red-lined Snake.*

*Abastor erythrogrammus*, Baird and Girard, 1853, *6*, 125; *Hydrops erythrogrammus*, Garman, 1883, *13*, 35.

The genus *Abastor* differs from the genus *Farancia* only in having the prefrontals distinct, those of opposite sides not being fused. *Abastor erythrogrammus* reaches a length of 40 inches, and has the same colors as *Farancia abacura.* The red, however, forms three longitudinal lines, or stripes. The two lower, or outer, rows of scales are red. Occasionally this stripe is a little wider or a little narrower. The next three rows of scales are black or blue-black. Then follows a stripe of red, occupying one row of scales. Above this is another blue-black stripe three scales in width. The tenth row of scales, the one on the middle of the back, is red. The lower surface is red or flesh color, with a series of blackish spots near the ends of the ventral plates. There are some spots of red on the head. Thus we have here a striped snake, instead of a spotted one, as is *Farancia abacura*. There are about 180 ventral plates.

This snake is best known as a resident of the Southern States east of the Alleghany Mountains, but it has been reported, on the authority of Mr. Garman (*13*, 35) and others as having been taken about Mt. Carmel, in Illinois. If this is true, it will yet be found in Indiana.

### Genus HALDEA, B. & G.

*Haldea*, Baird and Girard, 1853, *6*, 122.

A genus containing a single species of small snakes. Head rather elongated, hardly distinct from the neck; the snout pointed. The place of the prefrontals occupied by a single small plate. Postfrontals large, entering the orbits and suppressing the anteorbitals. Loral present. Nasals 2. Scales keeled. Anal plate divided.

### **Haldea striatula**, (Linn.).

*Brown Snake.*

*Coluber striatulus*, Linnæus, 1766, *64*, 375; *Haldea striatula*, Baird and Girard, 1853, *6*, 122; Cope, 1892, *3*, xiv, 376; *Virginia striatula*, Garman, 1883, *13*, 97, pl. vii, fig. 2.

A small, slender snake, not exceeding probably one foot in length; the tail forming about a fifth the total. Head pointed. Crown shields 8, the prefrontals being united. Nasals 2, with the nostril between. A single postorbital and one large temporal. Inferior labials 6. Superior labials 5, the eye over the 3d and 4th. Scales in 17 rows, feebly keeled, those of one or two outer rows large and smooth. Ventral plates 119 to 133; pairs of subcaudals 25 to 46.

Color of upper surface grayish or reddish brown. Abdomen yellowish. There is said sometimes to be a light chestnut band across the back of the head.

Distribution chiefly in the Southern States; said by Prof. S. Garman to occur from Massachusetts to Mississippi. I have taken it in central or southwestern Arkansas.

Little or nothing is known concerning the habits of this snake. In a female taken in Arkansas I found about half a dozen long slender eggs, in each of which was found a young *Haldea*. From the thinness of the egg membranes I judge that the young are brought forth alive and active.

### **Natrix rigida**, (Say).

*Stiff Snake.*

*Coluber rigidus*, Say, 1825, *2*, 239; *Tropidonotus rigidus*, Holbrook, 1842, *54*, iv, 39, pl. 10; *Regina rigida*, Baird and Girard, 1853, *6*, 46; *Tropidonotus leberis*, var. *rigidus*, Garman, 1883, *13*, 28; *Natrix rigida*, Cope, 1892, *3*, 668.

This species has been reported from Indiana, but there is now so much doubt about the matter that I prefer to arrange it among the species that have not yet been taken in the State. Indeed it is doubtful if it occurs west of the Alleghany Mountains.

The scales are arranged in 19 rows. Ventral plates 132 to 135; subcaudals 52 to 71. The outer row of scales is smooth, the second nearly so. The ground-color is greenish brown. The middle of the back is of the ground-color, but on each side of this there is a narrow dark stripe, which centers on the 8th row of scales. These stripes are usually distinct. Along the flanks, lying on the 2d row of scales, is a band of pale color. The belly is yellowish, with two rows of dark spots, which lie close together and run from the throat to the vent. Upper jaw, lower jaw and throat yellow.

A specimen with 170 ventrals, from Illinois, on which, in Jordan's Manual, I assigned *rigida* to that State, seems to be rather a specimen of *N. grahamii.*

### **Natrix grahamii,** (B. & G.).

*Graham's Water Snake.*

*Regina grahamii*, Baird and Girard, 1853, *6*, 47; *Tropidonotus grahamii*, Günther, 1858, *26*, 78; *Tropidonotus leberis*, var. *grahamii*, Garman, 1883, *13*, 28; *Natrix grahamii*, Cope, 1892, *3*, 668.

This species occurs from Michigan to Louisiana and Texas. It is therefore certain to be found in Indiana, though no one has yet recorded it.

The rows of scales are 19, and all keeled; and the number of ventral plates is greater than in the related species, being from 160 to 170. Pairs of subcaudals about 60.

The general color is brown. The middle of the back has a pale band occupying 3 scales in width. Outside of this, on the 8th row of scales, is a narrow dark stripe. On each flank, occupying the three outer rows of scales, is a pale streak. Both above and below this is a very narrow dark stripe. The belly is uniform yellow, except that in the middle line, along the hinder portion of the body, there is a dusky stripe.

The eggs of *N. grahamii* (taken from the oviducts) were found to be 1.5 inch long by .75 in the short diameter. The young, taken from such an egg, was 7 inches long, and was partly enclosed in a sort of concave disk formed of the remains of the yolk. The stripes of the young were much more distinct than those of the adult, and the determination of the species was less difficult. The young are no doubt brought forth alive and active.

### **Natrix cyclopion,** (Dum. & Bib.)

*Florida Water-snake.*

*Tropidonotus cyclopion*, Duméril & Bibron, 1854, *74*, vii, 576; Garman, 1883, *13*, 26, pl. 2, fig. 4; *Natrix cyclopium*, Cope, 1892, *3*, 673.

*Natrix cyclopion* is best known as a Floridan snake; but it has been sent to the National Museum, by Robert Kennicott, from Southern Illinois, and Mr. Garman, as cited above, gives its range as "Ohio to Florida." It is, therefore, not unreasonable to expect to find it yet in Indiana.

The scales of *N. cyclopion* are disposed in from 27 to 33 rows. All the scales are distinctly keeled, except those of the outer row, which are only faintly keeled. The ventrals are from 138 to 150; the subcaudals, 60 to 75 pairs. There is one anteorbital, two postorbitals and two suborbitals. The species may usually be readily recognized by the upper labials being cut off from contact with the eye by these suborbitals. However, this test occasionally fails. The general color is an olive brown or a lead color. Along the sides are faint vertical bands two scales long, and separated by narrow spaces. These may meet on the back, or they may alternate. This species appears to be closely related both to *N. taxispilota* and *rhombifera.*

### **Ophibolus calligaster,** (Harl.).

*Coluber calligaster*, Harlan, 1835, *39*, 122; *Ophibolus evansii*, Kennicott, 1859, *1*, 99; *Ophibolus calligaster*, Cope, 1875, *12*, 37; *Ophibolus triangulus*, var. *calligaster*, Garman, 1883, *13*, 66.

Resembles *O. doliatus triangulus*, but has the ground-color lighter. The scales are in 25 or occasionally 27 rows. Light olive-brown or gray, with a dorsal series of about 60 subquadrangular, emarginate, dark chestnut-brown blotches, and on each side two series of smaller lateral spots. Belly reddish yellow. Central Illinois to Indian Territory. Dr. Yarrow (*10*, 94) reports this snake in the National Museum from Mt. Carmel, Ill. There is. therefore, no reason why it should not occur in Indiana. It has been stated to occur at Brookville, but since there is doubt about the correctness of the identification, I do not include it among the known snakes of the State.

### Genus PITUOPHIS, Holbrook.

*Pituophis*, Holbrook, 1842, *54*, iv, 7; *Pityophis*, Hallowell, 1852, *1*, 181; Baird and Girard, 1853, *6*, 64; Garman, 1883, *13*, 51.

Large and rather stout snakes, with distinct heads and short tails. Head rather long and pointed. Crown shields 9 or 11; the postfrontals being usually divided into a transverse row of four. Rostral high and narrow. Loral present, small. Anteorbitals 2, rarely 1. Postorbitals 3 or 4. Nasals 2, with the nostril between. Scales keeled; in 29 to 35 rows. Anal plate entire.

**Pituophis melanoleucus,** (Daudin.)

*Eastern Bull-snake. Pine Snake*

*Coluber melanoleucus*, Daudin, 1802, *69*, vi, 409; *Pituophis melanoleucus*, Holbrook, 1842, *54*, 7, pl. 1; Baird and Girard, 1853, *6*, 65.

This snake has an Eastern and Southern range, but it has been reported by Dr. W. H. Smith (*18*, 688), on what authority I do not know, to occur occasionally in the State of Ohio. It is possible, therefore, that it may yet be found along our eastern border. Hence I give a description of the species.

The head is broad behind, pointed in front. Two pairs of postfrontals, an inner and an outer. Rostral narrow, rising to the inner postfrontals. One anteorbital. Upper labials 7, the 4th entering the orbit. Lower labials 13 or 14, the 5th and 6th largest. Scales in 27 to 29 rows, all keeled except about 4 of the lower rows. Ventral plates 212 to 216; subcaudals, about 60 pairs.

The ground-color above is whitish. On the middle of the back there is a series of about 30 large reddish brown blotches, all margined with black. On the sides there are three or four series of irregular spots, more or less indistinct. Posteriorly these unite into transverse bands, which may alternate with the dorsal series or come opposite them. The abdomen is yellow, with a series of brown blotches on each end of the ventral plates. The length may become five feet or more.

**Pituophis sayi,** (Schleg.).

*Western Bull-snake. Say's Pine Snake.*

*Coluber sayi*, Schlegel, 1837, Essai, ii, 157; *Pituophis sayi*, Baird and Girard, 1853, *6*, 152.

This species is much more likely to be found in Indiana than the one just described. In some parts of Illinois it was, in the past, quite abundant, and it has been found well into the eastern part of that State. I have no record of its occurring in Indiana, but it may be looked for along the western border, especially northward, with confidence.

It differs from *melanoleucus*, especially in its coloration. The spots along the back are more numerous, being about 70 in number. The general color, too, is darker, being reddish yellow or, on the back, chesnut brown. The ventrals are also greater in number than in *melanoleucus*, ranging from 220 to 240.

Genus TROPIDOCLONIUM, Cope.

*Tropidoclonium*, Cope, 1860, *1*, 76.

Head little distinct from the body. Crown shields 9. Loral present. Nasal single, grooved below the nostril. Anteorbital 1. Postorbitals 2. Scales in 19 rows; keeled. Anal plate entire.

### **Tropidoclonium lineatum,** (Hallowell).

*Streaked Snake.*

*Microps lineatus*, Hallowell, 1856, *1*, 241; *Tropidoclonium lineatum*, Cope, 1860, *1*, 76; H. Garman, *61*, iii, 187; *Storeria lineata*, S. Garman, 1883. *13*, 32, pl. 1, fig. 4.

This species will almost certainly yet be taken within the limits of our State. It has been found lately by Prof. Harry Garman, at Urbana, Ills., within 35 miles of the Indiana line. It has been reported from Hughes, Ohio, by Dr. Yarrow (*10*, 131), but I am informed by Dr. L. Stejneger, of the National Museum, that the specimen so determined is a *Storeria*.

This species greatly resembles *Tropidonotus rigidus*, but the generic characters are quite different. The scales are in 19 rows, are strongly carinated, and the animal has a very rough appearance. The ventrals are from 138 to 150; the subcaudals 26 to 35 pairs. The 6th upper labial has been crowded from its place and lies above and between the 5th and 7th. The ground-color above is ashy-brown. Along the middle of the back there is a streak of gray one scale and two half scales wide, and a similar band along each side on the 2d and 3d rows of scales. A row of black spots on the bases of the lowest row of scales, another just above the lateral line, and a third on each side of the dorsal streak. Belly gray or yellow, with two rows of black spots, one on each side of the middle line, the two spots on many of the ventrals narrowly confluent.

The size is somewhat greater than that attained by *Storeria dekayi*. The distribution of the species is from Texas to Kansas and east to Illinois.

### **Agkistrodon piscivorus,** (LaC.).

*Water Moccasin; Mokason.*

*Crotalus piscivorus*, LaCépède, 1789, Serp. ii, 130; *Trigonocephalus piscivorus*, Holbrook, 1842, *54*, iii, 33, pl. 7; *Toxicophis piscivorus*, Baird and Girard, 1853, *6*, 19; *Ancistrodon piscivorus*, Garman, 1883, *13*, 121, pl. 8, fig. 2.

This is an abundant snake everywhere about the water courses of the Southern States. It has not yet been seen by any scientific observer in any locality in Indiana, although Mr. Robert Ridgway says that he has been informed that it was abundant at one time about Vincennes. I believe that it will yet be found along the lower portions of the Wabash river and the neighboring parts of the Ohio. It is found in numbers in the swamps in Union county, Illinois, and this is little further south than

Posey county, Ind. However, no specimens of it were in the collection of Mr. Sampson, of New Harmony. It ought to be diligently sought for in that region, and specimens saved. It is entirely aquatic and will be found hiding among stones, and in fallen timber, or basking in the sun along the banks of ponds and streams.

This reptile differs from the Copperhead in having no loral plate, no suborbitals, the scales in 25, instead of 23 rows, and colors darker. The ground color is dark chestnut-brown, with blotches of still darker brown. The head is very dark. Upper lip with a whitish streak that continues back on the neck. Belly yellowish, with many blotches of black.

### **Aromochelys carinata**, Gray.

*Keeled Mud Turtle.*

*Aromochelys carinata*, Gray, 1855, *25*, 47, pl. 20; Yarrow, 1875, *19*, v, 582; *Goniochelys triquetra*, Agassiz, 1857, *4*, i, 423; *Cinosternum carinatum*, Boulenger, 1889, *84*, 38.

This species is common in the streams and ponds of the Southern States from Georgia to Arizona. It has been reported from Northern Illinois by Messrs. Rice and Davis, and if their determination is correct it adds to the known range of this turtle in a remarkable manner, and as a consequence it is to be looked for in Indiana along the Wabash River. It differs from *A. odorata* in attaining a larger size, in having a larger head and stronger jaws, and in having a high shell with a median sharp keel toward which the slightly convex sides slope up roof-like. The scutes of the carapace overlap those lying behind them. The plastron is truncated in front and notched behind. The gular scute is wanting. The pectorals are large, and the suture between them is longer than that between the humerals. The males are furnished with two patches of small, sharp-edged scales, one above, the other below, the hollow of the knee. The color of the shell and skin above is olive, with streaks of yellow and spots of brown. The posterior borders of the scutes of the carapace are blackish. All the inferior surfaces are more yellow. There are no streaks of yellow on the head. Habits in general those of its relative, the Musk Turtle.

### **Chrysemys picta**, (Schneider).

*Painted Tortoise.*

*Testudo picta*, Schneider, 1783, *87*, 348; *Emys picta*, Holbrook, 1842, *54*, i, 75, pl. 10; *Chrysemys picta*, Gray, 1855, *25*, 32; Agassiz, 1857, *4*, i, 438, pl. i, figs. 1-5, and pl. iii, fig. 4; Boulenger, 1889, *84*, 72.

This species has at various times been reported from localities in this State, and was given as a resident of Indiana in my "Preliminary List."

There is, however, now so much doubt concerning it that I give it as merely one of the possibilities and leave it to the future to settle.

*C. picta* is a close relative of *marginata*, so close that some authors regard the latter as only a variety of the former. *Picta* differs from *marginata* principally in the arrangement of the vertebral and costal scutes, these being so disposed that the sutures between the costals meet the corresponding sutures between the vertebrals. Hence the scutes form four straight rows right across the back, an unusual thing among turtles. The red or yellow margin of the front of the scutes is also much wider than in *marginata*, and they produce conspicuous colored bands across the shell. In the collection of the National Museum I have seen a specimen with the plates somewhat intermediate in arrangement; nevertheless I believe that *picta* has quite thoroughly and in a remarkable manner freed itself, as a species, from *marginata*.

HABITS.—The habits of *C. picta* are similar to those of *C. marginata* and have been more carefully observed. The reader is referred to Agassiz's "Contributions" for further information. Prof. J. A. Allen says of these turtles, as known to him in Massachusetts: "The shrill, piping notes of this species is frequently heard in May and June, especially during intervals between showers on hot sultry days."

### Chrysemys belli, (Gray).

*Emys belli*, Gray, 1831, *112*, 31; *Chrysemys belli*, Gray, 1855, *25*, 33; Agassiz, 1857, *4*, i, 439, pl. 6, figs. 8-9; *Chrysemys cinerea*, var. *belli*, Boulenger, 1889, *84*, 74,

This is another species that has not yet been taken within our limits, but which may nevertheless be an inhabitant of the State. It occurs from Mississippi to western Illinois, thence northwestward to British Columbia. It has been taken in western Illinois by Agassiz, and more recently by Prof. Harry Garman, and it appears to be very common in the sloughs of the "bottom land" about Quincy. It should be looked for in the lower Wabash.

The arrangement of the scutes of the carapace is the same as in *C. marginata*. The ground-color is copper-red or bronze-color. Across the costal scutes there are some irregular red or yellow bands and some red dots. The marginals are divided above by a yellow streak, while on their lower surface there are black, eyelike spots on a red ground. The plastron is covered all over with blackish markings of various shapes. The size becomes greater than that of either *picta* or *marginata*, some 8 inches as the length of the shell.

### **Cistuda ornata**, (Ag.).

*Ornate Box-tortoise.*

*Cistudo ornata*, Agassiz, 1857, *4*, i, 445, pl. iii, figs. 12 and 13; Boulenger, 1889, *84*, 118.

This species of the genus *Cistuda* occurs abundantly west of the Missouri River, being, as reported by F. W. Cragin, "so abundant in some sections of Southern Kansas that it amounts to a nuisance as a cumberer of the ground." (*49*, 100.) The species, however, ranges further east into Illinois, and some years ago specimens were sent to the National Museum from Fairfield, Wayne County, Illinois, within 35 miles of the Wabash River (*10*, 37), hence its occurence within Indiana territory may be discovered at any time.

The shell of *ornata* is proportionally shorter and broader than that of *carolina*. The back is also flatter, especially along the middle line, and there is no trace of a keel, even in the young. The plastron does not completely close the shell, and there is a short but distinct bridge. The head is larger, the snout shorter, and the upper jaw is notched in front. The shell is more elegantly marked than in *carolina*, the ground color being olive-brown to black, while there are numerous spots and streaks of bright yellow. The yellow markings usually seem to radiate from the center from which each scute began to grow.

# GLOSSARY.

ABDOMINAL SCUTES, or ABDOMINALS (of tortoises). See figure 12.

ALVEOLAR SURFACE. A flat masticatory surface of the jaws of tortoises, seen just within the cutting edge.

AMPHICŒLOUS. Concave at both ends; said of certain vertebræ.

ANAL PLATE. The large scale immediately in front of the vent of serpents.

ANKYLOSED. Joined by bony union.

ANTEORBITAL. A small epidermal plate of the head of snakes, which lies immediately in front of the eye. If there are but three plates between the eye and the nostril, either the anteorbital or the loral is missing. If the plate present next the eye has its greatest length horizontal, it is the loral; otherwise it is the anteorbital.

AXILLA. The arm-pit.

AXILLARY. Pertaining to or placed in the axilla.

AZYGOUS. Placed in the middle line, and, therefore, without a fellow.

BALANCERS. Organs of adhesion at the sides of the mouths of tadpoles; "holders."

BARBELS. A short, worm-like process of skin about the mouth or at the chin.

BRANCHIÆ. Gills.

BRANCHIAL ARCHES. Bony or cartilaginous arches that support the gills of fishes, or arches that correspond to these in other animals.

BRIDGE. That portion of the shell of a tortoise which joins the carapace and the plastron.

CALLOSITIES. Patches of hard skin on the plastron of soft-shelled turtles.

CANTHUS ROSTRALIS. A slight ridge from the eye to the tip of the snout, separating the upper surface of the head from the side.

CARAPACE. The upper portion of the shell of tortoises.

CARINATED. Furnished with a keel, or sharp ridge.

CHOANÆ. The internal nostrils.

CLAVICLES. A bone corresponding to the human collar-bone.

CLOACA. The common chamber into which the intestine, the ureters and the genital ducts open.

Coracoid. The bone or cartilage that forms the portion of the shoulder girdle in front of the glenoid cavity.

Costal. Pertaining to the ribs. The costal furrows, or grooves, of Urodeles run across the body between the fore and the hind legs. For costal scutes of tortoises, see figure 11.

Crown-shields. The large plates which cover the upper surface of snakes' heads. See figure 9.

Dentary. The anterior bone of the lower jaw, the one usually bearing the teeth.

Dermal folds. The thickened ridges of skin on the backs of some frogs; the glandular folds.

Diapophysis. The transverse process of a vertebra; here used of that of the sacral vertebra.

Entoplastron. One of the bones of the plastron of a tortoise.

Emarginate. Furnished with an obtuse notch.

Emargination. A broad, shallow notch.

Epidermal. Belonging to the outer layer of the skin.

Ethmoid. A bone or cartilage between and often surrounding the nasal sacs.

Eustachian tube. A passage from the tympanic cavity to the pharynx.

Extralimital. Outside of the limits immediately adjoining Indiana.

Femoral. Pertaining to the thighs; femoral pores are found on the under side of the thighs of some lizards.

Frontals. Plates of the heads of snakes. See figure 9.

Fontanelle. A space filled with membrane between bones that approach one another without meeting.

Gular. Pertaining to the throat; gular fold, a fold of skin across the throat; gular scute (of tortoises), see figure 12.

Holders. Organs of adhesion at the corners of the mouth of a tadpole.

Humerals. Scutes of the plastron of a tortoise; see figure 12.

Inframarginals. Scutes of some tortoises lying below the marginals.

Inguinal. Pertaining to the groin.

Keel. A well defined ridge. Keeled, furnished with a sharp ridge.

Labial. Pertaining to the lips. Labial plates (of snakes), see figure 9.

Larva. The undeveloped young of some animals, as the caterpillar of an insect or the tadpole of a frog.

Loral. Pertaining to the space in front of the eye; see anteorbital, also figure 9.

Marginals. See figure 11.

MAXILLARY. A bone of the upper jaw lying behind the premaxillary of each side, usually bearing the outermost row of teeth; missing in *Siren* and *Necturus*.

METAMORPHOSIS. Transformation; change from tadpole to adult form.

NUCHAL PLATE. See figure 11.

OCCIPITAL. Belonging to the hinder part of the head. See figure 9.

OCELLATED. Furnished with eye-like spots, spots consisting of concentric rings.

OLIVE. Brownish or yellowish green.

OPISTHOCŒLOUS. Said of vertebræ which are concave at the hinder end and convex at the anterior end.

OVIPAROUS. Producing young from eggs that hatch after deposition.

OVOPOSITION. The laying of eggs.

OVOVIVIPAROUS. Producing young from eggs which hatch before being laid.

PALATINE. A bone of the roof of the mouth lying behind the vomer on each side.

PALATOPTERYGOID. The united palatine and pterygoid.

PAPILLA. Minute folds or elevations of the skin or mucous membrane.

PARASPHENOID. A broad bone underlying the brain-case; parasphenoidal teeth are found in the hinder part of the roof of the mouth.

PARATOID. Belonging to the region found at the hinder lateral part of the head; paratoid glands of toads are elevated glandular bodies at the sides of the back part of the head.

PECTORALS (of tortoises). See figure 12.

PINNATE. Arranged along the sides of a central axis like the vane of a feather.

PLASTRON. The lower portion of the shell of a tortoise.

PLEURODONT. With the teeth grown fast to the inner side of the bone of the jaw.

POST-FRONTALS. See figure 9.

PREFRONTALS. See figure 9.

PREMAXILLARY. The bone forming that part of the upper jaw immediately at the snout. The two premaxillaries are sometimes united.

PROCŒLOUS. Said of vertebræ which have the anterior end concave, the hinder convex.

PTERYGOID. A bone of the roof of the mouth lying on each side immediately behind the palatine.

QUADRATE. The bone on each side to which the lower jaw of batrachians and reptiles is swung.

ROSTRAL. The epidermal plate covering the snout of snakes and lizards. See figure 9.

SCUTE. A large epidermal scale.

SEPTUM. A dividing wall, as that between the nasal passages.

SNOUT. The portion of the head in front of the eyes.

SPLENIAL. A bone at the hinder and inner part of the lower jaw; occasionally bearing teeth.

SQUAMOSAL. A bone usually overlying the inner ear; in snakes attached to the hinder portion of the skull and supporting the quadrate.

SUBCAUDALS. The large scales on the underside of the tail of a snake.

SUPERCILIARIES. The plates over the eye of a snake. See figure 9.

SUPRAORBITALS. Same as superciliaries.

SYMPHYSIS. The union of two bones of opposite sides, in the middle line, and with little or no motion.

TAIL. Portion of the body behind the vent.

TEMPORAL ARCH. A bony bar from the upper jaw to the quadrate, overlying the temporal muscle; found in some tortoises.

TERETE. Cylindrical and tapering.

UROSTYLE. The rod-like posterior termination of the spinal column of frogs.

VENT. The opening outwardly of the cloaca.

VENTRAL PLATES. The epidermal plates on the belly of snakes, etc.

VERTEBRAL SCUTES. The median row of plates on the back of a tortoise. See figure 11.

VERTICAL. See figure 9.

VILLIFORM. Having the form or appearance of villi; like the pile of velvet.

VITTA. A stripe.

VOMER. A bone lying in the roof of the mouth just behind the premaxiliary. One on each side of batrachia and reptiles.

VOMERO-PALATINE. The united vomer and palatine.

---

List of publications referred to in this work, together with the numbers by which they are cited.

*1.* Proceedings of the Academy of Natural Sciences of Philadelphia.
*2.* Journal of the Academy of Natural Sciences of Philadelphia.
*3.* Proceedings of the U. S. National Museum, Washington, D. C.
*4.* Agassiz's Contributions to the Natural History of the United States. 1857.
*5.* Wilkes' United States Exploring Expedition: Herpetology. 1858.
*6.* Baird and Girard's Serpents of North America. 1853.
*7.* Popular Science Monthly.

*8.* Bulletins of the U. S. Geological and Geographical Survey.
*10.* Yarrow's Check-list of N. A. Reptilia and Batrachia. 1882.
*12.* Cope's Check-list of N. A. Batrachia and Reptilia. 1875.
*13.* Samuel Garman's Serpents of North America. 1883.
*14.* Long's Expedition to the Rocky Mountains. 1823.
*18.* Reptiles and Amphibians of Ohio. Dr. W. H. Smith in Geological Survey of Ohio for 1882.
*19.* Wheeler's Survey West of 100th Meridian. Vol. V, 1878.
*20.* Reports on the Pacific Railroad Survey. Vol. X, 1859; Vol. XII, 1860.
*22.* American Naturalist.
*25.* Catalogue of the Shield Reptiles of the British Museum, 1855; Supplement, 1870; and Appendix, 1872. Dr. John Edward Gray.
*26.* Catalogue of the Colubrine Snakes of the British Museum. Dr. A. Günther. 1858.
*27.* Catalogue of Batrachia Salientia of the British Museum. Dr. G. A. Boulenger. 1882.
*28.* Catalogue of Batrachia Gradientia of the British Museum. G. A. Boulenger. 1882.
*29.* Catalogue of the Lizards of the British Museum. G. A. Boulenger. Vols. I and II, 1885; Vol. III, 1887.
*30.* Fauna of New York, J. E. DeKay. 1842.
*33.* Smithsonian Contributions to Knowledge.
*34.* Proceedings of the American Association for the Advancement of Science.
*36.* Transactions of the American Philosophical Society.
*37.* Marcy's Exploration of the Red River Valley, 1854.
*39.* Medical and Physical Researches. Dr. Richard Harlan. 1835.
*40.* B. S. Barton's Letter on *Siren lacertina.* 1821.
*41.* Schneider's Historia Amphibiorum. 1799.
*42.* Bulletins of the Essex Institute.
*43.* Proceedings of the Boston Society of Natural History.
*47.* American Journal of Science and Arts.
*48.* Bulletin of the American Museum of Natural History. New York.
*49.* Bulletin of the Washburn College Laboratory of Natural History.
*50.* Science, a Weekly Newspaper of all the Arts and Sciences. New York.
*51.* Batrachia of North America. Dr. E. D. Cope. 1889.
*52.* Fisheries Industries of the United States. Washington, D. C. 1884.
*53.* Holbrook's Reptiles of North America. Edition of 1838.
*54.* Holbrook's Reptiles of North America. Edition of 1842.

57. Latreille's Histoire Naturelle des Reptiles. 1802.
58. Storer's Report on the Reptiles of Massachusetts. 1809.
59. Pennant's Arctic Zoology. 1792.
60. Catalogue of the Batrachia of the British Museum. Dr. A. Günther. 1858.
61. Bulletins of the Illinois Laboratory of Natural History.
62. Annals of the Lyceum of Natural History of New York.
63. Reise in das Innere Nord America, von Maximillian Prinz zu Wied. 1839 and 1841.
64. Linnæus' Systema Naturæ. Edition X, 1758; edition XII, 1766.
66. Der Naturforscher.
67. Manual of Vertebrates of the Eastern United States. Dr. D. S. Jordan. Ed. v, 1888.
68. Daudin's Histoire Naturelle des Rainettes, etc. 1803.
69. Daudin's Histoire Naturelle des Reptiles. 1803.
71. Shaw's General Zoölogy. London. 1802.
72. D'Orbigny's Dictionaire d' Histoire Naturelle. 1843.
73. Zoölogical Miscellany. 1842.
74. Duméril & Bibron's Erpétologie Générale. 1834 to 1854.
75. Natürliches System der Amphibien. J. Wagler. 1830.
77. Isis von Oken. Erster Band, 1822.
79. Preliminary Catalogue of the Amphibia and Reptilia of Indiana. O. P. Hay, 1887, in No. 94.
80. American Monthly Magazine.
82. Fitzinger's Systema Reptilium. 1843.
83. Archiv für Naturgeschichte.
84. Catalogue of Chelonians in the British Museum. Dr. G. A. Boulenger. 1889.
85. Annals du Muséum de Paris.
86. Mémoires du Muséum d' Histoire Naturelle de Paris.
87. Schneider's Schildkröte. 1783.
88. Schweigger's Prodromus Monographiæ Chelonorum. 1814.
90. Spix' Species Novæ Testudinum, etc. 1824.
91. J. E. Gray's Catalogue of Tortoises. 1844.
92. Tableau Encyclopedique et Méthodique Erpétologie. Paris. 1789.
93. Reports of the Geological Survey of Indiana.
94. Journal of the Cincinnati Society of Natural History.
95. Amœnitates Academicæ Linnæi.
96. Wagler's Tentamen Systematis Amphibiorum. 1820.
97. DeBlainville's Journal de Physique.
98. Smith's Correspondence of Linnæus. 1821.
99. Tschudi's Classification der Batrachier. 1838.
100. Agassiz' Nomina Systematica Generum Reptilium. 1848.
101. Annals and Magazine of Natural History. London.

*102.* Contributions to Maclurean Lyceum.

*103.* Maximillian von Wied's Verzeichniss der Reptilien. 1865.

*104.* Tijdschrift voor Natuurlijke Geschiedenis en Physiologie.

*105.* Gravenhorst's Uebersicht der Zoölogischen Systeme. Göttingen, 1807.

*106.* Siebold's Fauna Japonica. 1838.

*107.* Atlantic Journal.

*108.* Rafinesque's Annals of Nature. 1820.

*109.* Laurenti's Synopsis Reptilium. 1768.

*110.* Zoölogical Journal.

*112.* J. E. Gray's Synopsis Reptilium. 1831.

*113.* Duméril's Catalogue Méthodique des Reptiles. 1851.

*114.* Annals of Philosophy.

*115.* Fleming's Philosophy of Zoölogy. Edinburgh, 1822.

*116.* Bonaparte's Osservazione sulla sec. Ed. del Regne Animale. 1830.

*119.* Duméril's Zoölogie Analytique. 1806.

*120.* Schriften der Gesellschaft Naturforschender Freunde. Berlin.

*122.* Studies from the Biological Laboratory of Johns Hopkins University.

*143.* Gmelin's Systema Naturæ. 1789.

*144.* Cuvier's Regne Animal.

# PLATES AND DESCRIPTION.

# PLATE I.

Figures all four times the natural size.

Figure 1. Open mouth of *Ambystoma microstomum.*

Figure 2. Open mouth of *Plethodon glutinosus.* *V. t.*, the vomerine teeth ; *p. t.*, the parasphenoidal bands of teeth. Above the vomerine bands are seen the choanæ.

Figure 3. Open mouth of *Spelerpes longicaudus*, showing the vomerine and parasphenoidel teeth and the tongue.

Figure 4. Roof of the mouth of *Spelerpes maculicaudus* ; *v.*, the hook-shaped bands of vomerine teeth ; *p.*, the parasphenoidal bands.

Figure 5. Open mouth of *Desmognathus fusca* ; *ch.*, the choanæ ; *v.*, the vomerine teeth ; *p.*, the parasphenoidal teeth ; *t.*, the tongue.

Figure 6. Open mouth of *Diemyctylus viridescens*, showing the two rows of vomerine teeth arranged in $\wedge$-form.

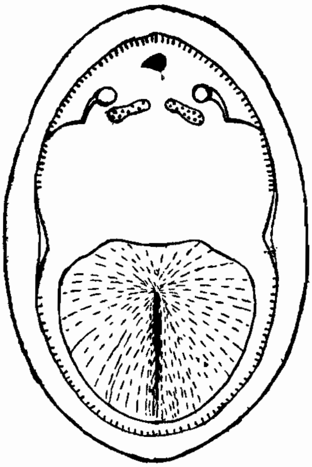


Fig. 1.

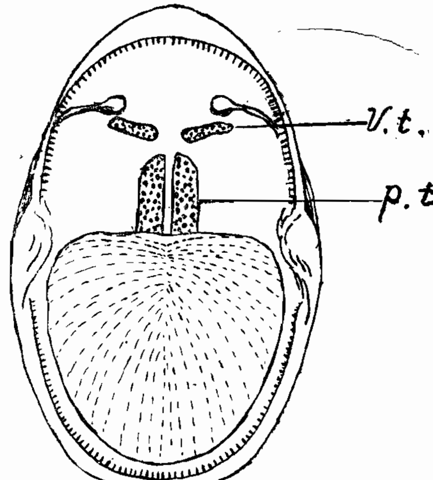



Fig. 2.

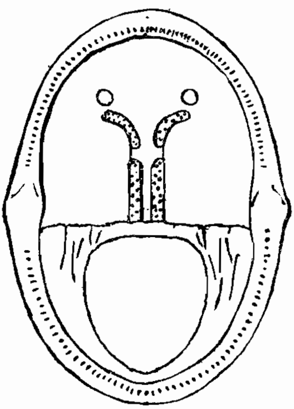


Fig. 3.

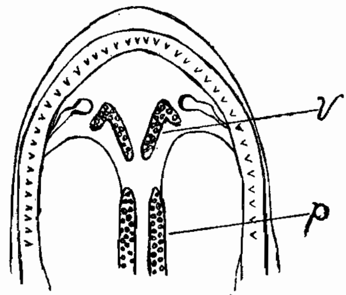



Fig. 4.

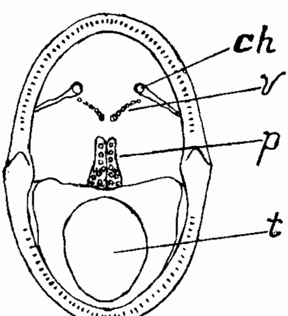



Fig. 5.

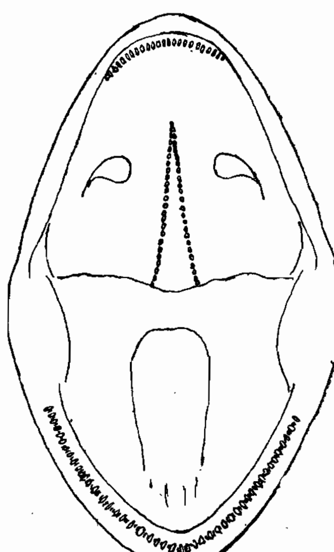


Fig. 6.

# PLATE II.

Figures all twice the natural size.

Figure 7. Sternum and shoulder-girdle of the Frog, *Rana*. *Os.*, omosternum; *st.*, sternum; *cr.*, coracoid; *cl.*, clavicle; *ec.*, epicoracoid; *sc.*, scapula; *h.*, humerus.

Figure 8. Sternum and shoulder-girdle of Toad, *Bufo*. Letters with the same significance as in Fig. 7.

Figure 9. Upper view of head of Black-racer, *Bascanion constrictor*.

Figure 10. Side view of same head. Numerals with same significance in both figures. 1, vertical plate; 2, occipital plates; 3, superciliaries; 4, the postfrontals; 5, the prefrontals; 6, the anteorbitals; 7, the loral; 8, the postorbitals; 9, the rostral; 10, the upper and lower labials; 11, the temporal; 12, the nasals.

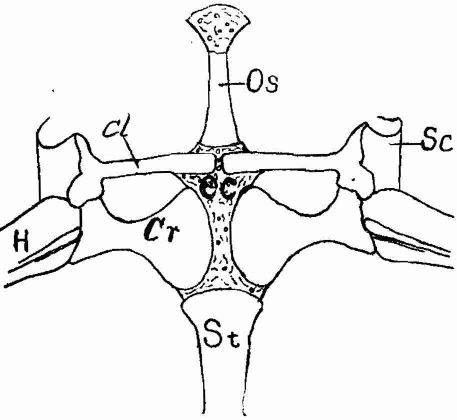



Fig. 7.

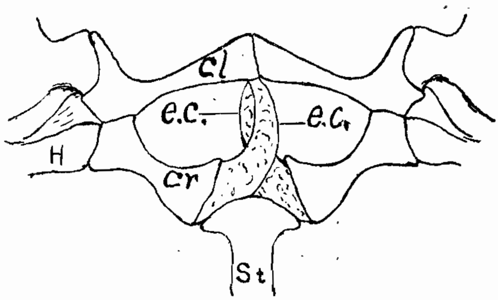



Fig. 8.

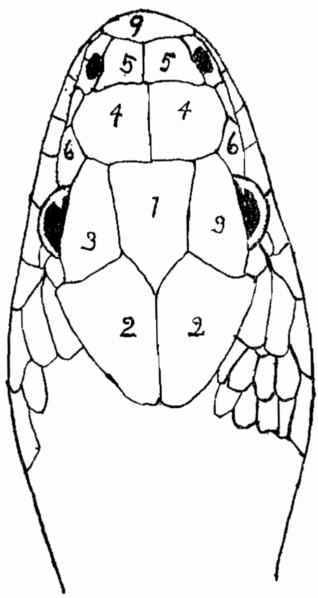



Fig. 9.

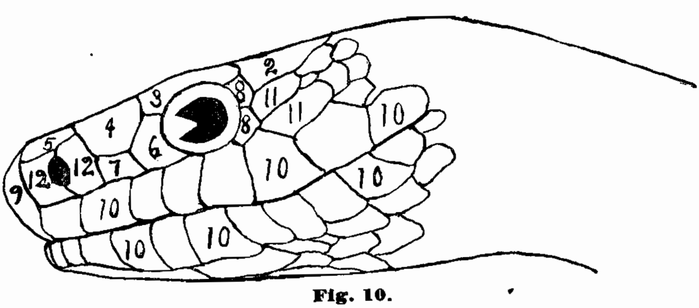



Fig. 10.

## PLATE III.

Figure 11. Carapace of *Chrysemys marginata*; *v.*, the neural epidermal plates; *c.*, the costals; *m.*, the marginals; *n.*, the nuchal. Natural size.

Figure 12. Plastron of *Chrysemys marginata*; *g.*, the gular plates; *h.*, the humerals; *p.*, the pectorals; *a.*, the abdominals; *f.*, the femorals; *an.*, the anals. Natural size.

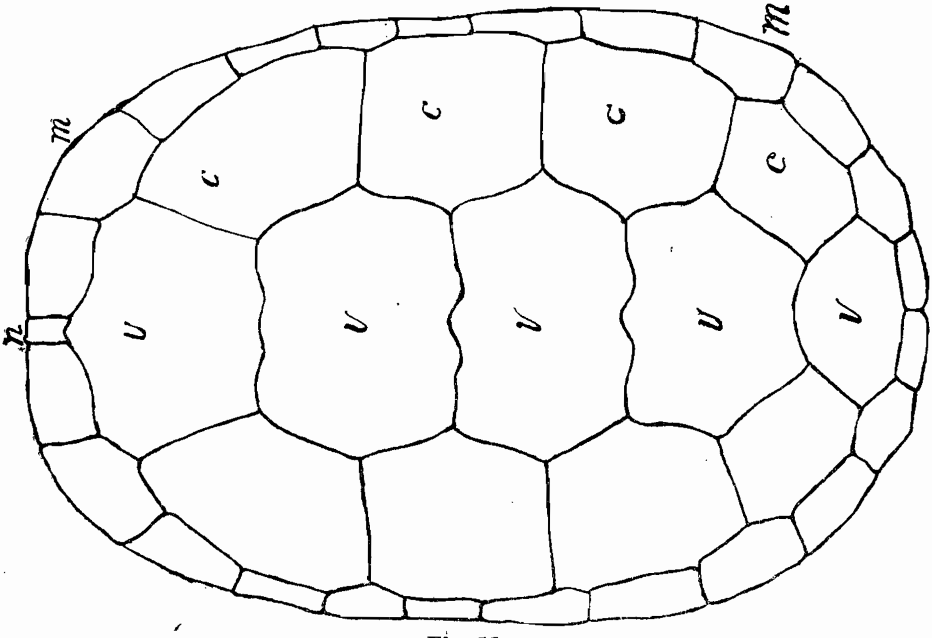



**Fig. 11.**

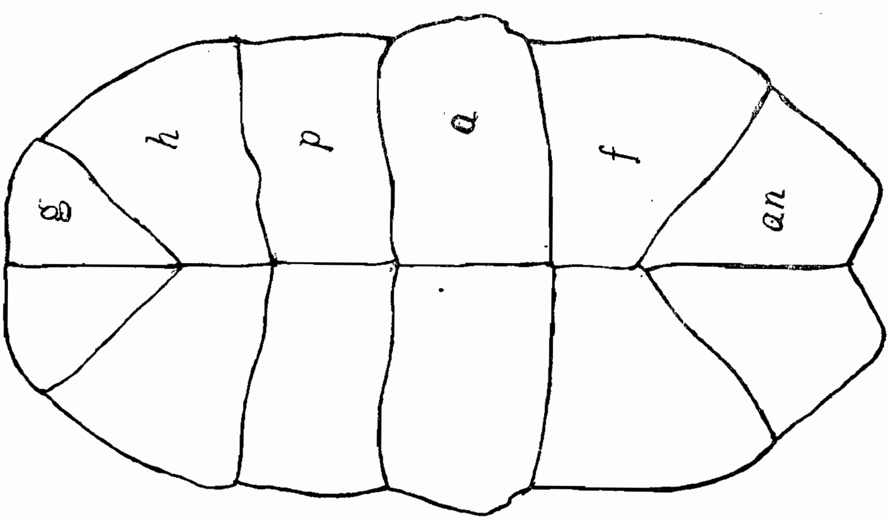



**Fig. 12.**

# PALÆONTOLOGY.

BY S. A. MILLER.

## PRELIMINARY REMARKS.

THE LOWER SILURIAN SYSTEM is represented, in the southeastern part of the State of Indiana, by rocky strata, about 750 feet in thickness, belonging to what is known to geologists as the Hudson River Group. These rocks have been studied a great deal, especially in the vicinity of Richmond, Weisburg, Versailles, and Madison, and have furnished many new species of fossils that have been described in the palæontological reports of New York, Ohio and Illinois, and in the Cincinnati Quarterly Journal of Science and Journal of the Cincinnati Society of Natural History. I am able now to add a few new species from the same localities, and some from rocks of about the same age, in Tennessee, which constitute what is called the Nashville Group.

The Hudson River Group of Indiana is followed, as it appears to me, by rocks of the age of the Niagara Group. At least, I have been unable to discover any evidence of the existence of the Medina and Clinton Groups, which intervene, between the Hudson River and Niagara, in New York and Canada. The lower part of the Niagara Group, in Indiana, is characterized by the presence of the remains of cystideans; while the upper part abounds with crinoids, brachiopods, bryozoa and other fossils. Most of the cystideans belong to *Holocystites*, a genus quite common in the magnesian limestone of the Niagara Group of Illinois and Wisconsin, but not known to rocks of any other age. This genus is the most remarkable, for variations in size and form, of any known to the subkingdom Echinodermata, beside some species were free, others sessile, and others possessed a column and attached to a muddy bottom with roots. I described, in the Journal of the Cincinnati Society of Natural History and in North American Geology and Palæontology, nineteen species of *Holocystites*, which were collected at Osgood, St. Paul, and near Madison, and am now able to add fifteen new species, from the vicinity of Madison, to this remarkably long list. And it may be worthy to note that about half of all the species of cystideans known from America occur in the Hudson River and

Niagara Groups of Indiana. The upper part of the Group, especially at Waldron, has been famous, for many years, for the abundance and perfection of its fossils. They have been sought to such a degree, that they have almost become an article of commerce, and now ornament every important collection in the civilized world. Only a few new species have been added from these rocks, but among them there are some very peculiar and interesting forms.

I have seen no fossils that indicate the existence of the Guelph Group, in Indiana, but the Waterlime member of the Onondaga Group rests upon the Niagara, and has considerable thickness. It is not very fossiliferous, but a few species new to science have been discovered and are herein described.

Though the Devonian strata of Indiana are very rich in fossils, I have not described many new species from them in this volume.

The Subcarboniferous rocks of Indiana have been famous for their fossils for many years, and new and peculiar forms are being constantly discovered. The lower division is called, in Ohio, the Waverly Group; in Indiana, the Knobstone Group or the Kinderhook Group; in Michigan, the Marshall Group, and in Missouri, the Chouteau limestone. I have added a few new species from this Group, in Indiana, and a few from the Chouteau limestone of Missouri, which throw some light on the Indiana forms.

The Keokuk Group of Indiana, is the most celebrated for fine fossils of all her Subcarboniferous strata, and new species are constantly coming to light wherever the rocks are investigated. I have described a few from rocks of the same age, in Missouri, where, in proportion to the thickness, they seem to be equally as fossiliferous.

I have also described a few from the Burlington, Warsaw and St. Louis Groups, and some from the Coal Measures. All are illustrated, and all except two or three belong to new species, and those are figured to show characters heretofore unknown, or which have been erroneously described.

Those from Missouri were collected by R. A. Blair and F. A. Sampson, two distinguished naturalists and geologists of Sedalia. All of the *Holocystites*, except three, were found by J. F. Hammell, in the Niagara Group of Jefferson County, Indiana, and belong to his collection. Otherwise than as thus indicated, the collections to which the type species belong are mentioned at the end of the several descriptions. The reason for stating the collection to which a type belongs is to afford an opportunity to others to re-examine the type, if the species or characteristics ascribed to it are questioned.

A few words in regard to fossils, their scientific value, and the method of naming them, will probably be appreciated by beginners in the study of Geology.

Fossils represent the skeletons and harder parts of animals and plants. Such parts produce fossils or petrifactions, as are sufficiently firm and hard to preserve their form, until water, holding mineral matter in chemical solution, penetrates the most minute cavities, and as the organism decays, or as it is taken up by the solvent power of water, deposits the mineral matter in its stead. Neither plants nor animals turn to stone. Fossils are generally casts, but where the original animal secretion was lime or silica, part of it may have been preserved by the protection afforded from the infiltrated mineral matter, and carbonaceous structures are frequently preserved in fish-teeth and Graptolites. Flesh can not petrify. Where a shell was filled with earthy matter that solidified before the shell was dissolved or otherwise destroyed, we may have a cast of the animal itself; but the casts of the organs of the animals are not shown unless the organs were of a bony texture. Sometimes we find the cast of the external part of a shell, and sometimes a cast of the interior, without the preservation of the slightest part of the original shell, though it may have been harder than the stone itself. It is also quite common to find silicious corals and shells, in which cases the original limestone secreted by the animals has been taken up by water and the silica deposited in its place. Sometimes the process of silicification very much enlarges the fossil without destroying the form.

The geological and relative ages of the rocks are known only by the fossils they contain, except as they may be seen and examined at a single place. Fossils characterize the different Groups of Rocks so fully, that if we know the fossils we know the Group, in any part of America. No two Groups are represented by like assemblages of organic remains, but certain generic and specific forms are characteristic of each. For instance, if we were to find a *Paradoxides*, *Microdiscus*, *Atops* or *Elliptocephala*, we would know it came from rocks below the Silurian, and therefore lower than any rocks exposed in Indiana; if we found a *Glyptocrinus decadactylus*, we would know it came from the Hudson River Group, and a *Holocystites*, would tell us we were in the Upper Silurian; a *Pentremite* or a *Zeacrinus* would inform us that we were much higher in the scale of stratification, and so, the better acquainted we are with the fossils, the greater is our certainty in judging of the relative ages of the rocks. A knowledge of the earth is, therefore, largely dependent upon a knowledge of the fossils. Indeed, the science of Geology is based upon our information respecting the organic remains, and no one can expect to become very proficient in the science who neglects to study palæontology.

Fossils are named in the same way that plants are named in botany and animals in zoology. Each one has a name consisting of two words —the first generic and the second specific. The generic name must always be a noun, the specific name when an adjective must be made to agree in gender with the generic name. The generic name should always be commenced with a capital letter, while the specific name never should be. For example, the generic name *Orthoceras* is derived from the Greek words, *orthos* (straight) and *keras* (horn); *keras* in Greek, is in the neuter gender, while *orthis* is feminine. *Palæaster* is from *palaios* (anient), *aster* (star); *aster* is masculine. If, now, we wished to indicate by the specific name that three fossils belonging to these genera were flexuous or full of turns, we would write *Palæaster flexuosus*, *Orthis flexuosa* and *Orthoceras flexuosum*. If the fossils had been collected by Mr. Hammell and we wished to name them complimentary to him we would reduce his name to a Latin genitive by adding the letter *i* to it, thus: *Orthoceras hammelli*, *Orthis hammelli* and *Palæaster hammelli*. If the fossils were found at Madison and we wished to indicate that locality by the specific name we would add *ensis* to it; thus, *Orthoceras madisonense*, *Orthis madisonensis* and *Palæaster madisonensis*. When, however, the name of the place ends in *a* or *e* these letters are dropped as in *Orthoceras indianense*, *Orthis indianensis* and *Palæaster indianensis*. When the specific name is a common noun the ending is not changed; for example, *cuneus*, a wedge, would be written *Orthoceras cuneus*, *Orthis cuneus* and *Palæaster cuneus*. It will be seen, the rules of nomenclature are not difficult or hard to learn, and they are the same in all branches of Natural History.

All illustrations of fossils in this work are natural size, except where otherwise expressed.

## SUBKINGDOM PROTOZOA.

## CLASS PORIFERA.

### FAMILY PALÆACIDÆ.

#### PALÆACIS CAVERNOSA, N. SP.

*Plate I, fig 5, summit view, the cell at the upper end not visible; fig 6, view of convex side.*

Cuneate below, expanded and broadly rounded above; one side flattened, the other convex in the central part; base sharp and slightly concave. Cells, fourteen, as shown in our specimen, and of unequal size and irregular form; there is one at each end, one of which is not visible in a summit view, and the two larger ones are located near the middle, one on each side; partitions thin. Surface furrows coarse, irregular. Tubuli, rather large, visible to the unaided eye, and quite conspicuous with an ordinary magnifier in the cells and wherever the fossil is fractured.

The species is founded on a single specimen, from which a small piece has been chipped off the lower part of each end. It would seem to be more nearly related to *P. obtusa* than to any other species, though the form is quite different.

Collected in the Knobstone Group or Waverly sandstone of Jackson County, Indiana, and belongs to the State Museum at Indianapolis.

## FAMILY UNCERTAIN.

### CYCLOSPONGIA, N. GEN.

(*Ety, kuklos, a circle; spongia, sponge.*)

Sponge, circular, button-shaped or discoid, and consisting of numerous thin, calcareous laminæ, having a concentric structure and filled with minute canals or interstices. The structure has some resemblance to that of *Strephochetus richmondense*, but the laminæ are much thinner, and the interlaminar spaces are much less marked and no vertical tubes have been found within them. That was a free sponge, this one is supposed to have been attached to some other object. Spicules, if any, unknown. Type C, discus.

### CYCLOSPONGIA DISCUS, N. SP.

*Plate I, fig 8, lower side, showing central place of attachment and shallow, undefined, circular furrow. Fig 9, upper face showing concentric lines.*

Sponge or spongoid mass small, circular, thin, discoid; upper face slightly convex and marked with numerous small, concentric lines; opposite or supposed under side slightly concave, and bearing a broad, undefined, shallow furrow near the circumference and a round depression in the center, one-fourth the diameter of the fossil and having a depth equal to about one-half its thickness, supposed to be the place of attachment. The fossil arches very gradually into this depression, but the limit of the depression is sharply defined at the bottom, which is nearly flat, except a central dot or minute, conical cavity. The concentric lines on the upper face divide it into a series of concentric rings, while the under face is very smooth; and where the least eroded, shows exceedingly thin laminæ, without any sign or evidence of concentric structure.

The specimens were found by Prof. S. S. Gorby, in the Corniferous limestone at Bunker Hill, Indiana, and vary in size from one-third of an inch to an inch in diameter, and from one-twentieth of an inch to three-twentieths of an inch in thickness. Throughout all the variations in size, they retain the same relative proportions and possess the same characters and the same structure, so far as can be ascertained.

# SUBKINGDOM CŒLENTERATA.

## CLASS ANTHOZOA.

## SUBCLASS ZOANTHARIA.

### ORDER TABULATA?

### FAMILY???

The genus Leptopora is not clearly referable to the Order Tabulata, as defined by Edwards & Haime, though such forms have been generally referred to it. It may belong to the Alcyonaria where Heliolites and Plasmopora have been more recently classed. The septa are mere striæ or vertical pseudosepta; no distinct tabulæ exist and the corallites are filled with porous cœnenchyma or vesicular tissue. I know of no nearly related genus and therefore no family to which it can be referred with any degree of certainty. I have hesitated, however, to found a new family, though, if the genus stands alone, it would be referred to the family Leptoporidæ.

#### LEPTOPORA GORBYI, N. SP.

*Plate I, fig.* 1, *complete specimen with central hexagonal cell; fig.* 2, *under side of a smaller specimen, showing concentrically wrinkled epitheca and radiating waves; fig.* 3, *specimen with heptagonal central cell and commencement of second circle of cells; fig.* 4, *under side of same.*

Corallum consisting of a thin, circular or subelliptical, lenticular expansion, with a concentrically wrinkled epithecal crust, on the lower side. Each side is about equally convex, though the under side is sometimes flat or slightly concave, the margin is extremely thin, and the greatest thickness, in the central part, is usually less than the diameter of a cell.

The central cell is either hexagonal or heptagonal. When hexagonal, it is surrounded by six cells, as shown in figure 1, and ordinarily, these are rounded on the periphery so that the corallum consists of only seven cells; but I have seen some specimens where a second circle of cells had commenced, in which case, the cells in the first series abutting upon them become hexagonal and of about the same size as the central one. When the central cell is heptagonal, it is surrounded by seven cells, but where a second circle of cells had commenced, the cells in the first series, become hexagonal; hence all complete cells are hexagonal, except the central one, which, in some cases, is heptagonal. I have examined more than a hundred and fifty specimens, and, in no case, have I seen a complete circle of the second series of cells; hence the largest and most complete specimens consist of eight cells surrounded by a few, less than ten, incomplete ones. It is the exception rather than the rule, that there are any cells commenced beyond the first circle, and the increase of the corallites is, in no case, uniform in the second circle, but always greater in one direction than in another. The under side of the corallum is thrown into radiating waves corresponding with the first series of cells. In figure 2, there are six waves corresponding with the six cells, and in figure 4, seven waves corresponding with the seven cells and a slight swelling for each additional cell commenced, in the second circle of cells.

The cells are shallow, separated by a common wall and vertically striated by imperfectly developed septa. In the central cell shown in figure 1, there are forty septa, which is about the number in all complete cells examined. The interior of each cell is flat or slightly concave and filled with coarse, vesicular tissue.

The specimens collected vary in diameter from one-half inch to an inch and a half; diameter of a central cell about .24 of an inch and thickness of corallum varying from .10 to .25 of an inch; depth of a cell about .04 of an inch.

The original definition of the type of the genus, by Prof. Winchell, in the Proc. Acad. Nat. Sci., Phil., p. 3, in 1863, is as follows:

"Polypary subcircular in outline, and slightly convex on the general surface; composed (in the specimens examined) of 25–30 rather large cells, of which the internal ones are hexagonal, and the peripheral rounded exteriorly; margins of cups strongly elevated; radial lamellæ about 20."

"Diameter of mass, .72; diameter of the cells about .14, and their depth about .07. In a specimen whose diameter is 1.27, the diameter of the cells is .22."

It will be observed this species is distinguished from the type of the genus, *Leptopora typus*, by the larger and shallower cells with twice as many imperfectly developed septa. Figure I represents a specimen about .72 of an inch wide, consisting of seven cells, each about .24 of an inch in diameter, and .04 of an inch in depth; while a specimen of *Leptopora typus* of the same size has 25 to 30 cells, about .14 of an inch in diameter, and .07 of an inch in depth. Again, in *Leptopora typus*, the larger the specimen the larger the cells, while in this species the cells do not vary in size with the size of the specimens. Prof. Winchell's specimens were in a limestone matrix and did not show the epitheca. He did not illustrate the species, but Dr. White, in 1883, gave a magnified view of some of the cells, in the 12th Ann. Rep. U. S. Geo. Sur. Terr. pl. 34, figures 12a and 12b.

Collected by R. A. Blair, at several stone-quarries, in the lower part of the Chouteau limestone or Waverly Group, near Sedalia, Missouri, and now in the museum, at Indianapolis, as well as in my own collection, through the generosity of Mr. Blair.

## ORDER RUGOSA.

## FAMILY CYATHOPHYLLIDÆ.

### AMPLEXUS BLAIRI, N. SP.

*Plate I, fig. 7, showing annulations and costæ at the dilations.*

Corallum below medium size, simple, elongate, subcylindrical, more or less curved, sometimes abruptly bending, irregularly, widely and deeply annulated. It rapidly expands from a pointed base to the first dilation, where it bends abruptly upward. Epithecal crust smooth and very strongly developed within the annulated depressions and much less distinctly at the dilations. Costæ not visible in the depressions, by reason of the thickness of the epitheca. Septa short, subequal, not alternating. Tabulæ concave, central area flat and smooth. Calyx not observed.

The specimen illustrated has the basal point broken off and the top injured so we can not determine whether the expansion, in that part, is the calyx or not. There are twenty-eight septa at the third dilation, where the diameter is .30 of an inch, though above, in the annulated depression, the diameter is only .23 of an inch. The broad and deep, annulated depressions of the coral are regarded as distinguishing features of the species.

Collected by R. A. Blair, in whose honor I have proposed the specific name, in the lower part of the Chouteau limestone, near Sedalia, Missouri, and now in my collection.

### AMPLEXUS BICOSTATUS, N. SP.

*Plate I, fig. 10, fragment of a silicified specimen showing septa, tabulæ and costæ.*

Corallum simple, medium size or large, elongate, subcylindrical, curved, constrictions linear. Epithecal crust very thin. Radial plates or costæ thin and each one grooved in the middle, giving the costæ the appearance of being arranged in pairs. Septa short, equal. Tabulæ inclined and then transverse from the outer walls, central area flat. Calyx not observed. Length unknown.

There are thirty-six septa, where the diameter is .9 of an inch, or thirty-six double costæ, and the tabulæ are distant from each other about .2 of an inch. A specimen five inches in length and broken at both ends tapers only one-fourth its diameter. The structure will distinguish this from all other species.

Found by R. A. Blair, in the Burlington group, near Sedalia, Missouri, and now in my collection.

The progress of palæontological knowledge in this century is well illustrated by this genus, which was described by Sowerby in 1814, in

Mineral Conchology, p. 165, as a multilocular shell, and his type species named *Amplexus coralloides*, because he thought it resembled a coral. His definition of the genus is as follows: "Shell nearly cylindrical, divided into chambers by numerous transverse septa; septa embracing each other with their reflexed margins." In describing the species, he said: "This extraordinary production, an example of the curious structure of organic antediluvian remains, is from the black rock at Limerick. I have been favored with specimens by my ingenious friends, Mr. Wright, of Cork, and Mr. Moore, of Dublin. They seem a type of a peculiar formation or æra in that limestone, which requires some penetrating research. Its resemblance to a coral or madrepore has probably caused it to be less noticed, as looking like ordinary specimens of branches of that tribe. Upon examining it, however, its uncommon structure is developed, and we are enabled to add another genus to the multilocular shells."

His specimens belong to two or three different species, but he thought they consisted of big shells and little ones. The early geologists of this country, who knew very little about palæontology, bunched specimens in like manner, and referred different species from different Groups to Sowerby's *Amplexus coralloides*, and in my work on North American Geology and Palæontology, on the authority of others, I retained the name for a species from the Warsaw Group, but after careful research and examination, I am convinced there is no species found in this country which can be referred with any confidence to *Amplexus coralloides*, and therefore the name should be stricken from catalogues of American palæozoic fossils.

### Amplexus corniculum, n. sp.

*Plate I, fig.* 21, *summit view with calyx broken off; fig.* 22, *side view.*

Corallum small, simple, subturbinate, resembling *Zaphrentis*, more or less curved, surface irregularly constricted by intermittent growth and smaller concentric wrinkles. Epithecal crust not preserved in our specimens. Septa equal, not alternating, coarse, reaching two-thirds of the distance from the wall to the center of the corallum. Tabulæ somewhat irregular in direction and at unequal distances from each other, but directed from the wall obliquely downward for a short distance and then transversely, leaving the central area flat or slightly concave. Calyx circular, shallow, the plain surface at its bottom equal to one-third the diameter of the calyx. Septal fossula not well developed.

There are twenty-four septa in the specimen illustrated, which is .45 of an inch in diameter. Another specimen of the same dimensions preserves the calyx. Other specimens taper to a point. None have been collected larger than the specimens described.

Found by R. A. Blair, at the stone quarries in the upper part of the Chouteau limestone, near Sedalia, Missouri, and now in my collection.

### ZAPHRENTIS CHOUTEAUENSIS, N. SP.

*Plate I, fig.* 11, *front view, showing calyx; fig.* 12, *side view.*

Corallum below medium size, slightly curved, rapidly expanding at the sides, and tapering to a point at the base. Usually constricted immediately above the base, and also having shallower constrictions on the convex side; caused by intermittent growth. Epitheca thin. Calyx subovoid, nearly parallel with the long axis of the corallum or standing almost upright; it constitutes nearly the whole corallum, for there is only a small point below it. Septa unequal, a few small ones near the margin of the calyx, but they soon fade away; primary septa short and thick in the expanded part of the calyx and coalesce as they approach the base of the cup. There are thirty-two primary septa in the calyx of the specimen illustrated by figure 11, a much smaller specimen has only twenty-four, and larger specimens probably have as many as forty. Septal fossula large, occupying the central part of the calyx and projecting toward the concave side of the corallum. This species is distinguished by its lateral expansion, upright calyx, and short, thick, coalescing septa.

Found by R. A. Blair, at the stone quarries, in the lower part of the Chouteau limestone, near Sedalia, Missouri, and now in my collection.

### ZAPHRENTIS CALYCULUS, N. SP.

*Plate I, fig.* 13, *front view, showing calyx; fig.* 14, *side view.*

Corallum quite small, slightly curved, turbinate, rapidly expanding from a bluntly pointed base. Surface constricted by intermittent growth and finer transverse wrinkles or concentric striæ. Epitheca well developed. Calyx slightly inclined to the long axis of the corallum and very broad and deep, outer wall thin. Septa very short, thick, alternate, increasing with the expansion of the cup by intercalation and bifurcation. There are forty-four septa at the margin of the specimen illustrated by figure 13, and twenty below, where they coalesce with the wall of the calyx in six undefined groups, varying in number from one to six in each, without any proper fossula. Below the point of coalescing with the wall of the corallum, the bottom of the calyx is smooth, and in the specimen illustrated the greatest depth is to the right.

This species is distinguished by the broad and deep calyx, which occupies nearly the whole corallum, and by the short septa coalescing with the wall of the corallum.

Probably it should not be referred to the genus *Zaphrentis*, because the septa are rudimentary or very short and the fossula so characteristic of *Zaphrentis* is absent. It would seem to be nearer *Anisophyllum*, but, so far, that genus is not definitely known as high as the Subcarboniferous rocks, though Prof. Worthen doubtfully referred a Subcarboniferous species to it. At present the generic reference is provisional.

Found by R. A. Blair in the lower part of the Chouteau limestone, near Sedalia, Missouri, and now in my collection.

### ZAPHRENTIS TENELLA, N. SP.

*Plate I, fig.* 17, *showing radiating septa, calyx broken away; fig.* 18, *side view of same specimen.*

Corallum simple, elongate, turbinate, twisted, moderately curved, regularly enlarging and tapering to an acute point at the base. Surface marked by shallow constrictions of growth and smaller concentric wrinkles. Epitheca not preserved. Calyx deep, very slightly inclined to the long axis of the corallum or nearly transverse, outer wall thin. Septa equal, thin, moderately large and uniting around a subcentral fossula, that extends to the wall, on the left side of the corallum. Septal fossula extends from the center to the wall and embraces a rudimentary septum. There are twenty-six septa in the specimen illustrated, which is .35 of an inch in diameter.

This species is distinguished by its elongated form, long, tapering point and number and position of septa and fossula.

Found by R. A. Blair, at the stone quarries, in the upper part of the Chouteau limestone, near Sedalia, Missouri, and now in my collection.

### ZAPHRENTIS EXIGUA, N. SP.

*Plate I, fig.* 19, *front view, showing calyx, magnified two diameters; fig.* 20, *side view of same specimen, magnified two diameters.*

Corallum very small, slightly curved, turbinate, and terminating in an acute point. Surface constricted by intermittent growth. Epitheca very thin, distinctly exposing all the costæ. Calyx moderately oblique to the axis of the corallum, broad and deep, outer wall very thin, even transparent. Septa equal, very thin, and uniting around a subcentral fossula, which extends to the transparent wall, on the concave side of the corallum. There are twenty septa in the calyx illustrated, which is about .24 of an inch in diameter.

This species is distinguished by its small size, pointed base, proportionally large calyx, and thin wall and thin septa.

Found by R. A. Blair, at the stone quarries, in the Chouteau limestone near Sedalia, Missouri, and now in my collection.

### ZAPHRENTIS TANTILLA, N. SP.

*Plate I, fig.* 23, *view of the calyx, for the purpose of giving an idea of its depth, magnified two diameters; fig.* 24, *side view of the same specimen, magnified two diameters.*

Corallum very small, moderately curved, elongate, turbinate, regularly enlarging, and acutely pointed at the base. Surface bearing a few shallow constrictions of growth. Epitheca thin. Calyx very deep, and mouth transverse, not oblique, to the long axis of the corallum. Septa equal, short and uniting at the center of the cavity. The calyx is so deep that I have been unable to see the fossula by looking into it. Where, however, the wall of the calyx is broken away, I have observed a subcentral depression, that indicates the position of a small fossula on the convex side of the corallum. There are twenty-four septa in the specimen illustrated, which is .1 of an inch in diameter; a little larger specimen has thirty septa.

This species is distinguished by its minute size, elongated form, and deep, transverse calyx.

Found by R. A. Blair, at the stone quarries, in the lower part of the Chouteau limestone, near Sedalia, Missouri, and now in my collection.

### Zaphrentis declinis, n. sp.

*Plate I, fig.* 25, *view of calyx and concave side; fig.* 26, *side view of another specimen.*

Corallum small, elongate, turbinate, more or less curved, and tapering to a point at the base. Surface with shallow constrictions, caused by intermittent growth, and finer transverse wrinkles or concentric striæ. Epitheca thin. Calyx moderately oblique to the long axis of the corallum and rather shallow, margin thick. Septa nearly equal, not alternate, thick within the wall, sharp centrally, not twisted; costæ thick, showing externally. Septal fossula not well developed and situate on the convex side of the corallum. There are twenty-four septa in the circumference of a calyx .4 of an inch in diameter.

This species is distinguished, by its elongate, turbinate form, coarse, sharp septa, and wide costæ.

Found in the Keokuk Group, at New Providence, Indiana, and now in the State Museum at Indianapolis.

## FAMILY CYSTIPHYLLIDÆ.

### Cystelasma, n. gen.

(Ety. *kustis*, a cavity; *elasma*, lamellæ.)

Corallum simple, irregularly turbinate or cylindrical, consisting of an outer wall, transversely wrinkled or constricted, which is connected by oblique plates, irregularly disposed, that give to the interior cystose chambers of unequal size and irregular shape. No septa or regular tabulæ. Structure vesicular. Type C, lanesvillense.

### Cystelasma lanesvillense. n. sp.

*Plate I, fig.* 15, *summit and side view; fig.* 16, *side view of another specimen showing rootlets for attachments.*

Corallum simple, small, subcylindrical, attaching by rootlets or by a basal pedicel, strongly wrinkled and constricted transversely; sometimes expanding rapidly from a small basal pedicel to the full size of the corallum, as shown in figure 15, or gradually expanding from rootlets, as shown by figure 16. Internal structure consisting of large and small cystose chambers or cavities, without any regular order, the walls being longitudinal, transverse and oblique, sometimes leaving the whole internal diameter of the corallum in a single chamber, and again dividing it into two, three, four or more cavities, some of which are much larger and much more elongated than others. The cavities in our specimens are empty or filled with calcite. There is no calyx, for the summit is open, or divided by the internal walls, showing incomplete cavities, and the same structure that exists below. There are no septa or true tabulæ.

Found in the Warsaw Group at Lanesville, Indiana, and now in the State Museum, at Indianapolis.

## SUBKINGDOM ECHINODERMATA.

## CLASS CRINOIDEA.

## ORDER CYSTOIDEA.

## FAMILY HOLOCYSTIDÆ.

### Holocystites adipatus, n. sp.

*Plate II, fig.* 1, *lateral view; fig.* 2, *basal view.*

Body large, somewhat obovate, free. Seven plates in the basal series, of irregular size, surround an opening, without any indication that the animal was ever attached to any other object. This opening, at the base, is quite peculiar and in striking contrast with the sessile species, that attach by a solid base, as illustrated in *H. madisonensis.* The plates are convex, of unequal size, and irregularly distributed over the surface. Between the first and second series there are four plates on the tumid side of the fossil and one on the opposite side. There are thirteen plates in the second series, five of which abut upon the plates of the first series. The plates are polygonal, some are large and others small, and if they were arranged in series there would be about ten series. Mouth and ambulacral opening not preserved in our specimen. Entire surface tubercular and poriferous.

Collected by J. F. Hammell, in Jefferson County, Indiana, in the lower part of the Niagara Group.

### Holocystites gorbyi, n. sp.

*Plate II, fig. 3, lateral view; fig. 4, summit view.*

Body somewhat ellipsoidal, sessile, attaching at one side of the basal part. Covered by five ranges of plates on the anterior side and a few additional plates on the posterior side. Plates slightly convex and poriferous. Mouth large, irregularly pentagonal and surrounded by six plates. Supposed anal opening between the mouth and ambulacral orifice two plates distant from the latter and in a suture between the plates adjoining the latter opening. Ambulacral orifice large, subquadrate, and surrounded by six plates. Four cicatrices for ambulacral spines.

Collected by J. F. Hammell, in the Niagara Group, in Jefferson County, Indiana.

### Holocystites scitulus, n. sp.

*Plate II, fig. 5, side view; fig. 6, summit view.*

Body small, somewhat globose, sessile, covered by four ranges of plates on the anterior side. Plates poriferous. Mouth large, irregularly pentagonal and surrounded by five plates. Supposed anal opening between the mouth and ambulacral orifice and in the plate adjoining the latter opening. Ambulacral orifice large, elongated side toward the mouth arcuate. Four cicatrices for ambulacral spines.

Collected by J. F. Hammell, in the lower part of the Niagara Group, in Jefferson County, Indiana.

### Holocystites commodus, n. sp.

*Plate III, fig. I, posterior view; fig. 2, summit view; fig. 5, side view of another specimen. fig. 6, summit view.*

Body subglobose or somewhat elliptical, sessile, basal place of attachment small. Covered by six ranges of plates. Plates moderately convex and poriferous. Mouth large, hexagonal and surrounded by six plates. Supposed anal openings two, one in the central part of each plate between the mouth and ambulacral opening. Ambulacral orifice large, subquadrate. Four cicatrices for ambulacral spines. I have illustrated two specimens of this species the better to show its characters and to distinguish it from *H. gorbyi*, which it very much resembles, though it is covered with more plates, has an hexagonal instead of a pentagonal mouth, and has two openings between the mouth and ambulacral orifice instead of one.

Collected by J. F. Hammell, in the lower part of the Niagara Group, in Jefferson County, Indiana.

### Holocystites madisonensis, n. sp.

*Plate III, fig. 3, side view; fig. 4, basal view.*

Body rather large, globose, very tumid on one side, sessile, place of attachment large. Plates large, slightly convex and poriferous. There are seven plates, very unequal in size in the first range; sixteen in the second range, and six plates inserted between these ranges on the tumid side. The summit of our specimen is destroyed, but there are apparently six or seven ranges of plates in the species. It need not be mistaken for any other species heretofore described.

Collected by J. F. Hammell in the lower part of the Niagara Group, in Jefferson County, Indiana.

### Holocystites indianensis, n. sp.

*Plate III, fig. 7, lateral view.*

Body, medium size, globose, sessile and covered by five ranges of plates. Plates slightly convex and poriferous. There are six plates in the first range, eight in the second and nine in the third. Mouth subpentagonal, and surrounded by five plates. Ambulacral orifice subquadrate and much smaller than in *H. commodus*. Four cicatrices for ambulacral spines. It is readily distinguished from all other species.

Collected by J. F. Hammell, in the lower part of the Niagara Group, in Jefferson County, Indiana.

### Holocystites wykoffi, n. sp.

*Plate IV, fig. 1, posterior view; fig. 2, summit view, compressed at the mouth.*

Species sessile, large, globose, rapidly expanding from the top of the second range of plates, excessively tumid on the right side, covered by about twelve irregular ranges of unequal plates, and a few intercalated ones. Plates numerous in each range; the first one having fifteen, and some of them having more than thirty. Ambulacral opening at the summit, large, elliptical, surrounded by six very thick plates, five of them bearing arm cicatrices. Mouth at the margin of the summit and compressed in our specimen, so its shape can not be determined. Surface of the plates bearing small pustules and all of them pierced by numerous pores.

Found in the Niagara Group, of Jefferson County, Indiana, and now in the collection of J. F. Hammell. The specific name is in honor of Mr. Charles W. Wykoff, an active collector of fossils at Madison, Indiana.

### HOLOCYSTITES COLLETTI, N. SP.

*Plate IV, fig. 3, showing the mouth and ambulacral opening. Part of the plates are broken between the mouth and ambulacral opening.*

Body long, slightly curved to the ambulacral side, very gradually increasing in size, toward the anterior end, and covered by nine ranges of rather large plates. The plates in the first and second ranges are longer than wide, while those in the third range are wider than long. The fourth range is composed of the largest plates in the body, and the sixth and seventh ranges are next in size. The summit is prolonged in the direction of the ambulacral orifice, though the orifice is not upon the summit, but upon the left anterior side. The orifice is subelliptical, and surrounded by seven very thick plates. There are no cicatrices or other evidence of arms. The mouth is large, subcircular, situated on the side, at the top of the seventh range of plates and surrounded by five plates. The surface of the plates is pustulated and numerous pores penetrate the body at the pustules.

Found in the Niagara Group, in Jefferson County, Indiana, and now in my collection.

I take great pleasure in dedicating this beautiful species to Prof. John Collett, late State Geologist of Indiana, who has devoted a long and useful life to the advancement of education and the development of the geological resources of the State, and whose genial disposition and kindness of heart have made him beloved by all with whom he has ever come in contact.

### HOLOCYSTITES PARVUS, N. SP.

*Plate IV, fig. 4, posterior view; fig. 5, summit view.*

Species sessile, small, subglobose, and covered by about five ranges of more or less tumid plates of unequal size and a few intercalated ones. Ambulacral orifice at the summit, subelliptical; surrounded by six very thick plates having four arm cicatrices. Mouth at the margin of the summit two plates distant from the ambulacral orifice, subpentagonal and surrounded by five plates. Plates covered with small pustules and pierced with numerous pores.

Collected by J. F. Hammell, in the Niagara Group, of Jefferson County, Indiana.

### HOLOCYSTITES SPANGLERI, N. SP.

*Plate IV, fig. 6, anterior view.*

Species sessile, large, subcylindrical in the central part and pointed below, tumid in the lower part of the left side and covered by about ten irregular ranges of unequal plates and a few intercalated ones. Ambulacral orifice at the summit and surrounded as indicated in our specimen by six very thick plates. Only one arm cicatrix is preserved in our specimen and, apparently, there were only four cicatrices. Mouth at the margin of the summit, subpentagonal and surrounded by five plates. Plates covered with small pustules and pierced with numerous pores.

Collected by J. F. Hammell, in the Niagara Group of Jefferson County, Indiana. The specific name is in honor of Mr. George Spangler, one of the first collectors of cystideans, in Jefferson County, and now a resident of Los Angeles, California.

### HOLOCYSTITES ORNATISSIMUS, N. SP.

*Plate V, fig. 1, right side; fig. 2, summit view.*

Species sessile, medium size, subglobose, tumid below, on the left, posterior side, and above, on the right anterior side, and covered with seven ranges of plates of unequal size and a few intercalated ones. Ambulacral orifice at the summit, subelliptical, surrounded by six very thick plates, four of which bear prominent arm bases. Mouth near the margin of the summit, subelliptical and surrounded by five plates. Plates ornamented with many large pustules and pierced with numerous pores.

Found in the Niagara Group of Jefferson County, Indiana, and now in my collection.

### HOLOCYSTITES BENEDICTI, N. SP

*Plate V, fig. 3, side view.*

Species sessile, medium size, subovate, covered with seven ranges of elongated plates and a few intercalated ones. There are ten small plates in the first range and thirteen in the second range. Neither the ambulacral orifice nor the mouth is preserved in our specimen. The plates are ornamented with pustules and pierced with numerous pores.

Found in the Niagara Group, of Jefferson County, Indiana, and now in my collection. The specific name is in honor of Mr. A. C. Benedict, an active collector and an assistant on the Geological Survey of Indiana.

### HOLOCYSTITES SUBOVATUS, N. SP.

*Plate V, fig. 4, anterior side; fig. 5, summit view.*

Species sessile, below medium size, subovate, tumid below, on the left posterior side, and above on the left anterior side, and covered by six ranges of plates and a few intercalated ones. The plates increase in size from below, upward; those on the summit very large. There are apparently, only six plates in the lower range, but they are quite numerous in the third, fourth and fifth ranges. Ambulacral orifice near the summit, subelliptical, surrounded by six very thick plates, four of which bear prominent arm bases. Mouth eccentric, subelliptical, and surrounded by only four plates. The pustules on the plates are large and the plates are pierced by numerous pores.

Collected by J. F. Hammell, in the Niagara Group of Jefferson County, Indiana.

### Holocystites parvulus, n. sp.

*Plate V, fig. 6, left posterior view.*

Species small, sessile, subelliptical, pointed below, most tumid on the left side and in front of mouth, and covered with numerous plates of unequal size without definite arrangement above the second series. The whole surface is strongly tuberculated. The attaching plates are not preserved in our specimen; the first and second ranges above these have eight plates each. Ambulacral orifice at the summit, subquadrate, and surrounded by six plates, four of which bear prominent arm bases. The mouth is subpentagonal and distant two plates from the ambulacral orifice. It is surrounded by five plates. The so-called anal opening is in the central part of the plate adjoining the mouth instead of in the suture between the two plates adjoining the ambulacral orifice.

Collected by J. F. Hammell, in the Niagara Group of Jefferson County, Indiana.

### Holocystites papulosus, n. sp.

*Plate V, fig. 7, left side view, showing how it attached to some small cylindrical object; fig. 8, summit view.*

Species sessile, medium size, irregularly subelliptical, and covered by eight ranges of plates, that gradually increase in size upward, and a few intercalated plates on the tumid side. Tumid below on the posterior side, and above on the left anterior side. There are seven plates in the first range that attached to some small cylindrical object. There are fourteen plates in the fifth range which contains more than any other series. Ambulacral orifice at the top of the prolonged summit, subelliptical, surrounded by six thick plates that stand nearly upright; four of which bear strong arm bases. Mouth close to the arm bases, subelliptical and surrounded by five plates. Plates covered with very large pustules and pierced by numerous pores.

Collected by J. F. Hammell, in the Niagara Group of Jefferson County, Indiana.

## FAMILY CARYOCRINIDÆ.

### CARYOCRINUS INDIANENSIS, N. SP.

*Plate V, fig. 9, azygous, side view; fig. 10, view of the summit.*

Body subturbinate, constricted below the arms. Four rather long plates in the first series; two pentagonal and two hexagonal, counting the faces that abut upon the column. Six plates in the second series, longer than wide and larger than those in the first series, two pentagonal, two hexagonal, and two heptagonal; eight plates in the third series; these are shorter and smaller than those in the first series; all of them support arm-plates, and two of them project up between the arm-plates, so that each unites with a small vault plate. There are twenty-one arms disposed in seven clusters; there are five in the cluster on the right of the azygous opening, four in the cluster on the left, and two others have three arms each, and the other three have two each.

The vault is depressed, convex, and sunken between the arm clusters so as to give it a wavy surface. The central plate is large, heptagonal; it is surrounded by seven plates that cover nearly the whole summit. Two of the seven plates curve upward and surround two-thirds of the prominent azygous opening. The seven plates are surrounded by a circle of smaller plates, some of which reach the arm-plates, and others extend to a second series that reach the arm-plates. The azygous opening is prominent and surrounded by either three or four plates; if there are four, one is quite small.

Surface of calyx covered by numerous granules that radiate from the central part of each plate to each angle of the plate; and sometimes they coalesce into radiating lines or ridges; there are also a few pustules between the radiating lines, the number depending upon the size of the space between the lines. The plates of the vault are also covered with granules, but they seem to have no definite arrangement. Every granule is punctured by either one or two pores. In some cases a pore punctures the summit of a granule, and, in other cases the pores penetrate the sides. The pores form a row upon each side of the radiating lines.

This species is distinguished from *Caryocrinus ornatus* by the general form of the calyx, by the general form of the vault, and by the proportionally smaller size of the second range of plates. There are fewer plates on the vault, the arms are much more numerous and differently disposed. The arrangement of the pustules on the plates is also different. These differences seem to me to be sufficient to constitute a new species. The vault of this species is so different from that of *C. ornatus*, the structure of which Wachsmuth thought was generic, and from which he attempted to draw morphological laws of development and to infer evidences of the relationship of *Stephanocrinus* with *Haplocrinus*, *Cyathocrinus* and other crinoids, that we quote some of his remarks from page 290, Part III, of his Palæocrinoidea. He says:

"As a further proof that the central piece is the representative of the orals, we refer to the Cystid genus *Caryocrinus*, which has three in place of five groups of arms, and which, according to our interpretation, has no proximals. The central piece which occupies the center of figure, and which we think represents the oral pyramid, is surrounded by eight plates, by *five* (not four) large ones, and three smaller ones, the latter conforming jointly to one of the other five. Three of the plates have a strictly radial position, the three others, including the compound one which takes the azygous side, are interradial."

He will find some difficulty in discovering eight plates surrounding the central plate in this species where only seven exist, and quite as much trouble in arranging the plates to conform to his views of those occupying radial and interradial positions.

Collected by J. F. Hammell, in the Niagara Group, in Jefferson County, Indiana.

## FAMILY STRIBALOCYSTIDÆ, N. FAM.

This family is proposed to receive the new genus Stribalocystites, and for the present, the family characters must be regarded the same as the generic.

## STRIBALOCYSTITES, N. GEN.

(Ety. *stribalos*, close pressed, thick; in allusion to the thick, tumid plates; *kustis*, bladder).

Body rudely subovate or subelliptical and covered by about five series of tumid plates. Basals four, unequal. Second series of plates six, unequal. Third series of plates eight, unequal. Fourth and fifth series irregular and covering the summit. No arms. Orifice at the summit, one near the summit on the azygous side, and another on the left near the summit, both being above the third range of plates. Type S. tumidus.

### STRIBALOCYSTITES TUMIDUS, N. SP.

*Plate VI, fig. 33, view opposite the azygous side; fig. 34, basal view, magnified two diameters.*

Body small, rudely subelliptical, plates very tumid. Basals four, of unequal size, standing upright, sutures deep, deeply excavated for the column, and pierced by a small round orifice, for the columnar canal. Second series of plates the larger plates of the body, of unequal size, very tumid, two pentagonal, two hexagonal, and two heptagonal The heptagonal plates are the larger plates in this series. The azygous side is somewhat depressed convex, and the plate in the second series is wider than high and hexagonal, the plate on either side is heptagonal, it supports on its upper sloping sides two plates of the third series, which are followed by three smaller plates that abut upon the anal or azygous orifice. The plate opposite the hexagonal one, on the azygous side, is hexagonal, and the other two, in the second series are pentagonal. Third series of plates of unequal size and not in line by reason of curving over the large heptagonal plates of the second series.

The plates above the third series are not in ranges and must be otherwise described. The orifice on the azygous side is surrounded by five plates, three small ones below and two larger tumid plates above; the latter abut upon three of the summit plates that surround the ambulacral orifice. The ambulacral orifice is surrounded by seven plates, four of them are very tumid and arranged in a subquadrate outline, with a small plate inserted between them on each of three sides. The two adjoining tumid plates, surrounding this orifice, are the larger ones and belong to the third series. The orifice on the left of the azygous side is surrounded by five plates, two small ones below, inserted above the third range, one that abuts the azygous orifice, and two of the plates that abut the ambulacral opening. Two small plates are also inserted on the right side above the third range of plates. Making in all thirty-two plates.

Collected by A. C. Benedict, in the Niagara Group, at St. Paul, Indiana.

? ? ?

*Plate VI, fig.* 29, *summit view; fig.* 30, *side view of same, magnified two diameters; fig.* 31, *summit view of another specimen; fig.* 32, *side view of same, magnified two diameters.*

A minute orifice may be seen at the summit, and also at the base of both these specimens, otherwise the illustrations show all that an examination reveals under an ordinary magnifier. The lower part of each is a short cylinder, the base is flat. The specimen represented by figures 29 and 30 preserves a pyramid, which projects at the base, beyond the cylindrical part above referred to, and consists of transverse imbricating pieces, thrown into longitudinal waves or crossed by concave furrows. There are five of these wave crests, one of which divides the pyramid into two equal parts, and has one wave crest upon one side and three upon the other. The base of the pyramid extends lower upon the side having the three wave crests than upon the other. In addition to these lines and furrows, there are numerous fine lines running down the pyramid on all sides. The specimen represented by figures 31 and 32 I believe to be the same species as that represented by figures 29 and 30, with the pyramidal part broken off at the first concentric imbricating line, above the flange, which projects beyond the cylindrical part of the body. If so, the imbricating pieces that constitute the pyramid are radiately furrowed upon the uniting faces. If the two specimens belong to distinct species they are nearly related, for the specimen represented by figures 31 and 32 has a convex summit, and is furrowed and radiately lined in the same manner as the other specimen. There is no evidence of any internal cavity.

These specimens are illustrated and defined for the purpose of calling attention to them, but I have not named them, because I do not know to what order, in the Class Crinoidea, to refer them. They are absolutely new to me, and I know of nothing with which to compare them.

Collected by J. F. Hammell, in the Niagara Group, near Madison, Indiana.

## ORDER BLASTOIDEA.

### FAMILY STEPHANOCRINIDÆ.

#### Stephanocrinus osgoodensis, S. A. Miller.

*Plate VI, fig. 1, the specimen figured originally; fig. 2, a much smaller specimen; fig. 3, summit view showing ambulacral areas, interambulacral plates, the five plates that cover the oral or central opening, and the anal opening; fig. 4, specimen broken off at the basiradial suture showing base of radials, apparently, uniting at the center. Magnified two diameters. All the figures on this plate are magnified two diameters.*

This species was described in the Journal of the Cincinnati Society of Natural History, vol. 2, p. 116, but the summit and ambulacral structure were then unknown.

The three basal plates form a solid obpyramidal body, (except a minute, round, perforation and shallow cup) hexagonal below, the three angles, at the junction of the plates rather obtuse, the others acute below, but fade away before reaching the top of the plates. Two of the plates are hexagonal, having three upper sides, the other is pentagonal. There is a small hemispherical cavity for the insertion of the column. On account of the thickness of the plates the cup above is very shallow.

The five radial plates form obtuse angles at the sutures, but the plates are convex, longitudinally, which well nigh destroys the pentagnal outline. The plates are longer than wide, expand very little, and are deeply and abruptly excavated above for the reception of the ambulacral structure. The appearance of the plates uniting at the center presented by fig. 4 must be abnormal or due to crystalization, for in another specimen, the basals are seen to possess a small cup.

There are no interradials or third range of plates such as Hall figured for *Stephanocrinus angulatus*, on plate 48, vol. 2 of the Palæontology of New York. I think he was mistaken about the generic structure of *Stephanocrinus* and that the third range of plates has no existence in either of the species he described. At least, I have collected *Stephanocrinus angulatus*, at Thorold, Canada, and none of the specimens show a suture that indicates the existence of the third range of plates, and none of the Indiana specimens of this or any other species bears any evidence of such a suture. On the contrary, the radial sutures extend to the top of the radial limbs.

The surface, in well preserved specimens, is covered with fine striæ which are transverse, longitudinal or oblique on different parts; they are transverse below, and oblique from the upper lateral angles of the radials.

The summit is moderately convex over the ambulacral areas, but does not rise to half the height of the radial limbs. There is one plate in each interambulacral area which rises about as high as the limbs of the radials and has steep sloping sides toward the ambulacra and a steep angular ridge sloping to the mouth or central opening, except one which is truncated at the summit by a round anal opening. These five interambulacral plates correspond, as it seems to me, with the deltoids or oral plates of *Codaster* and other kindred Blastoids. The anal opening is round and situate at an angle of union of a deltoid with two radial limbs. It does not seem to have been covered with plates and I am inclined to think it never was so covered.

The central part of the ambulacral area or mouth is pentagonal, in outline, and covered with a convex pentagonal pyramid, composed of five plates; each ray of the pentagonal pyramid directs its angle toward the central line of an interambulacral plate, and the re-entering angles unite with the median grooves in the ambulacral arms. The ambulacral arms are longitudinally convex with a median groove. No side plates of the ambulacra have been discovered, but there is a distinct furrow upon each side, which, in some specimens, is slightly roughened indicating some probability that they existed. The hydrospires have not been detected, but they may have existed at the ends of the ambulacra or within the thick radial plates.

I place the Stephanocrinidæ among the Blastoidea on account of the structure described above, which prevails in all the species I have examined, but there are others who think the affinities are with the Crinoidea and so class the family.

The specimens represented by figures 1 and 2, I collected several years ago, in the lower part of the Niagara Group, at Osgood, Indiana; and those represented by figures 3 and 4 and others examined were found by Mr. J. F. Hammell in rocks of the same age near Madison, Indiana.

## STEPHANOCRINUS ELONGATUS, N. SP.

*Plate VI, fig. 5, side view, magnifiied two diameters.*

This species is distinguish from *S. osgoodensis*, by the elongated form of the body, slight contraction of the basal plates and the triangular character of the base. In other particulars, so far as shown by the specimens at hand, they substantially agree. The basal plates are peculiarly elongated, expand very moderately to meet the radials, and are slightly contracted at the lower third. They are distinctly triangular at and below the contraction, while *S. osgoodensis* is hexagonal in the corresponding part. These differences might be regarded, by some, as indicating merely a variety, especially as *S. osgoodensis* is quite variable in size, and, as shown by figure 2, some specimens are more elongated than others; but I have taken them to be of specific importance, because three specimens, one of which is larger than the one illustrated, possess the distinguishing characters, while *S. osgoodensis* can be distinguished among the most minute forms as well as among those of larger size. The characters seem to be fixed in both species.

Collected by Mr. J. F. Hammell, in the lower part of the Niagara Group near Madison, Indiana.

## STEPHANOCRINUS OBPYRAMIDALIS, N. SP.

*Plate VI, fig. 6, side view magnified two diameters.*

Body obpyramidal and regularly expanding from the base to the summit; sharply triangular below and hexagonal above, the outer faces being more or less concave. The basals and radials about equal in length. The sutures in our specimens are exceedingly indistinct and not indicated by the artist in the illustration. Surface marked by transverse striæ, in the lower part, and by lines and granules above. Basal cavity, in which the column attached, hemispherical.

Radial limbs proportionally shorter than in *S. osgoodensis*, and sinus more broadly concave. The plates are very thick. The central part of the ambulacral area or mouth is pentagonal and covered with five plates. Anal opening as in other species of this genus. The other parts of the ambulacra not preserved in our specimens.

This is a very distinct and strongly marked species.

Collected by J. F. Hammell, in the lower part of the Niagara Group, near Madison, Indiana.

## STEPHANOCRINUS HAMMELLI, N. SP.

*Plate VI, fig. 7, summit view; fig. 8, side view of a large specimen; fig. 9, side view of a smaller specimen with a very small base. Magnified two diameters.*

Body triangular at the base, very rapidly expanding to the top of the basal plates; very slightly expanding, in some specimens, above the basals, and in others there seems to be no enlargement whatever. In specimens having the most abrupt expansion, there is no expansion of the radials. The body is pentagonal from the basals upward. It is shorter and more robust than *S. osgoodensis* or any of the associated species. The surface striæ are transverse, longitudinal or oblique on different parts of the body, but they are more conspicuous and better preserved than they are on *S. osgoodensis*, from the same rocks.

All specimens are distinctly pentagonal above the basals, and none of them are constricted, and in these respects they are quite different from typical *Stephanocrinus gemmiformis*, which are rotund in the middle and contracted near the summit. There are no interradials or third series of plates, as defined and illustrated for *S. gemmiformis*, in Palæontology, of New York, vol. 2, p. 215, pl. 48, though this species is very much like the one Hall described and illustrated in the 28th Rep. N. Y. St. Mus. Nat. Hist. p. 146, pl. 14, from Waldron, Indiana, except as to the interradials shown in the diagrammatic view on page 146, and in figure 20, on plate 14, all of which was reproduced on page 279, plate 13, of the 11th Report on the Geology and Natural History of Indiana. I have never seen a fossil from Waldron, having the characters attributed to it in the diagram and illustrations above referred to; but I have seen specimens of *Stephanocrinus* from Waldron, and have them in my collection that agree almost exactly with the species under consideration and are not separable from it by any well defined characters, though as they are from the upper instead of the lower part of the Niagara Group, more complete specimens might show specific differences. I can not believe the form figured and described by Hall, from Waldron, Indiana, is specifically identical with *S. gemmiformis*, which he figured and described from New York, and I believe he is mistaken in both cases concerning the existence of interradial plates. And I may add, if his diagrams and illustrations are correct in regard to the interradial plates, then none of the species described in this article belong to the genus *Stephanocrinus*, but, on the contrary, belong to an undefined genus.

The number and arrangement of the plates in this species is the same as in *S. osgoodensis*, but the limbs of the radials are proportionally shorter and the oral and anal openings proportionally larger. The summit is very slightly convex over the ambulacral areas, but the five plates that cover the oral opening are arranged as in *S. osgoodensis*. In a specimen having the covering plates of the oral opening quite well preserved, the ambulacral areas appear to be covered with imperfectly preserved plates; and a specimen having the covering plates of the oral opening removed shows concave ambulacral areas. Either a suture or a groove surrounds the ambulacral areas and curves around the points of the interambulacral plates, instead of forming sharp angles, giving the whole the appearance of a five rayed piece with a central pentagonal perforation; but the distal end of each uncovered ambulacral arm looks something like a capital letter B or as if it possessed two hydrospire openings at that place. But there is no depression, at the outer ends of the ambulacral grooves, "semiovoid or horse-shoe-shaped," "reniform" or of any other contour indicating that second radials could ever have been attached. I have examined more than fifty specimens belonging to this genus and have never found the slightest evidence of the existence of a second radial, neither have I found the ambulacral pinnules, which I believe existed; but the former ought not to have escaped observation, if ever present, while the latter being much more delicate might never have been preserved. The appendages, figured on plate lxxxv, vol. 2, of the Palæontology, of New York, do not as it appears to me, resemble the arms of a crinoid, but have the aspect of the pinnules of a blastoid, or at least, approximate them more closely than they do the arms of a crinoid.

Collected by Mr. J. F. Hammell, in whose honor I have proposed the specific name, in the lower part of the Niagara Group near Madison, Indiana.

## ORDER PALÆOCRINOIDEA.

### FAMILY PISOCRINIDÆ.

#### Pisocrinus gemmiformis, S. A. Miller.

*Plate VI, fig.* 10, *side view showing the heptagonal plate on the right that supports two radials, and the radial plate on the left; fig.* 11, *basal view; fig.* 12, *view from above, showing small central cavity and thickness of plates; figures* 24 *and* 25, *supposed to be vaults of this or some other species in this genus. Magnified two diameters.*

This species was described in the Journal of the Cincinnati Society of Natural History, vol. 2, p. 113, from Osgood, Indiana, but is now known from Madison, and other places, in the Niagara Group of Indiana.

Calyx globular, contracted above the middle, depressed at the base, which somewhat resembles a bell mouth; plates thick, surface smooth.

The five basal plates form a triangle, almost equilateral. The three plates in the angles are quadrilateral, the other two are of equal size and triangular; the two quadrilateral plates that are united are the larger ones. The basal triangle is followed by a large plate on each of the three sides, which constitute the principal part of the calyx. One of these plates is followed by two radials as shown in figure 10. The other two are radials in the central part and bear upon their approximate lateral sides a small radial. Two large primary radials and three small secondary radials support the arms or arm-blades. The cicatrices or excavations for the arm-blades are wide and the projecting limbs of the radials short and bent inward.

There are eleven plates in the calyx; five basals, one subradial or azygous plate and five radials, according to Koninck's formula; but they might be defined as five basals, three primary radials, and three secondary radials, for the three large plates occupy the position of subradials, in part, and primary radials in part.

The plates that occupied the place of the arms in ordinary crinoids were evidently blades dovetailed into the top of the radials, as shown to be the case, in *Pisocrinus gorbyi*, though the blades themselves are yet unknown.

Figures 24 and 25 represent the convex side of two plates first discovered by Mr. A. C. Benedict associated with *Pisocrinus* and which he supposed to be the vaults. Wachsmuth had then published the third part of his Palæocrinoidea and described the ventral surface and arms, which he knew nothing, whatever, about, (see p. 173) as follows:

"*Pisocrinus* has similar articular appendages as *Symbathocrinus*, which cover a good part of the ventral surface. The articulation, however, does not occupy the whole width of the radials; there is at each side of the plates an upright extension, which, together with that of adjoining radials, produces interradially, between the arms, a conspicuous projection, similar to that of *Haplocrinus*, but more prominent. The construction of the ventral side is not known, the space beyond the articular faces is open in all our specimens, but probably was covered in a similar manner as in *Symbathocrinus*. The arms are long, simple, rounded along the outer face, and less closely folded than in *Symbathocrinus*. They are composed of extremely long, single joints with parallel upper and lower faces."

Immediately after the discovery of these vaults, as I am informed by Mr. Benedict, he lent the specimens to Mr. Wachsmuth and informed him of the place and surroundings in which they were found and expressed the opinion that they were the vaults of *Pisocrinus*; one of them, Mr. Benedict says, showed indications of being composed of five plates. Afterward, in 1888, Wachsmuth figured the under side of one of these vaults, in the Proceedings of the Academy of Science of Philadelphia, on plate xviii, figure 14, as the "Inner floor of the orals of a *Pisocrinus* from Indiana." And he said, on page 350 of the Proceedings that, "We now recognize also in *Symbathorinus* and *Pisocrinus* five large orals as covering the greater part, if not all, of the ventral surface, more or less similar to those of *Haplocrinus*, though with a very different anal arrangement in *Symbathocrinus* and probably also in *Pisocrinus*.

None of the plates now in the possession of Mr. Benedict show any sutures, and only one any indication of a division of the plate, however, I have no reason to doubt the correctness of Mr. Benedict's observation, though Mr. Wachsmuth does not show the division in his illustration which is magnified four diameters. I am quite at a loss to understand why the under side of this vault should be brought in comparison with the upper side of that of a *Haplocrinus*, a genus with which it has no near affinity whatever. I will describe these specimens, as they appear, before considering the questions as to the division into five plates and the purposes subserved. The two plates differ only in size.

These supposed vault plates are convex, central part prominent, height equal to two-thirds the diameter. Apex apparently solid, with the exception of one specimen, which, being somewhat crystalline, shows, on holding it to the light, under a magnifier, some indications of a division. From near the apex, ten striæ originate and radiate toward the margin, but soon appear as upright plates or lamellæ, and have a height, at their distal ends, one-half greater than the distance from each other, or more than half the height of the whole convex plate. Between each of these and near the apex, ten other striæ originate and radiate to the circumferance of the plate, with very slight increase in size. Viewed from the under side, the larger striæ may be arranged into five pairs and the smaller ones into two classes. The under side is deeply excavated centrally, in the form of a pentagonal pyramid, from the re-entering angles of which a concave depression extends to the outer margin, and truncates the ends of five of the smaller striæ from the convex side, while the angles of the pyramid terminate in the projecting points of the other five of the smaller striæ. The concave depressions divide the lower side into five equal parts, each one of which includes a pair of the larger striæ, between which is the projecting point of one of the smaller striæ; and the furrows which constitute what we have called the angles of the pyramid, likewise divide the lower side, into five equal parts, each one of which includes two of the larger striæ, separated by a concave depression that truncates the end of one of the smaller striæ.

If one of these plates belonged to a *Pisocrinus* it covered the top of the visceral cavity, or, in other words, constituted the vault; the arm-blades enclosed it; the grooves on the inner side of the arm-blades must have had some connection with the furrows between the radiating striæ, so as to form channels to the margin of the plate. The radiating striæ or lamellæ extend beyond the general contour of the plate so as to leave openings or pores leading to the inner cavity of the calyx at the margin of the plate, otherwise I can see no place for food grooves, nor can I discover any mouth or anal orifice. There was no mouth or other opening at the summit of the vault, and if it was composed of five plates that united at the apex, their great thickness is inconsistent with the idea that they opened and closed at this point for any purpose. The five grooves on the under side may represent the continuation of the channels to the central part of the visceral cavity, but I can see no ground for comparison with *Stephanocrinus*, *Haplocrinus*, or any other genus with which Wachsmuth has sought to ally it. I quote the remarks of Wachsmuth from Palæocrinoidea, Part III, p. 287, as follows:

"*Stephanocrinus*, undoubtedly, is closely allied to *Allagecrinus*, *Haplocrinus* and *Pisocrinus*, and must be placed with them among the *Larviformia*, but, owing to marked differences in the form and arrangement of the arms, it can not be arranged either with the *Haplocrinidæ* or *Symbathocrinidæ*, and it will be necessary to establish for it a separate family, except in the arm structure the affinities seem to be particularly close with *Pisocrinus*, which has similar interradial processes, formed likewise by the extended limbs of the radials; but as we know little or nothing of the oral plates and ambulacral structure in this genus, a critical comparison is difficult."

It is sufficient to say there is no affinity in the arm structure of *Stephanocrinus* with *Pisocrinus*, and no similarity in the interradial processes. Certainly there is no family affinity between the two genera, and I think they are not to be classed in the same order.

## Pisocrinus benedicti, n. sp.

*Plate VI, fig.* 13, *side view, showing the position* [illegible] *the small radial, in the notch, between the upper approximate lateral sides of two large pl*[illegible]*tes; figs.* 14 *and* 15, *basal views; fig.* 16, *summit view, magnified two diameters.*

Calyx subcylindrical, and slightly expanding [illegible] the upper third; depressed at the base; plates thick; surface smooth.

Basals rather large, curving into the basal cavity an[illegible] upward so as to be visible in a side view. Plates the same shape as in *P. gemmiformis*, but the triangular plates extend farther beyond the lines of the triangle. The large plates that constitute the principal part of the calyx are more elongated than in *P. gemmiformis*; and the cicatrices or excavations for the arm-blades are narrower, and the radial limbs wider, proportionally. The arm-blades were, no doubt, the same as in *P. gorbyi*, and the dovetailed tenons narrower and longer than in *P. gemmiformis.* All that I have said in regard to the plates of the vault of *P. gemmiformis* applies with equal or greater force to the vault of this species, for they were found associated with it.

Collected by Mr. A. C. Benedict, now of the Geological Survey, in whose honor I have proposed the specific name, at Marion, Wabash and other places in the Niagara Group in Indiana.

## PISOCRINUS GORBYI, N. SP.

*Plate VI, figs.* 17 *and* 18 *side views; fig.* 19 *summit view; fig.* 20 *side view with arms-blades in position, all of which are from Indiana. Figs.* 21, 22 *and* 23, *the same species from Tennessee, but having a rather shorter calyx. Magnified two diameters.*

Calyx small, variable in size; height and width subequal; base small, round, sunken for the columnar attachment; rapidly expanding in the radial region and strongly lobed toward the tenons of the arm-blades, giving the summit a strong five-lobed outline; plates thick; surface smooth or finely granular.

The five basal plates form a small, nearly equilateral triangle, most of which is sunken in the basal cavity. The basal triangle is followed by a large plate on each of the three sides, which constitute almost the entire calyx. One of these is followed by two radials, and the others are radials in the central part and bear upon their approximate lateral sides a small radial. Thus, two large plates and three smaller ones support the arms. They are each excavated in the central part, which corresponds with the lobes of the calyx by a long dovetailed mortise, and have correspondingly long, wide limbs, that curve inward toward each other. The radial sutures do not divide the apex of the limbs, but terminate a little below on one side; for example, the radial limbs of the small, single, secondary radial are not quite as long as the adjoining limbs of the large primary radials and terminate on the sides below the greatest extension of the latter.

The radials, instead of bearing arms, as in ordinary crinoids, bear long, single pieces, which I designate, by the name of arm-blades. There are five arm-blades, one from the mortise of each radial lobe. They are longitudinally convex, depressed at the sutures, and together form a pentagonal pyramid. Each one has a long, dovetailed tenon inserted in the radial notch, and expands above the tenon to unite with the adjoining arm-blade. The expansions cross the terminations of the radial sutures, so that the suture lines between them are not a continuation of the sutures between the radials. Each arm is longitudinally concave or furrowed on the inside. There may have been more than one arm-blade in each arm, but we only describe one, because no more are preserved in our specimen.

From the shape of the arm-blades, their manner of uniting at the sides, and the insertion of the tenons in the radial mortises, one might infer that they were locked in position and were not capable of being opened. But the radial plates are mortised in the interior and have an internal opening at the base of the mortise so that the arm furrows had a continuous way to the visceral cavity, and therefore, there is no obstacle in the way of supposing the arms could expand or open outwardly as other crinoidal arms did, except the sides of the mortise or radial limbs must, necessarily, have remained stationary and curved toward the vault. The vault is not definitely known, but the remarks concerning the vault of *P. gemmiformis*, probably apply with equal force to this species, as the vaults which have been found differ only in size and occur in the same rocks with this species and *P. benedicti*. The specimens represented by figures 21, 22 and 23 were collected by Prof. S. S. Gorby, in the Niagara Group, in West Tennessee, and differ so far as can be ascertained, from the species here described, in being proportionally shorter or more depressed. If other parts were known possibly specific characters could be discovered that would distinguish the forms from this species.

The late N. P. Angelin, in Iconographia Crinoideorum, described three species of *Pisocrinus*, two of which he illustrated with arms, viz.: *P. flagellifer* and *P. pocillum*. The descriptions are short and I will quote them as follows:

*P. flagellifer*. "Calyx brevis, cyathoideus; lævissimus, testa crassa. Radialia primaria quinque, inæqualia, posteriora duo et dorsuale angusta, lunulata, inter se similia, intermedia, duo lata et inter se similia; secundaria subrectangularia. Anale magnum, diametro longitudinali transversalem superante, apice acuminatum. Brachia quinque, articuli simplices, teretiusculi, longitudine latitudinem plus triplo superantes. Columna angusta, apice incrassata, articulis crassiusculis."

*P. pocillum*. "Radialia primaria quinque inæqualia, acuta, posteriora minora, margine superiore plano, anteriora oblongula, clypeiformia; secundaria rectangularia. Interradiale oblongulum, sexangulum. Anale oblongum, acutum, heptagonum. Brachia articulis simplicibus, longissimis, longitudine làtitudinem quintuplo superantibus. Columna apice antrorsum incrassata. Affinibus paullo robustior, testa ornatissima instructus."

His illustration of *P pocillum* shows a transverse face at the top of the calyx, without any indication of radial limbs. The first arm plates are short, not half as long as wide, and unite around the top of the calyx, except at the azygous side, where a triangular plate is inserted to break the circle. The second plates are elongated. The illustration of *P. flagellifer* shows radial limbs and a short arm plate about as high as the limbs, resembling in position the second plate in the radial series of *Platycrinus*, it is succeeded by long plates forming long slender arms. Neither the descriptions or figures throw any light upon the structure of the *Pisocrinus* in Indiana. Possibly they are not congeneric.

The specific name of this species is in honor of Prof. S. S. Gorby. It occurs in the Niagara Group, at Wabash, Marion and at other places in Indiana.

### PISOCRINUS CAMPANA, N. SP.

*Plate XI, fig. 4, side view; fig. 5, summit view.*

Species rather large; calyx bell-shaped, one-half higher than wide, contracted in the middle, rounded below into the basal cavity; plates thick; surface smooth or probably, in perfectly preserved specimens, finely granular.

Basals form a cup conspicuous in a side view, the plates at the angles of the triangle extending high up on the side of the cup, while those between the angles are much lower. The constriction is around the three larger plates of the calyx, and does not include either of the three smaller arm bearing plates. The radial limbs are rather short and thin, and appear to rise higher on the inner side of the test as they approach each other, than on the outer side. The mortises on the inner sides of the radials, or continuation of the arm furrows toward the visceral cavity are large and deep.

This species is distinguished from all others found in Indiana by its larger size, campaniform shape, and small radial limbs. It is not necessary to compare it with any others.

Found in the Niagara Group, at Wabash, Indiana, and now in the collection of A. C. Benedict.

## FAMILY ZOPHOCRINIDÆ, N. FAM.

This family name is proposed to receive the new genus *Zophocrinus*, and, for the present, the family characters are the same as the generic.

### ZOPHOCRINUS N. GEN.

[*Ety zophos, dark obscure; krinon, lily.*]

Body ovate or pear-shaped, and covered by two circles of plates and the vault. Basals or first circle of plates, three forming an obconoidal cup, higher than wide; two of the plates are of equal size, and quadrangular; the other is larger and pentagonal. Second circle of plates, four, three pentagonal and one quadrangular; they are horizontally truncated on top, and bear a circle of numerous pinnules (?) surrounding a vault having a central elevation. Seven plates constitute the test of the calyx. It possessed a column with a small columnar canal. Type, *Z. howardi.*

This genus has the general form of a blastoid, except the summit, which has no resemblance to that order. If there were any of the pores that characterize Cystideans, it might very appropriately be referred to that order. It has neither the form or structure of any known genus or family of crinoids, and, therefore, it is only provisionally referred to the Palæocrinoidea. It is highly probable that when more is known of its structure and affinities, it will become the type of a distinct order.

### ZOPHOCRINUS HOWARDI, N. SP.

*Plate VI, figures 26 and 28, side views of two specimens, with basal ends up, (they should be reversed); figure 27, summit view , with an eroded vault. Magnified two diameters.*

Boby subovate or pear-shaped, greatest diameter at the upper third, pointed below, length more than twice the diameter; surface smooth or possible finely granular; specimens differ much in size.

The basals or first circle of plates form an obpyramidal cup, most rapidly expanding above, and sutures most depressed below so as to give the base, in transverse section, a subhexagonal outline. The cup is one-half higher than wide, the upper faces arcuate. The two smaller plates are equal, quadrangular, the two upper sides the shorter ones. The other plate is pentagonal and has two, upper, short, lateral sides and a longer, central, superior, arcuate side. The base is sunken for the attachment of a small, round column, having a small, central, columnar canal. The second circle of plates or radials, if that is better, are the larger plates of the body, they expand slightly and curve upward, contracting toward the top, where they are horizontally truncated, and when the succeeding plates are attached, they appear as if constricted at this place. They are longitudinally convex, in the central part, and inclined or depressed toward the sutures, so as to distinctly outline the four plates. Three of them are pentagonal and one quadrangular, this is caused by each of three having two under sides, while the other has only one. The length of a plate is about one-half greater than its width. The upper face, while horizontally truncated as seen in a side view, is thickened and beveled toward the interior, and when the superior plates are removed, five pores or arm-openings may be seen to enter the beveled edge of each plate or twenty in all. I do not say these are properly arm-openings, but they are pores passing through the projecting rim of the plates to the visceral cavity of the body, and if this genus is to be classed with the Palæocrinoidea, then they must be regarded as representing the arm openings.

At the time the figures were made, the specimens at hand were eroded, at the summit, and indicated only a single plate or small anchylosed plates with a central elevation for the vault, and hence that is all shown in the illustration; but since that time, Prof. Gorby has purchased Dr. Howard's collection, for the State Museum, at Indianapolis, which contains sixty-five specimens belonging to this species, and the better preserved ones show that twenty compact plates form a circle with pores passing down perpendicularly through them and connecting with the pores passing through the beveled edges of the plates above described; and within this circle there are smaller plates that cover the vault. Prof. Gorby and Mr. Benedict are of the opinion that the circle of twenty plates are the first arm-plates and although they are different from all other arm-plates with which I am acquainted I yield to their judgment.

Found in the Niagara Group, at St. Paul, Indiana. Dr. F. W. Howard of that place was the first to discover and collect this peculiar species, and I have proposed the specific name in his honor.

## FAMILY MELOCRINIDÆ.

### MARIACRINUS AUREATUS, N. SP.

*Plate VI, fig. 36, side and basal view, magnified two diameters.*

Calyx small, bowl-shaped; plates radiately sculptured; each radial series marked by an angular ridge and abruptly curving outward at the top of the calyx. Basals four, unequal, extending beyond the round column, and forming a pentagonal disc. First primary radials, the larger plates of the calyx wider than high, four heptagonal and one hexagonal; second primary radials a little smaller, wider than high, hexagonal; third primary radials as high as wide, hexagonal, axillary. First secondary radials about as high as wide; second secondary radials smaller and axillary, except in the rays adjoining the azygous area, where there are three secondary radials. There are two tertiary radials, the second being axillary, in the ray adjoining the azygous area, preserved in our specimen, and, if the rays are uniform, there are forty arms in this species.

Interradial areas convex, elongate-subovate. Regular interradials seven or eight, the first one resting between the upper sloping sides of two first primary radials, and being nearly as large; it is followed by two smaller plates, and these by two, above which there are two or three minute plates. Intersecondary radial areas having one or two small plates. Azygous area a little wider than the regular areas, and having nine or ten plates; the first one is as high as wide and as large as a first primary radial; it is followed by three plates, and these by two, above which there are three or four smaller ones. One arm commences with three plates in single series, otherwise the structure of the arms is not preserved in our specimen. Vault unknown.

Collected by A. C. Benedict, in the Niagara Group, at St. Paul, Ind.

### Mariacrinus granulosus, n. sp.

*Plate VI, fig. 35, basal view.*

This species is founded upon the basals and first radials, and the propriety of founding a species, on such a fragment may well be doubted; but if there is any justification, it is because these parts are so different from all other species described, that it may be readily separated from them.

The basals are small, sunken and form a pentagonal disc, only a little larger than the end of the column; they are thickened and radiately furrowed at the outer circumference of the place of columnar attachment. Primary radials large, four of them heptagonal and one hexagonal; they rapidly expand from the basals upward, the lateral sides are the longer, and the surface is covered with numerous tubercles. The sutures are wide and deeply beveled, and the lower part of each plate terminates in a tubercle-like blunt end, below the point of columnar attachment. Superior face of the plates arcuate about two-thirds the width of each for the second primary radials; upper lateral sides rather steep forming a sharp angle, for the reception of the first interradials.

Distinguished by the large, rapidly expanding, granular, first primary radials, and by the deep, wide, beveled sutures between them.

Collected by A. C. Benedict, in the Niagara Group, at St. Paul, Indiana.

## FAMILY CALCEOCRINIDÆ.

### Calceocrinus indianensis, n. sp.

*Plate VI, fig. 37, side view of calyx and part of the column, magnified two diameters. The ventral arching plate should be more sharply pointed at the suture.*

Calyx small, basal part; as it appears in a dorsal view, in the form of an inverted, conical frustum, to the shorter plane, of which the column is attached; it is separated from the dorsal side, by a wide, gaping suture, and consists of four plates; it is longitudinally divided, in the center, and has a trapezoidal plate on each side, which extends to the base or place of the columnar attachment. The sides of the calyx are parallel with each other, there being no expansion above the basal suture. The centro-dorsal plate is narrow and tapers a little, from the gaping suture, to the upper dorsal plate. The lower part of the upper dorsal is subtriangular, the lower angle being truncated by the narrow upper end of the centro-dorsal plate. The upper dorsal is not preserved in our specimen. The dorso-lateral plates are irregularly hexagonal and regularly rounded to the ventral side, where each terminates in an angle only slightly truncated, by a ventral plate. Each ventral arching plate is rather large and terminates in a point, at the suture and dorso-lateral angle of a dorso-lateral plate. Lateral brachials not preserved. Column round and at the distance of half an inch from the calyx, each of the plates has a length about equal to the diameter.

Distinguished by the trapezoidal plates in the base, by the narrow centro-dorsal plate, and by the regularly rounded, parallel sides of the calyx.

Collected by A. C. Benedict, in the Niagara Group, at St. Paul, Indiana.

## FAMILY DICHOCRINIDÆ.

### DICHOCRINUS HUMBERGI, S., A. MILLER.

*Plate VI, fig. 38, side view of calyx, magnified two diameters.*

This species was described in Bulletin No. 4, of the Geological Survey, of Missouri, p 26, *from a single specimen, in which the first radials were only about one-half longer than wide. Since that time I have received several specimens which show considerable variation in the size and relative proportions. The specimen illustrated is less than two-thirds the size of the type, and the first radials are twice as long as wide.

Found by R. A. Blair, in the Keokuk Group, at Boonville, Missouri, and now in my collection.

### DICHOCRINUS BLAIRI, N. SP.

*Plate VIII, fig. 12, specimen with arms and part of column, but having the calyx flattened.*

Calyx short, somewhat obconoidal or turbinate; plates thin; surface granular. The two basals form a cup a little more than one-third the length of the calyx; the notch at the union of the basals is distinct.

First radials nearly twice as long as wide, longitudinally convex, and projecting at the arm or brachial facets; very slightly expanding. Articulating facets for the brachials about half the width of the plates, concave and sloping downward. There are two brachials in each series; the first one very short and the second axillary. The first arm-plate is short, the second rather long, constricted in the middle and axillary, giving to the species twenty arms. Arms large, long, and composed of a single series of short, cuneiform plates. Pinnules long and coarse. Column round and composed of very thin plates alternately projecting.

Found by R. A. Blair, in the Keokuk Group, at Boonville, Missouri, and now in my collection. The specific name is in honor of the collector, who is an energetic naturalist, learned geologist, and member of the Geological Board, of Missouri.

*NOTE.—The capital letters in specific names in that Bulletin were inserted without my consent, by the State Geologist, beside, he otherwise interfered with my manuscript, and altered the text without my consent.

## FAMILY DOLATOCRINIDÆ.

### ALLOCRINUS BENEDICTI, N. SP.

*Plate VII, fig.* 1, *basal view of calyx and part of the arms.*

Calyx small, depressed turbinate, interradial areas depressed so as to give a subpentagonal outline to the upper part; sutures distinct; surface granular. The three basals form a pentagonal disc more than twice the diameter of the column; one plate is only half the size of either of the others. First radials large, gradually expanding, wider than high, three heptagonal and two hexagonal. Second radials short, quadrangular, four times as wide as high, and gradually arching from one interradial area to another. Third radials about the same size as the second, but axillary and supporting upon the upper sloping sides the free arms. Arms ten, large, round externally and composed of short plates. Interradial areas depressed. A single interradial rests between the two short superior sloping sides of two adjacent first radials and between the second and third radials, and extends as high as the latter. Vault and other parts unknown.

Found by A. C. Benedict, in the Niagara Group, at St. Paul, Indiana. The specific name is in honor of the collector, who is an excellent palæontologist.

## FAMILY EUCALYPTOCRINIDÆ.

### EUCALYPTOCRINUS SUBGLOBOSUS, N. SP.

*Plate VII, fig.* 3, *side view of an entire specimen.*

Body below medium size; with the arms and interbrachial plates, subglobose, being only slightly produced at the base and less at the summit; surface granular and some of the plates have a central tubercle. Calyx a little more than one-third the entire length of the body. Basal plates nearly covered externally, by the column. First radials wider than high, expanding upward, and almost as large as the second and third together. Second radials quadrangular, one-third wider than high. Third radials hexagonal, rather larger than the second, wider than high, and supporting on the upper lateral sides the secondary radials. First secondary radials pentagonal and smaller than either of the primary radials. Second secondary radials expand upward and each is somewhat in the form of an inverted frustum, but the upper plane is not quite parallel with the lower and supports two tertiary radials upon its slightly sloping sides. The top of the first tertiary radials is on a line with the top of the interradials. The tertiary radials are succeeded by thin, quadrangular plates, which become more and more cuneiform, until they graduate into an arm composed of a double series of interlocking plates, which gradually tapers to the summit, where the solid interbrachials unite around the orifice. The interbrachial plates consist of one large and two smaller ones in each area; the large one has ten sides and height and width are about equal; the others are of equal size, hexagonal, a little more than twice as high as wide, and extend to the top of the first tertiary radials. The intersecondary radials are single, octagonal, truncate the third radials, and have the form of the two small interradials when united, but smaller than the two together. The solid interbrachials become only slightly narrower in their upward extension, and unite at the summit, with each other and with small plates that surround the orifice.

Found by Prof S. S. Gorby, in the Niagara Group, at Hartsville, Indiana, and now in his collection.

## EUCALYPTOCRINUS ELLIPTICUS, N. SP.

*Plate VII, fig. 4, side view of nearly an entire specimen.*

Body quite small, and, with the arms and interbrachials, somewhat elliptical in outline, being most strongly produced at the base, and somewhat depressed at the interradial areas; surface of the plates smooth. Calyx not more than one-third the length of the body. Basals nearly covered externally by the column. First radials standing nearly upright, slightly expanding, wider than high, and almost as large as the second and third together. Second radials quadrangular, one-half wider than high. Third radials pentagonal, one-half larger than the second, a little wider than high, and supporting, on the upper sloping sides, the second radials. First secondary radials hexagonal, and about as large as a third radial. Second secondary radials pentagonal, expand upward and support, on the upper sloping sides, the tertiary radials. The top of the first tertiary radials is about on a line with the top of the interradials. The tertiary radials are succeeded by one or two quadrangular plates, and these by cuneiform ones that graduate into an arm composed of a double series of interlocking plates and tapers to the summit, where the solid interbrachial plates surround the orifice. The large interradial plate is depressed in each area, and the two succeeding ones reach only about as high as the top of the first tertiary radials. The intersecondary radials are very small, narrow, and rest between the upper sloping sides of the first secondary plates, without truncating the third radial as is usual in this genus. The solid interbrachials are quite thin until they unite around the orifice.

Distinguished from all other species by the small size, by the general form, comparatively large first secondary plates, sunken interradials, and by the small intersecondary radials, which rest between the upper sloping sides of the first secondary radials, instead of truncating the third radial as in all other species of this genus.

Found by Prof. S. S. Gorby, in the Niagara Group, at Hartsville, Indiana, and now in his collection.

### EUCALYPTOCRINUS GORBYI, N. SP.

*Plate VII, fig.* 5, *side view of calyx; fig.* 6, *basal view.*

This is the largest species found in this country; the calyx, only, is preserved in our specimen, and even that has a fragment broken from one side and part of the first radials torn away.

Calyx broadly subturbinate, constricted in the middle or abruptly expanding from the second radials, and separated into five lobes above; the depressions corresponding with the double interradials, and less distinctly into ten lobes by a slight depression of the intersecondary plates; sutures well defined and always arched or curved instead of being straight as is usual in this genus; surface granular; diameter, 2, 5 inches; height, 1, 5 inches. Basal plates sunken, not exposed externally. First radials very little wider than high, extending below the point of columnar attachment, expanding upward, flattened on their faces, projecting most at the sutures, and, together, forming a subpentagonal cup with a deep columnar pit. Second radials nearly as large as the first and only a little wider than high. Third radials as large as the second, hexagonal, as high as wide, and supporting on steep, upper, lateral sides the secondary radials. First secondary radials pentagonal, and smaller than either of the primary radials. Second secondary radials smaller than the first, pentagonal, about as high as wide, and support, on the steep, upper, sloping sides, the tertiary radials; in one of the rays both the first and second tertiary plates abut upon the upper sloping sides of this plate which gives it an heptagonal outline. The first tertiary plate is triangular, and it is succeeded by at least three thin quadrangular plates that enter into and form part of the calyx. First interradial large, ten sided, long and rather pointed both above and below. The double second interradial is wider and larger than the first and longitudinally concave, giving to the upper part of the calyx its pentalobate character. It extends as high as the sixth plate in the tertiary series. The intersecondary plate is about the size of one of the double interradials, truncates the third radial, extends as high as the sixth plate in the tertiary series, is flattened or concave in the upper part which divides the top of the calyx into ten indistinct lobes.

Found by Prof. S. S. Gorby, in the Niagara Group, near Nashville, Tennessee, and now in his collection.

### EUCALYPTOCRINUS ELRODI, N. SP.

*Plate VII, fig.* 9, *side view of the calyx a little elevated at the top, so as to show the columnar cavity at the base; fig* 10, *basal view of the same specimen.*

Calyx medium or above medium size, broadly saucer-shaped or moderately arching from the columnar cavity to the circumference; sutures well defined, even beveled, generally curved; surface covered with round or angular nodes, sometimes they are elongated, but rarely if ever confluent, there seems to be about the same number, occupying about the same position on corresponding radial and interradial plates; diameter, I, 45 inches, height, .38 inch. Basal plates sunken and rising in the interior nearly as high as the top of the calyx, not exposed externally. First radials wider than long, extending below the point of columnar attachment, gradually expanding, directed outward and rising not more than ten degrees above a horizontal line, and forming a disc with a round, central, columnar pit. Second radials nearly as large as the first, quadrangular, and only a little wider than high. Third radials as large as the second, hexagonal, as high as wide, and supporting on steep upper, lateral sides the secondary radials. First secondary radials, pentagonal, and about the same size as the second or third radials; the unusual proportions are necessary to keep pace with the rapidly expanding calyx. Second secondary radials smaller than the first, pentagonal, one-half wider than high and support on the moderately sloping upper sides the tertiary radials. The first tertiary plates fill the angular spaces, between the sloping sides of the second secondary radials and the interradials and abut against each other, over the apex of the second secondary radials, which makes them quadrilateral, with the longer side above. The first tertiary plates are succeeded by thin, quadrangular plates, one of which, at least, enters into and forms part of the calyx, and two more are necessary to reach as high as the top of the interradials.

The first interradials have ten sides and are about as wide as long. The double second interradial is about as wide and about as long as the first, and marked by an angular depression at the separating suture. The intersecondary plates truncate the third radials, are wider than one of the double interradials and nearly as long. The arms are ornamented by two subparallel ranges of rounded nodes along the central part, and a range of smaller nodes on each margin. The interbrachials bear two or three ranges of rounded, subparallel nodes, with intervening, longitudinal furrows. None of the nodes have been seen confluent or producing either longitudinal or transverse furrows.

This species is distinguished from all others by its comparatively short calyx, and, therefore, by the great width of the secondary and tertiary plates in proportion to their length. It is also distinguished from *E. cœlatus*, with which it may be compared, by the form of the columnar pit, and also from the fact that the first radials do not incurve at their basal margins nor recurve upward above the middle. The surface ornamentation is not like that of *E. cœlatus*, for the nodes are not disposed in the same manner and there are none of the confluent nodes and none of the straight or tortuous ridges that characterize *E. cœlatus*.

Found in the Niagara Group, at Hartsville, Indiana, and now in the collection of Prof. S. S. Gorby. The specific name is in honor of Dr. Moses N. Elrod, a prominent physician, ardent collector and well known palæontologist of Hartsville, who was the first to discover this species and point out the fact that it is distinct from all others and undescribed.

## FAMILY ICHTHYOCRINIDÆ.

### Lecanocrinus tennesseensis, n. sp.

*Plate VII, fig. 7, view of azygous side of calyx; fig. 8, basal view.*

Calyx medium size, hemispherical, somewhat inflated on the azygous side; plates thick; surface delicately sculptured. The three basals form a pentagonal disc twice the diameter of the column; the small basal is directly below the first azygous plate. Subradials moderately large, of unequal size, the two larger ones adjoin the first azygous plate and are heptagonal, the one opposite the azygous side is hexagonal and the other two are each pentagonal. The first radials are pentagonal and about twice as wide as high. First azygous plate quadrangular, a little longer than wide, nearly as large as a pentagonal subradial, rests obliquely between the two heptagonal subradials, and supports on the right a first radial, and on the left the second azygous plate. The second plate is one-half larger than the first, hexagonal, rests between the first and one of the sloping sides of a heptagonal subradial, supported on either side by a first radial, and bears two upper sloping sides. The column is round. Arms and vault unknown.

Collected by Prof. S. S. Gorby, in the Niagara Group, sixteen miles west of Nashville, Tennessee, and now in his collection.

When Hall redescribed *Lecanocrinus pusillus*, in the 28th Report of the New York State Museum of Natural History, p. 136, republished, in the 11th Report of the Geological Survey of Indiana, p. 267, he compared it with *Poteriocrinus pisiformis* of Roemer, for what reason I am unable to state, as they seem to have no relation to each other. *Poteriocrinus pisiformis*, as figured and described by Roemer, in Die Silurische Fauna des westlichen Tennessee, p. 54, pl. iv, figures 7a and 7b, has five basal plates and only a single azygous interradial. It can not be classed in the same family with *Lecanocrinus*. It is either a true *Arachnocrinus*, as pointed out by Meek, in the Geological Survey of Illinois, vol. 11, p. 177, and classed by me, in North America Geology and Palæontology, or it is a *Cyathocrinus*. Wachmuth's late reference of it to *Lecanocrinus* seems to have been without any consideration.

## FAMILY POTERIOCRINIDÆ.

### SCAPHIOCRINUS PORRECTUS, N. SP.

### SCAPHIOCRINUS ROBUSTUS (?) HALL.

*Plate VII, fig. 2, side view, showing part of the arms and column.*

Calyx short, bowl-shaped, wider than high; plates thick, convex, sutures sunken; surface smooth. Basals forming a flattened, pentagonal disc a little more than twice the diameter of the column. Subradials larger than the basals, expanding but little, standing nearly upright and depressed at the sutures. First radials pentagonal, about twice as large as the subradials, much wider than high, convex, depressed toward the lateral sutures, truncated the full width, and having gaping, serrated sutures separating them from the single brachials. Brachial plates wider than long, contracted in the middle, and having moderately steep upper sloping sides for the articulation of the free arms. Arms ten, no division, round externally, remarkably large and very long, and composed of a single series of tolerably thick, slightly cuneiform plates. Pinnules coarse and composed of long joints. First azygous plate rather large and resting obliquely between the sloping sides of two subradials and the under sloping side of the right first radial. Second azygous plate broadly truncates the subradial on the left of the first azygous plate. Third azygous plate truncates the first, and above, the plates are in the usual alternate double series. Column round, moderately large and composed of thicker and thinner plates, with one projecting here and there beyond the others.

This species is distinguished by the remarkably large, slowly tapering long arms.

Found in the Keokuk Group, at Crawfordsville, Indiana, by the late Dr. C. A. Miller, the distinguished Superintendent of Longview Asylum, and now in my collection. It may be referred to Hall's species, but, if so, his specimen had an abnormal azygous area, and his definition is very incorrect.

### POTERIOCRINUS BOONVILLENSIS, N. SP.

*Plate VIII, fig. 3, side view; fig. 4, azygous view.*

Calyx turbinate or cup-shaped, height and width subequal, and composed of smooth, rounded plates. Basals small, pentagonal, expanding and pierced by a very small columnar canal. Subradials hexagonal, three times as large as the basals, and about as high as wide. Radials pentagonal, wider than high, larger than the subradials, truncated the full width, and having gaping sutures separating them from the single brachials. Each ray has a single axillary brachial, which is as long or longer than wide, rounded externally, and constricted in the middle; the brachials are of unequal length. Arms ten, composed of long, slightly cuneiform plates. Pinnules coarse.

The azyogus area is wide, long, tumid, and exposes eight plates; the first is pentagonal, smaller than a subradial, rests between the upper sloping sides of two subradials, and between the first radial on the right and the second azygous plate on the left, and is truncated on top for the third azygous plate; the second plate is hexagonal, as large or larger than the first, rests upon the truncated end of a subradial and between the first radial and first brachial on the left, and the first and third azygous plate on the right, and is truncated at the upper end for the fourth plate; the third plate is hexagonal, rests upon the first and between the first radial and first brachial on the right, and the second and fourth plates on the left, and is truncated at the upper end for the fifth plate.

The fourth, fifth, sixth, seventh and eigth plates are hexagonal, and alternately arranged. A small part of the proboscis is exposed at the upper end of the specimen illustrated, where it is flattened and composed of smooth, polygonal plates. The column is small, round, and composed of thicker and thinner plates.

Found by R. A. Blair, in the Keokuk Group, at Boonville, Missouri, and now in my collection.

### POTERIOCRINUS AGNATUS, N. SP.

*Plate VIII, fig. 6, symmetrical side; fig. 7, azygous view of the same specimen, which is injured at the azygous area.*

Calyx turbinate, truncated below or cup-shaped, wider than high, and composed of smooth, rounded plates. Basals small, pentagonal, expanding and pierced by a very minute, columnar canal. Subradials, hexagonal, four times as large as the basals, and about as high as wide. Radials pentagonal, about the size of the subradials, nearly twice as wide as high, truncated the entire width of the plates and separated from the single brachials by a gaping suture. Each ray has a single axillary brachial, which is wider than long, rounded externally, and constricted in the middle. Each arm adjoining the azygous area, and the arm opposite thereto, bifurcate on the first plate; there are nc other divisions of the arms. Arms sixteen, composed of long, slightly cuneiform plates. Pinnules coarse. The azygous area exposes seven plates, which have the same form and arrangement as those in *P. boonvillensis*, but they are proportionally smaller. Column round.

This species is more robust than *P. boonvillensis*, has shorter brachials, and is distinguished from it and all other species by the number, arrangement and character of the arms.

Found by R. A. Blair, in the Keokuk Group, at Boonville, Missouri, and now in my collection.

## ZEACRINUS COMMATICUS, S. A. MILLER.

*Plate VIII, fig.* 8, *a specimen eroded on the azygous side, showing part of the proboscis and what is supposed to be part of the convoluted organ.*

This species was described in Bulletin No. 4 of the Geological Survey of Missouri, p. 36, from the Keokuk Group, at Boonville, Missouri. The specimen here illustrated has the azygous plates removed and discloses canals passing up into the proboscis which represent the convoluted organ. Meek described and illustrated the convoluted organ in *Actinocrinus proboscidialis* and Wachsmuth and Springer have illustrated it in *Eretmocrinus verneuilanus*, *Teleiocrinus rudis*, *Goniasteroidocrinus tuberosus* and *Batocrinus longirostris*. The organ in our specimen is convoluted and has winding and ascending channels from the base of the azygous area. It appears to be attached to the basal plates, in the central part, and to have the outer covering of the proboscis attached to the top of the first primary radials. There is a cavity between it and the primary radials and subradials. The arm furrows connected with this outer cavity and through it, with the internal canals. The proboscis instead of being a hollow tube contained a solid framework inclosing winding channels.

## POTERIOCRINUS CORYPHÆUS, N. SP.

*Plate IX, fig.* 1, *view opposite the azygous side showing one ray with two arms and another with four. The specimen is somewhat flattened.*

Species robust, arms large and long in comparison with the size of the calyx, and fit closely together. Calyx subturbinate, height a little more than the diameter; sutures distinct, surface granular. Basals gradually expanding and forming a pentagonal cup. Subradials larger than the basals and longer than wide. First radials about the same size as the subradials, wider than long, truncated the entire width above and separated from the single brachials by a gaping suture. Brachials pentagonal, wider than long, rounded and constricted in the middle, and support the free arms upon the upper sloping sides. In the ray on each side of the azygous area and in the one opposite the area, the brachials are followed, on each upper side, by a long, round, axillary plate, giving to each of these rays four arms. The two lateral brachials bear only two arms each. There are no other divisions of the rays. This gives to the species sixteen arms. The first plates are long but they gradually shorten and become more and more cuneiform. The arms are flattened on the sides and fit closely together. Pinnules long and coarse. The azygous area exposes five plates arranged as in other species in this genus. The first azygous plate is smaller than the second and rests between the upper sloping sides of two subradials and the under sloping side of the first radial on the right, and supports the third azygous plate. The second azygous plate broadly truncates a subradial. Column round, moderately large.

Distinguished from other species by the number and character of the arms.

Found on Indian Creek, in Montgomery County, Indiana, in the Keokuk Group, and now in the collection of Wm. F. E. Gurley.

### POTERIOCRINUS AMŒNUS, N. SP.

*Plate IX, fig. 6, view opposite the azygous side, showing one ray with four arms and one with two arms having single brachials, and one with two arms having two brachials.*

This species is smaller than *P. coryphœus* and distinguished from it by the structure of the arms, and form of the calyx. Calyx subturbinate, a little wider than high; sutures distinct, slightly depressed; surface granular. Basals small, as high as wide, slightly expanding, and forming a pentagonal cup Subradials larger than the basals and wider than high. First radials about as high as wide, convex longitudinally, depressed at the lateral sutures, truncated the entire width above, and separated from the brachials by a gaping suture. Single brachials, pentagonal as high as wide, rounded and constricted in the middle, and support the free arms, upon the upper sloping sides; the first brachial in the double series is quadrangular, and wider than high, the second is pentagonal, longer than wide, rounded and slightly concave transversely, and supports free arms on the upper sloping sides. The azygous side is not disclosed in our specimen, but it is probable that the ray on each side of it has four arms and if so the species has sixteen arms. We do not know whether the rays on each side of the azygous area have one or two brachials. The arms are flattened externally or very slightly rounded, especially in the upper part, and flattened on the sides and fit very closely together. The plates are long and very slightly cuneiform below, but gradually shorten and become more cuneiform above. Pinnules short and coarse. Column of moderate size, round and composed of subequal plates.

Distinguished by the number and structure of the arms, and especially from the fact that some rays have single brachials and others double brachials.

Found in the Keokuk Group, on Indian Creek, in Montgomery County, Indiana, and now in the collection of Wm. F. E. Gurley.

### SCAPHIOCRINUS SAMPSONI, N. SP.

*Plate IX, fig.* 12, *view of a specimen, as it appears on a slab, showing azygous side, arms and column somewhat fractured.*

Calyx small in proportion to the size of the arms, low, somewhat bowl-shaped, inflated on the azygous side; surface delicately sculptured, too fine to be shown in the illustration. Basals sunken in the basal cavity so they can not be seen in a side view. Subradials comparatively large and about as high as wide. Radials more than twice as wide as high, truncated the entire width above and separated from the single brachials by a gaping suture. Brachials longer than wide, constricted on the sides, longitudinally angular in the middle, and having moderately steep upper sloping sides for the articulation of the free arms. Arms remarkably large, bear a longitudinal more or less well defined, external, central ridge, and are composed of short, transverse plates, having a width equal to about half the diameter of the arm. Arms numerous, some of those in our imperfect specimen preserve the second bifurcation, which indicates forty or more. First azygous plate rather large, pentagonal, rests obliquely between the upper sloping sides of two subradials and the under sloping side of the right first radial, and abuts the second azygous plate, and upon its upper sloping side, it supports a large hexagonal plate that extends one-third its length above the top of the first radials. The other azygous plates not exposed in our specimen. Column round and composed of quite thin plates, some thicker than others.

Found by F. A. Sampson, in the Chouteau limestone, in Pettis County, Missouri, and now in his collection. The specific name is intended as a compliment to Mr. Sampson, who is a well-known naturalist, palæontologist and active worker in science.

### SCAPHIOCRINUS GORBYI, N. SP.

*Plate XII, fig.* 15, *side view, the specimen is depressed.*

Calyx short, bowl-shaped, wider than high, plates thick, convex, sutures deeply sunken at the angles; surface smooth. Basals sunken in the columnar cavity and not visible in our specimen. Subradials large, the lower margin curving into the basal depression, and below the middle part curving abruptly upward, nearly as high as wide. First radials pentagonal, gradually expanding between the lateral sides, wider than high, truncated the entire width above, convex longitudinally, slightly constricted in the middle part, sutures sunken, the lower angles depressed into little pits, and separated from the single brachials by a gaping suture. Brachials wider than long, lateral sides short, slightly constricted in the middle, upper sides long and steep. Arms ten, no division, rather small for the size of the calyx, first plates long, constricted, second, third and fourth plates gradually shortening and constricted, above these the plates are cuneiform, and project at the larger side presenting a rugged aspect. Pinnules long, coarse and composed of long joints, azygous area covered with rather long plates. First azygous plate large, pentagonal, rests obliquely between the upper sloping sides of two subradials and the under sloping side of the first radial on the right, abuts one side against the second azygous plate, and supports the third azygous plate on the upper sloping side. Second azygous plate truncates a subradial, third, fourth and fifth plates arranged as in other species in this genus. Column subpentagonal near the calyx and composed of thicker and thinner plates.

A few plates of the proboscis are visible, at the upper end of our specimen, showing it extended as high or higher than the arms. The plates are large, longer than wide, convex longitudinally, and bear two peculiar teeth-like processes, centrally, on the left side of each. These processes are hollow and differ from all other plates I have ever seen.

Distinguished by the pits, at the angles of the plates in the calyx, and by the proportionally small arms.

Found in the Keokuk Group, at Boonville, Missouri, and now in my collection. The specific name is in honor of Prof. S. S. Gorby, the first State Geologist ever elected, in any country, by the votes of the people.

## FAMILY CYATHOCRINIDÆ.

### Cyathocrinus gurleyi, n. sp.

*Plate IX, fig. 4, showing azygous plate and arms, the arms are torn from the opposite side so as to expose the proboscis, and two holes are shown, at the top of the calyx, in the illustration.*

Species rather above medium size; calyx bowl-shaped, one-half wider than high, sunken at the base; subradials protuberant below; sutures depressed between the radials; surface granular.

Basals forming a pentagonal disc, one-half wider than the diameter of the column, not visible in a side view. Subradials large, wider than high, convex, depressed toward the sutures, curving into the basal cavity and abruptly bending upward so as to leave the subcentral part quite tumid. Radials about the size of the subradials, as high as wide, convex toward the brachial sutures, most abruptly depressed toward the lateral sutures; separated from the brachials by a slightly gaping suture; articulating scar longitudinally subovate, about half the width of a plate, very concave or round below, and having the face directed obliquely outward, at an angle of about forty-five degrees. The brachials are rounded externally, there is only one in the ray on the right of the azygous plate while there are three in the right lateral ray and three in the ray on the left of the azygous plate; the axillary brachials are about the same size; the first one in each compound series is thin, the second one nearly or quite half as high as wide.

The arms are round externally, taper very slowly between the bifurcations, and are composed of rather long plates separated by transverse sutures. The first bifurcation takes place in some of the arms on the third plate, and in others on the fourth plate; the second bifurcation takes place on the fourth, and in others on the sixth, and in others on the eighth plate. This gives to the species forty arms; but there may be another bifurcation in part or all of the rays which is not shown in our specimen.

Azygous plate large, standing nearly upright, extending higher than the radials, transversely truncated above for a large second plate, and at the upper lateral angles for small plates. Proboscis composed of longitudinal series of polygonal plates, four of which series are shown in our specimen. It tapers upward to near the top, then expands a little; the top is covered with polygonal plates. Our specimen preserves part of the top, which may be distinguished in the illustration, but the arms are broken off, which indicates they extended beyond the proboscis, though they may not have covered or protected it. Column medium size, round.

Found in the Keokuk Group, in Washington County, Indiana, and now in the collection of Wm. F. E. Gurley.

### CYATHOCRINUS BENEDICTI, N. SP.

*Plate IX, fig. 7, view showing azygous plate.*

Calyx subturbinate, height and width subequal, truncated below, plates thick, convex; sutures depressed and angles sunken; surface granular. Basals small, forming a low pentagonal cup. Subradials large, not of uniform size, height and width subequal, highly convex, obscure or undefined ridges radiating toward the middle of the sides, angles deeply sunken. Radials larger than the subradials, wider than high, sunken at the angles and the lateral sutures, except at the projecting rim at the top, most convex at the brachial sutures and the rim or projecting flange on the superior lateral sides. Articulating scar about two-thirds the width of a plate, broadly rounded and directed obliquely outward. Azygous plate rather large, truncates a subradial and gradually expands to the top of the first radials. The plates are very thick at the top of the calyx, and the thickness is maintained for the support of the interradials by a projecting flange. The angles for the support of the interradials are quite obtuse. Arms and column unknown.

Distinguished by the thick, highly convex plates and deeply sunken angles, and also by the peculiar projecting flange at the upper lateral sides of the radials, where the interradials are supported.

Found by A. C. Benedict, in the Niagara Group, at Hartsville, Indiana, and now in his collection. The specific name is in his honor.

### Cyathocrinus sp.

*Plate IX, fig.* 8, *view showing the basals and subradials.*

This specimen is illustrated for the purpose of calling attention to it. There is not enough of it to justify giving it a name, though it belongs to an undescribed species. Calyx bowl-shaped, plates highly convex and radiately sculptured in undefined waves toward each side; sutures depressed and angles deeply sunken. Basals form a low pentagonal cup with sharply defined angles and depressed sutures. Subradials very large. Column large and having a very large five-rayed, petaloid, columnar canal.

Found in Niagara Group, at Hartsville, Indiana, and now in the collection of A. C. Benedict.

### Cyathocrinus labyrinthicus, n. sp.

*Plate XII, fig.* 11, *shows part of the large arm and numerous smaller ones; fig.* 12, *shows part of the larger arm, and the one on the left wrapping around the calyx; fig.* 13, *shows the large first radial opposite the azygous area, which bears the larger arm; fig.* 14, *shows some of the numerous arms.*

Calyx small in proportion to the arms, somewhat cup-shaped or subturbinate, but having unequal sides; sutures indistinct; surface smooth. Basals form a shallow cup about two and a half times as wide as the diameter of the column. Subradials about as wide as high and differing slightly in size. First radials unequal in size and not uniform in shape. The first radial opposite the azygous side is the larger one, extends higher than the others and bears the larger arm; it is flattened or depressed and thus adds to the irregularity of the calyx; the arm rises perpendicularly from the calyx, is composed of long, round, constricted plates, bifurcates on the third plate, both divisions again and again dividing on the third or fourth plates above each bifurcation until there are more than forty arms in this ray. The first radial on the right of the one just described is on the left of the azygous area; it is short and wide and has the arm cicatrix facing outward; the arm is directed outward almost at right angles to the calyx and bifurcates on the second plate, one branch of which is wrapped around the calyx, crossing the base of the first large radial above described and bifurcating about every second plate, and each branch dividing in like manner until there are forty or more arms in this division; the other division divides in like manner until there are eighty or more arms in this ray. The radial on the left of the large one first above described, and also the one on the right of the azygous area, are similar to the one described on the left of the azygous area, and the arms are similar and are thrown around the calyx, sometimes completely covering it, and directed upward forming a net-work or labyrinth of arms around the proboscis and extending beyond it. The other radial and arm is similar to the one first above described, though a little smaller. I have found it impossible to count the number of arms, in any of the specimens collected, but I would estimate the number somewhere between three hundred and four hundred, probably nearer the latter figure than the former.

The first azygous plate truncates a subradial and is about one-third its size. Part of the proboscis is visible at the top of the specimen illustrated in figure 12. It is composed of moderately large polygonal plates and is compressed or flattened in all our specimens so I can not determine its normal shape, but I infer it was cylindrical in its upper extension. Column round, of moderate size, composed of rather thick plates radiately furrowed near the outer circumference, and possessed of a small internal canal.

Found in the Keokuk Group, at Boonville, Missouri, by R. A. Blair, and now in my collection.

## FAMILY PLATYCRINIDÆ.

### PLATYCRINUS ALABAMENSIS, N. SP.

*Plate IX, fig. 5, side view; calyx flattened.*

Calyx cup-shaped, subpentagonal, wider than high, sutures distinct, surface smooth. Basals forming a shallow disc, and having a rather wide, circular ridge surrounding the column, which extends below the point of the columnar attachment; upper faces for the support of the radials concave; keels mark the sutures of the basals and terminate in small tubercles, at the columnar cavity. First radials about as wide as high, slightly expanding above, convex longitudinally, in the central part; articulating facets for the second radials concave, about half the width of the plates; upper faces inclined toward the sutures, so as to form rather sharp angles. Second radials triangular, axillary, and rising in the central part, so as to completely separate the first arm plates. Each arm bifurcates on the second plate, and one of these, in each of the five radial series, again bifurcates on the second plate, which gives to the species twenty-five arms. The arms consist of a single series of long plates, constricted in the central part and expanded at the sutures, until about the fourth or fifth plate above the last bifurcation, when they change into a double series of interlocking plates. The pinnules are very coarse and long-jointed, especially where the arms consist of a single series of plates, and so numerous as to give the head a very bushy aspect. Column quite small, round at the base of the calyx, and composed of alternately thicker and thinner plates. The interradial that rests between the upper sloping sides of the first radials, is exposed in a side view.

Found in the Subcarboniferous rocks, at Huntsville, Alabama, and now in my collection.

## FAMILY RHODOCRINIDÆ.

### GONIASTEROIDOCRINUS TUBEROSUS, LYON & CASSEDAY.

*Plate IX, fig.* 11, *side view, showing the vault and pendulous arms, exposing the arm furrows.*

This species is illustrated for the purpose of correcting some erroneous observations that have been made about the arms and arm furrows, and for the purpose of showing that if the arms were turned up, they would be like arms in other genera and species of crinoids, and that they differ only in the fact that they are directed downward with the arm furrows outward. The arm furrows are well illustrated in the figure, with the pinnules directed downward. The back of the arms is against the calyx and the furrows and pinnules on the outside. If the arms were lifted up the furrows and pinnules would be over the vault, hence the only difference between the arms of this species and those of other species is that they are directed downward instead of upward. Probably they were capable of lifting themselves up to a greater or less extent, but on account of the expanded vault and so-called pseudo-brachial appendages they could not straighten up or curve over and protect the vault. Some species in this genus have upright arms or those that curve over upon the vault, as *G. spinigerus*, *G. spinosus* and *G. tuberculosis.* I have never seen either species, but Hall figured the two former on a plate dated 1872.

Meek & Worthen, in describing this genus, in Vol. II, Ill. Geo. Sur. p. 219, said:

"True arms, very long, slender, pendulous, and more or less branching, supporting minute, ascending tentacula."

They illustrated the vault, and arms bent downward below it, with the backs of the arms outward, on page 220, which erroneous cut, so far as the arms are concerned, I copied into North American Geology and Palaeontology, p. 250. They said:

"The parts in this type homologous with the arms in Rhodocrinus and other crinoids, instead of being stout and erect, as in Rhodocrinus, are very slender, long, pendent organs (see * of cut B, fig. 19), having much the delicacy and appearance of tentacles. In the above cut, the minute true arms of the typical species of *Goniasteroidocrinus*, are seen to branch so as to form nine to each ray. The cut shows only their outside, in which we have seen no indications of ambulacral furrows; but these may have been obliterated in cleaning the specimen, or possibly they may present the anomalous character of being on the *under side*, and thus differ from all other known crinoids."

It will be observed, the arms do not support "minute ascending tentacula;" but on the contrary, bear pinnules directed downward and outward just as arms do in other crinoids when turned downward. The arms do not have "the delicacy and appearance of tentacles;" but they are reasonably large, composed of a double series of interlocking plates and bear pinnules composed of long joints. Meek & Worthen's cut is erroneous, because it should show a double series of plates below the bifurcations instead of a single series; and the arms are represented with the furrows against the calyx instead of being turned outward.

The mistake of Meek & Worthen respecting the position of the arms was made almost ludicrous, by Wachsmuth & Springer, who accounted for the arms, in the position that Meek & Worthen had erroneously supposed them to be placed in this manner:

"This peculiar structure is easily explained if we consider that the pendent position of the arms in these species is due, not to a forcible bending out of their normal attitude, but to the peculiar construction of the brachial parts, which directs them downward and makes this their natural position; and, while it appears as if the arm structure was entirely reversed in these two types (*G. typus* and *G. tuberosus*), this is really not the case, the furrow is still on the ventral side, but the arms have rotated on their axes so as to bring it on the inner side when hanging down." See their article in Proc. Acad. Nat. Sci. Phil., 1878, p. 262.

I can not understand how any one ever came to the conclusion that a crinoid arm could rotate on its axis. The first plates in an arm are never transverse, beside if they were, the plates were always held in position by ligaments and if the arms were made to rotate the ligaments would necessarily be broken and the arms twisted off. But the facts effectually get away with the erroneous supposition and philosophy.

I take pleasure in correcting any mistake I find in the palæontological part of the Geological survey of Illinois, because I was an assistant on the work on the 7th volume and was frequently consulted by the late State Geologist, Prof. A. H. Worthen, in regard to palæontological subjects and received numerous courtesies from him, during many years of friendly intercourse. I was also the personal friend of Prof. Meek, who adopted and published the first new variety of fossils I described nearly twenty years ago. There is no palæontological work with which I have more cause to be familiar than with that contained in the Geological Survey of Illinois. And yet, in a recent diatribe, by an English schoolmaster, named P. Herbert Carpenter, I am told that "It is not too much to expect" that I should make myself acquainted with the "Illinois Geological Reports."

## FAMILY ACTINOCRINIDÆ.

### BATOCRINUS AGNATUS, N. SP.

*Plate VIII, fig, 1, symmetrical side; fig. 2, azygous side, specimen depressed.*

Species medium size. Calyx turbinate or obconoidal, truncated below, higher than wide; arm bases projecting, and openings directed upward; plates convex; surface granular.

Basals three, forming a pentagonal disc about twice as wide as the diameter of the column and abruptly bent upward. First primary radials wider and larger than the second and third together, three heptagonal, two hexagonal, upper face arcuate for the inferior side of the succeeding radial, and the upper lateral sides support the first interradials. Second primary radials quadrangular, about one-half wider than long. Third primary radials wider and larger than the second, pentagonal, the lower lateral sides spreading so as to give the greatest width, at the middle part of the plates, at the angles made with the upper sloping sides. Secondary radials two by ten, the upper the larger, but both variable in size and shape. The ray on the left of the azygous side bears four tertiary radials and four arms, the ray opposite the azygous side bears none and has two arms, the other three arms have three tertiary radials and three arms each, there are, therefore, fifteen arms, in this species. A single plate follows each tertiary radial, and above this the arms are constructed of interlocking plates bearing long jointed pinnules.

Regular interradials three, one large, having nine sides, the other two small. Azygous interradials eight, the first one the largest plate in the calyx, and in line with the first primary radials; there are three in each of the two following ranges, and one above, projecting an angle up between the under sloping sides of tertiary radials. Proboscis projecting beyond the ends of the arms. Column round.

This species most resembles *Batocrinus jucundus*, but is distinguished by having only fifteen arms while the latter has sixteen. There are other minor differences that may be noticed by comparison.

Found in the Keokuk Group, on Indian Creek, in Montgomery County, Indiana, and now in A. C. Benedict's collection.

### AGARICOCRINUS INDIANENSIS, N. SP.

*Plate VIII, fig. 5, symmetrical view.*

Species medium size, base concave, the depression including the basals and first and second radials, surface granular. In the ray opposite the azygous side, the third radial is pentagonal, tumid and has the outer face somewhat angular; the superior sloping sides support the secondary radials. There are three, thin, secondary radials in each series; the first is subquadrangular, about two and a half times as wide as high, and abuts slightly upon the first interradial, and more upon an interradial in the second range; the second is pentagonal, three times as wide as high, abuts an interradial, and supports upon the upper face a third secondary radial and also part of one of the first arm plates; the third one on the left is somewhat triangular in outline, but as it supports upon the upper sloping sides the two arm plates, it has four sides; the third one on the right is distinguished from the one on the left by abutting against an interradial, and consequently, has five sides. Arms twelve, three in each ray adjoining the azygous side, and two in each of the other rays; all of them taper rapidly. They are composed of a double series of short, wide plates, abruptly wedgeformed at their junction. There are about fifty plates in each series. Pinnules long and compact.

The first regular interradial extends nearly as high as the third radial and supports two, long, narrow plates, and a fourth interradial is inserted in the range, commencing at the top of the first secondary radial. This is the structure of the interradial area on the right of the radial series above described; the other interradial areas are not determinable from the specimen at hand. Some of the plates of the vault are visible between the arms of our specimen and indicate a high summit. Column round and rather small.

Found in the Keokuk Group, of Washington County, Indiana, and now in the collection of A. C. Benedict.

### AGARICOCRINUS GORBYI, N. SP.

*Plate VIII, fig. 9, azygous view, a piece of a colnmn in the azygous area.*

Species large, base moderately concave, the concavity not extending beyond the second radials; plates convex or rounded; surface granular. Basals small. Second radials quadrangular, slightly expanding, nearly as high as wide. Third radials pentagonal and hexagonal, wider than high, and supporting on each upper sloping side secondary radials. In the ray opposite the azygous side, and in each of the two lateral rays, there are two secondary radials, in each series, from which the arms arise, making six arms, in these three series. In the ray, on the right of the azygous area, there is a single secondary radial, which is axillary, and supports one tertiary radial in the series adjoining the area and two tertiary radials, in the other series which are axillary. There are, therefore, four arms in this ray. In the ray on the left of the azygous area, there is a single secondary radial, which is axillary, in the series adjoining the area. It supports two tertiary radials on the right and one on the left, from which the arms arise. There are two secondary radials supported on the left side of the third radial, from which an arm arises. There are, therefore, three arms in this ray. This gives to this species thirteen arms. The arms are large, very long, and composed of a double series of short plates, abruptly wedged, at their junction. Pinnules long and compact.

There are three regular interradials in each area; the first one is short, not extending as high as the third radials; it is followed by two long narrow plates. The azygous area is wide, and so far as shown in our specimen, is covered with large plates. The column is elliptical near the head, but, probably, round below, and very little larger than an arm.

Found in the Keokuk Group, on Indian Creek, in Montgomery County, Indiana, and now in the collection of A. C. Benedict.

### Agaricocrinus splendens, Miller & Gurley.

*Plate VIII, fig. 10, vault, with azygous area on the right.*

This species was described, in Vol. XIII of the Journal of the Cincinnati Society of Natural History, in April, 1890, from the Keokuk Group, at Crawfordsville, Indiana, but it seems it should have been credited to Indian Creek, which is two or three miles from Crawfordsville. The vault was not described. The vault is low. The series of tumid plates that usually extend from the arms to the summit, in species of this genus, are not regular in this species, as will be observed from the illustration. A single row of three plates will be seen on the left of the figure, extending from a two armed ray to the larger plate that crowns the summit; while the three armed ray, on the left of the azygous area and in the center of the figure has two tumid plates over the arm passages, and flattened plates toward the summit. The regular interradials are followed by two ranges of three small plates, and above these there are a few plates irregularly disposed, before reaching the summit plate. The azygous area is quite convex and plates rather large below the opening; about three plates in a range crosses it, though they are not exactly in line; between the opening and the summit plate, the plates are smaller. The opening is directed upward.

Now in my collection.

### Agaricocrinus dissimilis, n. sp.

*Plate VIII, fig. 11, side view of a vault, showing three arm openings in one radial series, the series on the right of the illustration is on the left of the azygous area and has four arm openings.*

Body robust, base concave, the depression including the basals, primary radials and first secondary radials; surface strongly granular. The third radials are pentagonal, nearly as high as wide, with steep upper sloping sides. The one on the left of the azygous area supports two secondary radials on each side The first secondary radial on the right of the series is a peculiarly wide, curved, hexagonal plate, resting upon the upper sloping side of the third primary radial, abutting two secondary radials on the left and extending to the first tertiary radial; while it supports on top, the second secondary radial and unites with the interradial on the right. The second one is axillary, though it has only four sides, which is caused by the first one curving up to a tertiary radial and thus forming a sharp angle on the left side. There is one tertiary radial on the right and two on the left which support the arms. The first secondary radial in the left series is quadrangular, and about two and a half times as wide as high. The second one is a wide, curved, hexagonal plate abutting on the first secondary and first tertiary radial on the right and the interradial on the left and supporting upon each of the upper sloping sides two tertiary radials. There are, therefore, four arms in this series. The third primary radial in the left lateral series or to the left of the one above described, supports two secondary radials on the right and three on the left. The first one on the right supports the second and also abuts upon a tertiary radial so as to prevent the second from extending to an interradial. The second though axillary has only four sides, which is caused by the first extending to a tertiary radial and thus forming a sharp angle on the right side. There are two tertiary radials in each series. The first secondary in the left series, is a wide hexagonal plate standing somewhat upright and abutting two secondary radials and one tertiary on the right. It is followed by two thinner plates that support an arm. There are, therefore, three arms in this series.

There are only two arms in the series opposite the azygous side. Thus there are nine arms in three series. The other two series are injured, in our specimen, but it is evident the one on the right of the azygous area had three arms, and the other one had two or three arms, which gives to the species fourteen or fifteen arms. The arms are composed of a double series of interlocking plates.

There is only one regular interradial, which is an extremely elongated, polygonal plate extending from the first primary radials to the plates of the vault. The azygous area is wide and covered by numerous plates.

The vault is high, tumid plates extend from the arm series to the summit plate and the interradial areas are flat or depressed. A single row, the first one being quite large, covers the two armed series, and a double row covers each of the other series. The summit plate is very large and surrounded by six large, tumid plates and three smaller ones that separate it from the azygous opening.

It has been usual for authors to call the secondary radials, in this genus, brachials, but the secondary and tertiary radials, in all the species, enter into and form part of the calyx; hence I have used the same names I would in describing an *Actinocrinus*, *Batocrinus* or other fossil belonging to this family.

Found in the Keokuk Group, in Allen County, Kentucky, and now in the collection of A. C. Benedict.

### SACCOCRINUS GORBYI, N. SP.

*Plate IX, fig. 2, lateral view, the azygous area being on the right; fig. 3, summit view, the outline of the plates being destroyed on the right. The specimen is a cast.*

Calyx bowl-shaped, rounded below, most rapidly expanding immediately below the arms; width nearly twice as great as height. Plates of the cast bear a central tubercle. Basals form a pentagonal disc, about twice as wide as the diameter of the column. First primary radials wider than high, two heptagonal and three hexagonal. Second primary radials a little smaller than the first, two hexagonal, and the two adjoining the azygous area and the left lateral one pentagonal. Third primary radials nearly as large as the second, three pentagonal and two hexagonal and bearing upon the upper sloping sides single secondary radials.

Secondary radials hexagonal and pentagonal and bear upon the superior sloping sides single tertiary radials, except in the rays adjoining the azygous area, where there are two tertiary radials. The tertiary radials unite, cutting off all the interradials, including the azygous plates, from direct connection with the plates of the vault.

There are four plates in each of three of the regular interradial areas and five in the other one. The first one is smaller than a second primary radial, and is followed by two smaller ones, and these by a single plate, except in the area having five plates, and in that there are two, one of which is higher than the other. There are seven plates in the azygous area; the first one is in line with the first primary radials and rather larger than any of them; it is followed by three smaller plates, and these by three still smaller ones.

Vault highly convex or subconical, having a height about equal to that of the calyx and spreading like a canopy over the top of it. It is covered with polygonal plates, the central ones being the larger. The largest plate is subcentral, heptagonal and surrounded by seven subequal plates. The cast bears a prominent subcentral tubercle.

Distinguished from other species by the general form, remarkably high and spreading vault, when compared with the size of the calyx, and by the union of the tertiary radials cutting off all connection between the interradials and the plates of the vault. In the latter respect it is like *Batocrinus*.

Found in the Niagara Group, at Adams, in Decatur County, Indiana, and now in the collection of Prof. S. S. Gorby. The specific name is in honor of Prof. Gorby.

## Alloprosallocrinus gurleyi, n. sp.

*Plate X, fig, 1, lateral view; fig. 2, basal view.*

Species small; calyx concave; columnar pit depressed; sutures distinct; interbrachial spaces sunken so as to mark the separation of the five radial series.

Basals three, having an hexagonal outline within the columnar depression. First primary radials one-half wider than long, rounding slightly into the columnar cavity, upper faces arcuate, three heptagonal and two hexagonal. Second radials quadrangular, three or four times as wide as long. Third radials a little wider and larger than the second, pentagonal, axillary, about twice as wide as high. Secondary radials four by nine, and one by one; the first one short, trapezoidal; the second one short but wide and curving around into the sunken interbrachial areas and uniting with the secondary radials on either side; the third one short and curving around the radial extension and uniting with the plates of the vault; the fourth one very short and apparently axillary, for the support of a double series of arm plates. The radial series on the right of the azygous area has, upon the left sloping side of the third radial, a single secondary radial which is axillary and bears upon each of its upper sloping sides four tertiary radials, which are like the secondary radials in other series. There are, therefore, eleven arms.

There is one regular interradial in each area, which has ten sides. It is a large plate. There are four azygous interradials; the first one is in line with the first primary radials and is longer than either of them; it is followed by one plate on each upper sloping side, and another that truncates its upper face.

Vault pyramidal and covered with more or less convex tumid and spinous, polygonal plates. The interbrachial depressions are continued up the vault so as to give it a subpentagonal outline, and the spinous plates are in line with the brachial series. Two or three plates are broken from one side of the summit of our specimen, but no evidence of a proboscis is preserved and its existence may well be doubted.

The type of the genus, (*Alloprosallocrinus conicus,*) was described as having only two primary radials in each series, and a specimen in my collection agrees with the description in that respect. If such is a correct diagnosis of the type, we need look no further to distinguish it from the species here described, which has three primary radials. If, however, the second and third radials are anchylosed, in Lyon & Casseday's species, this one may be distinguishad from it by its concave calyx, deeply sunken interbrachial spaces, more numerous secondary radials, proportionally smaller and shorter pyramidal vault, without spinous plates in the interbrachial areas, as well as by other differences manifest on comparison.

Found in Brown County, Kentucky, in what is called the Keokuk Group, but I have not seen the locality, and suggest the possibility that it may be the Warsaw Group, and now in the collection of Wm. F. E. Gurley, in whose honor I have proposed the specific name.

### ERETMOCRINUS LYONANUS, N. SP.

*Plate X, fig. 3, side view showing azygous plates; fig. 4, basal view, part of two of the plates being broken away.*

Species rather large; calyx more than twice as wide as high; base expanded; radial series sharply angular and more or less nodose, in the central part of each plate; abruptly expanded from the third radials; arm openings directed horizontally; and plates nodose. Surface probably granular.

Basals three, forming a subcircular, expanded disc, having a diameter one-fourth greater than the diameter of the calyx at the base of the first radials, and being broadly concave below, and having the plates radiately furrowed for the attachment of the round column. First primary radials more than three times as wide as long and bearing a high, sharp, longitudinal ridge in the central part, which is continued across the primary, secondary and tertiary radials to the free arms; upper face arcuate. Second radials quadrangular, three times as wide as long. Third radials pentagonal, more than twice as wide as long. Two secondary radials in each series; the first one more than twice as wide as long and pentagonal by reason of abutting against two interradials at one end; the second one about three times as wide as long, axillary, and supporting upon each upper sloping side the tertiary radials. Tertiary radials three in each series; they are very short and wide; the first plates unite around the calyx except at the azygous area, where the circle is broken by the interposition of a single plate; the second unite in a circle around the calyx; the third are united only in pairs. The five radial series are separated by interbrachial depressions, the most marked being over the azygous area, and each series has four arm openings and four arms. There are, therefore, twenty arms in this species. The arms are not preserved in our specimen.

Regular interradials two, one above the other; the first one is rather large, has nine sides, and bears a strong central tubercle; the second is heptagonal, about half as large as the first, and supports on its two upper sloping sides the under sloping sides of the first tertiary radials. Azygous interradials five; the first one is heptagonal, as large or larger than a first regular interradial and bears a very strong central tubercle; it is followed by three plates, about half as large and each bearing a central tubercle; above the central one of these, a single plate separates the first tertiary radials, and supports upon its two upper lateral sides the under sloping sides of the second tertiary radials. The vault is much larger than the calyx, high, conoidal, covered with polygonal plates, each one of which is produced in an obtuse spine. The proboscis is broken off from our specimen, as shown in the illustration. Column unknown.

This species is so distinct from all others in the genus, that it is unnecessary to make a comparison for the benefit of any American student, and life is too short to undertake to instruct a weak-minded Assistant Master at Eton College.

Found in the Keokuk Group, at Little Bear River, Kentucky, and now in the collection of Wm. F. E. Gurley. The specific name is in honor of the late distinguished palæontologist, Sidney S. Lyon, whose son, Victor W. Lyon, is the well known geologist and palæontologist of Jeffersonville, Indiana.

### Batocrinus spergenensis, n. sp.

*Plate X, fig. 5, side view; fig. 6, basal view; the specimen is slightly compressed.*

Species above medium size; calyx basin-shaped, three times as wide as high; radials ornamented with a small rounded ridge from the basals to the free arms; arms projecting and openings horizontal; surface irregularly sculptured and coarsely granular.

Basals three, forming a hexagonal disc, which bears a hexagonal, flattened rim that extends below the point of columnar attachment, and within which, there is a concave depression radiately furrowed for the attachment of the column. First primary radials one-half wider than high, upper face arcuate for the reception of the second radials. Second radials quadrangular, as large as the first and about as long as wide, though not quite as wide as the first. Third radials heptagonal, by reason of abutting two interradials at either end, except those adjoining the azygous area which are hexagonal; they are wider than the second radials but not quite as long, and they support on the upper sloping sides the secondary radials. There are two secondary radials in each series, the first is quadrangular, wider than high; the second is axillary and supports upon each of the upper sides two tertiary radials. Tertiary radials short; the first unite around the calyx, except at the top of the azygous area, where a small plate is interposed; the second unite with each other, in each of the five radial series, and with the plates of the vault; they are axillary and bear either a double series of arm plates or bifurcating arms. The arms are not preserved in our specimen. There are twenty arm openings, four for each radial series.

Regular interradials six; the first one is large and followed by two smaller ones and these by two still smaller that are of unequal size, and above these, there is a small elongated plate that supports, upon its upper lateral sides, the second, tertiary radials. Azygous interradials ten;

the first one is in line with the first primary radials, it is followed by three plates and these by three of nearly the same size, and these by two, one of which is on the right side of the area and below the under sloping side of the other, the higher one is in line above the first plate, and it is followed by a narrow elongated plate, that separates the tertiary radials and unites with the plates of the vault. Vault convex and covered with numerous, unequal, convex, coarsely granular, polygonal plates. Proboscis subcentral, rather small, length unknown.

Any citizen of Indiana will be able to distinguish this species from all others in the genus, and we have no Eton Colleges, in this country, where royalty supports effeminate school teachers, who need comparisons made for them, in order to comprehend specific differences.

Found in the Warsaw Group, at Spergen Hill, Indiana, and now in the collection of Wm. F. E. Gurley.

### BATOCRINUS DECORIS, N. SP.

*Plate X, fig. 7, side view, fig. 8, basal view; some of the plates in the azygous area are anchylosed and therefore not indicated.*

Species above medium size; calyx depressed, nearly flat; radials form angular ridges from the basals to the free arms; interradial areas flattened, though the plates are somewhat convex and bear small tubercles or coarse granules; arm openings horizontal.

Basals three, forming a rather large disc, which bears a round or obscurely hexagonal rim extending below the radial ridges, and within which there is a deep concavity for the columnar attachment. First primary radials about four times as wide as long. Second radials quadrangular, and about three and a half times as wide as long. Third radials pentagonal, nearly three times as wide as long and support the secondary radials. There are two secondary radials in each series; the first usually abuts two interradials and therefore becomes pentagonal, it is about twice as wide as long, the second is more than twice as wide as long, axillary, and supports upon each upper sloping side three tertiary radials. The tertiary radials are short and wide; each of the first ones abut an interrdial; the second unite around the calyx, cutting off connection between the azygous area and the vault; the third unite in pairs and with the plates of the vault; they are axillary and bear either a double series of arm plates or bifurcating arms. The arms are not preserved in our specimen. There are twenty arm openings, four for each radial series.

Regular interradials four; the first one is large, bears a central tubercle, and is followed by two of unequal size and length, and beyond the longer of these, there is a narrow elongated plate that separates the tertiary radials and inserts an angle between the under sloping sides of the second tertiary radials. Azygous interradials eight, and possibly nine; the illustration shows only five, but the lower central one consists of two anchylosed plates and each of the upper ones should be divided. Vault high, conoidal, covered with unequal, more or less convex, polygonal plates, three of which, above each of the five radial series, is produced into an obtuse spine. The proboscis is subcentral, and where broken off, in our specimen, rather large; length unknown.

Found in the Warsaw Group, at Spergen Hill, Indiana, and now in the collection of Wm. F. E. Gurley.

### BATOCRINUS MEDIOCRIS, N. SP.

*Plate X, fig. 9, lateral view, showing the ray having seven arms, including the small double arm.*

Species rather above medium size; calyx obconoidal, about twice as wide as high; radial ridges small; interradial areas slightly depressed; arms projecting and openings outward; surface delicately sculptured.

Basals three, forming a hexagonal disc, one-half wider than the diameter of the column, which bears a circular rim that projects below the point of columnar attachment. First primary radials a little wider than high, upper face arcuate for the reception of the second radials. Second radials quadrangular, more than twice as wide as high. Third radials pentagonal, larger than the second, more than twice as wide as high, axillary, greatest width below the middle, at the angles formed by the junction of the lower expanding and upper sloping sides. In one lateral ray there are four secondary radials upon one side bearing a double arm and two secondary radials on the other side, followed by two tertiary radials, upon each of its upper sloping sides, from one of which a single arm arises and from the other two arms, making five arms in this radial series. The single arm is between the double arms. In the other lateral ray there are two secondary radials upon each side followed by three tertiary radials, in each of the four series, the one on the right supports a double arm, the next one a single arm, the next a double arm and the next a small or rudimentary arm, making seven arms in this radial series. If the small double arm is regarded as abnormal, then the arms will be substantially the same as they are in the other lateral ray. There are three rays on each side of the azygous area which bifurcate, making six arms in each series; in the distal rays there are four secondary radials, in the proximate rays three, the last being axillary and bearing on one side two tertiary radials and on the other three, the arms bifurcate on the first plate. The arms bifurcate on the fourth secondary radials, in the series opposite the azygous area, giving it four arms. There are, therefore, twenty-eight arms in this species, or if the small double arm, in one of the lateral series, is deemed abnormal then twenty-six arms. Arms large, long, round and composed of a double series of interlocking plates. Pinnules long and dense.

Regular interradials five, the first one large, followed by two smaller ones of unequal size and these by two smaller ones also of unequal size. Azygous interradials nine, the first one in line with the first primary radials, octagonal, and the largest plate in the calyx; it is followed by four plates and these by three smaller ones, above which, there seems to be only one. Vault convex. Column round.

This species is distinguished by the structure of the lateral rays, by the number of arms, and by the four plates in the second range in the azygous area. In other particulars it is much like *B. boonvillensis.*

Found by R. A. Blair, in the Keokuk Group, at Boonville, Missouri, and now in my collection.

### Batocrinus gorbyi, n. sp.

*Plate X, fig.* 10, *side view, with part of the arms removed showing calyx, vault and part of the proboscis.*

Species medium size; calyx globose; height and width about as eight to eleven; arm bases projecting and openings directed upward; surface of plates convex, transversely angular; sutures beveled.

Basals three, forming a hexagonal disc, two-thirds wider than the diameter of the column, truncated or flattened below, standing upright, exposing a height about equal to the distance from the column to the margin. First primary radials very little wider than high, upper face slightly arcuate, sutures deeply beveled, and bearing a sharp, transverse, central ridge. Second radials quadrangular, about one-fourth wider than long and having a central transverse angular ridge. Third radials wider and larger than the second, three hexagonal and two pentagonal, greatest diameter below the middle, at the angles with the upper sloping sides. Secondary radials two by ten, generally wider than long, the upper the larger, but both of them of variable size and shape in the different series; nine of them bear tertiary radials, but an arm rises from the second secondary radial, in the series opposite the azygous side. Tertiary radials one by eighteen. The arms do not bifurcate. There are thus nineteen arms composed of a double series of interlocking plates, from the first plate that follows the tertiary radials and the secondary radial. The arms are long and rounded externally. Pinnules numerous and composed of ten or twelve long joints.

Regular interradials three, the first one large and having nine sides, the other two smaller and one only about half as large as the other. Azygous interradials nine, the first one is heptagonal, rests upon the basal plates, in line with the first primary radials, and is the largest plate in the calyx; it is followed by three plates, and these by three smaller ones, and the latter by two still smaller. Vault high, conoidal, and covered with convex polygonal plates. Proboscis almost central, small, cylindrical, extending beyond the arms and covered with rather large, slightly convex plates. Column round, medium size and composed of alternately thicker and thinner plates.

Distinguished by its globose calyx, conoidal vault, beveled sutures, transversely angular ridge in the central part of the plates, and number of single arms. This is a marked species approaching *Eretmocrinus* in form.

Found by R. A. Blair, in the Keokuk Group, at Boonville, Missouri, and now in my collection. The specific name is intended as a compliment to Prof. S. S. Gorby.

### BATOCRINUS CRAWFORDSVILLENSIS, N. SP.

*Plate X, fig.* 11, *side view, showing top of vault, and proboscis broken off; fig,* 12 *azygous view.*

Species rather below medium size; calyx obpyramidal, truncated below, one-half wider than high; each radial series bears an angular ridge from the basal plates to the free arms, the axillary plates being tumid; interradial areas depressed and plates convex; arm openings directed upward; surface more or less sculptured.

Basals three, forming a disc about twice the diameter of the column and bearing a subcircular rim projecting below the point of columnar attachment; truncated below and having a deep cavity for the insertion of the end of the column. First primary radials sculptured, one-half wider than high. Second radials quadrangular, one-half wider than high. Third radials pentagonal, one-half wider than high, axillary, and support on the upper sloping sides the secondary radials. There are two secondary radials in each of the lateral rays, the second ones being axillary, and bearing upon each upper sloping side four tertiary radials, the last one of which is axillary and bears two arms. This gives to each lateral ray eight arms. In the ray opposite the azygous area there are five secondary radials, the fifth ones being axillary and each bearing two arms, which gives to this ray four arms. There are two secondary radials adjoining the azygous area on each side, the second ones being axillary and bearing upon one upper sloping side three and upon the other four tertiary radials, the last ones of which are axillary and bear two arms; there are five secondary radials on the distal side of each third primary radial adjoining the azygous area, the fifth ones being axillary and each bearing two arms. This makes six arms in each ray adjoining the azygous area and gives to the species twenty-four arms.

The arms are delicate, reach but little beyond the summit of the vault, and are composed of a double series of small plates. Pinnules small.

Regular interradials three, the first one large and tumid, the other small and convex, one extends higher than the other. Azygous interradials six, the first one heptagonal, in line with the first radials, the largest plate in the calyx, tumid and sculptured; it is followed by three plates of moderate size and above these there appear to be two small ones. Vault highly convex, almost equaling the calyx in size and covered with large, tumid, polygonal plates. Proboscis subcentral, evidently short.

Found in the Keokuk Group, at Crawfordsville, Indiana, and now in the collection of Prof. S. S. Gorby.

### Batocrinus boonvillensis, n. sp.

*Plate X, fig.* 13, *showing the right lateral series.*

Species large; calyx turbinate, rapidly expanding, twice as wide as high; each radial series bears an angular ridge from the basal plates to the arms; interradial areas flattened; arm openings directed upward; surface granular.

Basals three, forming a subcircular rim, a little wider than the diameter of the column and projecting below the point of columnar attachment. First primary radials wider than high, upper faces slightly arcuate for the reception of the second radials. Second radials quadrangular, twice as wide as high. Third radials small, more than twice as wide as high, the one on the left of the azygous area hexagonal, the others pentagonal and support on the upper sloping sides the secondary radials. There are two secondary radials in each of the lateral rays and three in the rays adjoining the azygous area and in the ray opposite thereto. In the lateral rays, there are four tertiary radials in one outer series and three in the other, and two in each of the inner ones; from the latter only a single arm arises, but the arms bifurcate in the former, making six arms in each lateral series. There are three rays on each side of the azygous area which bifurcate, making six arms in each series; in the distal rays there are four secondary radials, in the proximate rays three, the last being axillary and bearing on one side two tertiary radials and on the other three; the arms bifurcate on the first plate. The arms bifurcate on the first plate above the third secondary radials in the series opposite the azygous area, giving it four arms. This makes twenty-eight arms in this species. Arms large, long and composed of a double series of interlocking plates. Pinnules long and dense.

Regular interradials five, the first one large, two in the second range and two smaller ones above, one of which projects high between the adjacent radials. Azygous interradials nine, the first one heptagonal, in line with the first radials and the largest plate in the calyx; it is followed by three plates, and these by four smaller ones, and the latter by a single one still smaller. Vault convex, covered with convex polygonal plates and bearing a long, small proboscis. Column round.

This species is distinguished by the angular ridges on the radial series, flattened interradial areas, by the two single arms in each of the lateral rays, and by the number of arms.

Found by R. A. Blair, in the Keokuk Group, at Boonville, Missouri, and now in my collection.

### BATOCRINUS GURLEYI, N. SP

*Plate XI, fig. 9, azygous view of calyx and vault; fig. 10 symmetrical view of specimen with arms.*

Species medium or below medium size; calyx somewhat obpyramidal, rapidly expanding, about twice as wide as high; radial series forming angular ridges from the basal plates to the free arms; interradial areas flattened; arms projecting below and openings directed horizontally; surface finely sculptured and granular.

Basals three, forming a hexagonal disc, one-half wider than the diameter of the column, truncated below and exposing a height about equal to the distance from the column to the margin. First primary radials nearly as high as wide, upper face strongly arcuate for the reception of the second radials. Second radials quadrangular, about twice as wide as high. Third radials pentagonal, larger than the second, more than twice as wide as high, axillary, greatest width below the middle at the angles formed by the junction of the lower expanding and upper sloping sides. In each lateral ray there are two secondary radials succeeded by three tertiary radials that bear single arms or four arms in each lateral series. In the ray opposite the azygous area, there are four secondary radials that bear single arms or two arms, in that ray. On each side of the azygous area, there are four secondary radials in the distal series that bear single arms, and two in the proximate series, followed by tertiary radials that bear single arms or three arms in each ray adjoining the azygous area. There are, therefore, sixteen arms in this species. The arms are coarse, long, uniform in size, and composed of a double series of interlocking plates. Pinnules long and dense.

Regular interradials three, the first one very large, the other two small and of nearly equal size. Azygous interradials seven, the first one heptagonal, in line with the first primary radials and the largest plate in the calyx; it is followed by three plates, the lateral ones being as large or larger than the central one; these are succeeded by two plates that are followed by a single small one that separates the under sloping sides of the third tertiary radials. Vault depressed, convex toward the margin, but becoming more convex toward the proboscis and covered with convex polygonal plates. Proboscis small, subcentral. Column round.

Collected by R. A. Blair and F. A. Sampson, in the Keokuk Group, at Boonville, Missouri, and now in their collections and in mine. The specific name is in honor of Wm. F. E. Gurley, of Danville, Illinois.

### Batocrinus venustus, n. sp.

*Plate XI, fig.* 11, *side view, showing arms; fig.* 12, *showing calyx and vault.*

Species robust, above the average size. Calyx depressed or saucer-shaped; radial ridges not defined; height of calyx less than one-fourth the diameter; arm openings directed horizontally and arms projecting before curving upward; interradial areas not defined; surface smooth or possibly granular.

Basals three, forming an hexagonal disc, a little more than one-half wider than the diameter of the column and bearing a rim that extends below the point of the columnar attachment, within which the hemispherical cup is radiately furrowed. First primary radials more than twice as wide as high, upper face slightly arcuate for the reception of the second radials. Second radials small, quadrangular, less than twice as wide as high. Third radials small, pentagonal, twice as wide as high, axillary, greatest width below the middle at the angles formed by the junction of the lower expanding and upper sloping sides. There are two secondary radials and three tertiary radials in each of the lateral rays, or four arm openings to each ray. In the ray opposite the azygous area there are four secondary radials and two arm openings. On each side of the azygous area there are four secondary radials in the distal series, two in the proximate series, followed by two tertiary radials in one branch and three in the other, or three arm openings to each ray. This makes sixteen arm openings to the vault. The arms bifurcate on the second plate; there are, therefore, thirty-two arms in this species. The arms are rather small, very uniform in size, and composed of a double series of short, interlocking plates. Pinnules long and compact.

Regular interradials three, the first one moderately large, the other two small. Azygous area wide; interradials seven, the first one large, followed by three plates in the next range, and three in the next. Vault high, conoidal, having three times the capacity of the calyx, and covered with large, slightly convex polygonal plates. Proboscis subcentral, rather large, very long, cylindrical, extending beyond the arms, and covered with large polygonal, granular plates. Column round, small, and composed of alternately thicker and thinner plates.

Found by R. A. Blair, in the Keokuk Group, at Boonville, Mo., and now in my collection.

## BATOCRINUS PULCHELLUS, N. SP.

*Plate XI., fig.* 13, *side view of calyx and vault; fig.* 14, *side view showing arms.*

Species medium size. Calyx subglobose, one-half wider than high, plates convex, angular; sutures deeply beveled; arm-bases projecting at the lower side, openings directed upward; surface granular.

Basals three, forming an hexagonal disc, about twice as wide as the diameter of the column, truncated below, standing upright and exposing a height less than the distance from the column to the margin. First primary radials one-half wider than high, upper face slightly arcuate for the reception of the second radials. Second radials quadrangular, one-half wider than high. Third radials pentagonal, larger than the second, axillary, greatest width below the middle at the angles formed by the junction of the lower expanding and upper sloping sides. Secondary radials two by ten, wider than long, but both of them slightly variable in size and shape in the different series; eight of them bear single tertiary radials. Tertiary radials one by sixteen, or all the rays have tertiary radials except the one opposite the azygous area, where the arms rise from the secondary radials. There are eighteen arm-openings to the vault and eighteen arms in this species. None of the arms bifurcate. The arms are coarse, long, sharply rounded externally, and composed of a double series of interlocking plates. Pinnules long and dense.

Regular interradials three, the first one large, the other two smaller, but differing in size. Azygous interradials eight, the first one heptagonal, in line with the first primary radials and the largest plate in the calyx; it is followed by three smaller plates, and these by three still smaller ones, and the latter by a single plate. Vault moderately high, and covered with convex polygonal plates. Proboscis small, subcentral, cylindrical, extending beyond the arms, and covered with convex, polygonal plates. Column round, rather large, and composed of alternately thicker and thinner plates.

This species has some resemblance to *B. gorbyi*, but it is a much smaller species, has proportionally a smaller vault and much larger arms, beside, this species has only eighteen arms, instead of nineteen, and there is a corresponding difference in the construction of the calyx.

Found by R. A. Blair, in the Keokuk Group, at Booneville, Missouri, and now in my collection.

## Blairocrinus, n. gen.

(*Ety. proper name; krinon, lily; the generic name is dedicated to R. A. Blair, of Sedalia, Missouri.*)

This genus belongs to the *Actinocrinidæ*. The calyx is low, saucer-shaped, but not depressed at the base. The surface is deeply sculptured and bears radial ridges, though the interradial areas are not sunken. The vault is elevated immediately above the arm-openings and more or less convex above, with a short subcentral proboscis, having an opening on top, surrounded by numerous small plates. The plates of the vault are smooth, convex or spinous.

There are three basal plates, usually anchylosed, that form a flat, hexagonal disc, extending beyond the column and perforated, at the center, by a minute, five-rayed opening for the columnar canal. Primary radials three by five. Secondary radials one by ten, axillary. Tertiary radials one by twenty. Regular interradials, one large plate resting upon the upper sides of first radials, followed sometimes by two ranges of two small plates, and then by two elongated plates that connect with the plates of the vault; in other cases only one range of small plates intervene. First azygous plate in line with the first radials, followed by ranges of two plates until they connect with the plates of the vault.

It need hardly be compared with *Batocrinus*, *Dorycrinus*, or *Eretmocrinus*, from which it is distinguished, by the general structure of the calyx and vault, and by the union of the interradials with the plates of the vault. It is distinguished from *Actinocrinus* by the general form of the calyx and vault, by the basal plates, interradial areas and short proboscis, though it seems to be more nearly related to that genus than to any other in the family. Type, *Blairocrinus trijugis*.

## Blairocrinus trijugis, n. sp.

*Plate XI, fig.* 1, *summit view; fig.* 2, *side view; fig.* 3, *basal view.*

Calyx saucer-shaped, height from one-fourth to one-third the diameter; plates deeply sculptured; radial ridges sharp; interbrachial areas sunken; arm-openings directed nearly horizontally.

Basals three, forming a thin, almost flat, hexagonal disc, nearly covered below by a round column, which is indicated by strong radiating furrows upon the basal plates. There is a minute, five-rayed perforation in the center for the columnar canal. The basals are thin where they rest upon the column, but bear a thickened rim surrounding it, with nodes or short ridges extending toward the center of the adjoining plates. First primary radials large, nearly as high as wide, two heptagonal and three hexagonal, deeply sculptured, having stellate rays from the center toward the center of the adjoining plates. Second primary radials quadrangular, twice as wide as high, but width less than that of a first primary, radial ridge larger than the transverse one and central node distinct. Third primary radials very little larger, if any, than the second, pentagonal, axillary. Tertiary radials small, single, axillary. There are twenty elongated arm-openings to the vault, but the tertiary radials bear a ridge that forms a notch in the lower part of each orifice, which shows that the species possessed forty arms.

Regular interradials, one large, hexagonal plate, resting between the upper sloping sides of two first primary radials, followed by two smaller ones, that separate the secondary radials, and these by two which fill the interbrachial space and connect with the plates of the vault. In some cases the large plate is heptagonal by reason of abutting against a third primary radial. The first azygous plate is hexagonal, in line with the first primary radials, but somewhat smaller; it is followed by two plates of nearly its own size, and these by two that separate the secondary radials, and these by two that fill the interbrachial space and connect with the plates of the vault. The azygous area has only two more plates than each of the regular areas, and the plates are but little larger.

The vault is elevated, and the arm-openings of each radial series is separated by a large plate, standing upright, between each pair of third radials and the openings, and a smaller plate, in like manner, separates the plates and orifices of each pair. These plates and the elongated orifices are succeeded by three large spinous plates that suggested the specific name. The three spinous plates over each radial series are uniform so far as observed. Above the spinous plates the vault is convex, covered with rather large, plain, polygonal plates that graduate into a short, subcentral proboscis, that terminates in a large number of very small plates. The central part of the summit of the short proboscis is open.

Found by R. A. Blair, in the Chouteau limestone near Sedalia, in Pettis County, Missouri, and now in my collection.

## FAMILY EUPACHYCRINIDÆ.

### EUPACHYCRINUS TUMULOSUS, N. SP.

*Plate IX, fig. 9, azygous view of calyx; fig. 10, basal view with azygous side below.*

Calyx low, broadly basin-shaped, diameter twice as great as the height, except upon the azygous side, which is bulged and elevated; plates remarkably tumid and sutures sunken; surface granular.

Basals form externally a small, flat, pentagonal disc, deeply sunken in the basal cavity, and internally a moderately elevated cone. Subradials much the larger plates of the calyz, very tumid, curving into the basal cavity and extending upward two-thirds the height of the calyx, unequal; the one on the right of the azygous area about one-half larger than the one on the left.

Radials twice as wide as high, pentagonal, the one upon the right of the azygous area rests upon an upper sloping side of the large subradial and the first azygous plate, and between a radial and the third azygous plate, while the one upon the left rests between the upper sloping sides of two subradials and between a radial and the second azygous plate. They are truncated the entire width above and separated from the brachials by a gaping suture; a crenated ridge the width of a plate marks the depth of a gaping suture, and within it there is a furrow upon the upper face of the plate; the lateral sides of each plate, behind the furrow, project upward, leaving a central notch-like depression between them.

There are three tumid plates in the azygous area. The first one is more than half as large as an average subradial, pentagonal, rests obliquely between the upper sloping sides of two subradials and below the first radial on the right, and supports the other two, its upper angle is on a line with the upper face of the opposite radials. The second azygous plate is about one-fourth as large as the first, and rests between it and the radial on the left, and extends in a sharp angle to the subradial so as to separate the first azygous plate from the radial on the left. The third azygous plate is about as large as the second, rests upon the first and between the second, on the left, and the first radial on the right. The cicatrix on the basals shows the column is rather small. Other parts of this species unknown.

Distinguished by the remarkably tumid plates and by their relative proportions, and also by the azygous area and plates, from other species.

Found in the Kaskaskia Group, in Breckinridge County, Kentucky, and now in the collection of William F. E. Gurley.

### Eupachycrinus harii, n. sp.

*Plate XI, fig. 8, view opposite the azygous area.*

Calyx low, sunken at the base, basin-shaped; diameter twice as great as height; plates convex; sutures beveled; surface finely granular.

Basals form, externally, a small pentagonal disc, one-half wider than the diameter, of the column sunken in the basal cavity so as not to be visible in a side view; and, internally, they form a small cone. Subradials the larger plates of the body, slightly convex, curving into the basal cavity and extending upward more than half the height of the calyx; unequal, the two adjoining the azygous area being larger than the others. Radials pentagonal, two and one-half times as wide as high, truncated the entire width above and separated from the brachials by a gaping suture. At the depth of the suture there is a serrated ridge for the articulation of the brachials, and behind this the upper face of the plates is prolonged toward the interior, leaving the orifice, at the top of the radials, less than half the greatest diameter of the calyx. Brachials single, axillary, convex, and obtusely angular in the upper central part; more than twice as wide as high; sunken at the lateral sutures.

In the ray opposite the azygous side there are only two arms, as shown in the illustration. In the lateral rays the arms bifurcate on the first plate which gives to each ray four arms, as shown in the illustration. This evidently shows the species has eighteen arms. The arms, so far as preserved in our specimen, in the ray opposite the azygous area, are longitudinally angular in the central part and composed of a single series of plates, while all the other arms are flat, externally, and composed of a double series of interlocking plates. The arms are flattened on the sides so as to fit closely and compactly together. Pinnules rather small and not compact but free. Column rather small, composed of alternately thicker and thinner, externally convex or beaded plates, radiately furrowed on their uniting faces.

Found by S. J. Hare, in the Coal Measures, at Kansas City, Mo., to whose collection it belongs. The specific name is in honor of the collector.

## ORDER MYELODACTYLOIDEA.

## FAMILY MYELODACTYLIDÆ.

### MYELODACTYLUS GORBYI, N. SP.

*Plate XI, fig. 6, side view; fig. 7, showing the circular pore in the outer whorl and the lines indicating the connection between the whorls and places of passage of the radiating pores. The two lower dark spots represent fractures.*

The specimen from which this species is named preserves nearly two and a half coils, and the outer one bears the evidence of having been surrounded by another, so that a perfect specimen would have, probably, four or more coils. The coils consist of a double series of plates, the inner series being much smaller than the outer, and they taper gradually toward the center, so that both sides of the specimen are concave. The outer whorl or series of plates is flattened on the lateral sides. The thickness of the plates is about one-half the width of the dorsal side. The dorsal side is slightly convex and marked with a furrow near each side, where the inner series or coil attached, and minute pores may be seen in each furrow between each of the plates representing the radiating system of circulation. The plates of the inner series are about one-third as large as the plates of the outer series. The circular canal in the large series is wide and narrow or corresponding with the outer shape of the coil. The circular canal in the smaller series can not be definitely determined from our specimen. The two lower pores in fig. 7, as illustrated, are probably both erroneous, and represent the fracture rather than the pores.

The overlapping finger-like processes, which I described in *M. bridgportensis*, have been broken off from our specimen, but the place of attachment may be clearly seen with the aid of an ordinary magnifier.

The characters of this genus, so far as known, were first ascertained by me from casts found in the magnesian limestone at Chicago. The radiate and concentric system of pores and passages then described are found to exist in the species under consideration, but they are not so conspicuous as they are in the Chicago species. The shape of the coils will readily distinguish this species from all others heretofore described.

Found in the Niagara Group, near Nashville, Tenn., and now in the collection of Professor S. S. Gorby, in whose honor I have proposed the specific name.

## CLASS ECHINIDA.

## ORDER PERISCHOECHINIDA.

## FAMILY ARCHÆOCIDARIDÆ.

### Eocidaris blairi, n. sp.

*Plate XII, fig. 1, flattened specimen, mouth central; fig. 2, specimen depressed in the opposite direction, or laterally, showing spines.*

Body depressed spheroidal, having, as near as can be estimated from our specimens, a height equal to about half the lateral diameter. Ambulacral areas linear, indicated by concave depressions or slight swellings of the interambulacral areas, but the areas are so narrow and the plates so minute they can not be determined in our specimens. Interambulacral areas covered with hexagonal plates. In the middle part of each area there are two rows of large plates and one row of smaller ones on each side. Each plate has a large, perforated, central tubercle for the articulation of the primary spines, and minute tubercles around the margin for the articulation of secondary spines. The area between the central tubercle and the marginal tubercles is concave. Primary spines long, gradually tapering, slightly compressed or nearly round, articulating end moderately enlarged or bearing a small ring; surface, under a good magnifier, shown to be minutely granular; secondary spines very small, length about half the diameter of a plate.

This species is so distinct from all others that no comparison with any of them is necessary.

Found by R. A. Blair, in the Keokuk Group, at Boonville, Missouri, and now in my collection.

## CLASS STELLERIDA.

## ORDER ASTEROIDEA.

## FAMILY ONYCHASTERIDÆ.

### ONYCHASTER ASPER, N. SP.

*Plate XII, fig.* 3, *large specimen, covered with the outer integument of small plates and broken down spines; fig.* 4, *a smaller specimen, with part of the outer integument preserved and having the arms abruptly bent toward the ventral side; fig.* 5, *a still smaller specimen, showing the infolding arms, with part of the integument removed.*

Dorsal side covered with an integument of small plates and numerous short spines. Central disc rather large, circular, convex, inflated from the point of contact with the arms. The outer integument covers the whole surface of the central disc leaving no orifice exposed. Where the outer integument is worn off the disc is composed of rather large, polygonal, spine bearing plates. The spines do not arise from the center of the plates, but laterally from little pits or sockets at the sutures. These sockets give the plates a somewhat sculptured appearance. The spines have a bulb at the base and taper to an obtuse point above.

The arms are long, rounded on the dorsal side, and very flexible. Fix. 4 shows the arms abruptly folded from the middle over the ventral part, while figs. 3 and 5 have the arms folded like the claws of a bird grasping some small object. There is a row of spines on each side of the arm furrows.

This species is so different from the type that the generic reference is very doubtful.

Found by R. A. Blair and F. A. Sampson, in the Keokuk Group, at Boonville, Mo. The specimen represented by fig. 3 is in Mr. Sampson's collection, and those represented by figs. 4 and 5 are in my collection.

### ONYCHASTER CONFRAGOSUS, N. SP.

*Plates XII, figs.* 6 *and* 7, *dorsal views of two specimens.*

This species is so different from the one last described, and also from the type of this genus, that it may not be congeneric with either of them. I have no doubt that it belongs to the same family. I have seen only the dorsal side of the disc and the dorsal and lateral sides of the rays. There is no such integument of small plates covering the dorsal side as belongs to *O. asper*, but the surface is covered with short spines.

The central part of the disc is somewhat injured in our specimens, and its character can not be definitely determined. It is surrounded by large, centrally convex, six-rayed plates. These rays seem to be the elevated ridges that separate the sockets for the insertion of the spines. Outside of this circle of ten six-rayed plates, there is a circle of quadrilateral plates more or less sculptured by the sockets for the spines, and here the radials may be said to commence. The dorsal side of each ray consists of three series of plates, and there is one series upon each side, or five series in an arm. The first plates are connected laterally by smaller ones, in the angular depressions, between the commencement of the rays, which form part of the disc. All of the radial plates are more or less sculptured by the depressions for the insertion of the spines. The spines are longer than the diameter of a plate, bulbous at the lower end, and taper to an obtuse point. The arms are long, round on the dorsal side, flexible and capable of being rolled up on the ventral side or being twisted laterally. No such ovarian pores piercing the plates of the disc, as described and illustrated in *O. flexilis*, have been discovered.

Found by R. A. Blair, in the Keokuk Group, at Boonville, Mo., and now in my collection.

### Onychaster demissus, n. sp.

*Plate XII, figs.* 8, 9 *and* 10, *three views of different specimens,*

This species hangs its arms down and folds them like the claws of a bird grasping some small object, and in these respects is more like *O. flexilis* than either of the preceding species. The central disc is slightly concave, subpentagonal in outline, and the rays drop down at right angles to the circumference of the disc.

In the center of the disc there is a low, subcircular elevation, in which I have been unable to find any sutures, or to determine whether or not there is an opening of any kind, it appears to consist of a single plate. It is surrounded by a series of ten plates that form the subpentagonal rim of the central disc. These plates are large, very convex, radiately sculptured, and bent down in the direction of the radial series as well as curving in to unite with the central plate. The sculpturing is due to the sockets for the insertion of the rays. The radial series commence from this circle of plates. The rays are angular on the dorsal side or obtusely rounded. The dorsal side of each ray consists of three series of plates, and there is one series on each side, or five series in an arm. The first two plates in each ray are connected laterally by smaller ones, which form part of the disc, in the angular depressions, between the commencement of the rays. All of the radial plates are more or less sculptured or pitted by the depressions for the insertion of the spines.

The arms are longer, more angular and have rather smaller spines than either of the preceding species. I have been unable to detect any ovarian pores, but spine sockets very much resembling pores are indicated in fig. 8, but they occur in the sutures and are readily distinguished from pores that pierce the plates.

Found by R. A. Blair, in the Keokuk Group, at Boonville, Missouri, and now in my collection.

## ORDER AGELACRINOIDEA.

## FAMILY AGELACRINIDÆ.

### Echinodiscus sampsoni, n. sp.

*Plate XII, fig.* 16, *outer part of the specimen destroyed; mouth in the interambulacral area on the left.*

Body circular, thin, interambulacral areas depressed, flat; ambulacra higher than wide and regularly arched at the top; diameter of a complete specimen, probably three inches.

Plates in the interambulacral areas large, not imbricating, and those adjoining the ambulacra curved upward nearly half the height of the ambulacra. A few plates adjoining or near the orals are preserved in the wider interambulacral area of our specimen, which show the mouth is distant more than half an inch from the central point of the union of the ambulacra. Ambulacra long, radiating in nearly straight lines from the central part of the disc, and curving back from near the margin, and covered by numerous small plates that are thrown into a waving line on top. These plates are too small to be shown in the illustration.

Found by F. A. Sampson, in the Keokuk Group, at Boonville, Missouri, and now in his collection. The specific name is in his honor.

## SUBKINGDOM MOLLUSCA.

## CLASS BRACHIOPODA.

## ORDER ARTHROPOMATA.

## FAMILY TEREBRATULIDÆ.

### Cryptonella ovalis, n. sp.

*Plate XIII, fig.* 1, *dorsal view of a large specimen; fig.* 2, *side view of same.*

Shell subovate, gibbous, rounded in front, greatest width slightly above the middle. Surface concentrically banded, the bands apparently imbricating. Shell structure punctate.

Ventral valve more gibbous than the dorsal; arcuate from the beak to the front; greatest convexity above the middle. Beak prominent, incurved, inflected along the umbonal slopes, truncated by a small foramen. No hinge area.

Dorsal valve shorter than the ventral, less gibbous, greatest convexity above the middle. Beak incurved beneath the beak of the ventral valve. No hinge area.

This species resembles *Cryptonella planirostra*, but is much more gibbous, and the ventral valve is more convex than the dorsal, while in that species the dorsal valve is most convex. Our specimens vary in length from three to seven-tenths of an inch.

Found in the Hamilton Group, at Bunker Hill, Indiana, and now in the collection of Prof. S. S. Gorby.

### Terebratula gorbyi, n. sp.

*Plate XIII, fig.* 3, *dorsal view; fig.* 4, *side view of same.*

Shell variable in size, but growing very large; elongate-elliptical in a dorsal view; cuneate in front in a side view; valves unequally gibbous; rounded in front; sides subparallel. Shell structure beautifully punctate, under an ordinary magnifier, and the punctures may be seen with the unaided eye.

Ventral valve more gibbous than the dorsal; arcuate from the beak to the front; greatest convexity in the middle part. Beak very prominent, strongly incurved, inflected along the umbonal slopes; truncated by a very large foramen. No hinge area.

Dorsal valve much shorter than the ventral, less gibbous, somewhat depressed, convex in the middle part. Beak incurved beneath the beak of the ventral valve. No hinge area.

This species may be distinguished by its large size, elongate-elliptical form, and large foramen.

Found by Prof. S. S. Gorby in the Keokuk Group, at Edwardsville, Indiana, and now in his collection and in the State Museum, at Indianapolis. The specific name is in honor of the collector.

## FAMILY PEMTAMERIDÆ.

### Pentamerus colletti, n. sp.

*Plate XIII, fig.* 5, *dorsal view of a fragment showing beaks and the narrowness of the species; fig.* 6, *side view of a specimen crushed in front.*

Shell large, subovate, gibbous, narrow, rounded in front, greatest width above the middle. Surface longitudinally striated; striæ moderately large; concentrically marked with strong imbricating lamellæ, marking stages of growth. No mesial fold or sinus.

Ventral valve much more gibbous than the dorsal; arcuate from the beak to the front; most rapid curvature from the beak over the umbo; greatest convexity above the middle; umbo very high, rapidly inflected or rounded along the umbonal slopes. Beak prominent, pointed, incurved over the beak of the other valve and resting the point upon the umbo, without exposing any of the concave arch beneath. No hinge area.

Dorsal valve much shorter than the ventral and less gibbous; regularly curved from beak to front; greatest convexity near the middle. Beak strongly incurved into the ventral valve.

Distinguished by the narrowness of form, high umbo of the ventral valve, and the character of the plications and concentric lines of growth.

Found in the Waterlime Group, at Kokomo, Indiana, and now in the collection of Prof. S. S. Gorby. The specific name is in honor of Prof. John Collett, late State Geologist of Indiana.

## FAMILY ORTHIDÆ.

### Orthis benedicti, n. sp.

*Plate XIII, fig. 7, ventral view; fig. 8, dorsal view; fig. 9, lateral view.*

Shell medium or below medium size; wider than long; hinge line exceeding the breadth of the valves at any part farther forward; lateral margins oblique but rounding to the front, which is regularly arched. No mesial fold or sinus.

Dorsal valve much more convex than the other, greatest convexity in the middle part; umbo prominent; beak pointed, contracted on the sides, and incurved over the area; area of moderate height, oblique, sharp along the margin, and continuing to the lateral extremities. Surface marked by coarse radiating striæ, with wide and deep furrows, which gradually increase in size toward the front and lateral margins. The striæ increase by intercalation, but rarely beyond the umbo; no increase by bifurcation on our specimen, and no imbricating marks of growth or concentric striæ.

Ventral valve most convex near the apex of the beak, from which it slopes regularly and evenly to the front and lateral margins. Beak elevated, straight, pointed. Cardinal area rather high at the beak and sloping to the lateral extremities, very oblique, or standing at an angle of only about forty-five degrees to the plane of the valve, and quite sharp along the margin. Surface marked by coarse radiating striæ, with wide and deep furrows, which gradually increase in size toward the front and lateral margins, and increase by intercalation as they do on the dorsal valve.

The species is founded on a single incomplete specimen, but it is so different from any heretofore described, from rocks of the same age, that I have not hesitated in naming it.

Found in the Niagara Group, at Hartsville, Indiana, and now in the collection of Mr. A. C. Benedict. The specific name is in honor of the collector.

## FAMILY NUCLEOSPIRIDÆ.

### NUCLEOSPIRA INDIANENSIS, N. SP.

*Plate XIII, fig.* 13, *dorsal view; fig.* 14, *ventral view; fig.* 15, *profile or lateral view.*

Shell small, transversely subelliptical, compressed; valves nearly equally convex; hinge line short. No area. Surface marked by radiating striæ that do not increase by implantation or bifurcation, but gradually enlarge toward the basal and lateral margins, and these are crossed by fine concentric striæ. Shell distinctly punctate under an ordinary magnifier.

Ventral valve most convex, the greatest convexity a little above the middle and in the umbonal region, a little concave toward the front, which shows an undefined sinus; beak small, pointed, extending a little beyond the beak of the dorsal valve and slightly incurved over its apex.

Dorsal valve slightly less convex than the ventral, greater convexity about the middle; undefined mesial fold in front; beak slightly incurved into the other valve. Some of the shell is exfoliated from the umbonal region of our specimen, and exposes a small sinus from the beak over the umbo. Interior unknown. This species is quite different from any hitherto described, and therefore no comparison is necessary.

Found in the Hamilton Group, at Bunker Hill, Indiana, and now in the collection of Professor S. S. Gorby.

## FAMILY PRODUCTIDÆ.

### PRODUCTUS BLAIRI, N. SP.

*Plate XIII, fig.* 16, *a cast showing the external markings of the dorsal valve, the shell being exfoliated; fig.* 17, *cast of the interior of the ventral valve, the shell being exfoliated.*

Shell medium size, wider than long, hinge line equaling the width of the shell and inflected or turned up at the cardinal extremities. Visceral portion of the shell nearly flat; margin abruptly deflected at the sides and in front. A broad undefined mesial sinus arises on the flat visceral region of the valve and continues over the deflected margin to the front. Surface marked by uneven, radiating costæ, over the visceral portion, which become, in their extension toward the front and lateral margins, more uneven and much coarser; the increase is by implantation. The surface of both valves is also marked with rather obscure, somewhat irregular, concentric wrinkles, and, as shown in the cast, covered with more or less numerous elongated nodes that I suppose represent the bases of appressed spines. And a small fragment of what I suppose to be the shell of the same species bears short, appressed, tubular spines. These were born upon both valves. The illustration of the cast of the interior of the ventral valve does not show them as distinctly as the cast of the exterior of the dorsal valve, but the fragment above referred to is from the exterior of a ventral valve, and it shows them quite as large and abundant as they are upon the opposite valve.

This shell will be readily distinguished from others by its large, flattened, visceral region, short deflected lateral and front margins, coarse striæ and appressed spines. None have been described from rocks of the same age having any close resemblance to it.

Found by R. A. Blair, in considerable abundance, in the Chouteau limestone, at Sedalia, Missouri, and now in my collection. The specific name is in honor of the collector.

## ORDER LYROPOMATA.

### FAMILY DISCINIDÆ.

#### Discina sampsoni, n. sp.

*Plate XIII, fig.* 10, *cast of a large dorsal valve; fig.* 11 *smaller dorsal valve with shell only slightly exfoliated; fig.* 12, *cast of the ventral valve, showing concentric lines and longitudinal slit. It should be reversed on the plate so as to have the slit above.*

Shell about medium size; oval; antero-posterior diameter greater than the transverse. Upper or dorsal valve quite convex; apex situate at the posterior third of the shell, acute and directed backwark. Surface of the dorsal valve marked with obscure radiating and concentric lines, too indistinct to be shown in the illustration without giving an erroneous impression of their size. The cast represented by fig. 10 has a delicate sinus extending from near the beak nearly half way to the front of the shell and four pits just beyond the end of the sinus. The pits are shown in the illustration and the sinus may also be detected.

Under or ventral valve flat and marked with about sixteen strong concentric lines. Oval impression extending from the center about half way to the posterior margin.

Found by R. A. Blair and F. A. Sampson, in the Chouteau limestone, at Sedalia, Missouri, and now in Mr. Sampson's collection and in mine. The specific name is in honor of the collector.

## CLASS PTEROPODA.

### ORDER THECOSOMATA (?).

### FAMILY CONULARIIDÆ.

#### Conularia sampsoni, n. sp.

*Plate XIV, fig.* 11, *natural size; fig.* 12, *part of same magnified two diameters.*

Shell rather small, slender, elongate-pyramidal, with equal or subequal lateral surfaces. Lateral surfaces nearly flat, having a delicate mesial ridge where the shell is well preserved, but showing a lineal, mesial furrow where the shell is exfoliated. Each of the four angles sharply and deeply furrowed. Surface marked with fine, crenate, transverse costæ that are separated by wider, rounded furrows. The costæ are straight and directed a little forward near the apex and terminate alternately at the mesial ridge; but farther forward they curve and finally make a more or less marked sigmoid flexure before terminating at the mesial ridge. Furrows between the costæ smooth. The crenulations on the costæ are extremely fine, and only visible with the aid of a good magnifier where the shell is well preserved.

Found by F. A. Sampson, in the Chouteau limestone, at Sedalia, Missouri, and now in his collection. The specific name is in honor of the collector.

## CLASS GASTROPODA.

## ORDER BRANCHIFERA.

## FAMILY CALYPTRÆIDÆ.

### PLATYCERAS PETTISENSE, N. SP.

*Plate XIV, fig.* 1, *lateral view of an internal cast.*

Shell rather large, pyramidal, most rapidly expanding toward the aperture, laterally compressed, apex pointed and slightly curved. The anterior half of the shell bears five unequal, wide longitudinal furrows, that increase in size toward the aperture and are separated by narrower, rounded longitudinal ridges. The furrows are rounded and deep, leaving the diameter of the aperture, from furrow to furrow, less than half the diameter from ridge to ridge. The diameter of the aperture, from the anterior to the posterior side, is one-half greater than the lateral diameter. Peristome deeply sinuous. The species is founded on internal casts, but some of them preserve the markings of concentric undulating striæ, which became subimbricating toward the aperture.

This species is more like *P. quincyense* than any heretofore described; but in that species the shell is straight, obliquely conical, narrowing regularly from the aperture, the ridges regularly disposed and each flattened or slightly concave along its middle, aperture subcircular with a tendency to a pentahedral outline; characters quite different from those posessed by this species.

Found by R. A. Blair, in the chert, in the Burlington Group, at Sedalia, Mo., and now in my collection.

### Platyceras missouriense, n. sp.

*Plate XIV, fig. 2, lateral view of an internal cast.*

Shell medium or above medium size, erect, conical, most rapidly expanding toward the aperture after the commencement of the longitudinal furrows; apex pointed. Ten longitudinal furrows arise about or nearly midway in the length of the shell and increase in size to the aperture; they are separated by ten broadly rounded longitudinal ridges. The furrows are narrowly rounded, in contrast with the broadly rounded ridges. Five of the furrows are larger than the other five, and they divide the ridges into five subequal pairs. The species is founded upon an internal cast, but the shell was doubtless ornamented with concentric undulating striæ.

This species is so different from all others, from rocks of the same age, that comparisons are unnecessary.

Found by R. A. Blair, in the chert, in the Burlington Group, at Sedalia, Mo., and now in my collection.

### Platyceras boonvillense, n. sp.

*Plate XIV, fig. 15, posterior view showing aperture and apex; fig. 16, lateral view.*

Shell small, conical, almost regularly arched on the dorsal and ventral sides and acutely pointed at the apex. Lateral diameter greater than the dorso-ventral diameter. Aperture subcircular, very oblique. Surface of the shell bears obscure lines of growth arching from an obscure and undefined sinus on the back of the shell toward the aperture. This species is distinguished from all others by its small size, general form and nearly perpendicular, subcircular aperture.

Found by R. A. Blair in the Keokuk group, at Boonville, Missouri, and now in my collection.

### Platyceras nasutum, n. sp.

*Plate XIV, fig. 17, lateral view; fig. 18, anterior view.*

Shell below medium size: highly arched in the middle part with a strong backward obliquity and a slender apex which makes about one volution over and near to the posterior side of the aperture. The shell rapidly expands below the apical volution, especially on the anterior side. Antero-posterior diameter more than twice as great as the lateral diameter. Lateral slopes expanding very little. Posterior side only slightly concave. Anterior side more than twice as long as the posterior. An undefined depression arises on each side of the anterior slope and gradually expands to the aperture, leaving the central part of the anterior slope narrowly rounded or subangular. Aperture subovate, greatest breadth at the posterior third, and antero-posterior diameter twice as great as the extreme lateral diameter. Anterior lip more or less sinuous. Surface marked by distinct lines of growth that curve backward in crossing the anterior slope, making a sigmoid flexure on each side of it. A lateral view of a specimen may be said to have a fanciful resemblance to a Roman nose, which suggested the specific name.

Found by R. A. Blair and F. A. Sampson in the Chouteau limestone, at Sedalia, Missouri, and now in Mr. Sampson's collection and in mine.

## FAMILY PLEUROTOMARIIDÆ.

### PLEUROTOMARIA HARII, N. SP.

*Plate XIV, fig. 3, front view, showing aperture and height of shell; fig. 4, summit view, showing surface furrows.*

Shell above medium size, depressed, length less than half the breadth. General form much like an *Holopea*. Volutions five, rounded on the top and side, but subangular at the periphery and flattened below; the first two very small and the last one constituting three-fourths of the shell. Suture deep, canaliculate. Aperture large, subovate. Umbilicus closed. Surface ornamented with nine or ten wide revolving furrows on the upper side of the whorls or above the fissure in the outer lip, and about twice as many smaller furrows on the under side or below the fissure in the outer lip. The furrows are rounded and the ridges that separate them narrow and angular. Very fine thread-like lines, closely arranged, mark the volutions transversely.

Though a large number of species of *Pleurotomaria* have been described, I do not call to mind any one with which this species might be confounded, and hence no comparison is necessary.

Found by Sid. J. Hare in the Upper Coal Measures, at Kansas City, Missouri, and now in my collection. The specific name is in honor of the collector.

### PLEUROTOMARIA SEDALIENSIS, N. SP.

*Plate XIV, fig. 13, lateral view.*

Shell medium or below medium size, trochiform, height and breadth subequal; spire conical. Volutions five, rounded, the last one subangular on the periphery. Suture deep, canaliculate. Umbilicus closed. Surface ornamented with three wide, shallow, revolving furrows above the subangular periphery, separated by narrow, angular ridges, and crossed transversely, by small, distant, thread-like lines. Aperture not preserved. This species is generally found in the shape of casts in the hard limestone, but one specimen, in Mr. Sampson's collection, preserves part of the surface ornamentation.

Found by R. A. Blair and F. A. Sampson in the Chouteau limestone, at Sedalia, Missouri, and now in Mr. Sampson's collection and in mine.

## FAMILY SUBULITIDÆ.

### MACROCHILINA BLAIRI, N. SP.

*Plate XIV, fig. 5, front view.*

Shell above medium size, subglobose or somewhat elongate; height one-third more than the greatest breadth, rhombic-subovate. Spire conical, acutely pointed, and forming more than one-third the length of the shell. Volutions six, convex, smooth, increasing rather rapidly in size, the last one large, constituting more than half the length of the shell, but not very ventricose. Suture distinct, somewhat canaliculate. Aperture subovoid or somewhat rhombic, angular above and subangular below. Outer lip sharp and regularly curved. Inner lip thickened, but without any twisting or transverse wrinkles. The callosity of the inner lip smooth. Surface, so far as it can be ascertained, smooth.

Found by R. A. Blair, in the Chouteau limestone, at Sedalia, Missouri, and now in my collection. The specific name is in honor of the collector.

### SUBULITES BENEDICTI, N. SP.

*Plate XIV, fig. 6, posterior view.*

Shell below medium size, rather short, fusiform, slightly bent to one side or curved above the body volution, and consisting of five or six rather rapidly tapering, moderately convex whorls. The body volution forms nearly two-thirds the length of the shell. Sutures only slightly oblique. Aperture narrow, elongate and terminal. Surface of the shell in our specimen smooth, though it may be slightly eroded, or at least sufficient to destroy delicate lines.

Distinguished from *S. brevis*, which it most resembles, by the convex whorls and less oblique sutures, beside it tapers much more rapidly above the body volution, which would be even more apparent in a cast.

Found by A. C. Benedict, in the Niagara Group, in Franklin County, Indiana, and now in his collection. The specific name is in honor of the collector.

## FAMILY BELLEROPHONTIDÆ.

### BELLEROPHON GORBYI, N. SP.

*Plate XIV, fig. 7, front view; fig. 8, side view; fig. 9, dorsal view.*

Shell medium size, involute, longer than wide. Volutions expanding very moderately, rounded over the dorsum, and subangular on the sides. Umbilicus deep, sides converging with a slightly convex outline from the subangular sides. Mesial band or keel narrow, subangular.

Aperture wider than high, subelliptical or reniform. Lip moderately thickened at the inner whorl, but not spreading, thinner on each side of the sinus in the outer margin. Surface beautifully sculptured and ornamented by numerous strong waving lines that curve forward from the mesial band on the dorsum and backward over the subangular sides, without interruption, and down the converging sides to the umbilicus.

This is a beautiful species, and distinguished from all others, in rocks of the same age, by the reniform aperture, subangular sides and surface ornamentation.

Found by Prof. S. S. Gorby, in the Hudson River Group, in Dearborn County, Indiana, and now in his collection. The specific name is in honor of the collector.

## FAMILY TURRITELLIDÆ.

### Aclisina bellilineata, n. sp.

*Plate XIV, fig.* 10, *front view.*

Shell long, slender, elongate-conical, very slowly enlarging from an acute apex. Volutions about fourteen, last one not larger in proportion to the gradual increase in size of the shell than the others. Suture distinctly defined or canaliculate, and the volutions convex. Surface ornamented by small, prominent, thread-like revolving lines or costæ, separated by impressed spaces, from two to five times their breadth, the closer ones being on the under side of the volutions and the more distant ones on the outward sloping faces below the suture. A good magnifier discloses numerous minute, sigmoid lines of growth crossing the spaces between the revolving lines, or curving gently backward from the suture toward the middle of the whorl. Aperture nearly circular, but straightened on the inner lip below.

Found by F. A. Sampson, in the Chouteau limestone, at Sedalia, Missouri, and now in his collection.

## FAMILY PATELLIDÆ.

### Tryblidium indianense, n. sp.

*Plate XIV, fig.* 14, *apical or dorsal view.*

Shell patelliform, oval, narrowed anteriorly, widened posteriorly; greatest width behind the median, transverse axis of the shell. Apex within the anterior third of the shell, moderately elevated. Greatest convexity of the shell immediately behind the apex. Shell sloping very gradually toward the posterior part of the shell and more abruptly in front of the apex, until it approaches the margin, where it graduates into a wide, very gently convex marginal slope, which in front becomes nearly flat. Surface of the shell, though not well preserved in our specimen, evidently concentrically lined, but if other ornamentation existed, it is wholly obliterated.

The internal scars are unknown, but from external appearance of the shell, there is no reasonable doubt about the generic reference.

Found by A. C. Benedict, in the Hudson River Group, in Fayette County, Indiana, and now in his collection.

## FAMILY PLATYSTOMIDÆ.

### PLATYSTOMA BROADHEADI, N. SP.

*Plate XIV, fig. 19, front view; fig. 20, summit and lateral view of a large specimen.*

Shell small, varying much in size, transverse, more than twice as wide as high, consisting of two and one-half volutions, the last one very rapidly expanding. Apex depressed nearly on a plane with the top of the last volution, very small and closely inrolled. Aperture entire and transversely elliptical. Lip thin; surface marked with wavy lines of growth.

From an examination of the aperture of several specimens, I am convinced this species never attached to other objects, at the mouth, like *Platyceras*, and, therefore, it can not be referred to that genus. As able an author and scientist as Lindstrom, of Sweden, classes *Platystoma* as a synonym of *Platyceras*, but as their habits of life were entirely different, I prefer to retain both generic names; and if *Platyceras* is to be classed with the living limpets, in the family *Calyptrœidæ*, I prefer a separate family for *Platystoma*. Of course the shells, above the mouth, very much resemble each other, except there are usually more whorls in *Platystoma* than there are in *Platyceras*.

Found by R. A. Blair and F. A. Sampson, in the Chouteau limestone, at Sedalia, Mo., and now in Mr. Sampson's collection and in mine. The specific name is in honor of Prof. G. C. Broadhead, late State Geologist of Missouri.

## FAMILY EUOMPHALIDÆ.

### STRAPAROLLUS BLAIRI, N. SP.

*Plate XV, fig. 3, part of the last whorl, showing some of the surface markings.*

Shell very large, discoid, apex nearly on the level with the plane of the body whorl. Volutions two or a little more than two, subcircular, regularly rounded, except a slight flattening on the upper side, very gradually tapering from the apex, barely contiguous, the adjacent sides not being perceptibly flattened. Lower side broadly umbilicate or concave and perforated, the concavity equaling the diminishing size of the volutions. Aperture slightly expanded, subcircular, a little transverse, outer margin slightly advanced beyond the inner margin; curved a little upward from the plane of the last volution.

Surface marked by crowded concentric striæ, directed forward from the inner side of the volution.

Found by R. A. Blair in the Chouteau limestone, at Sedalia, Missouri, and now in my collection. The specific name is in honor of the collector.

## CLASS CEPHALOPODA.

## FAMILY ORTHOCERATIDÆ.

### ORTHOCERAS HARII, N. SP.

*Plate XVI, fig. 2, specimen compressed in the central part, making it appear somewhat fusiform.*

Shell small, elongate, tapering very gradually from the body chamber to the apex. Body chamber rather long and cylindrical. Septa only slightly arched and distant from each other toward the apex from one-third to one-fourth the diameter, but near the body chamber one-sixth to one-seventh the diameter; in other words, the chambers increase more in diameter than in length with the growth of the shell. Siphuncle rather large and slightly constricted in passing through the septa. Surface smooth.

Found by Sid. J. Hare, in the Upper Coal Measures, near Kansas City, Missouri, and now in my collection. The specific name is in honor of the collector.

## FAMILY CYRTOCERATIDÆ.

### CYRTOCERAS NASHVILLENSE, N. SP.

*Plate XVI, fig. 1, side view.*

Shell rather large, very gradually curving from the body chamber; greater diameter from the dorsal to the ventral side. Septa highly arched and distant about one-fourth the transverse diameter of the shell. Body chamber and siphuncle unknown.

Found near Nashville, Tennessee, in the Niagara Group, and now in the collection of Prof. S. S. Gorby.

### CYRTOCERAS SAFFORDI, N. SP.

*Plate XVII, fig. 2, side view; fig. 3, showing siphuncle.*

Shell large, rapidly tapering, strongly curved. Septa moderately arched, chambers thin. Surface showing longitudinal lines on the inner half. About ten chambers on the dorsal side and about twenty on the ventral side equal the diameter. Transverse section circular.

Siphuncle small, expanding in the chambers, and placed close to the outer margin. Though our specimen is only a fragment, the species may be readily distinguished by the rapidly tapering and strongly curved shell and small siphuncle at the extreme outer margin.

Found by Professor S. S. Gorby, in the Nashville, or Hudson River Group, at Nashville, Tennessee, and now in his collection.

### CYRTOCERAS INDIANENSE, N. SP.

*Plate XVIII, fig. 1, specimen from St. Paul; fig. 2, specimen from Hartsville.*

Shell large, curved near the apex. Transverse section subelliptical, the greater diameter being from the dorsal to the ventral side. Septa highly arched, and distant about one-third the transverse diameter at the place of measurement. Siphuncle subcentral, more than one-third the diameter of the shell, subcylindrical or very slightly expanding in the chambers and sharply contracted at its passage through the septa, appearing as if it was transversely cut by the septa. Where the outer shell is preserved neither the chambers or septa can be seen. Surface covered by very fine transverse lines that arch toward the apex on the outer side of the shell. There are about thirty-five or forty transverse lines in an inch. Body chamber unknown.

Collected in the Niagara Group, at St. Paul and at Hartsville, Indiana, and now in the State Museum, at Indianapolis. The larger specimen, from St. Paul, I prefer to consider the type of the species, as, possibly, the smaller one may be distinct from it. The only difference shown in our specimens is the proportionally larger siphuncle in the St. Paul specimen. The siphuncle in the Hartsville specimen is only about one-fourth the transverse diameter of the shell, and possibly better preserved specimens might show other differences that would distinguish it.

## FAMILY GOMPHOCERATIDÆ.

### GOMPHOCERAS CLARKI, N. SP.

*Plate XIX, fig. 1, showing siphuncle and curving septa.*

Shell exceedingly large and rapidly tapering from the body chamber. Transverse section subelliptical. Septa deeply concave and curve toward the apex twice, or make a sigmoid flexure, giving the chambers a waving outline. The distance between the two arching curves is about one-third the circumference of the shell, on one side and opposite thereto the curving toward the body chamber is correspondingly increased. The distance between septa is about two-fifths of an inch. Siphuncle excentric, moniliform and about an inch in diameter. The species is founded on a single specimen, preserving three chambers and part of eleven more. Body chamber and aperture unknown.

Found by Dr. J. C. Clark, in whose honor the specific name is proposed, in the St. Louis Group, at Corydon, Indiana, and presented by him to the State Museum, at Indianapolis.

## FAMILY PHRAGMOCERATIDÆ.

### PHRAGMOCERAS MISSOURIENSE, N. SP.

*Plate XV, fig. 2, lateral view.*

Shell rather below medium size, broadly rounded on the outer side, arched, laterally compressed, the contraction of the chamber approaching the slit being strongly marked. Body chamber short. Septa concave, chambers more than three times as long on the outer side as they are on the inner side.

The lip projects from the inner side so that the dorso-ventral diameter is twice as great as the lateral diameter. The specimen illustrated is on a slab and does not show the projecting lip nor full curvature of the shell. Other characters unknown.

Found by R. A. Blair, in the Chouteau limestone, in Pettis County, Missouri, and now in my collection.

## FAMILY NAUTILIDÆ.

### SOLENOCHILUS ROCKFORDENSE, N. SP.

*Plate XVI, fig. 3, side view. Plate XVII, fig. 1, dorsal view, showing siphuncle. Both illustrations rather smaller than the specimen.*

Shell very large, globose, expanding. Volutions two, moderately embracing, increasing rapidly in size, and a little wider from the dorsal to the ventral side than transversely. Umbilicus deep, apparently perforated and having almost perpendicular walls to the second volution. Septa very concave and distant, about one-fifth the transverse diameter of the volutions at the place of measurement. Siphuncle medium size and seemingly in contact with the outer shell. The body chamber is not preserved in our specimen but the cast shows that it had a length of about one-fourth of a volution and it was, probably, greatly expanded.

Collected in the Waverly or Knobstone Group, at Rockford, Indiana, and now in the State Museum, at Indianapolis.

## FAMILY GONIATITIDÆ.

### GONIATITES INDIANENSIS, N. SP.

*Plate XIX, fig. 2, side view; fig. 3, dorsal view of broken specimen.*

Shell small; each outer volution embraces the inner ones. Umbilicus does not expose any of the inner volutions. Four furrows or constrictions radiate from the umbilicus and cross the dorsal side dividing the shell into four subequal parts. Dorsal side round. Body chamber, sutures and surface markings unknown.

The species is founded upon two sandstone casts from the Knobstone or Waverly Group, of Clark County, Indiana, now in the State Museum at Indianapolis. The smaller specimen is only half the diameter of the one illustrated.

### GONIATITES BROWNENSIS, N. SP.

*Plate XVIII, fig. 3, side view; fig. 4, dorsal view, showing part of a septum.*

Shell medium size, globose, broadly rounded on the dorsal side. Outer volutions not entirely covering the inner ones. Umbilicus moderately large, showing less than one-fourth the vertical diameter of each inner volution. Dorso-lateral lobe acutely pointed. Dorsal lobe angular, but the entire shape not determined. The sinuosities of the septa are quite complex, there being three conical points, at the ventral side, corresponding with the dorsal and dorso-lateral angles of the lobes. Outer chamber and siphuncle unknown.

Our specimen is silicified. It was collected in the Waverly or Knobstone Group, in Brown County, Indiana, and now belongs to the State Museum, at Indianapolis.

### GONIATITES GORBYI, N. SP.

*Plate XV, fig. 1, lateral view, showing part of the body chamber.*

Shell very large, lenticular, volutions all embraced within the outer one, so the number can not be determined. Sides depressed, convex. Periphery angular. Umbilicus closed. Body chamber having the length of about one-fourth of a volution. The sinuosities of the septa are very numerous, there being ten or twelve lobes and as many saddles on each side. They are generally linguiform, though one series is trifid and another bifid, and, as the body chamber is approached, two are bifid and one trifid. The linguiform lobes and saddles have some resemblance, in shape, to those of *Goniatites lyoni*.

Collected by R. A. Blair, in the lower part of the Choteau limestone or Waverly Group, at Pin Hook Bridge, in Pettis County, Missouri, and now in the collection of the author. The specific name is in honor of Prof. S. S. Gorby, State Geologist.

# CLASS LAMELLIBRANCHIATA.

## ORDER ASIPHONIDA.

## FAMILY SCHIZODIDÆ.

### SCHIZODUS HARII, N. SP.

*Plate XX, fig.* 1, *interior of left valve; fig.* 2, *left valve; fig.* 3, *cardinal view.*

Shell rather large but quite variable in size; transversely subelliptical or subtrapezoidal in outline; widest in front; convex in the middle and cuneate below and toward the anterior and posterior ends; anterior end regularly rounded; basal margin curving slightly and terminating rather abruptly at the posterior extremity; dorsal line regularly curving from the beaks to the posterior extremity. Umbonal region regularly rounded toward the beaks. Beaks moderately prominent, rising above the cardinal line, obtusely pointed, and located a little forward of the middle of the shell. Posterior umbonal slopes broadly rounded from the beaks obliquely to the posterior basal extremity.

Pallial line indistinct and some distance from the margin. An undefined ridge extends from beneath the beaks more than half way to the posterior basal extremity. Two teeth in the left valve, the anterior one just forward of the beak and directing its cutting edge forward and obliquely downward; the posterior one rising below the beak and directed backward with its cutting edge downward. An elongated socket occurs above and behind the posterior tooth. Surface nearly smooth, showing lines of growth only near the hinge line at the anterior and posterior extremities.

This genus has been referred to the families *Trigoniidæ* and *Lucinidæ* that belong to different orders. I can not see that it has any near relationship with either *Trigonia* or *Lucina*. It has also been referred to the family *Cytherodontidæ*, but it is as far from *Cytherodon* as it is from the other genera. The Carboniferous shells have not been very satisfactorily classed in families and a general overhauling is necessary. I have used the name *Schizodidæ* only provisionally and for the purpose of calling attention to the subject, and not with the intention, at present, of establishing the family.

Found by Sid. J. Hare, in the Coal Measures, at Kansas City, Mo., and now in my collection. The specific name is in honor of the collector.

## FAMILY MODIOMORPHIDÆ.

### CYPRICARDELLA GORBYI, N. SP.

*Plate XX, fig. 6, right valve; fig. 7, cardinal view.*

Shell small, transversely subtrapezoidal in outline, height nearly equaling the length, most convex in the umbonal region, cuneate below and toward the anterior end. Anterior end nearly straight and directed but little forward half the width of the shell and then abruptly rounded into the basal margin; basal margin slightly rounded in the middle and toward the posterior end. Cardinal line horizontal from the beaks back three-fourths the length of the shell; posterior extremity obliquely truncated. Beaks at the extreme anterior end, very prominent, sharp, rising high above the hinge line and coming in contact. Umbonal slope distinctly angular and extending to the post-inferior extremity. Surface marked by numerous concentric, imbricating lines of growth. Interior unknown.

Found by R. A. Blair, in the Keokuk Group, at Boonville, Missouri, and now in my collection. The specific name is in honor of Prof. S. S. Gorby.

## FAMILY PECTENIDÆ.

### AVICULOPECTEN SCULPTILIS, N. SP.

*Plate XX, fig. 5, left valve.*

Shell medium size. Body subovate, axis slightly inclined to the hinge line. Height one-half more than the length. Hinge line shorter than the greatest width of the shell. Anterior margin broadly rounded below the ear; basal and posterior margins rounded. Beak anterior to the middle of the hinge, rounded, acute, and projecting beyond the cardinal line. Umbonal region moderately convex. Anterior ear small, subtriangular, lateral margin concave. Posterior ear three times as large as the anterior one, subtriangular, lateral margin concave; separated from the body of the shell by a well defined, deep, arcuate sulcus. Surface ornamented by very close, fine rays and close, concentric, imbricating striæ that form a beautiful network made rough by the concentric striæ crossing the rays. The radiating lines do not appear on the anterior ear, which is marked only by the fine, concentric lines. The rays and striæ are more prominent on the posterior ear than elsewhere on the shell and give it a strongly pitted aspect.

Found by Sid. J. Hare, in the upper Coal Measures, at Kansas City, Missouri, and now in my collection.

### PTERINOPECTEN SEDALIENSIS, N. SP.

*Plate XX, fig. 8, right valve with the posterior wing broken off; fig. 9, an entire specimen.*

Shell small. Valves subequal. Hinge line straight, equal to the greatest length of the shell and longer than the height of the shell. Anterior end slightly arcuate; basal margin uniformly rounded; posterior margin oblique. Beak obtuse, rounded, directed slightly forward. Anterior ear triangular, flattened and distinctly defined. Posterior ear triangular, twice as large as the anterior one and separated from the body by an undefined depression. Surface ornamented by distant rounded rays, with an occasional short one implanted near the margin, and obscure distant concentric striæ.

Found by R. A. Blair, in the Chouteau limestone, at Sedalia, Missouri, and now in my collection.

## ORDER SIPHONIDA.

## FAMILY GRAMMYSIIDÆ.

### GRAMMYSIA BLAIRI, N. SP.

*Plate XX, fig. 4, view of the two valves.*

Shell medium size, transversely subelliptical, length one-third greater than the height, umbonal region gibbous. Anterior end rounded from the lunule to the base; base forming a semielliptical curve; posterior end regularly rounded. Cardinal line almost horizontal, and extending about half the length of the shell. Beaks prominent and coming nearly in contact forward of the anterior third of the shell. Posterior umbonal slopes broadly rounded, not defined. Surface ornamented with wide concentric undulations or furrows that increase in size from the beak to the base and are separated by narrow ridges. Interior unknown.

Found by R. A. Blair, in the Chouteau limestone, at Sedalia, Missouri, and now in my collection. The specific name is in honor of the collector.

## FAMILY CONOCARDIIDÆ.

### CONOCARDIUM INDIANENSE, N. SP.

*Plate XX, fig.* 10, *view of the ventral or under side from point of alation to the posterior end.*

Shell medium size. Ventral view somewhat angularly subovate. Margins of the valves nearly straight, and incurved toward each other, uniting with denticulated edges anteriorly and gradually separating posteriorly and terminating in a wide, subovate hiatus. Surface marked by transverse, distant striæ, between which there are finer lines, all of which are crossed longitudinally by lines of irregular size. The longitudinal lines do not cross the transverse striæ on the incurved part of the margins. The species is founded on a single specimen, which is on a slab exposing only the ventral side.

Found in the Keokuk Group, at Crawfordsville, Indiana, and now in the State Museum, at Indianapolis.

### CONOCARDIUM PARVULUM, N. SP.

*Plate XX, fig.* 11, *side view, small piece broken from the posterior end. Magnified two diameters.*

Shell very small, subtrigonal. Height and length subequal. Hinge line straight, horizontal. Beaks acute, projecting beyond the cardinal line. Anterior umbonal rib sharply angular, and nearly at right angles to the cardinal line. Anterior end moderately arched and having an acutely pointed cardinal extremity. Valves uniting with denticulated edges anteriorly and gradually separating posteriorly, and terminating with a wide, subovate hiatus. Surface marked with moderately distinct transverse striæ and apparently no other ornamentation. Striæ finer on the anterior face of the valves than behind the umbonal ridge.

Found by Prof. S. S. Gorby, in the Hamilton Group, at Bunker Hill, Indiana, and now in his collection.

### CONOCARDIUM EXIGUUM, N. SP.

*Plate XX, figs.* 12 *and* 13, *side views of two different specimens. Magnified two diameters.*

Shell small, subtrigonal, length behind the alation one-fourth greater than the height. Hinge line straight, horizontal. Beaks obtuse. Anterior umbonal rib directed obliquely forward; sides convex behind the umbonal rib, followed by an undefined depression that terminates in an undefined sinus or slight curvature on the ventral side of the shell. Hiatus much elongated on the ventral side. Valves uniting with crenate edges.

Surface ornamented with rather coarse radiating costæ and concentric imbricating lines of growth. Costæ finer on the anterior end than behind the umbonal ridge.

Found by Professor S. S. Gorby, in the Hamilton Group, at Bunker Hill, Indiana, and now in his collection.

### CONOCARDIUM ELRODI, N. SP.

*Plate XX, fig.* 14, *view of the ventral or under side, with the alation in front. Magnified two diameters.*

Shell very small, subtrigonal; length behind the alation about equal to the height. Hinge line declining behind the beaks. Beaks obtuse. Cardinal extremity pointed in front. Anterior umbonal rib directed obliquely forward, and shell gently sloping behind. Hiatus much elongated on the ventral side, and, in our specimen, apparently closed at the end. No denticulations on the uniting edges of the valves. Alation in front of the umbonal slope nearly equaling in length the shell behind the beaks.

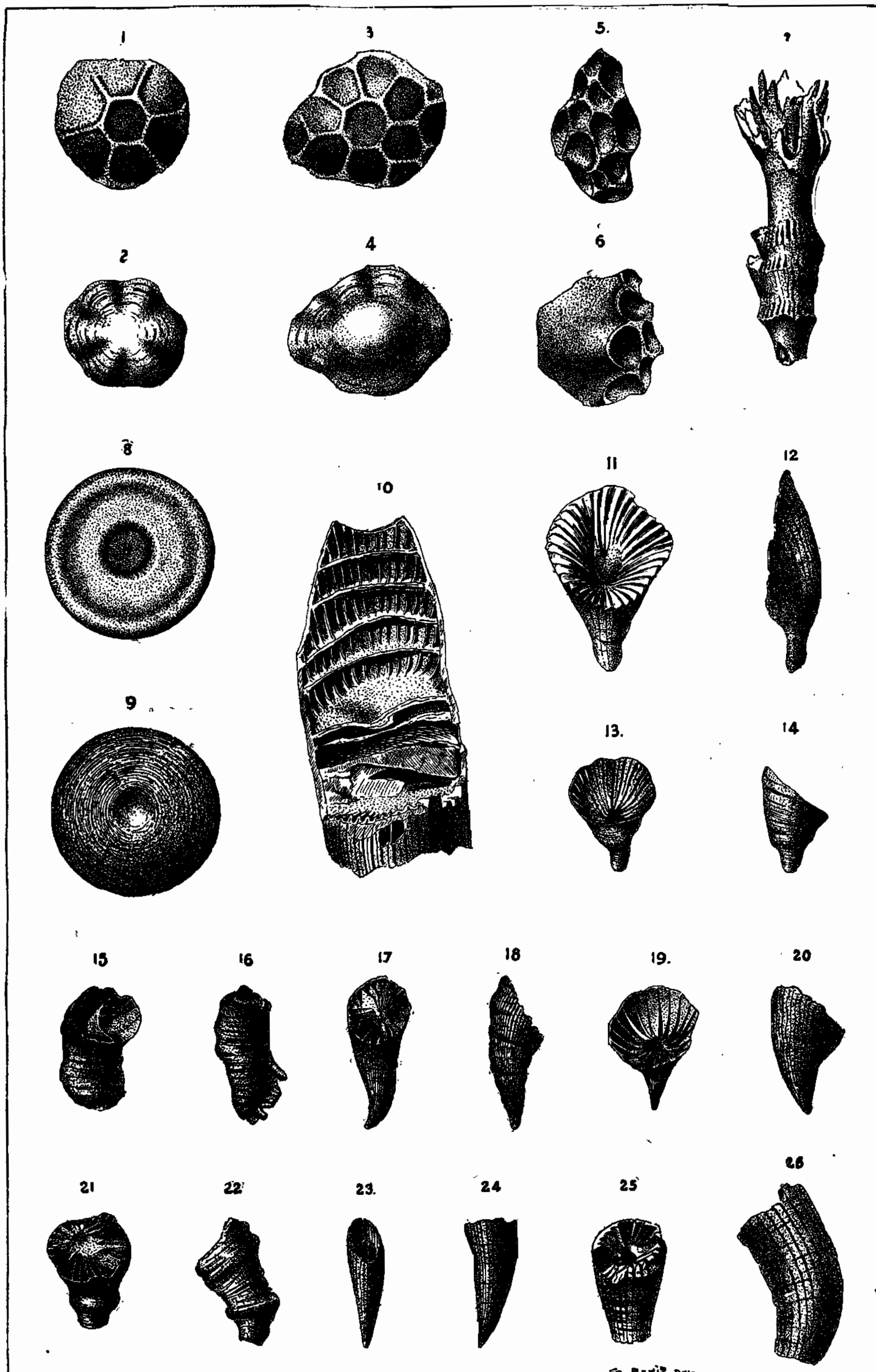
Surface ornamented with longitudinal striæ, crossed by fine transverse lines, that give it a highly ornamental, cancellated appearance.

Found by Dr. M. N. Elrod, in the Niagara Group, at Hartsville, Indiana, and now in his collection. The specific name is in honor of the collector.

# EXPLANATION OF PLATES.

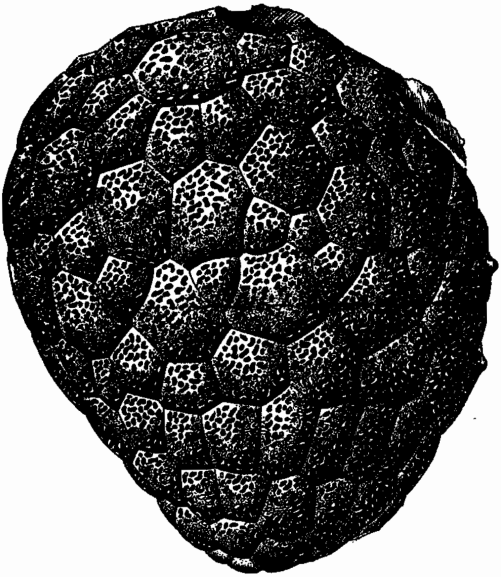
# INDEX TO PLATES.

## PLATE I.

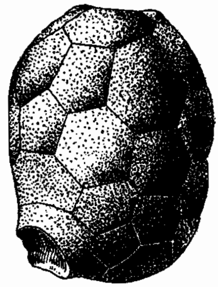

1
3
5.
7
2
4
6
8
10
11
12
9
13.
14
15
16
17
18
19.
20
21
22
23.
24
25
26
FR BAHR DEL.

## PLATE II.

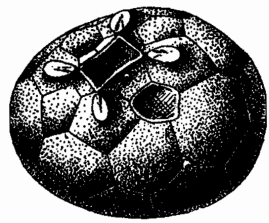
1.



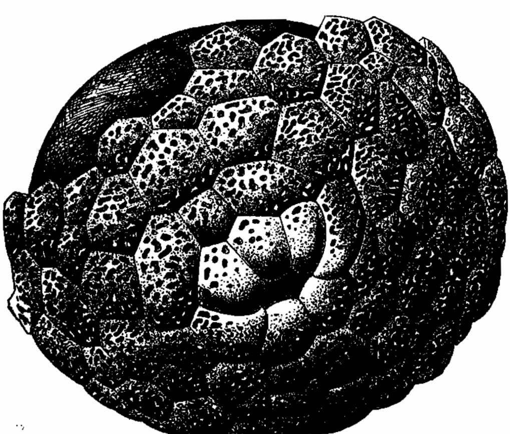
3.



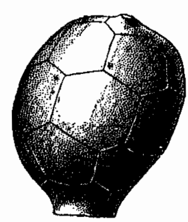
4.



2.



5.

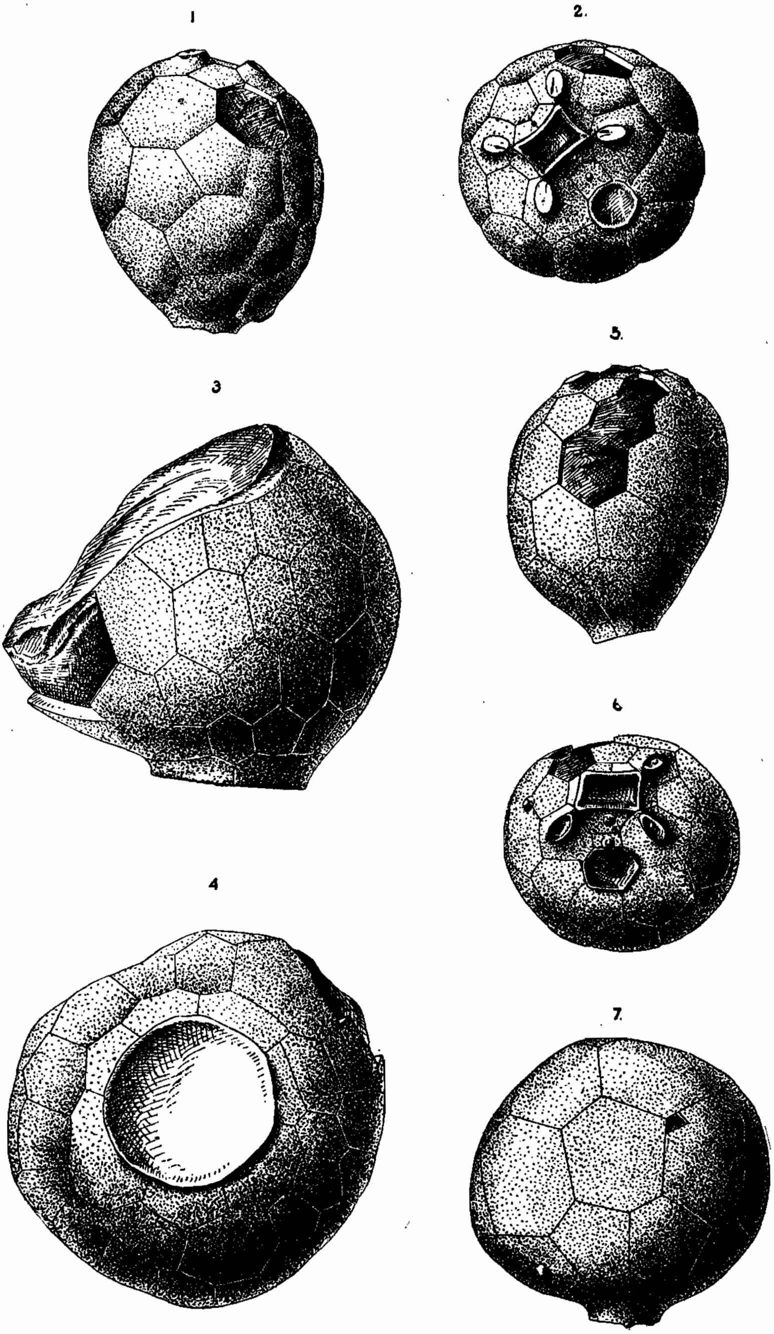


6.

KLINE ENG. CO.

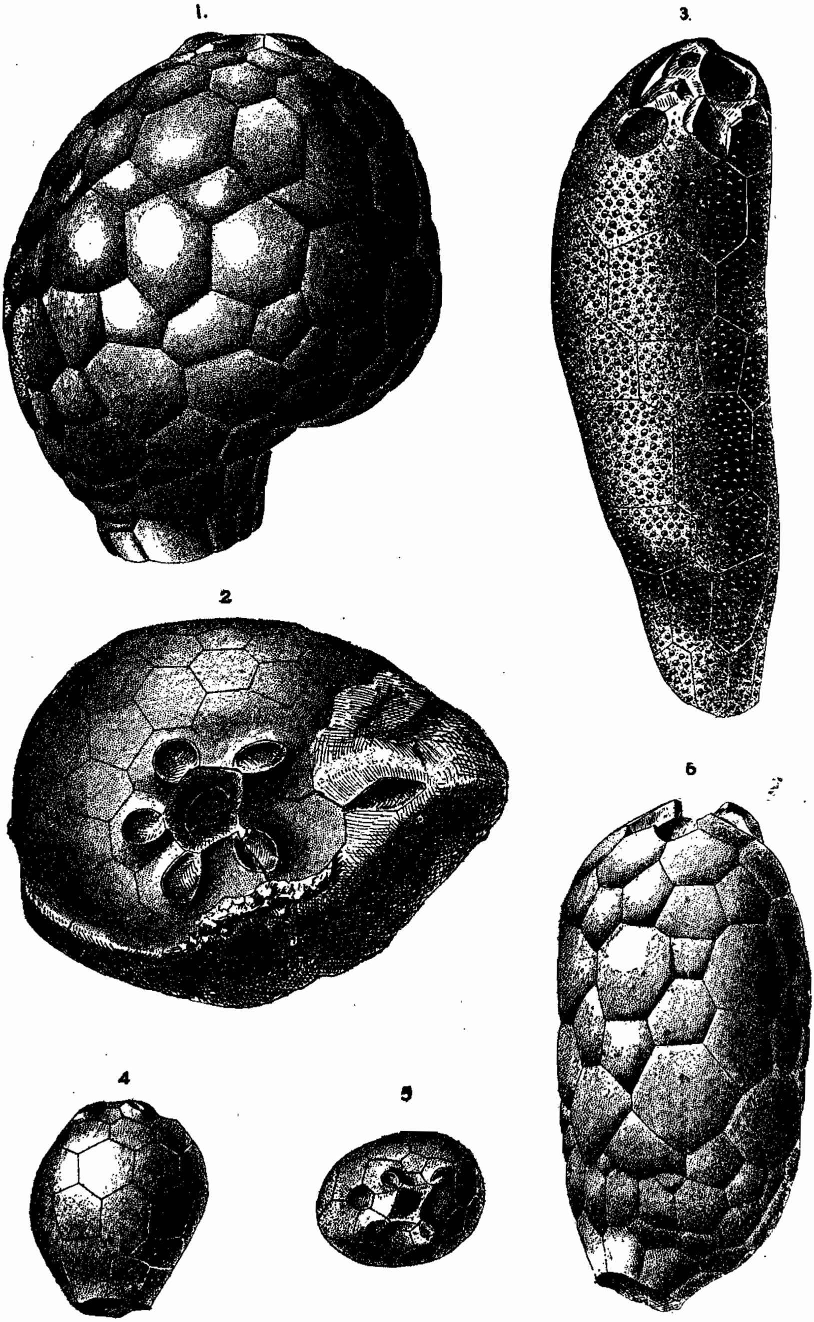
FR. BAHR del.

# PLATE III.

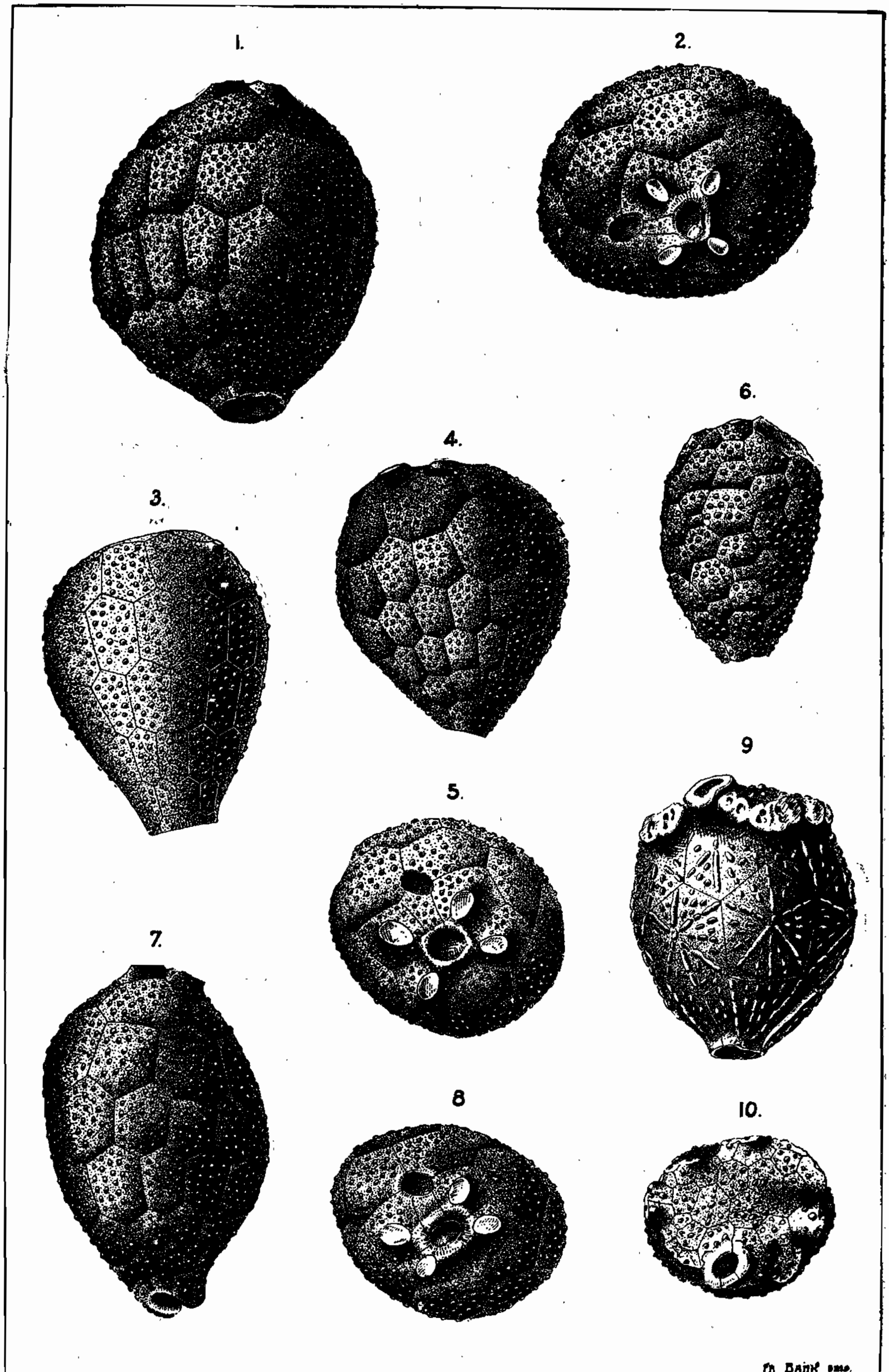



KLINE ENG. CO. FR. BAHR. DEL.

# PLATE IV.

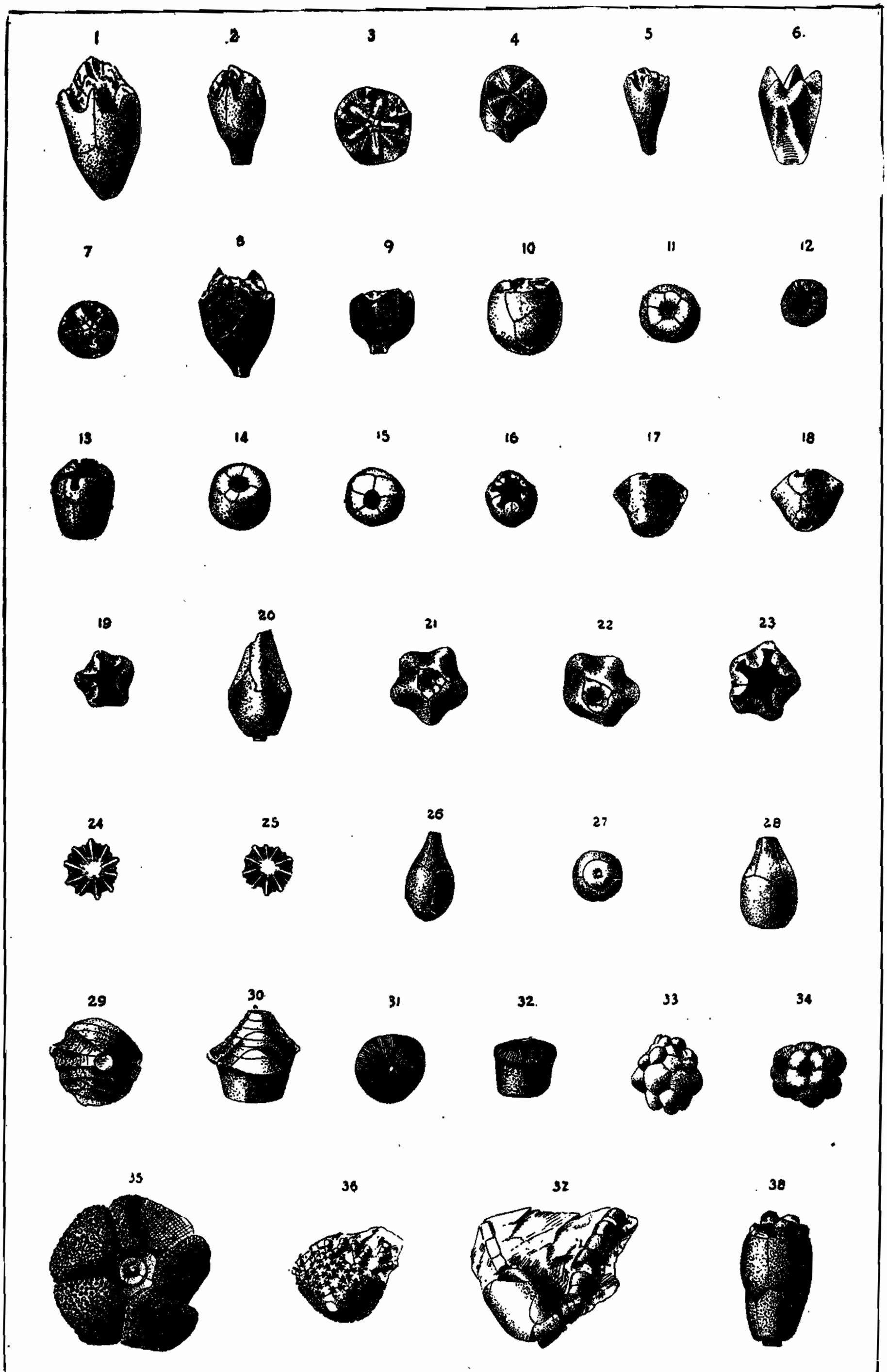

1.
3.
2
6
4
5

# PLATE V.



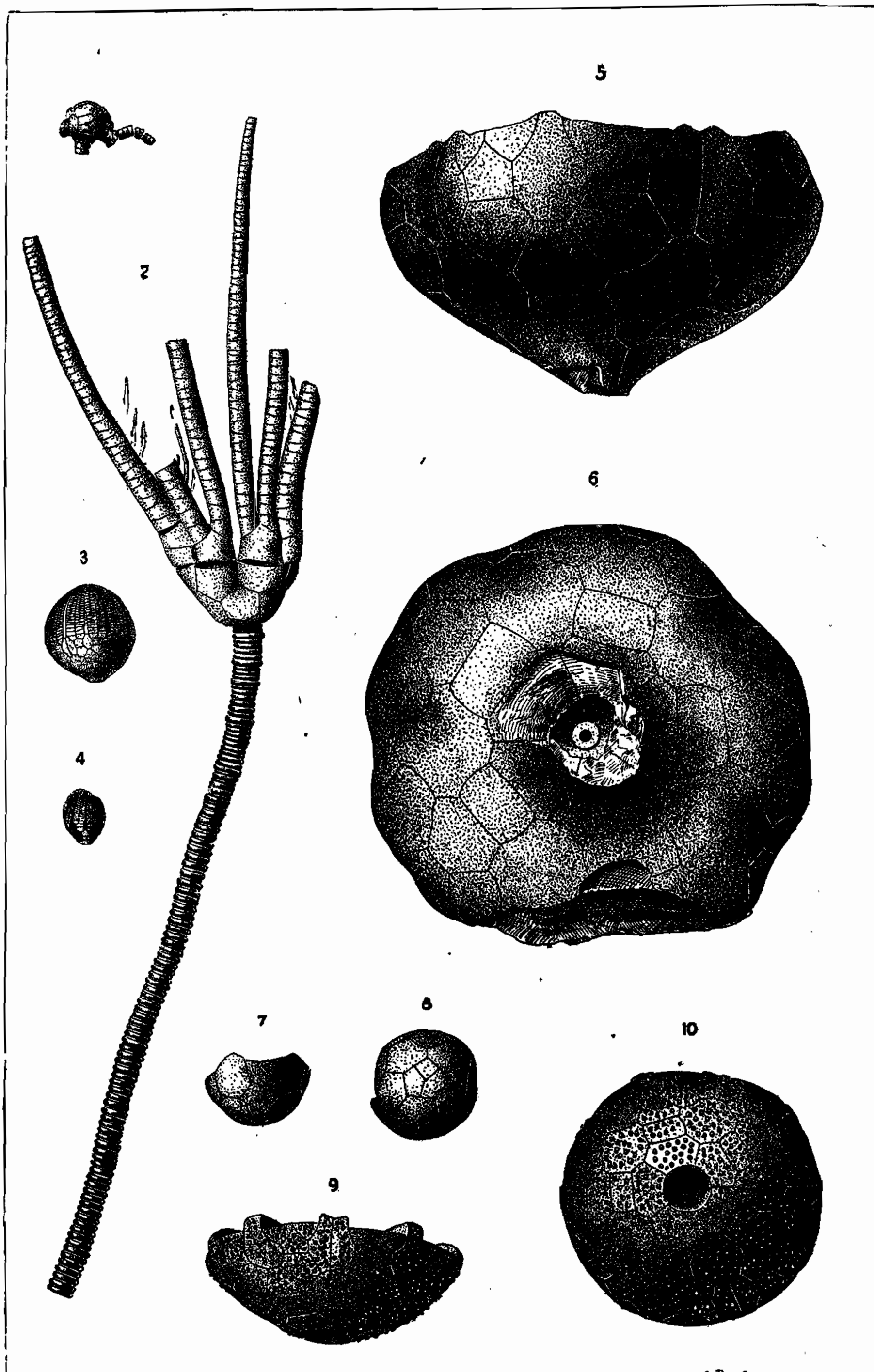
1.
2.
6.
4.
3.
9
5.
7.
8
10.
FR. BAHR

# PLATE VI.


1
2
3
4
5
6.
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32.
33
34
35
36
37
38

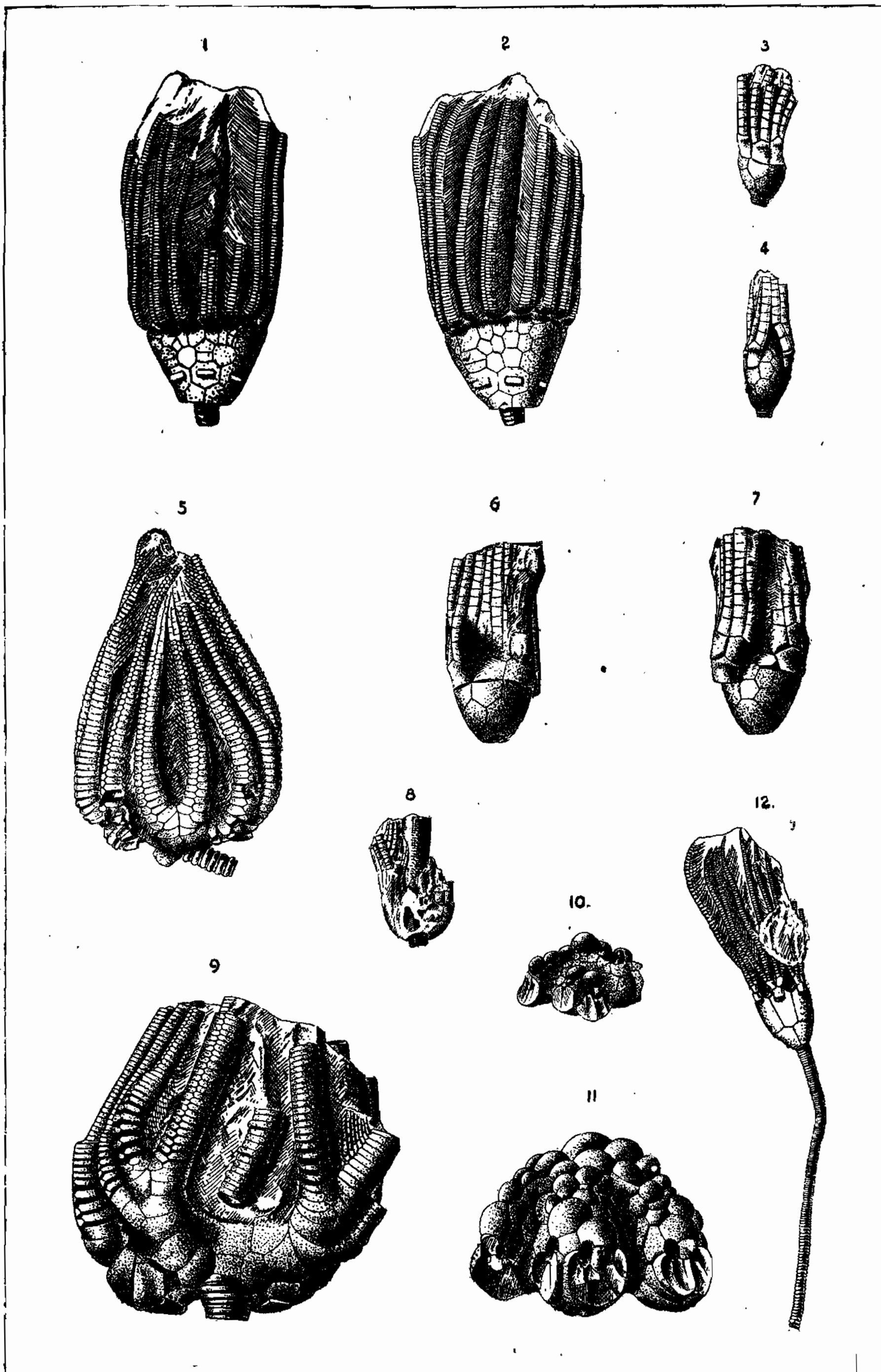
FR. BAHR, Del.

## PLATE VII.

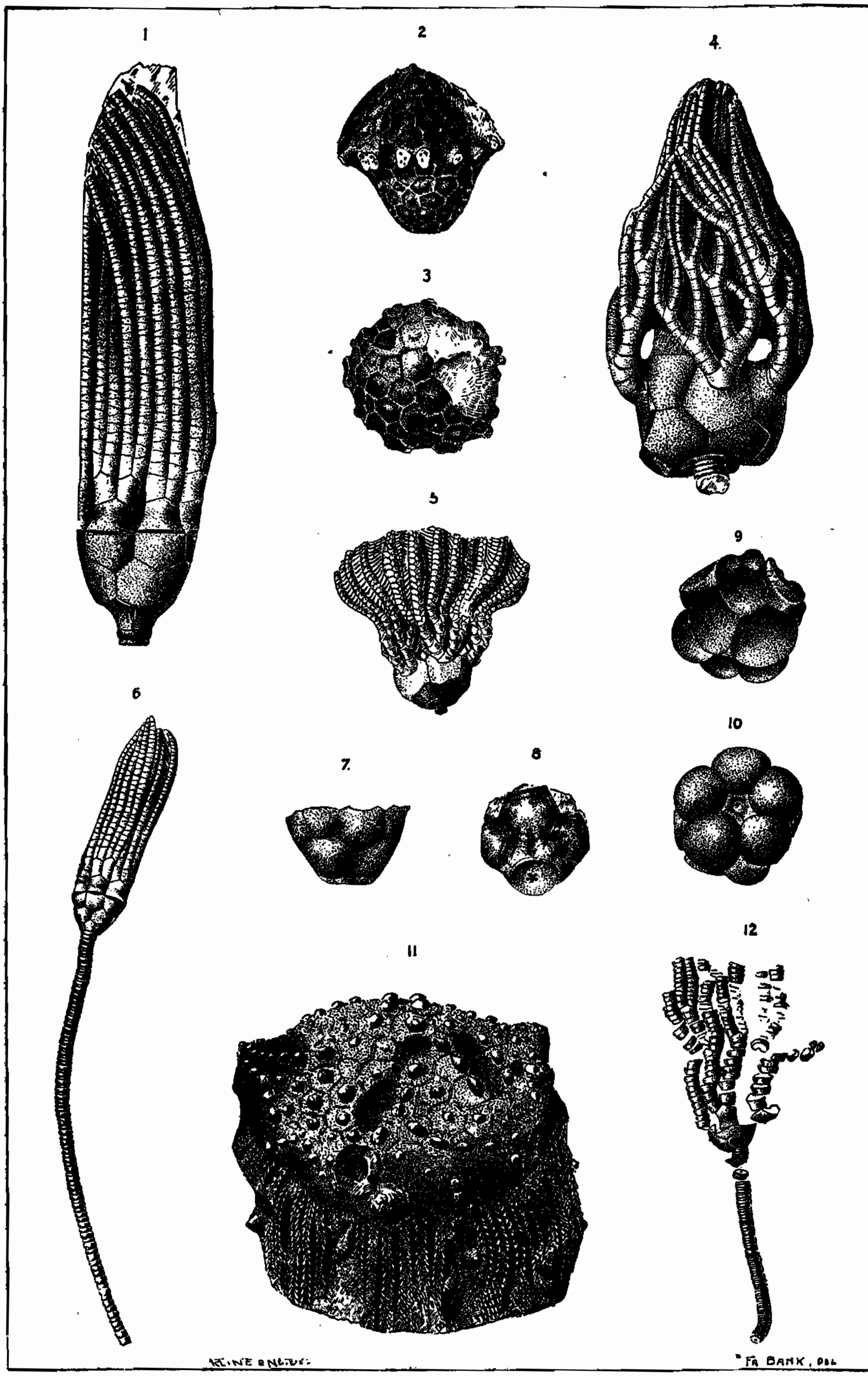


1
2
3
4
5
6
7
8
9
10
F. BAHR DEL.

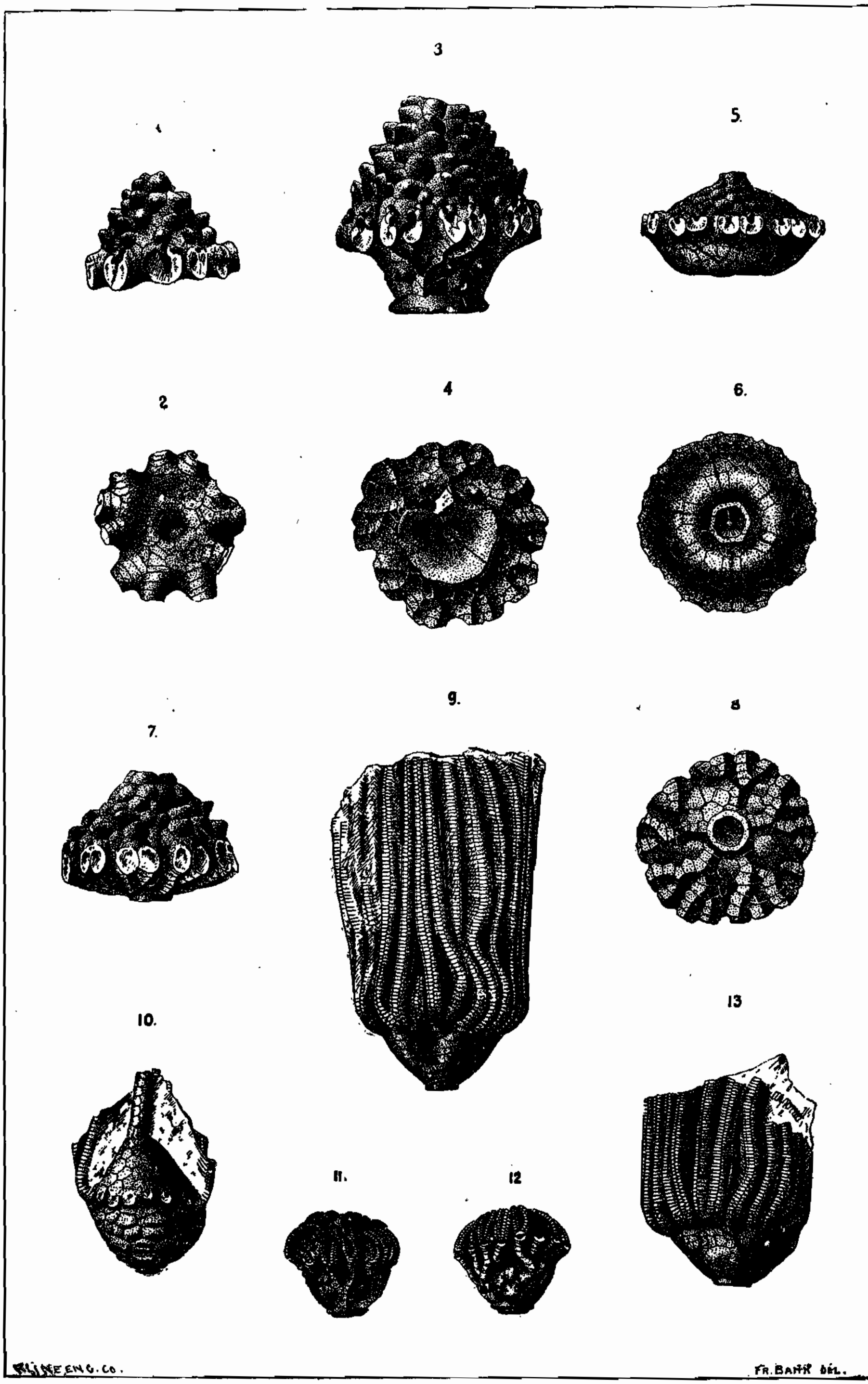
# PLATE VIII.


1
2
3
4
5
6
7
8
9
10.
11
12.

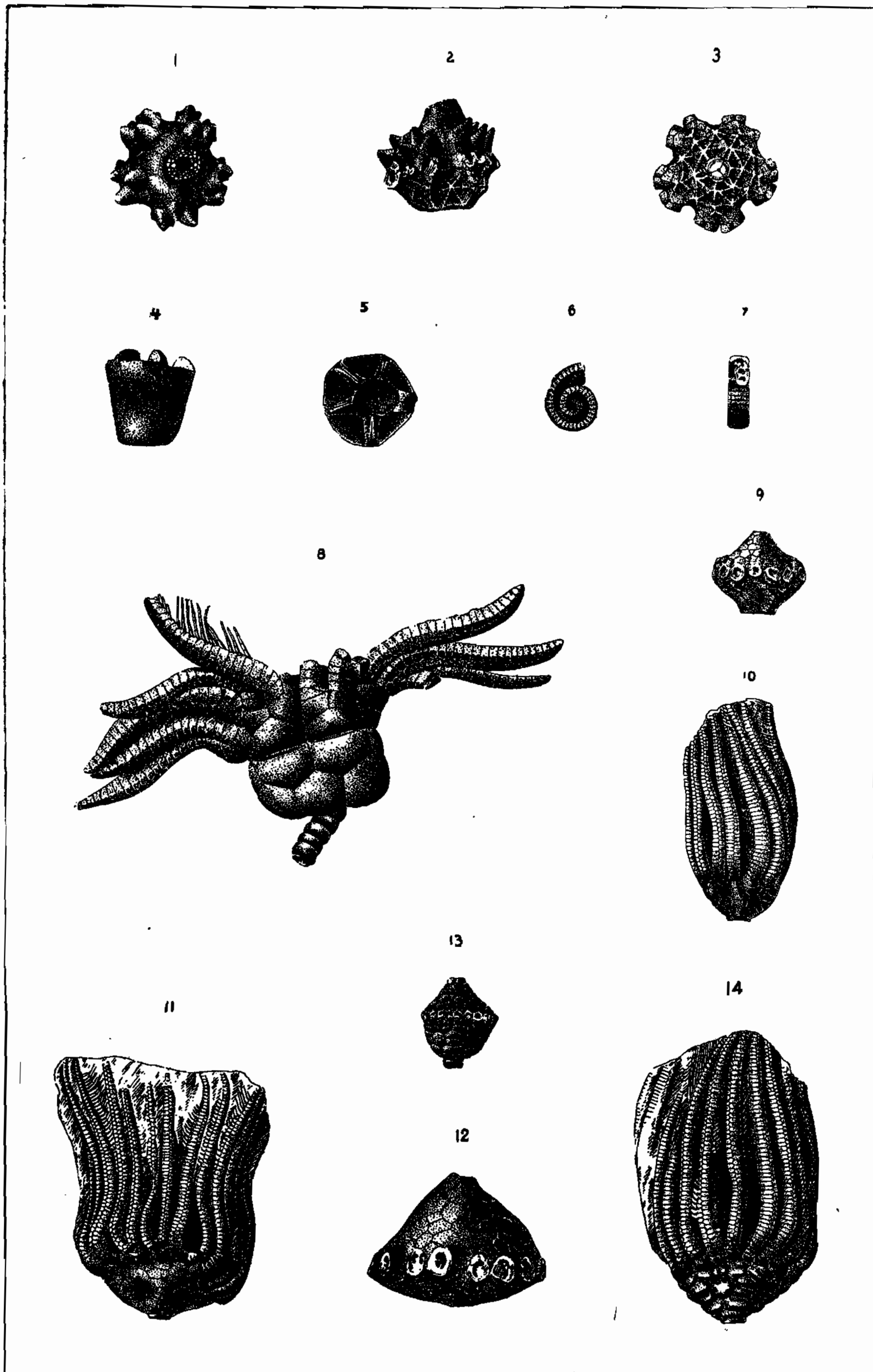
# PLATE IX.


1
2
3
4
5
6
7
8
9
10
11
12
FR BANK, DEL

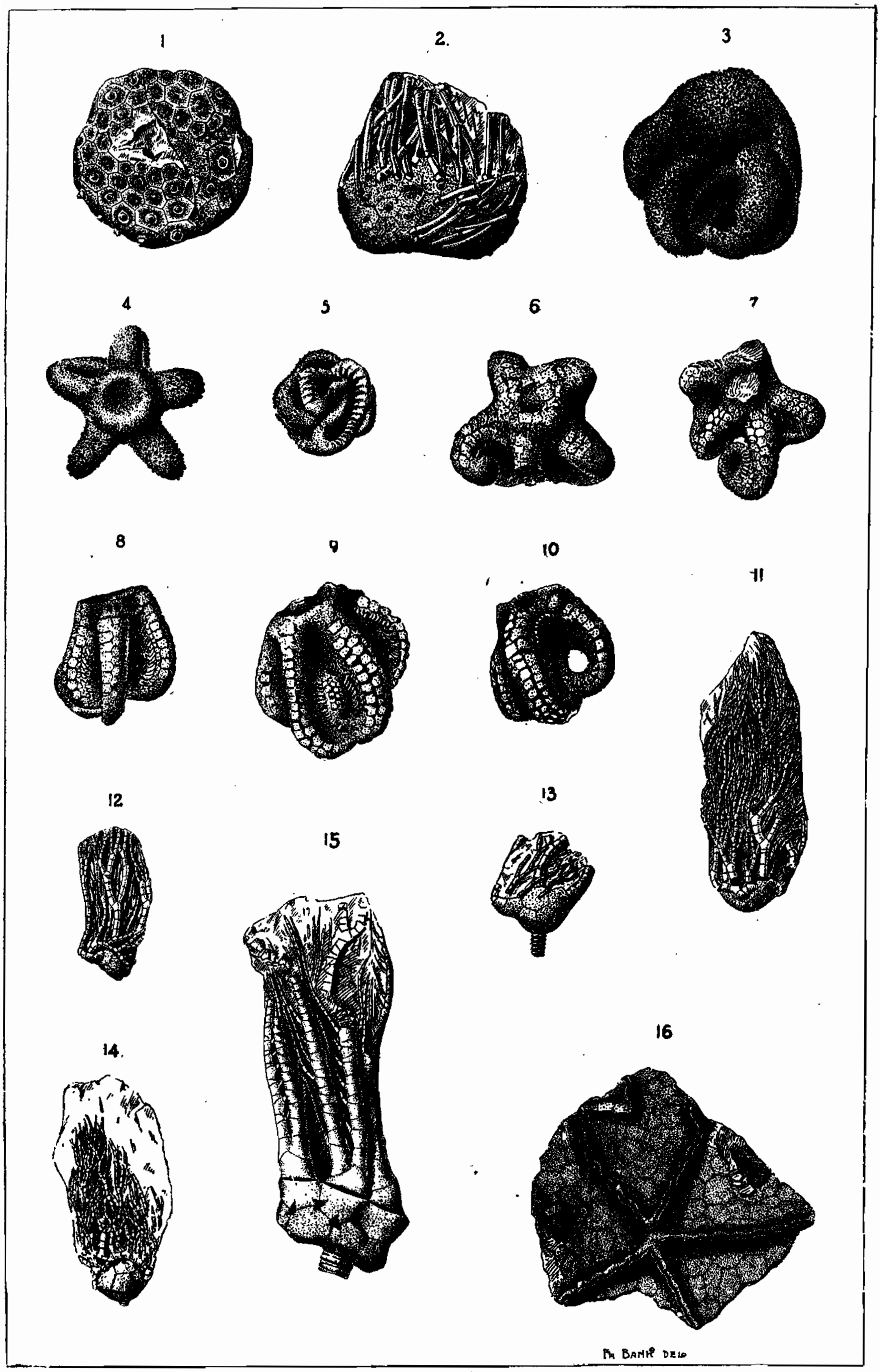
# PLATE X.


3
5.
2
4
6.
9.
7.
8
10.
13
11.
12
FR. BAHR DEL.

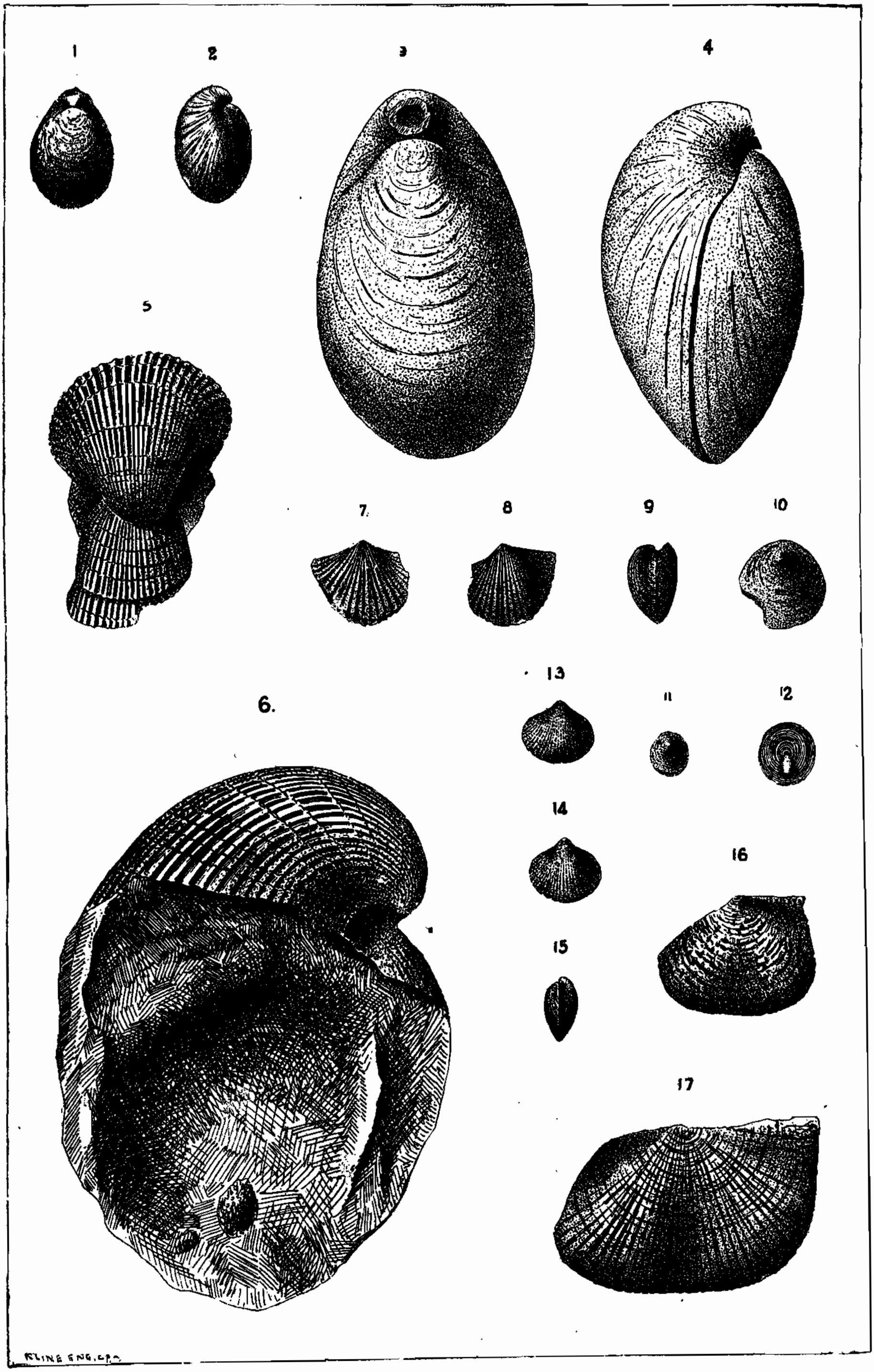
# PLATE XI.


1
2
3
4
5
6
7
8
9
10
11
13
14
12

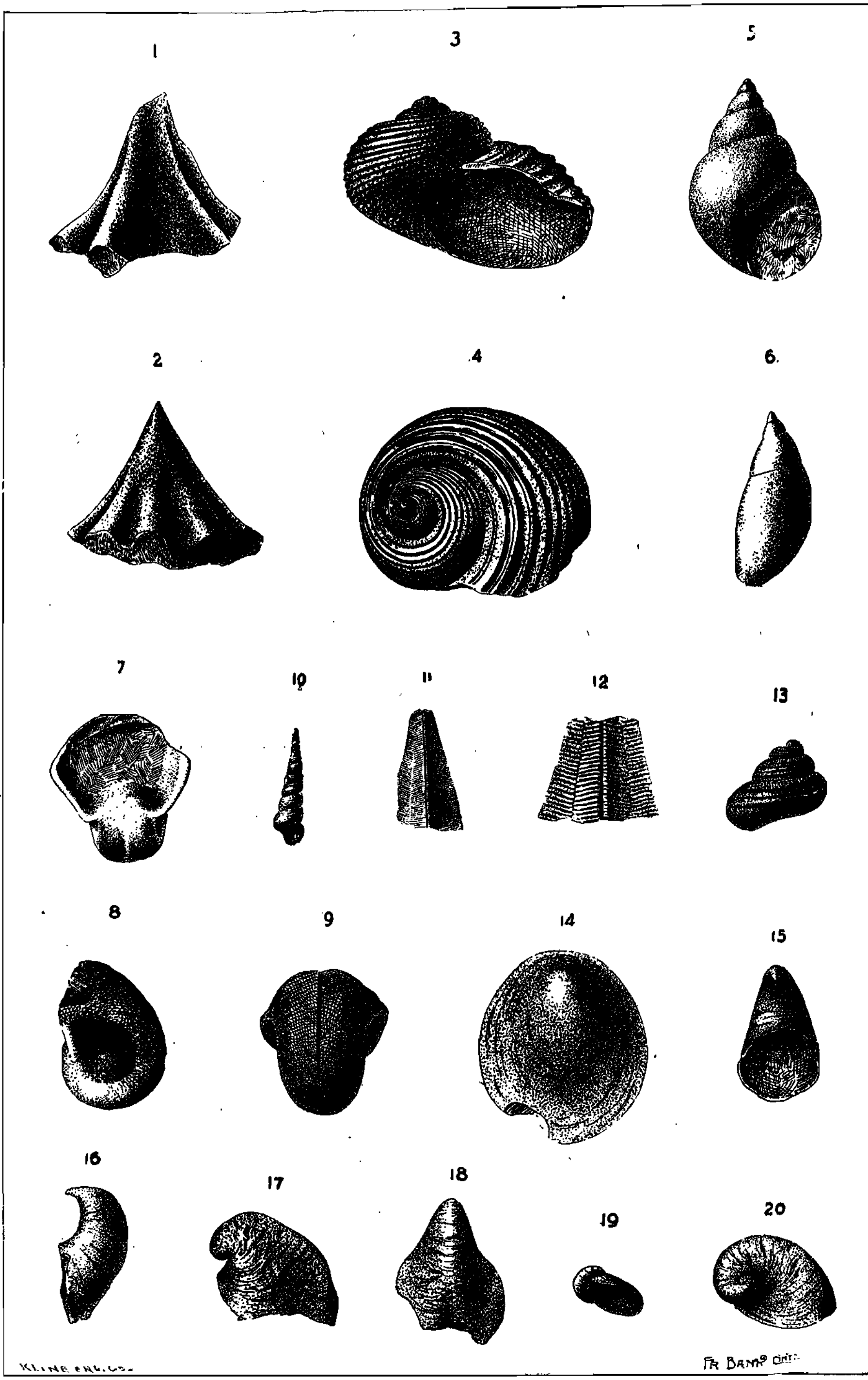
# PLATE XII.


1
2.
3
4
5
6
7
8
9
10
11
12
13
15
14.
16

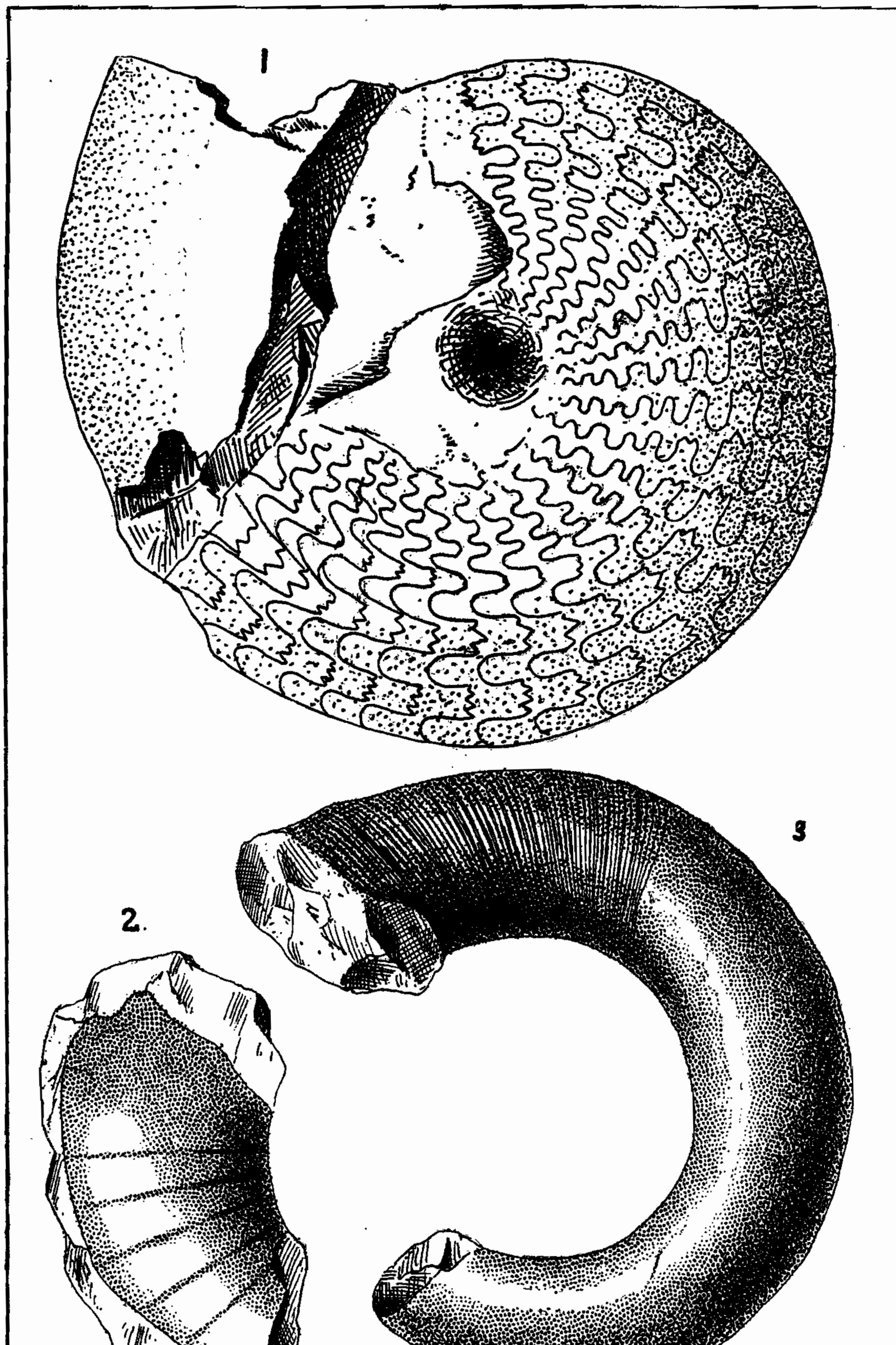
# PLATE XIII.


1
2
3
4
5
6.
7
8
9
10
11
12
13
14
15
16
17

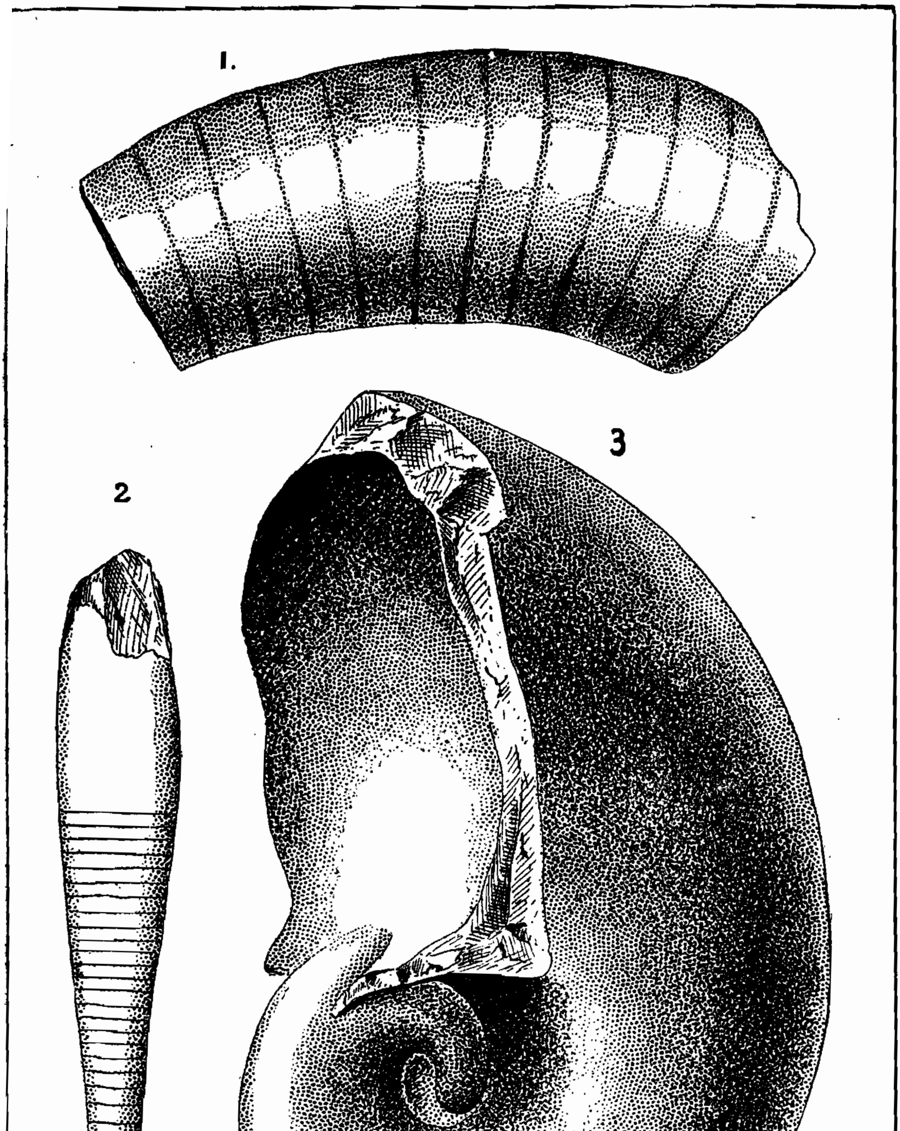
# PLATE XIV.


1
3
5
2
4
6
7
10
11
12
13
8
9
14
15
16
17
18
19
20
KLINE ENG. CO.
FR BAND DEL.

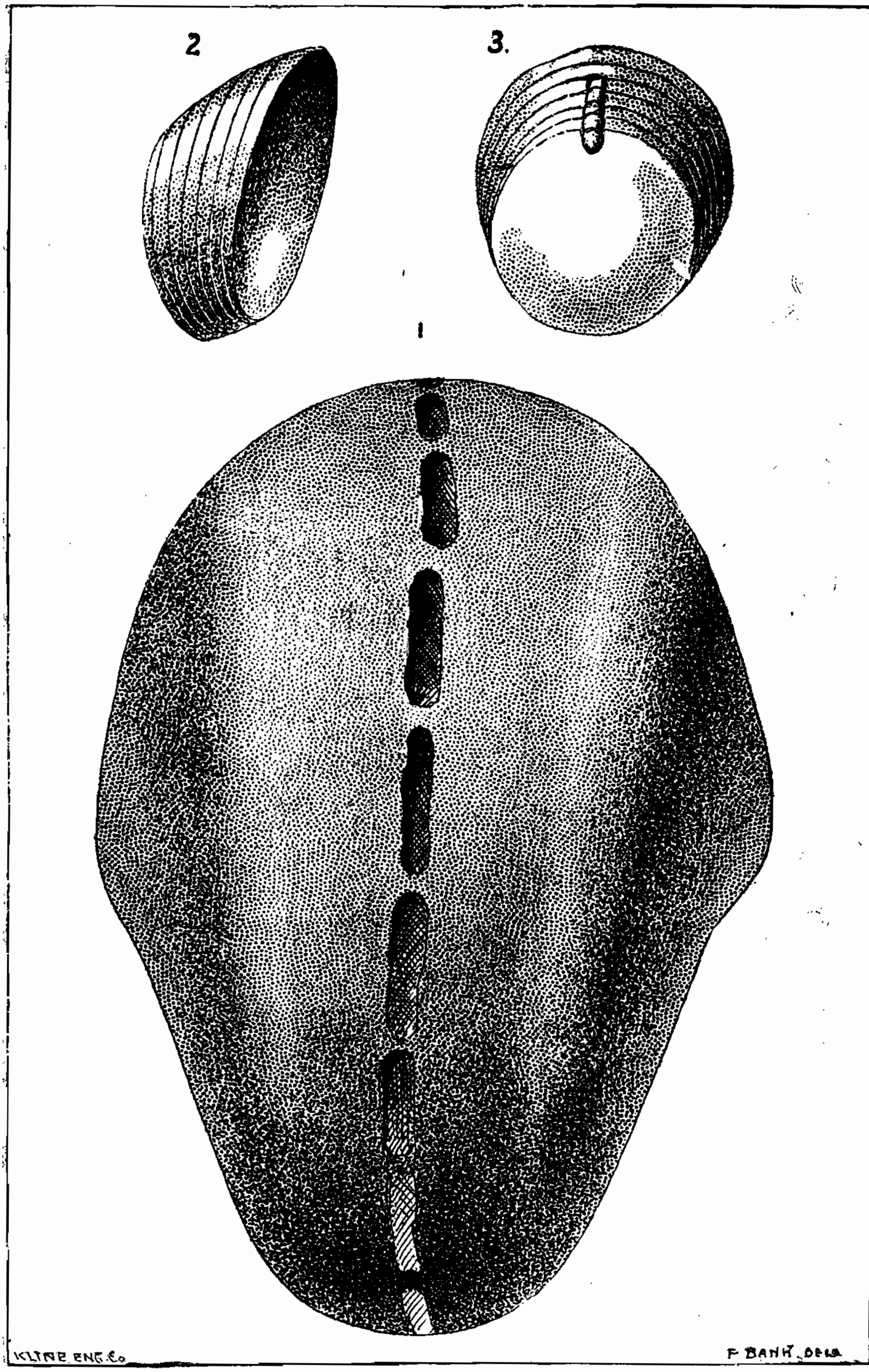
# PLATE XV.


1
2.
3
FR. BAHN. DEL

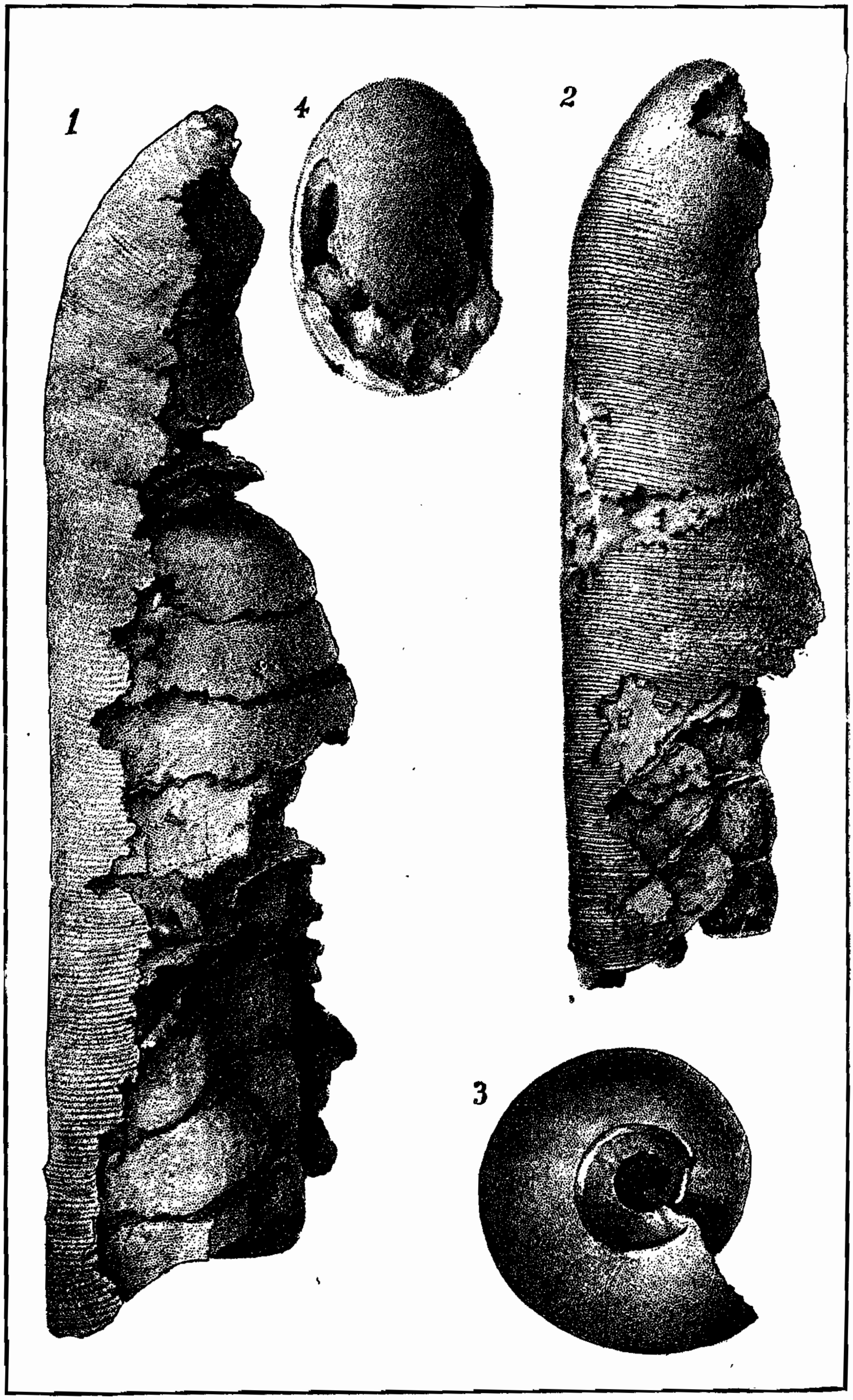
## PLATE XVI.


1.
2
3
F BANKS DEL.

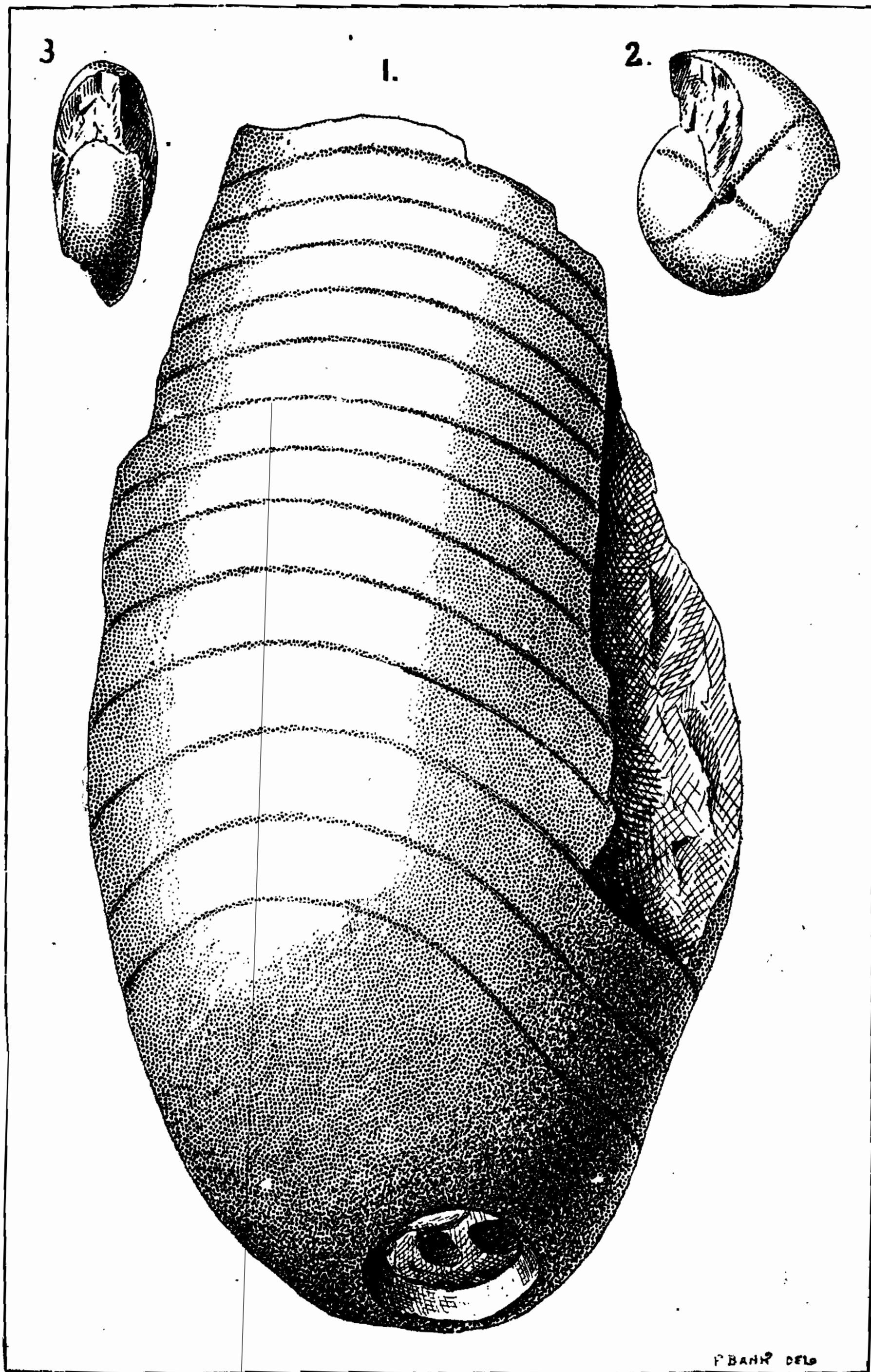
## PLATE XVII.


2
3.
1
KLINE ENG. Co.
F. BAHR, DEL.

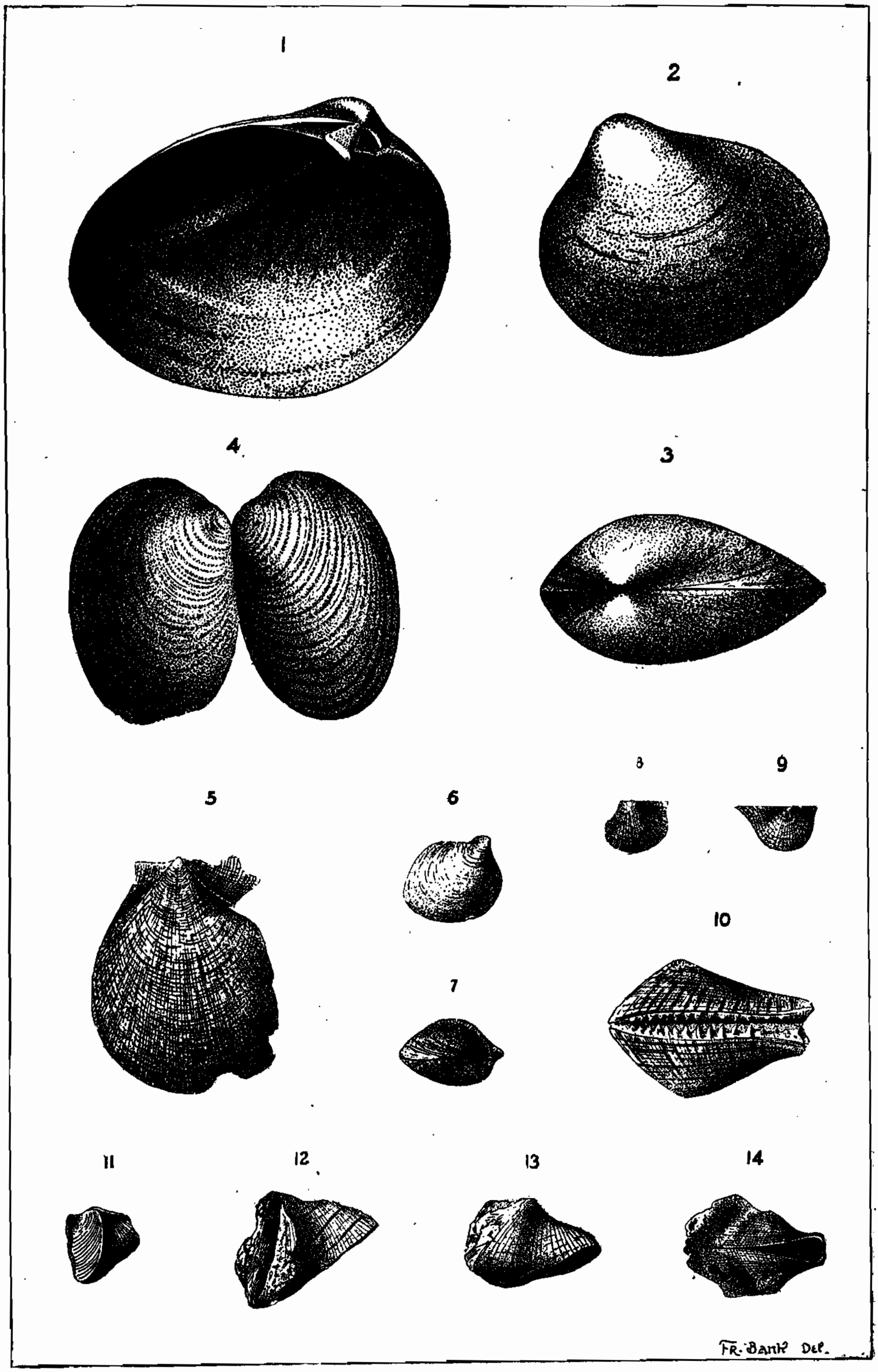
## PLATE XVIII.


1
4
2
3

## PLATE XIX.


3
1.
2.
F BAHR DEL

# PLATE XX.


1
2
4
3
8
9
5
6
10
7
11
12
13
14
FR. Bank? Del.