INDIANA.

DEPARTMENT

OF

Geology and Natural History

(THIRTEENTH ANNUAL REPORT.)

Part I, Geology and Natural History.
Part II, Paleontology.

JOHN COLLETT,
STATE GEOLOGIST

1883.

TO THE GOVERNOR.

INDIANAPOLIS:
WM. B. BURFORD, STATIONER, PRINTER, LITHOGRAPHER AND BINDER.
1884.

STATE OF INDIANA,
OFFICE OF STATE GEOLOGIST,
February 14, 1884.

HON. ALBERT G. PORTER,

Governor of Indiana:

Herewith I transmit to Your Excellency the Thirteenth Annual Report of the State Geologist, being for the year 1883, containing the labors of myself and assistants in the field, study and cabinet, with detailed surveys of several of the most important counties of the State. To this is added Part II, containing Paleontological studies, with figures and descriptions by leading scientists.

With high esteem, I am your obedient servant,

JOHN COLLETT,
State Geologist.

STATE OF INDIANA,
EXECUTIVE DEPARTMENT.

Received February 14, 1884, examined by the Governor, ordered by the Board of Public Printing to be published and filed in the office of the Secretary of State.

FRANK. H. BLACKLEDGE,
Private Secretary.

Filed in the Secretary of State's office February 14, 1884.

W. R. MYERS,
Secretary of State.

DEPARTMENT OF GEOLOGY AND NATURAL HISTORY,

INDIANAPOLIS, IND.

JOHN COLLETT, State Geologist.

PLEASE ACKNOWLEDGE RECEIPT OF THIS VOLUME.

In return, Scientific Books, Fossils, Etc., and Implements of the "Stone Age" are acceptable.

State Museum and Office, corner of Market and Tennessee Street.

ROSTER.

JOHN COLLETT, A. M., M. D., Ph. D.
Chief of Department, and State Geologist.

MUSEUM ASSISTANT.

GEO. K. GREENE, New Albany, Ind.

FIELD-WORK ASSISTANTS.

RYLAND T. BROWN, M. D., Indianapolis, Ind.
MOSES N. ELROD, M. D., Hartsville, Ind.
A. J. PHINNEY, M. D., Muncie, Ind.
Rev. D. S. McCASLIN, A. M., Pullman, Ill.

SPECIAL ASSISTANTS.

BOTANIST.

Prof. JOHN M. COULTER, Crawfordsville, Ind.

CHEMIST.

JOHN N. HURTY, M. D., Indianapolis, Ind.

CONCHOLOGIST.

FRED. STEIN, M. D., Indianapolis, Ind.

ENTOMOLOGIST.

RALPH St. J. PERRY, Indianapolis, Ind.

ORNITHOLOGIST AND TAXIDERMIST.

FLETCHER M. NOE, Indianapolis, Ind.

HERPETOLOGIST.

Prof. OLIVER P. HAY, Irvington, Ind.

PALEONTOLOGISTS.

Prof. JAMES HALL, Albany, N. Y.
CHAS. A. WHITE, M. D., Washington, D. C.
Prof. LEO LESQUEREUX, Columbus, Ohio.

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PART I.

PART II.

STATE OF INDIANA.

DEPARTMENT OF GEOLOGY AND NATURAL HISTORY.

JOHN COLLETT, STATE GEOLOGIST.

OFFICE AND STATE MUSEUM, CORNER OF MARKET AND TENNESSEE STREETS.

INTRODUCTION.

The Geological Survey.

What It has Accomplished in the Economic Interests of the State.

It is proper that some statements should be made as to the direct results of the workings of the geological department. One of the most important is the development of the vast Indiana coal fields. Before the initiation of the geological survey, Indiana coal was used only for blacksmithing and locally for fuel. The examinations made proved conclusively its purity and general good qualities, and also indicated the abundance of the supply. Reports were issued by State authority. They were read, believed and quoted. In this way the resources of the State were advertised to the world, and the attention of capitalists, miners and manufacturers was attracted. Before the survey, the coal lands of this State were worth from $2 to $10 per acre. They now sell readily at from $50 to $200 per acre, while Indiana coal is used to a very large extent by railroads and manufacturing establishments, and for household purposes. Not only have its uses extended over our own State, but it finds a profitable market in our neighboring States, and extensive shipments are made as far west as the State of Kansas. The reports issued showing the good quality of our coal have either suggested or aided the construction of four or five important railroads, and prepared the way for others.

THE GREAT INCREASE IN VALUES.

Placing the average extent of counties included in the coal regions at 250,000 acres, the increased value of previously unproductive land would exceed $30,000,000, and adding the benefits derived from the setting up of forges, furnaces, factories and mills, and the building of railways, it is probably within the mark to state that the aggregate increase in values resulting from the development of the coal fields has reached $100,000,000. This great benefit to the State has been brought about to a very great extent, if not altogether, by the labors of the geological survey, and it should also be remembered in this connection that the money invested in operating our coal fields is largely foreign capital which has been brought within our reach for the purposes of taxation.

Such results alone represent more than a thousand per cent. profit on the cost of the survey. But many of the equally suggestive facts remain to be stated. The increased shipments from the town of Brazil, in Clay county, represent annually more money than the entire cost of the survey. Ten years ago a few car loads per annum constituted the entire export trade; and the same statement holds equally true in regard to the Washington mines, in Daviess county. The annual shipments are now from 250,000 to 300,000 tons, and the proprietors of mines are glad to arm themselves with analyses and letters from the State Geologist showing the purity and excellence of Indiana coal, by means of which they have built up an extensive shipping trade, while the cannel coal of Daviess county, by reason of its superiority as a grate fuel and for its illuminating qualities, now commands a full market in all directions outside of this State. The proprietors of coal mines are very frank to acknowledge the benefits derived from the geological survey.

There are 206 mines in nineteen counties of the State, employing 5,403 men, producing 2,500,000 tons of coal, requiring a capital of $1,600,000 for the present year.

THE BUILDING-STONE QUARRIES.

The fact that Indiana has more than two hundred square miles of the best building stone to be found in any Western State, if not in the world, has also been made known through the work of the Geological Department. This stone has been found in great variety of color and grade, and the tests applied have shown it to be of such enduring strength as to create a large demand. In this way another channel has been opened for the investment of large sums of money by Eastern capitalists, and many quarries are now being operated by skilled workmen, with the aid of the most approved machinery and tools. The product of these quarries, which a few years ago did not exceed $30,000 per annum, will, during the present year, amount to a very large sum. The citizens of Owen, Monroe, Lawrence, Washington, Harrison and other counties, fully appreciate the assistance they have received from the geological survey, and recognize that the prospect before them is that in the near future the increase of Indiana's wealth from her stone quarries will be equal to that resulting from the successful working of her coal mines.

NEW LINES OF RESEARCH.

If proper methods were adopted, nearly as good returns might be made from the sale of clays and other materials, which are at present almost unknown. The fine porcelain clay of Lawrence county, which was supposed at first to be confined to an area of about forty acres of profitable beds, is now found to extend over several hundred acres, and opens up a field for the introduction of the most extensive porcelain manufactories in the United States, since nowhere else is a clay found of such a pure white color and freedom from oxide of iron. Other States carefully test and report upon their medicinal springs and derive handsome revenues therefrom. The Indiana sulphur waters are equal, and in some respects superior, to any in the world. It would pay the State well to make them more widely known, as the effect would be to induce our own citizens to spend their money at home, and to bring extensive patronage from strangers for our railways, stage coaches, hotels, etc. Indiana could readily reap a profit of several hundred thousand dollars per annum from this source.

WHAT THE REPORTS HAVE ACCOMPLISHED.

The Geological Reports which have been published from time to time have gone over the whole land, and their accuracy has scarcely been questioned. The highest scientific authorities of this country and Europe have commended them as meritorious; while scientific journals, magazines, and newspapers of the Eastern States, England, Germany, and France have copied extracts with commendation. It has been charged that these reports are advertisements. The results show that they have been good advertisements, and that it pays Indiana well to advertise in that way. The State has done well in the past by advertising her resources, and will do still better by continuing it in the future. Indiana must show her attractions—must thrust her invitations into the hands of outsiders to enlist them in her army of productive citizens. We have room for millions. Our mines and quarries are only opened. Our forests offer the best of timber to the workers in wood. Our farm land is not half improved. We not only have room for emigrants, but we need their help.

The Ways and Means Committee's recommendation of an appropriation of $2,000 for salary, and $4,000 for expenses of the geological survey, would be a cost of less than $45 per county, or three cents to each of the two million inhabitants in the State.

Finally, the survey has been a good educator. It enables every one to understand the geology of his county, the minerals he can or can not find; saves useless and expensive search, and sends forth men so posted that some of the most profitable enterprises in other States have been begun and conducted by those who were Hoosier boys.

Experience has shown in every country and State the importance of having a permanent office of geology and natural history, with a director in charge who is able to give strangers and people at home accurate and official information on all subjects relating to the rocks, clays, coals, and all other minerals, especially those within the limits of his jurisdiction, and general information regarding the geological and mineralogical resources of all other portions of the United States. Indeed, it becomes a bureau stored with important information, to be furnished gratuitously to all who seek for counsel and advice in matters within its range. Geology is a department of natural history that depends on investigation and developments for its progress. Evidences which tend to enrich science, that are not found to-day, may be found to-morrow, consequently the science is being daily promoted by new discoveries. The geological surveys of England, Scotland and Ireland have been in progress for at least fifty years, and still furnish new and important information to promote the welfare of the people. The same may be said of New York: while extensive field-work has been stopped, the venerable State Geologist, James Hall, from whose labors have evolved the fundamental nomenclature of geological epochs, which serve as a basis for American geology, still holds the office of State Geologist and finds plenty of work to do. Pennsylvania prosecuted an extensive survey under the able directorship of the late Henry D. Rogers, and then stopped, under the mistaken impression that his reports exhausted the subject. But it was soon discovered by wise statesmen that very much remained to be done, and the work was reinstated with J. Peter Lesley as director. He is aided by a large corps of assistants, and the work is being carried on with admirable detail and is alike creditable to science and the people of the State, whose welfare it has so greatly promoted. It is not for myself that I speak, when expressing the hope that the Legislature will see the wisdom of keeping alive the geological survey of Indiana, but for the people of the State, whose commercial welfare it has and will continue to promote.

Work of the Department.

The State Geologist in offering this, his third annual report (Thirteenth General Report), has pleasure in presenting to the citizens of Indiana the Geological Map of the State, which comprises more than one hundred years of the labors of himself, of his predecessors and their and his assistants, compiled upon a single sheet. This map will fill a want imperatively demanded *now* by students throughout the State and by scientists. The general outlines of the formations will be found to be correct, but future investigations may point out some minor changes to be made in their area.

He recurs with pleasure to the work of Prof. Leo Lesquereux on the "Principles of Vegetable Paleontology." This science is scattered through fifty different books of high price. Here, for the first time, it is gathered in a small space that will enable thousands to study a science heretofore accessible only to those who were able to purchase or obtain the use of expensive and rare works on the subject. He has here brought together the work and study of half a century in the space of a hundred pages. It is a triumph that Indiana gives this offering to science, and her sons and daughters should appreciate the work thus advantageously preserved.

The Fauna of the Coal Measures, by C. A. White, United States Paleontologist, presents the animal life of the Coal Measures, with his usual energy and fidelity.

These combined will enable the boys and girls of Indiana, as well as citizens, to *know* where coal is, and where it is not. Where these fossils exist coal may be expected. Where they do not exist coal can not be found. The rule is final and without appeal or variation. These papers and illustrations are found in Part II.

During the current year, 1883, surveys have been made by my assistants as follows: Morgan county, by Ryland T. Brown, M. D.; Rush county, by Moses N. Elrod, M. D.; Johnson county, by Rev. D. S. McCaslin; Grant county, by A. J. Phinny, M. D.

These surveys have been conducted with the characteristic care and fidelity of my assistants, to whom merited recognition and thanks are returned.

The State Geologist has continued his usual service. He has done the routine duties of his office, answering more than two thousand letters of inquiry, and given advice and opinions upon subjects of every branch of economic science, involving the investment sometimes of thousands of dollars, consuming hours and days of study. In addition he has been Chief of the Department, Office Assistant, Secretary, workman and errand boy.

Besides this, he has made field examinations in the Northwestern and Southern parts of the State, and made a detail survey of Posey county.

His time has been fully occupied, compelling a large amount of work outside of usual business hours.

The State museum has constantly increased. In silent work it instructs many of the fifteen thousand teachers and one hundred thousand students of the State. In Silurian, Devonian and Carboniferous fossils, and Archeological relics, it fairly rivals the favored collections of other States. It is valued by experts at over one hundred thousand dollars.

His term of office expires by law in April, 1885. He earnestly urges that such an office should be maintained and filled by a competent man, on whom citizens may call, without money or price, for information as to their mistakes or discoveries, and where those from abroad can obtain information of the wealth and resources of Indiana. This is believed to be more important to the State than additional field work or Paleontological descriptions and discoveries.

This office has, in the past, done much to advance the economic interests of the State. More can be done in the future.

By careful foresight on the part of the State Geologist, the last report was produced at a very low cost—less than $1 a volume. In other States such reports have cost from $2 to $15, averaging $4.80 a volume. The Department is proud of this report, and the high favor and unqualified commendation it has received from scientists, not only at home and in our sister States, but also in Canada, England, Germany, Australia and other foreign countries. The demand for it has been sufficient to require a far larger number than the law limited the issue to. These reports, as well as those issued previously by this Department, embodying the careful and efficient work of my talented predecessors, are in great demand among scientists all over the world, and are already regarded as valuable geological works, and have now become rare and difficult to obtain.

They are not alone contributions to the science of the age, but enable the students and teachers of the State to gain access to valuable scientific knowledge at a nominal cost, while the library of a scientist will often cost from $10,000 to $20,000. It is believed that the State should continue this course until not only her geology is accessible to her sons and daughters, but, adhering to her duty to humanity and the advancement of knowledge and civilization, such reports shall also embody the botany, conchology and each branch of the vertebrate life of the State.

A comparison of the cost of surveys in Indiana with those of other States will show that the work has been performed here at a minimum. The Ohio Geological and Paleontological Reports cost $3.47 a volume. The Indiana Report of 1881, the most expensive yet produced, cost eighty cents per copy, while Illinois Paleontology cost about $3.00 per volume. Indiana, at a former session of the Legislature, appropriated $5,000 annually for geological surveys. Georgia appropriates $10,000 annually; New York, $25,000, and Pennsylvania, $50,000.

At the last session of the Legislature an appropriation of $5,000 per annum was reported, and passed both houses. Immediately, by telegraph, orders were given by me to complete work under negotiation, as was at the time necessary. By accident of legislation the general appropriation bill failed. The Chief of the Department was left without funds for expenses, with *mandatory duties*. He was *directed by law* "to continue the geological survey of the State by counties or districts, to give attention to the discovery of minerals, stone or other natural substances useful in agriculture, manufacture and the mechanical arts," and "to care for the geological cabinet, museum, apparatus and library, and their increase."

These duties, commanded by law, required the expenditure of cash funds. He has, by extra labor at his own hands, reduced these expenses to a minimum—below their real worth—which he has paid out of his private funds, and shall, at the next session of the Legislature, present an account for repayment. He expects that every citizen who is satisfied with his reports will, as a committee of one, see his Senator and Representative on the subject of repayment and making a permanent endowment for this department.

The quota of Geological Reports for each county are distributed through the respective County Auditors to citizens and township and public libraries, and by County Superintendents to teachers. No reports are sent except on receipt of twenty to twenty-five cents in stamps—the expense of mailing.

The following shows the financial exhibit for the year ending October 31, 1883, but it must be observed that this department has had no public funds for expenses since June, 1883, so that all work of assistants since that time has been paid by the State Geologist, in faith that future legislation will reimburse him.

FINANCIAL STATEMENT FOR THE YEAR ENDING OCT. 31, 1883.

STATE OF INDIANA,
DEPARTMENT OF GEOLOGY AND NATURAL HISTORY,
INDIANAPOLIS, IND., October 31, 1883.

To His Excellency ALBERT G. PORTER,
Governor of Indiana:

SIR: In pursuance of custom, I have the honor to submit the following "detailed statement, accompanied with the proper vouchers" (Nos. 75 to 115 inclusive) of and for all moneys expended during the fiscal year ending October 31, 1883.

AUDITOR'S VOUCHER, NO. 17.

1882.		
Nov. 4.	Voucher No. 75, Geo. K. Greene, for freight, etc. .	$4 29
Oct. 4.	Voucher No. 76, C. Gehring, for broom and mop.	1 00
Nov. 11.	Voucher No. 77, Am. Express, for expressage . .	1 15
Nov. 9.	Voucher No, 78, R. T. Brown, for Geological Report of Marion county	100 00

AUDITOR'S VOUCHER, NO. 17—*Continued.*

Nov. 21.	Voucher No. 79, C. E. Beecher, for clerical services	25 00	
Nov. 8.	Voucher No. 80, Geo. K. Greene, for one lot of fossils	4 30	
Oct. 31.	Voucher No. 81, R. T. Brown, for field work and Geological Report of Marion county	100 00	
Nov. 20.	Voucher No. 82, A. J. Phinney, for field work and writing Geological Report of Grant County	65 00	
Nov. 31.	Voucher No. 83, D. S. McCaslin, for Geological Survey of Jay county	50 00	
Nov. 31.	Voucher No. 84, John Collett, office expenses	9 05	
Nov. 21.	Voucher No. 85, C. E. Smith, for clerical services	5 00	
Nov. 30.	Voucher No. 86, G. K. Greene, for work in museum	65 00	
Nov. 30.	Salary of State Geologist for November	150 00	
			$579 79

AUDITOR'S VOUCHER, NO. 18.

Dec. 8.	Voucher No. 86½, George L. Curtis, for six plates of drawings	40 00
Dec. 12.	Voucher No. 87, Dr. Chas. A. White, for descriptions and drawings coal measure fossil-fauna—part payment	300 00
Dec. 15.	Voucher No. 88, Conrad Gehring, for office fixtures	1 85
Dec. 25.	Voucher No. 89, J. A. Wildman, for postage stamps	20 00
Dec. 27.	Voucher No. 90, W. De M. Hooper, for one lot of fossils	30 00
Dec. 30.	Voucher No. 91, George K. Greene, for work in museum	65 00
Dec. 30.	Voucher No. 92, William A. Green, for work in museum	18 00
1883.		
Jan. 11.	Voucher No. 93, Leo Lesquereux, for balance on manuscript on Vegetable Palæontology	200 00
Jan. 11.	Voucher No. 94, Chas. Reece, for painting doors.	7 00
Jan. 11.	Voucher No. 95, W. B. Burford, printing and stationery	151 13
Jan. 20.	Voucher No. 96, Moses N. Elrod, for survey and report of Decatur county	100 00
Jan. 25.	Voucher No. 97, C. A. White, for descriptions and drawings coal measure fossil-fauna—part payment	392 00
Jan. 31.	Voucher No. 98, William A. Green, for work in museum	42 00
Jan. 31.	Voucher No. 99, George K. Greene, for work in museum	72 75

AUDITOR'S VOUCHER, NO. 17—*Continued.*

1882.			
Dec. 27.	Voucher No. 100, W. B. Burford, for photo engraving	278 00	
Dec. 30.	Salary of State Geologist for December	150 00	
1883.			
Jan. 31.	Salary of State Geologist for January	150 00	
			2,017 73

AUDITOR'S VOUCHER, NO. 19.

	Voucher No. 101, Ketcham & Wannamaker, for altering geological map of Indiana	2 15	
Jan. 31.	Voucher No. 102, Lyman Simonton, for fossils	30 00	
	Voucher No. 103, Chas. A. White, for full payment	450 00	
Jan. 30.	Voucher No. 104, James Hall, for writing descriptions and arranging Vancleve corals and other work	300 00	
Jan. 25.	Voucher No. 105, E. Emmons, for drawings of fossils	15 00	
Jan. 25.	Voucher No. 106, Chas. E. Beecher, for clerical work	30 00	
Feb. 1.	Voucher No. 107, A. N. Taylor, for paper boxes	7 50	
Feb. 15.	Voucher No. 108, Van Benthuysen Printing House, for electrotype	4 75	
Feb. 16.	Voucher No. 110, John M. Coulter, for correcting proof	5 00	
Feb. 20.	Voucher No. 111, G. B. Simpson, for making drawings of fossils	25 00	
Feb. 27.	Voucher No. 112, W. De M. Hooper, for clerical services	66 25	
Feb. 14.	Voucher No. 113, John T. Campbell, for clerical services	30 00	
Feb. 28.	Voucher No. 114, John Collett, for express and office expenses	29 45	
Feb. 28.	Salary of State Geologist for February	150 00	
			1,145 10

AUDITOR'S VOUCHER, NO. 20.

Mar. 2.	Voucher No. 115, John Collett, for office expenses	$71 00	
	Salary of State Geologist for March	150 00	
			221 00

AUDITOR'S VOUCHER, NO. 21.

Apr. 10.	Voucher No. 116, John Collett, for office expenses		12 93
	Total of special appropriation for department exhausted April 10, 1883		$3,976 55

STATUTE APPROPRIATION.

Salary of State Geologist for April	$150 00	
Salary of State Geologist for May	150 00	
Salary of State Geologist for June	150 00	
Salary of State Geologist for July	150 00	
Salary of State Geologist for August	150 00	
Salary of State Geologist for September	150 00	
		$900 00
Grand total		$4,876 55

Respectfully submitted,

October 31, 1883. JOHN COLLETT, State Geologist.

OFFICE OF AUDITOR OF STATE.

This financial exhibit corresponds with the books in the office of the Auditor of State.

JAS. H. RICE,
Auditor of State.

July 19, 1884.

EXECUTIVE DEPARTMENT.

Filed June 28, 1884.

F. H. BLACKLEDGE,
Secretary.

GEOLOGY OF INDIANA.

GEOLOGICAL MAP.

The accompanying geological map of Indiana gives a fair exhibit of the surface geology of the State. It is a compilation of all the labors of my distinguished predecessors and their assistants, as Owen, Lawrence, Brown, Cox, etc., etc., also of myself and assistants. To all workers in the State and amateurs the fullest credit and acknowledgments are given.

Much of the geology of the northern and northwestern areas is given, not accessible before the surveys of Newton and Jasper counties. The map comprises over one hundred years of labor and study of these devotees to science, but as well the results of thousands of miles of travel with pick and hammer.

In every dividing line between formations, outliers will be found to the east and north on the hill tops; to the west and south denuded areas will be found of lower strata.

The map is the best that can be prepared on so small a scale now; in the future, with better facilities and on a sectional scale, more finished work may be expected. It is believed that it will be appreciated by our citizens as a chart giving years of study and labor, condensed in a single sheet, and invaluable to teacher, student and citizen.

The sections on the borders of the map exhibit a large amount of labor and observation. The vertical sections are an average of studies along each line of outcrop and the deep bores in all divisions of the State. The horizontal section, from Vincennes to Lawrenceburg, shows the railway lines of the Ohio and Mississippi road, the surface rocks, etc. The dip is at the conventional rate of 30°, as the dip of each stratum is rapid near the rim of each basin—from 40 to 100 feet to the mile, but afterward ranges at 10 to 20 feet to the mile.

OUTLINE GEOLOGY OF INDIANA.

LOWER SILURIAN.

The rocks of the Lower Silurian age, known as the Hudson River or Cincinnati group, are found in the southeastern division of the State, extending also throughout large areas in Ohio and Kentucky. They are well exposed in the bluffs of the Ohio River, extending west to the mouth of Fourteen-mile Creek, in Clark county, and form the surface rocks in the counties of Wayne, Union, part of Fayette, Franklin, Dearborn, Ohio, Ripley and Switzerland. In several of the adjoining counties to the west are exposures of Lower Silurian in ravines and deep cuts, as on the extreme east side of Clark, Jefferson, Decatur and Rush. The rocks of this formation are filled with well-preserved fossils, and, by decomposition, form a rich and highly productive soil.

UPPER SILURIAN.

Strata of the Upper Silurian formation form the general surface rocks of the counties immediately west and northwest of those in the Lower Silurian, including Adams, Wells, Huntington, Wabash, Miami, part of Jasper, White, Cass, part of Carroll, Jay, Blackford, Grant, part of Howard, Delaware, Madison, Tipton and Hamilton, Randolph, Henry, Hancock, Rush, Shelby, Decatur, the eastern part of Marion, Bartholomew, Jennings, Jefferson, and the eastern part of Clark county. The Upper Silurian strata also extend north and northwest from these counties to the northern boundary of the State, at many points being capped by uneroded areas of Devonian age, but so deeply covered with bowlder drift as to be rarely seen, and its presence is more known by test bores than by outcrops in the drift district.

Soils derived from the disintegration of rocks of this age are, as a rule, cold, heavy clays, which, when drained, produce good crops of wheat and the grasses.

DEVONIAN.

The Devonian rocks are exposed in a narrow band, commencing, on the south, at the Ohio River in Clark and Floyd counties, and extend, thence, north and west through the counties of Scott, Jackson, Bartholomew, Johnson, Marion, Boone, Clinton and Carroll, with local exposures in Tippecanoe, Cass, White and Jasper, Miami, Wabash, parts of Shelby, Jennings, Jefferson and Jackson. From fossils collected in the drift area, to the the north and west and from test bores, it is known that Devonian rocks have been more or less eroded, but once covered much of the northern third of the State, and at many points they are still in place.

LOWER CARBONIFEROUS OR MOUNTAIN LIMESTONE.

Rocks of the Lower Carboniferous series form the surface strata in a wide belt west of the Devonian and east of the Coal Measures, and these, for the most part, constitute the rocky exposures of the counties of Harrison, Crawford, Orange, Washington, Lawrence, Brown, Monroe, Owen, Morgan, Putnam, Hendricks, Montgomery, Tippecanoe and Benton, with parts of Perry, Floyd and Jackson. The eastern line of this belt is composed of shales and sandstones of the Knobstone group, while adjoining on the west are the great cavernous limestones of the State, so well exhibited in the southern counties, but which thin out to a few feet at the north. The soil of this district is remarkable for its growth of cereals and grasses.

COAL MEASURES.

The rocks of the Coal Measures are found in the counties of Posey, Vanderburg, Warrick and Spencer, the western parts of Perry and Crawford, in Gibson, Pike, Dubois, Knox, Daviess, Martin, Sullivan, Greene and Clay, the western part of Owen, and in Vigo, Parke, Vermillion, Fountain and Warren, with a projection in a narrow band of Coal Measure rocks (Conglomerate sandstone), underlaid by thin beds of Keokuk limestone and Knobstone shales of the Lower Carboniferous group, extending from the northern part of Warren county, in a northeasterly direction across Benton, and terminating near Rensselaer, in Jasper county, where the Conglomerate is massive. It is probable that this projection is not continuous, but interrupted at intervals.

It is apparent, therefore, that the Lower Silurian, being the oldest rocks brought to the surface, underlie all the more recent rocks which in succession have been deposited upon or about it during the different ages of the earth's existence. A shaft or bore put down in the western part of Gibson county would pierce, in succession, all the geological formations of the State, and would show the approximate depth of each.

STONE COALS OF INDIANA.

Humanity, in its progress, has passed its infancy—the Age of Stone;* its boyhood—the Age of Bronze; its young manhood—the Age of Iron; and, with wondrous achievements, its ripening manhood—the Age of Gold and Silver. To-day, armed with all the glories of the past, its cycles of thought and labor, and advancing with the momentum of all the Ages, we stand upon the summit of these thoughts and works, and, boldly invading the future, achieve the Age of Steel—of quick, exact thought and realizations. Every work of forest, farm, field and commerce requires this adjutant, grander and greater than gold or silver, and welcomes the aids of science and steel.

Steam is the soul and spirit of our past advancement; at every step its voice, tame as the sigh of love, terrible as the cyclone, is heard, but the food, the nerving fire that drives the great advances of progress, civilization, Christianity and happiness, is Coal.

I am indebted for arrangement and compilation of many succeeding facts to favor of Oscar F. Mayhew, to whom thanks are returned.

COAL.

The Coal period was the grand culmination of the earth's existence. Long ages were required to reach it, and ages upon ages to pass it. From what is known, coal is the result of slow chemical action upon vast bodies of vegetable growth, accumulated under conditions favorable to the condensation of its carbon and hydrogen into solids embodying more or less of the latter element, and forming the anthracite, or pure carbon, and the bituminous, or hydro-carbon, coals as we find them—though the anthracite is the result of subsequent elimination of the volatile matter from previously formed bituminous coal. As a hint of the vast period of time and immense quantity of vegetation required for the formation of the Coal Measures, "all the forests of the Mississippi Valley could not furnish to the sea from their river spoils, during a hundred thousand years, one of the anthracite beds of Schuylkill county, Pennsylvania."—*Lesley.*

The great economic value of coal to man can not be estimated, and is the justification for repeated attention to it in these Reports. Until something better (electricity perhaps) shall be controlled and made subservient to the production of light and heat, coal must rank as only second to the food we eat in its relation to man's necessities. It has made ocean steam navigation not only a possibility but a grand success. It has rendered practicable the building and profitable operation of vast systems of railways, until they ramify into every civilized quarter of the globe, in the more densely populated parts, forming a network of connections and establishing stations in close proximity to the homes of millions of people, cheapening transportation, diffusing and equalizing the benefits of manufactures and traffic, opening up vast tracts of new country to settlement and cultivation, and reaching out to newer and cheaper sources of iron, timber, stone and hundreds of other raw materials that contribute to man's progress and enjoyment. It makes the steam that operates millions of machines, facilitating and lightening labor, and increasing and cheapening billions of mechanical productions. It makes the iron that enters into all these. It furnishes the light for the streets and business places of hundreds of towns and cities and thousands of homes. It cooks the food and warms the abodes of millions of people. And when inventive genius shall have devised appliances for its perfect combustion and consequent better utilization, its already immense value will be more than doubled.

Anthracite coal, of which none exists in this State, is, when free from impurities, a pure carbon, very hard, difficult to ignite, burns slowly, under a moderate draft, with a light bluish flame, evolving carbonic-oxide gas. Its waste in burning in the stoves and furnaces in common use is 67 per cent. of its heat value, in the uncombined gas that is carried off by the smoke flue.

Bituminous coal, of which Indiana has 7,000 square miles, is, when free from impurities, nearly pure hydro-carbon in varying combination, easily ignited, evolving nearly pure carburetted hydrogen gas, that burns with a luminous and more or less ruddy flame. The bituminous coals are utilized for illuminating as well as heating purposes. On account of the volatile matter contained in them, they are wasted, even in the best constructed furnaces, at the rate of more than 75 per cent. of their heat-producing capability.

Although there is considerable variety in the coals found in Indiana, ranging from the non-caking block, or splint, through all the grades of caking up to the most highly bituminous, including cannel, affording, in abundance, varieties best adapted to steam and gas making and domestic and metallurgic purposes, yet, for some of these and other purposes, it becomes necessary or advantageous to convert it into coke. Since the discovery and development of the bituminous or caking coals, and before the discovery of the block or non-caking coal, coke was principally used in the blast furnace and cupola of the iron founder, and, except in this State, is still generally so used. Block coal is used in the cupola here. The principal object of coking is to get rid of the sulphur that is contained in most coals, and to provide a fuel that will not cake, or become packed, under the weight of the superincumbent mass, so that the heat may freely permeate every part. Sulphur, whether in the coal or the ore, destroys the tenacity and malleability of the iron.

Coke is the solid carbon and ash of coal, and is produced by driving off the volatilizable constituents, as the water, hydrogen, sulphur, etc. This is done by heat, in ovens built for the purpose, though the primitive, wasteful method of coking in pits made of earth is still in use in some places. The volatile matters driven off are nearly one-half by weight, but their expulsion does not lessen, materially, the volume, though this varies with the method of coking. Under pressure, with a slow fire at beginning and until the the sulphur is driven off, followed by a brisk fire, the product will be a hard, heavy, bright coke that has a ring when struck, while a smouldering fire, without pressure, yields a dark, spongy product.

Indiana is highly favored in having many hundreds of square miles of the best natural fuel in the world for the reduction of iron ore in the blast furnace, in her non-caking block coal, as well as in the vast area of coal adapted to making excellent coke.

COAL PRODUCTS.

"The readiness shown by the elements of coal to enter into new combinations where it is exposed to an increase of temperature, and the great variety of combinations obtained under different degrees of heat, or by the admission or exclusion of air, indicate the close relation of coal to the elements of the vegetable kingdom. It consists of carbon, hydrogen, oxygen and nitrogen, which make up the great bulk of vegetable matters, and these show the same disposition as in the plants themselves to separate from existing combinations and enter into new. The number of new products thus formed is almost unlimited. They differ from one another and from the original substance from which they are generated, as do those obtained in the processes of vegetable fermentation. When heat is applied without access of air, the vapor of water, set free, acts on the existing combinations of the elements. These are broken up, and hydrogen and oxygen are evolved under the most favorable circumstances, in their nascent state, to form new compounds with the carbon present, the characters of which vary greatly with the temperature. The process is called dry distillation. By keeping the retorts in which it is conducted at a cherry-red heat, the gases used for illumination are most copiously evolved, the tar itself being decomposed and converted into gaseous matters. But if the object is to obtain the coal oils, parafine, benzole and other hydro-carbons of this nature, care is taken that the retorts are heated very gradually, and do not acquire more than a low, red heat. The tarry matters thus escape decomposition, and, by repeated distillations, afford crude naptha and its secondary products. Coal tar was, for a long time, a troublesome product of the gas works, no useful application of it, to any great extent, being known. It was employed as a covering to protect iron work exposed to the weather, and the pitch obtained by distilling it was found, when mixed with earthy matters, to be a good substitute for the natural product, asphaltum, used for artificial pavement, water-tight covering for roofs, etc. Finally, the tar came to be an object of purchase by tar distillers, who learned to extract from it the crude naptha and also the light oily fluids. The pitch, too, by repeated distillations, was made to yield more oily matters, which are useful for lubricating machinery and other purposes. The crude naptha is now purified by mixing it with a tenth its bulk of concentrated sulphuric acid, adding, when cold, five per cent. of peroxyde of manganese, and distilling off the upper portion. A rectified naptha is thus obtained, which readily dissolves caoutchouc, and, mixed with wood naptha, produces a powerful solvent of various resinous substances useful in making varnishes. Still further purified, the liquid benzole is obtained, which has been applied to many useful purposes. The light essential oils, as also the heavier qualities which come over after these, are found to possess antiseptic properties, which render them of value for preserving wood from decay. From the essential oils, the tar creosote or carbolic acid is obtained, which possesses extraordinary antiseptic properties, and is used in the preparation of a valuable dye-stuff, carbazotic acid. The heavy oil yields a substance called aniline, which gives, with bleaching powder and other agents, a magnificent blue color, and is employed in dyeing. Napthaline, also (which is a solid white substance, obtained in large quantities in the distillation of the tar), yields two coloring matters—one called napthalic acid and the other chloro-napthalic acid, the latter of which is nearly identical with the coloring principle of madder, and gives, with alkalies, a beautiful red color. Instead of napthaline, by conducting the distillation at a lower temperature, may be obtained the waxy substance of parafine, which is now used for the manufacture of candles and the parafine oils. * * * By oxidizing aniline with bichromate of potash, a bronze-colored substance is produced, dissolving in alcohol with a beautiful purple color. In concentrated sulphuric acid its solution is green. On adding water, and precipitating with an alcoholic solution of potash, the coloring matter is precipitated unchanged. It is of intense hue, and considered as good, if not better, than archil. It is very stable, not being decomposed at a temperature of 482° Fahr. One pound of the solid substance will dye 200 pounds of cotton a moderately dark lilac, the color standing well the action of light and heat, acids and alkalies."—*Amer. Cycl., Vol. 4, page 752.*

Coal oils have been made from the cannel and other fat coals, and also from the bituminous shales, which, until late years, were considered worthless; but the wonderful production of petroleum renders their manufacture unprofitable.

LOCOMOTIVE USE OF COAL.

The world, in an economic sense, is made up of little things. Like building a house, it is only one brick on another. As an illustration of the importance of detail in all the affairs of life, the following is copied:

HOW GREAT THINGS ARE DONE.

Success in great things generally depends upon the care and faithfulness with which all the little details are done. This is true, whether it be a sermon or a shoe factory, a play or a printing house, a picture or a war.

The fact is strikingly illustrated by a description of the manner in which the fastest railroad train on the continent is run between New York and Philadelphia, as described in the American Machinist:

"To accomplish the distance in the time requires the most minute supervision—the engine, even down to the oil cans, must be in perfect order, the brake air-pump working, the valves, joints and reservoirs in exact condition. To pass over what would be obviously necessary in the skill and judgment of the engineer, there is the skill of the fireman alone, whose neglect would cause a serious difference in the time which the train is obliged to make. His coal is all broken into lumps of equal size; it is to be pitched, while the engine rocks and leaps, to the right spot in the fire-box ten feet long; only one shovelful is thrown in at a time, so the fire is not choked with fuel, as it would be by an unskillful fireman; but every two minutes in goes the right quantity at the right spot, and the door closed quickly.

"When the engine arrives at its destination there are only a few inches of glowing coals left, so accurate is the calculation by which the steam in the boiler is kept to an exact and steady degree of temperature, and the very highest service got of the engine in consequence. It is in this way invariably that great and substantial achievements in every department of life are gained."

CONNECTED SECTION OF THE COAL MEASURES IN INDIANA.

0 to 20 feet.	Buff, brown, mottled, flaggy sandstone.
5 to 20 "	Merom sandstone, upper division shaly.
5 to 40 "	Merom sandstone, massive.
10 to 24 "	Gray or buff shales and flaggy sandstone, ripple marked.
1 to 6 "	Hard, clinky, gray limestone, sometimes flinty; to the west a calcareous shale.
0 to 34 "	Argillaceous shale and shaly sandstone.
0 to 2 "	Black slate with fish spines and fossils.
0 to 1 "	SECOND RASH COAL.
0 to 2 "	Fire clay.
0 to 6 "	Gray shales.

3 to 12	feet.	Yellow, ferruginous limestone, passing to calcareous shale or clod, in the west.	
10 to 25	"	Gray shale.	
0 to 2	"	FIRST RASH COAL and black slate.	
1 to 2	"	Fire clay.	
40 to 110	"	Flaggy, blue, buff and gray sandstone, with much gray shale and beds of clay iron-stones.	
15 to 28	"	Yellow and gray sandstone quarry beds.	
0 to 1	"	Black slate, or clod, with fossils.	
0 to 2	"	COAL N. Choice, gassy, caking.	
1 to 5	"	Fire clay, shaly at bottom, with pyrite.	
2 to 8	"	Brown or gray limestone, with *Chætetes*.	
30 to 40	"	Gray or white shale, with bands of sandstone.	
40 to 70	"	Siliceous shale, passing to massive sandrock at the south and west. "Anvil Rock," of Dr. Owen.	
2 to 4	"	Black slate and clod, with many animal and vegetable fossils.	
3 to 6	"	COAL M.	
2 to 4	"	Fire clay.	
3 to 14	"	Shale, with balls of pyrite.	
2 to 4	"	Brown, compact limestone.	
2 to 20	"	Argillaceous sandstone.	
20 to 84	"	Gray shale and soapstone.	
1 to 2	"	Soapstone crowded with plant remains.	
3 to 11	"	COAL L.	
2 to 5	"	Fire clay.	
20 to 120	"	Siliceous shale and coarse, massive ferruginous sandstone.	
2 to 8	"	Bituminous limestone and black slate.	
2 to 8	"	COAL K.	
2 to 10	"	Fire clay.	
16 to 22	"	Gray shale and soft sandstone.	Block coal (local.)
3 to 4	"	COAL I. Main "Block."	
6 to 10	"	Fire clay.	
0 to 2	"	Dark shales.	
0 to 2	"	COAL H.	
16 to 24	"	Fire clay and shale.	
0 to 1	"	COAL G.	
15 to 23	"	Shale and sandstone.	
2 to 4	"	COAL F. Lower "Block."	
30 to 80	"	Sandstone and gray shales.	
0 to 3	"	COAL B. Part "Block" and splinty cannel.	
2 to 4	"	Fire clay.	
10 to 22	"	Siliceous shale and coarse, soft sandstone.	
60 to 125	"	Massive conglomerate gritstones.	

2 to	30 feet.	Black, aluminous, pyritous shale, highly ferruginous.
0 to	2 "	Black slate.
0 to	2 "	COAL A. Impure.
2 to	4 "	Fire clay.
10 to	40 "	Dark pyritous shale, with ferruginous clays. Kaskaskia limestone, Chester group Lower Carboniferous period.

FUEL VALUES OF COAL.

HEAT UNITS—STEAM VALUES.

The State Geologist is indebted to Dr. G. M. Levette for the preparation of the following tables of the heat units and steam values of the coals of Indiana and other competing regions.

Prof. John Collett, State Geologist:

SIR—Herewith you will find a compilation of all the analyses of Indiana coals given in the reports of Dr. David Dale Owen, Prof. Richard Owen and Prof. E. T. Cox, comprising, in the aggregate, 390 examples; also two analyses of peat from the north end of the State. In addition, for comparison, are given fifty-six examples of coal analyses from Ohio, Pennsylvania, Kentucky, Illinois, Missouri, Iowa and other States and Territories, not forgetting the widely known Newcastle coal of England and the Albertite of New Brunswick. In all cases the authority is given in the heading of the tables or in the column under "Remarks."

The figures in the column headed "Units of Heat"* indicate the pounds water one pound of the coal will raise from 39° to 40°. As an example, one pound of coal, No. 1, of the tables (Barnett's mine) will raise the temperature of 8086 pounds of water 1° Fahr., or 4043 pounds 2° or 44.9 pounds from 32° to 212°.

The units of heat in any fuel are calculated from the per cent. of carbon and hydrogen contained in it.

The rules for these calculations are deduced from numerous experiments, through several years, by MM. Scheurer-Kestner and C. Meunier-Dollfuss, who, following the line of investigation instituted by Favre and Silberman, devised a modification of their calorimeter, by which the theoretical and experimental calorific value of fuels were made to coincide so closely that approximately correct multipliers were established for each per cent. of carbon or hydrogen found by chemical analysis in a fuel.

The column headed "Steam Value" gives the gallons of water that one ton (2,000 pounds) of the coal will raise from 100° F. to steam, at atmospheric pressure. For example, 2000 pounds of coal, No. 2, of the table

*A *unit of heat* is the quantity of heat required to raise the temperature of one pound of water from 39° to 40° Fahr., 39° being the temperature of greatest density.

(Garlic & Collins) will convert 1396 gallons of water into steam, starting with the water at 100° F., a temperature at which many heaters deliver water to the boilers.

All the calculations under the head of "Steam Value," and all in black face type, under "Units of Heat," were made specially for this report, while all other figures in the following tables were copied from the authorities given in the headings or in the column under "Remarks."

The first analyses of Indiana coals of which I find any record, were made by Dr. David Dale Owen, in his laboratory in New Harmony, by authority of an act of the Legislature "to provide for a geological survey of Indiana," approved February 6, 1837. Wood being more of a burden than a blessing, at that time, in most parts of the State, its extreme low price rendered coal mining unprofitable and unnecessary; but few coal banks were known, simple outcrops along streams or valleys having attracted the attention of settlers. It was from these few exposures Dr. Owen took his samples and made his analyses.

In 1859, the Legislature of Indiana authorized "a geological reconnoissance of the State." Dr. D. D. Owen was again made State Geologist. His death occurring soon after the appointment, his principal assistant, Professor Richard Owen, made the report in which is found analyses of twenty-two examples of coal.

In 1869, the Legislature provided for a geological survey. Professor E. T. Cox was appointed State Geologist, and served in that capacity until the spring of 1879, during which time all the important coal banks or mines in the State were visited, samples selected and analyses made, 363 of which are given in the following tables.

All of which is respectfully submitted by

Yours truly,

G. M. LEVETTE.

Analyses of Coals, Clay County, Indiana. Geological Report of Indiana, 1869, *E. T. Cox.*

	NAME OF MINE OR OWNER.	Specific gravity.	Lbs. Weight of one cubic foot.	Fixed Carbon.	Ash.	Color of Ash.	Coke.	Gas.	Water.	Total volatile matter.	Units of Heat.	Steam value. See page 10.
1	Barnett's mine	1.250	78.12	57.0	1.5		58.5	37.5	4.0	41.5	**8086**	1500.
2	Garlic & Collins	1.230	76.87	57.5	3.0		60.5	31.0	8.5	39.5	**7523**	1396.
3	Knightsville No. 1.	1.176	73.50	59.8	0.3		60.1	30.9	9.0	39.9	**7725**	1433.
4	Knightsville No. 2.	1.167	72.93	57.0	2.0		59.0	33.0	8.0	41.0	**7668**	1423.
5	McClelland's No. 1.	1.279	79.93	54.7	1.5		56.2	38.8	5.0	43.8	**8023**	1489.
6	McClelland's No. 2.	1.279	79.93	53.0	2.5		55.5	40.0	4.5	44.5	**7994**	1481.
7	Star Mine, Harmony	1.242	77.62	61.5	2.5		64.0	32.5	3.5	36.0	**7985**	1483.
8	Newburg mine	1.327	82.93	47.3	6.0		53.3	39.7	7.0	46.7	**7550**	1400.

Clay County Coals—Continued. *Geological Report of Indiana,* 1870, *E. T. Cox.*

	NAME OF MINE OR OWNER.	Specific gravity.	Lbs. Weight of one cubic foot.	Fixed Carbon.	Ash.	Color of Ash.	Coke.	Gas.	Water.	Total volatile matter.	Units of Heat.	Steam value. See page 10.
9	Carbon Block Coal Company	1.296	81.00	55.25	1.5	White.	56.75	39.85	3.40	43.25	**8176**	1517.
10	Garlic & Collins, Otter creek	1.244	77.75	57.90	3.5	White.	61.40	35.85	2.75	38.60	**8027**	1489.
11	Otter creek, lower seam.	1.232	77.00	57.95	2.6	White.	60.55	37.35	2.10	39.45	**8166**	1515.
12	Niblock & Zimmerman	1.231	76.93	55.63	0.75	White.	56.38	40.62	3.00	43.62	**8243**	1529.
13	Morris Coal Company	1.244	77.75	52.00	1.00	White.	53.00	43.50	3.50	47.00	**8238**	1528.
14	Markland Mining Company, 1873	1.211	75.69	52.00	2.0	White.	54.00	41.50	4.50	46.00	**8053**	1494.

15	E. Cooprider, Middlebury, top	1.280	80.00	44.00	4.50	Pink.	48.50	47.50	4.00	51.50	7924	1469.
16	E. Cooprider, Middlebury, middle	1.533	95.81	45.00	8.50	Brown.	53.50	44.00	2.50	46.50	7673	1423.
17	E. Cooprider, Middlebury, bottom	1.211	75.88	50.50	4.00	Yellow.	54.50	42.50	3.00	45.50	7980	1480.
18	J. Cooprider, Middlebury, middle	1.271	79.44	44.50	5.50	Purple.	50.00	47.00	3.00	50.00	7808	1448.
19	J. Cooprider, Middlebury, bottom	1.274	79.62	41.50	7.50	Purple.	49.00	47.50	3.50	51.00	7711	1431.
20	Kennedy, Centre Point, top	1.354	84.62	46.50	15.50	Brown.	62.00	35.00	3.00	38.00	6968	1292.
21	Kennedy, Centre Point, middle	1.204	75.25	49.50	9.00	White.	58.50	39.00	2.50	41.50	7575	1405.
22	Kennedy, Centre Point, bottom	1.188	74.25	52.00	4.50	White.	56.50	40.50	3.00	43.50	7917	1468.
23	Knickerbocker Coal Company, top	1.167	72.93	55.00	5.50	Buff.	60.50	37.00	2.50	39.50	7838	1454.
24	Knickerbocker Coal Company, middle	1.184	74.00	52.50	6.00	White.	58.50	39.50	2.00	41.50	7774	1442.
25	Knickerbocker Coal Company, bottom	1.241	77.56	50.50	6.50	White.	57.00	40.00	3.00	43.50	7750	1438.
26	Kress, Middlebury, top	1.318	82.37	44.00	13.00	Red.	57.00	39.50	3.50	43.00	7179	1332.
27	Kress, Middlebury, middle	1.287	80.43	40.50	10.50	Brown.	51.00	44.50	4.50	49.00	7355	1365.
28	Kress, Middlebury, bottom	1.432	89.40	38.50	13.00	Gray.	51.50	44.50	4.00	48.50	7194	1335.
29	Limited Liability Coal Company	1.231	76.93	57.00	3.00	White.	60.00	37.00	3.00	40.00	8000	1484.
30	Lodi	1.303	81.43	43.00	13.50	Red.	56.50	40.50	3.00	43.50	7190	1334.
31	Markland Coal Company, top	1.202	75.12	58.00	4.00	White.	62.00	36.00	2.00	38.00	7989	1482.
32	Markland Coal Company, middle	1.145	71.56	63.50	0.50	White.	64.00	35.50	2.50	36.00	8205	1522.
33	Markland Coal Company, bottom	1.221	76.31	59.00	2.50	White.	61.50	36.00	2.50	38.50	8070	1497.
34	Morrison's, Centre Point, top	1.233	77.06	52.50	7.00	Flesh.	59.50	37.00	3.50	40.50	7637	1417.
35	Morrison's, Center Point, middle	1.253	78.31	58.50	4.50	White.	63.00	34.00	3.00	37.00	7846	1455.
36	Morrison's, Centre Point, bottom	1.209	75.56	57.00	3.50	Flesh.	60.50	36.00	3.50	39.50	7909	1467.
37	Muir & Free, top	1.269	79.31	52.00	3.00	White.	55.00	42.50	2.50	45.00	8101	1503.
38	Muir & Free, middle	1.167	72.93	48.50	6.00	White.	54.50	41.50	4.00	45.50	7727	1433.
39	McClelland & Zeller	1.285	80.31	56.50	2.50	White.	59.00	32.50	8.50	41.00	8005	1485.
40	J. McCrea, Hoosiertown, top	1.196	74.75	56.50	2.00	White.	58.50	39.50	2.00	41.50	8189	1519.
41	J. McCrea, Hoosiertown, middle	1.229	76.81	56.00	5.50	White.	61.50	36.00	2.50	38.50	7828	1452.
42	J. McCrea, Hoosiertown, bottom	1.227	76.06	58.00	2.50	White.	60.50	37.00	2.50	39.50	8080	1499
43	Niblock & Co., "Chicago mine"	1.251	78.19	50.50	2.00	White.	52.50	41.50	6.00	47.50	7888	1463.

Clay County Coals—Continued. *Geological Report of Indiana*, 1875, *E. T. Cox.*

	NAME OF MINE OR OWNER.	Specific gravity.	Lbs. Weight of one cubic foot.	Fixed Carbon.	Ash.	Color of Ash.	Coke.	Gas.	Water.	Total volatile matter.	Units of Heat.	Steam Value. See page 10.
44	A. Phipps, Middlebury, top	1.303	81.43	52.00	5.50	Brown.	57.50	39.50	3.00	42.50	7826	1452.
45	A. Phipps, Middlebury, middle	1.266	79.15	48.50	4.50	Pink.	53.00	44.50	2.50	47.00	8002	1484.
46	A. Phipps, Middlebury, bottom	1.333	83.31	40.00	10.50	Red.	50.50	47.00	2.50	49.50	7544	1400.
47	J. Roush, Middlebury	1.239	77.42	49.50	7.00	Flesh.	56.50	40.00	3.50	43.50	7670	1423.
48	Stedman's, Centre Point, top	1.208	75.50	57.50	4.00	White.	61.50	35.50	3.00	38.50	7903	1466.
49	Stedman's, Centre Point, middle	1.216	76.00	50.50	8.00	White.	58.50	39.50	2.00	41.50	7904	1466.
50	Stedman's, Centre Point, bottom	1.220	76.25	60.00	5.00	White.	65.00	32.00	3.00	35.00	7784	1444.
51	J. Storm, Middlebury, top	1.204	75.25	52.50	7.00	White.	59.50	38.00	2.50	40.50	7728	1434.
52	J. Storm, Middlebury, middle	1.257	78.56	59.00	2.50	White.	61.50	36.00	2.50	38.50	8070	1497.
53	J. Storm, Middlebury, bottom	1.230	76.87	55.50	7.00	White.	62.50	35.50	2.00	37.50	7731	1434.
54	Wagstaff, Clay City, top	1.319	82.43	61.00	3.00	Red.	64.00	33.50	2.50	36.00	8003	1484.
55	Wagstaff, Clay City, middle	1.231	76.93	59.00	2.50	Pink.	61.50	36.00	2.50	38.50	8070	1497.
56	Wagstaff, Clay City, bottom	1.214	75.87	54.50	2.50	Pink.	57.00	40.50	2.50	43.00	8120	1506.
57	Ward & Perry, Oakland, bottom	1.165	72.81	57.00	3.50	Red.	60.50	36.50	3.00	39.50	7955	1476.
58	Ward & Perry, Oakland, top	1.162	72.62	58.50	3.00	White.	61.50	36.00	2.50	38.50	8030	1489.
59	Ward & Perry, Oakland, top	1.222	76.37	58.00	5.00	White.	63.00	34.50	2.50	37.00	7851	1456.
60	Woodruff & Fletcher, Hoosiertown, middle	1.221	76.31	55.50	6.50	White.	62.00	36.00	2.00	38.00	7787	1447.
61	Woodruff & Fletcher, Hoosiertown, middle	1.216	76.00	59.00	3.50	Flesh.	62.50	35.50	2.00	37.50	8024	1489.
62	Woodruff & Fletcher, Hoosiertown, bottom	1.188	74.12	58.00	1.50	White.	59.50	38.50	2.00	40.50	8218	1524.
63	Woodruff & Fletcher, near Brazil	1.142	71.37	59.00	1.50	White.	60.50	35.50	4.00	39.50	8024	1489.

Analyses of Coals, Daviess County, Indiana. Geological Report of Indiana, 1870, *E. T. Cox.*

64	Allen, Joseph, coal . . . . K	1.293	80.81	56.00	6.50	Brown.	62.50	30.50	7.00	37.50	7355	1364.
65	Aikman's coal L	1.270	79.37	56.50	3.00	N'rly white.	59.50	35.50	5.00	40.50	7860	1458.
66	Berry,s, Walter, coal	1.288	80.50	59.00	5.50	Brown.	64.50	28.50	7.00	35.50	7412	1375.
67	Cox's coal L	1.259	78.68	57.50	3.50	White.	61.00	35.00	4.00	39.00	7894	1465.
68	Clark's coal I	1.277	79.81	57.30	3.50	White.	60.80	34.70	4.50	39.20	7848	1456.
69	Dutch Bank L	1.264	79.00	61.50	2.00	White.	63.50	34.50	2.00	36.50	8171	1515.
70	Gregory's coal . . . . K?	1.276	79.75	60.50	2.00	Drab.	62.50	30.50	7.00	37.50	7719	1432.
71	John Gregory's coal . . . . K?	1.275	79.68	49.50	2.00	Lilac.	51.50	42.00	6.50	48.50	7897	1465.
72	McCord's coal . . . . K	1.245	77.81	54.00	2.00	Flesh.	56.00	40.00	4.00	44.00	8075	1498.
73	O'Brian's . . . . K	1.270	79.37	56.50	1.50	Salmon.	58.00	35.50	6.50	42.00	7860	1458.
74	Odell's coal . . . . A	1.262	78.87	53.00	2.00	White.	55.00	36.50	8.50	45.00	7670	1423.
75	Raymond's coal X	1.200	75.00	50.75	1.75	Cream.	52.50	46.50	1.00	47.50	8416	1561.
76	Spink & Cable, main shaft L	1.294	80.87	60.00	4.50	Fawn.	64.50	30.00	5.50	35.50	7632	1416.
77	Sulphur Spring Bank L	1.280	80.00	58.30	6.00	Brown.	64.30	31.20	4.50	35.70	7650	1419.
78	Spicer's Mill L	1.268	79.25	48.50	1.00	Blue.	49.50	44.00	6.50	50.50	8002	1484.
79	Stone's coal	1.264	79.00	54.30	2.00	Red brown.	56.30	35.20	8.50	43.70	7652	1419.
80	John Shaffer's coal . . . . A	1.308	81.75	58.00	3.50	Brown.	61.50	30.50	8.00	38.50	7517	1395.
81	Turner's coal . . . . A	1.278	79.75	55.50	1.50	White.	57.00	35.50	7.50	43.00	7779	1443.
82	Ward's coal . . . . A	1.261	78.81	55.00	2.50	White.	57.50	36.00	6.50	42.50	7785	1444.
83	Wilson's coal L	1.268	79.25	59.20	2.50	White.	61.70	34.90	3.40	38.30	8915	1489.
84	Buckeye Cannel Coal Company, Cannel coal	1.229	76.87	42.00	6.00	White.	48.00	48.50	3.50	52.00	7894	1465.

Daviess County Coals—Continued. *Geological Report of Indiana*, 1875, *E. T. Cox.*

85	J. S. Morgan, top, No. 1	1.277	79.81	56.00	5.50	Red.	61.50	32.50	6.00	38.50	7507	1393.
86	J. S. Morgan, bottom, No. 2	1.252	78.25	53.50	5.00	White.	58.50	36.00	5.50	41.50	7626	1415.
87	J. S. Morgan, lower seam, No. 3	1.239	77.44	53.00	2.50	White.	55.50	39.50	5.00	44.50	7906	1466.

Analyses of Coals, Dubois County, Indiana. Geological Report Indiana, 1871, *E. T. Cox.*

	NAME OF MINE OR OWNER.	Specific gravity.	Lbs. Weight of one cubic foot.	Fixed Carbon.	Ash.	Color of Ash.	Coke.	Gas.	Water.	Total volatile matter.	Units of Heat.	Steam Value. See page 10.
88	Burnham coal . . . . A	1.306	81.62	53.00	3.50	White.	56.50	39.00	4.5	43.50	7902	1466.
89	Elkin . . . . A	1.295	80.93	50.50	4.00	Brown.	54.50	39.00	6.5	45.50	7700	1429.
90	Harbison . . . . A	1.198	74.87	23.50	18.00	Pink.	33.50	60.50	6.0	66.50	7513	1394.
91	Hay, upper part . . . . A	1.289	80.56	51.50	3.50	White.	55.00	40.50	4.5	45.00	7920	1469.
92	Hay, middle part . . . . A	1.264	79.00	49.50	3.00	White.	52.50	40.50	7.0	47.50	7758	1439.
93	Hay, bottom part . . . . A	1.271	79.43	51.50	2.00	White.	53.50	40.00	6.5	46.50	7873	1461.
94	Kesler, upper part . . . . A	1.333	83.31	40.00	11.50	Blue.	51.50	41.50	7.0	48.50	7083	1314.
95	Kesler, middle part . . . . A	1.268	79.25	40.50	8.50	Gray.	49.00	45.00	6.0	51.00	7448	1382.
96	Kesler, bottom part . . . . A	1.260	78.75	40.50	9.00	Brown.	49.50	44.00	6.5	50.50	7356	1365.
97	Fest . . . . A	1.305	81.56	48.00	5.50	Faun.	53.50	41.00	5.5	46.50	7682	1425.
98	Bridenbaugh, upper part . . . . K	1.273	79.56	52.50	4.00	Red.	56.50	37.00	6.5	43.50	7676	1423.
99	Bridenbaugh, middle part . . . . K	1.265	79.06	51.50	3.50	Red.	55.00	40.50	4.5	45.00	7920	1469.
100	Bridenbaugh, bottom part . . . . K	1.246	77.87	52.50	3.50	Red.	56.00	39.00	5.0	44.00	7861	1458.
101	Rudolph . . . . K	1.361	78.81	48.50	4.00	Red.	52.50	42.00	5.5	47.50	7816	1450.
102	J. Stein	1.260	78.75	48.50	3.50	Brown.	52.00	43.50	4.5	48.00	7955	1476.
103	M. Wilson . . . . K	1.416	88.50	53.00	2.50	White.	55.50	40.50	4.0	44.50	8041	1491.
104	M. Wilson, another part of mine . . . . K	1.286	80.37	44.50	5.00	Red.	49.50	44.50	6.0	50.50	7725	1433.
105	Adam Smith, upper part . . . . K ?	1.256	78.50	43.50	3.50	White.	47.00	46.00	7.0	53.00	7783	1443.
106	Adam Smith, middle part . . . . K ?	1.335	83.43	49.00	2.50	White.	51.50	43.50	5.0	48.50	7996	1483.
107	Adam Smith, bottom part . . . . K ?	1.261	78.81	44.50	4.50	Gray.	49.00	45.50	5.5	51.00	7818	1149.
108	Bretzville . . . . A ?	1.275	79.68	49.00	3.50	White.	52.50	43.00	4.5	47.50	7950	1475.

Analyses of Coals, Fountain County, Indiana. Geological Report Indiana, 1869–'70–'75, *E. T. Cox.*

109	Norbourn Thomas, semi-block coal	1.277	79.81	59.80	4.5	. . . .	64.30	32.70	3.0	35.70	7818	1450.
110	W. B. Coates, top, coal . . . N	1.249	78.06	51.80	2.6	Brown.	54.40	42.60	3.0	45.60	8146	1511.
111	W. B. Coates, bottom . . . N	1.301	81.31	49.00	7.2	Gray.	56.20	40.20	3.6	43.80	7671	1423.
112	Hatfield's Mill, cannel coal	1.195	74.68	47.50	1.0	Red.	48.50	47.00	4.5	51.50	8199	1521.
113	Barker's	1.195	74.68	54.50	4.5	White.	59.00	36.00	5.0	41.00	7707	1429.
114	Judge Coates	1.220	76.25	47.50	3.0	White.	50.50	44.00	5.5	49.50	7875	1461.
115	Kirtland, top	1.203	75.18	47.50	2.5	Red.	50.00	46.00	4.0	50.00	8058	1493.
116	Kirtland, bottom	1.211	75.68	39.00	4.5	Brown.	43.50	53.00	3.5	56.50	8014	1487.
117	J. W. McKee, top	1.205	75.31	55.00	4.0	White.	59.00	35.00	6.0	41.00	7655	1420.
118	J. W. McKee, bottom	1.225	76.56	47.50	5.5	White.	53.00	41.50	5.5	47.00	7646	1418.
119	S. Thompson, top	1.239	77.43	52.50	4.5	White.	57.00	37.50	5.5	43.00	7682	1425.
120	S. Thompson, bottom	1.207	75.43	51.50	4.0	Flesh.	55.50	41.50	3.0	44.50	7969	1478.

Analyses of Coals, Greene County, Indiana. Geological Report Indiana, 1869, *E. T. Cox.*

121	Babbitt	1.238	77.30	59 90	1.5	. . . .	61.40	35.60	3.0	38.60	8142	1510.
122	Bledsoe	1.251	78.20	63.00	0.5	. . . .	63.50	29.50	7.0	36.50	7828	1452.
123	Harrell	1.263	78.31	48.10	2.5	. . . .	50.60	42.40	7.0	49.40	7822	1451.
124	McKissick	1.189	74.37	62.50	2.0	. . . .	64.50	32.00	3.5	35.50	8020	1488.
125	Templeton	1.238	77.37	59.30	4.5	. . . .	63.80	28.70	7.5	36.20	7499	1391.

Analyses of Coals, Gibson County, Indiana. Geological Report Indiana, 1873, *E. T. Cox.*

126	Finney	1.307	81.68	51.50	6.5	Brown.	58.00	36.00	6.0	42.00	7502	1391.
127	McGregor, coal . . . N	1.249	78.06	52.50	3.5	Yellow.	56.00	39.50	4.5	44.00	7908	1467.
128	Oakland City . . . L?	1.391	86.93	43.50	18.5	Red.	62.00	32.00	6.0	38.00	6484	1200.
129	G. S. Vanada	1.275	69.68	54.00	5.5	Red.	59.50	35.50	5.0	40.50	7658	1421.

Analyses of Coals, Knox County, Indiana. Geological Report Indiana, 1873, *E. T. Cox.*

	NAME OF MINE OR OWNER.	Specific gravity.	Lbs. Weight of one cubic foot.	Fixed Carbon.	Ash.	Color of Ash.	Coke.	Gas.	Water.	Total volatile matter.	Units of Heat.	Steam value. See page 10.
130	Curry, coal L	1.319	81.87	57.00	4.5	White.	61.50	34.50	4.0	38.50	7807	1447.
131	John Hooper. . . . . M	1.261	78.81	51.50	6.5	Red.	58.00	38.50	3.5	42.00	7734	1435.
132	Dr. Keith, upper . . . . . K	1.292	80.75	49.50	5.0	Gray.	54.50	39.50	6.0	45.50	7665	1422.
133	Dr. Keith, middle . . . . . K	1.311	81.93	49.00	6.0	Gray.	55.00	39.00	6.0	45.00	7578	1405.
134	Dr. Keith, lower . . . . . K	1.305	81.56	49.00	6.5	Brown.	55.50	39.00	5.5	44.50	7578	1405.
135	McKenna	. . . .	. . . .	57.50	4.0	White	61.50	35.00	3.5	38.50	7894	1465.
136	Sanborn . . . . . K	1.287	80.43	48.00	3.5	Brown.	51.50	44.50	4.0	48.50	8000	1484.
137	Sanborn, cannel coal . . . . . K	1.601	100.07	38.50	25.0	Brown.	63.50	33.00	3.5	36.50	6173	1146.
138	Shepard & Hazlet . . . . . K	1.304	81.50	49.00	6.5	Blue.	55.50	39.00	5.5	44.50	7578	1405.
139	A. Simonson, upper L	1.250	78.12	47.00	2.5	Faun.	49.50	47.00	3.5	50.50	8159	1514.
140	A. Simonson, middle L	1.244	77.75	49.50	3.5	Faun.	49.00	47.50	3.5	51.00	8408	1559.
141	A. Simonson, lower L	1.253	78.31	48.50	3.0	Pink.	51.50	45.50	3.0	48.50	8048	1493.
142	Simonson & Hulan, upper . . . . . K	1.281	80.06	45.50	3.0	White.	50.50	45.50	4.0	49.50	7899	1465.
143	Simonson & Hulan, middle . . . . . K	1.276	79.75	49.00	3.5	White.	52.50	43.00	4.5	47.50	7950	1475.
144	Simonson & Hulan, lower . . . . . K	1.286	81.00	52.00	7.0	Red.	59.00	37.50	3.5	41.00	7682	1425.
145	Swick . . . . . M ?	1.276	79.75	46.00	5.5	Red.	51.50	46.50	3.0	48.50	8032	1490.
146	James D. Williams . . . . . M ?	. . . .	. . . .	54.00	4.0	Brown.	58.00	38.50	3.5	42.00	7936	1472.
147	Weaver Coal Company (borings) . . . . . M ?	. . . .	. . . .	59.00	3.5	White.	62.50	34.00	3.5	37.50	7969	1478.
148	Weaver Coal Company, mine . . . . . M	1.277	79.81	52.00	4.5	Brown.	56.50	38.50	5.0	43.50	7774	1442.
149	Weaver Coal Company, mine L	1.286	81.00	53.00	5.0	Red.	58.00	38.50	3.5	42.00	7855	1457.

Analyses of Coals, Martin County, Indiana. Geological Report, Indiana, 1870, *E. T. Cox.*

150	Baker, upper part . . . . . A	1.238	77.37	51.25	1.5	White.	52.75	44.75	2.5	47.25	**8294**	1539.
151	Baker, lower part . . . . . A	1.239	77.43	48.75	0.8	White.	49.50	47.50	3.0	50.50	**8367**	1551.
152	Horn & Co . . . . . A	1.246	77.87	42.50	2.5	Brown.	45.00	52.00	3.0	55.00	**8259**	1532.
153	P. Hultz . . . . . A	1.262	78.87	47.50	2.5	White.	50.00	46.50	3.5	50.00	**8153**	1512.
154	Munson's Ridge, upper . . . . . A	1.270	79.37	50.00	1.5	Brown.	51.50	45.50	3.0	48.50	**8262**	1532.
155	Sampson's Hill, upper I	1.588	99.25	28.50	41.0	Gray.	69.50	25.00	5.5	30.50	**4228**	892.
156	Sampson's Hill, middle I	1.232	77.00	53.00	1.0	White.	54.00	44.00	2.0	46.00	**8365**	1551.
157	Sampson's Hill, bottom I	1.252	78.12	47.00	1.5	Red.	48.50	48.50	3.0	51.50	**8298**	1539.
158	Sampson's Hill, carbon markings	. . . .	. . . .	83.40	0.8	. . . . . .	84.20	13.30	2.5	15.80	**7963**	1477.
159	Turner, Sampson's Hill . . . . . A	1.350	84.31	45.50	9.0	Red.	54.50	41.50	4.0	45.50	**7528**	1396.
160	Willow Valley . . . . . A	1.286	80.37	48.00	2.5	Lead.	50.50	46.75	2.8	49.50	**8240**	1529.

Analyses of Coals, Montgomery County. Geological Report, Indiana, 1875, *E. T. Cox.*

161	B. Clover, near Waveland	1.254	78.37	52.00	3.5	White.	55.50	41.50	3.0	44.50	8010	1486.
162	H. S. Burford, near Waveland	1.202	75.12	49.00	5.0	White.	54.00	43.50	2.5	46.00	7950	1475.

Analyses of Coals, Owen County. Geological Report, Indiana, 1875, *E. T. Cox.*

163	Arney's, top	1.212	75.75	49.50	2.5	White.	52.00	45.00	3.0	48.00	8129	1508.
164	Arney's, middle	1.206	75.37	49.50	2.0	White.	51.50	45.00	3.5	48.50	8129	1508.
165	Arney's, bottom	1.271	79.44	51.50	5.0	Red.	56.50	40.50	3.0	43.50	7877	1461.
166	Reuben Barton	1.267	79.18	44.00	4.5	Red.	48.50	49.00	2.5	51.50	8051	1493.
167	James Beaman	1.240	77.50	52.50	3.0	Red.	53.50	41.00	3.5	44.50	8004	1485.
168	J. Brammer, Patricksburg, top	1.192	74.50	46.00	1.5	Yellow.	47.50	48.50	4.0	52.50	8167	1515.
169	J. Brammer, Patricksburg, middle	1.204	75.25	53.50	3.5	Red.	57.00	41.00	2.0	43.00	8085	1500.
170	J. Brammer, Patricksbarg, bottom	1.277	79.81	46.00	4.5	Pink.	50.50	47.00	2.5	49.50	8029	1489.

Analyses of Coals, Owen County—Continued. *Geological Report Indiana*, 1875, *E. T. Cox.*

	NAME OF MINE OR OWNER.	Specific Gravity.	Lbs. Weight of one cubic foot.	Fixed Carbon.	Ash.	Color of Ash.	Coke.	Gas.	Water.	Total volatile matter.	Units of Heat.	Steam Value. See page 10.
171	T. Burger, middle	1.191	75.68	54.00	1.5	White.	55.50	42.50	2.0	44.50	8262.	1532.
172	T. Burger, bottom	1.223	76.44	58.00	3.5	White.	61.50	35.00	3.5	38.50	7897.	1464.
173	Chambers, top	1.230	76.87	49.00	3.0	Brown.	52.00	45.50	2.5	48.00	8134.	1509.
174	Chambers, middle	1.237	77.31	56.50	2.0	White.	58.50	39.00	2.5	41.50	8143.	1511.
175	Chambers, bottom	1.248	78.00	50.00	8.5	Brown.	58.50	39.00	2.5	41.50	7618.	1413.
176	D. C. Cress	1.248	78.00	55.00	2.5	Yellow.	57.50	39.50	3.0	42.50	8068.	1496.
177	G. Croft, middle	1.214	75.87	57.50	2.0	White.	59.50	38.50	2.0	40.50	8178.	1516.
178	G. Croft, bottom	1.250	78.12	57.00	4.5	White.	61.50	36.00	2.5	38.50	7909.	1467.
179	Joel Dillon	1.243	77.68	53.00	4.5	White.	57.50	39.50	3.0	42.50	7906.	1467.
180	A. Fiscus	1.362	85.12	45.00	19.5	Gray.	64.50	33.00	2.5	35.50	6664.	1237.
181	C. Fletcher, top	1.219	76.18	60.00	3.0	White.	63.00	35.00	2.0	37.00	8059.	1495.
182	C. Fletcher, middle	1.206	75.37	58.00	2.5	White.	60.50	37.50	2.0	39.50	8126.	1507.
183	C. Fletcher, bottom	1.241	77.56	44.00	8.5	Red.	52.50	45.50	2.0	47.50	7638.	1416.
184	Louisa Hester, cannel slate	1.333	83.31	47.00	12.5	Gray.	59.50	36.00	4.5	40.50	7101.	1317.
185	James Jackson	1.222	76.31	32.50	9.5	Pink.	42.00	54.00	4.0	58.00	7580.	1406.
186	McCreary, top	1.280	80.00	53.50	5.5	Brown.	59.00	38.00	3.0	41.00	7809.	1449.
187	McCreary, bottom	1.276	79.76	51.60	4.5	Red.	55.50	42.00	2.5	44.50	7974.	1479.
188	W. S. Norris	1.282	80.12	45.00	5.0	Red.	50.00	48.00	2.0	50.00	8040.	1491.
189	Oberholtzer, middle	1.242	77.62	57.00	4.5	Yellow.	61.50	35.00	3.5	38 50	7817.	1450.
190	Oberholtzer, bottom	1.292	80.75	53.00	9.5	White.	62.50	34.50	3.0	37.50	7447.	1381.
191	Jesse Reagan, top	1.261	78.81	52.50	7.5	White.	60.00	37.00	3.0	40.00	7555.	1402.

192	Jesse Reagan, middle	1.230	76.87	52.00	5.0	White.	57.00	40.50	2.5	43.00	7918	1450.
193	Jesse Reagan, bottom	1.250	78.12	52.50	5.5	White.	58.00	39.50	2.5	42.00	7866	1441.
194	J. Rowe, middle	1.235	77.18	56.00	5.0	White.	61.00	36.00	3.0	39.00	7828	1433.
195	J. Rowe, bottom	1.213	75.81	53.50	4.5	White.	58.00	39.00	3.0	42.00	7901	1466.
196	Wm. Royer, top	1.260	78.75	55.50	4.0	White.	59.50	38.00	2.5	40.50	7970	1479.
197	Wm. Royer, middle	1.193	74.56	55.00	3.0	Pink.	58.00	39.00	3.0	42.00	8022	1488.
198	Wm. Royer, bottom	1.219	76.18	51.50	4.0	White.	55.50	41.50	3.0	44.50	7969	1478.
199	J. C. Stahl	1.203	75.18	58.00	3.0	White.	61.00	36.00	3.0	39.00	7989	1482.
200	White	1.216	76.00	55.50	2.5	Pink.	58.00	39.00	3.0	42.00	8062	1495.

Analyses of Coals, Parke County. Geological Reports Indiana, 1869–'70–'71–'75, *E. T. Cox.*

201	Batty's Mine I	1.231	76.93	56.00	2.5	. . . .	58.50	38.50	3.0	41.50	8097	1502.
202	Buchanan's Mine I	1.232	77.00	62.50	2.0	. . . .	64.50	31.00	4.5	35.50	7927	1470.
203	Judge Maxwell	. . . .	. . . .	48.75	2.5	White.	51.25	45.50	3.25	48.70	8182	1518.
204	Cannel slate, near Rockville	. . . .	. . . .	34.50	26.0	Dark.	60.50	32.00	7.5	39.50	5757	1066.
205	Sand Creek coal	1.296	81.00	45.50	4.5	Light.	50.00	45.50	4.5	50.00	7899	1465.
206	Beard's coal	1.191	74.43	48.50	1.0	White.	49.50	42.50	8.0	50.50	7863	1459.
207	Moore's Mill	1.228	76.75	46.50	3.5	Brown.	50.00	46.00	4.0	50.00	7977	1479.
208	Bethany, cannel? coal	. . . .	. . . .	43.00	4.5	White.	47.50	47.00	5.5	52.50	7836	1453.

Analyses of Coals, Perry County. Geological Report Indiana, 1871, *E. T. Cox.*

	NAME OF MINE OR OWNER.	Specific gravity.	Lbs. Weight of one cubic foot.	Fixed Carbon.	Ash.	Color of Ash.	Coke.	Gas.	Water.	Total volatile matter.	Units of Heat.	Steam value. See page 10.
209	Everard's, coal . . . . A	. . . .	. . . .	54.00	1.5	Red.	55.50	37.00	7.5	44.50	7797	1446.
210	Rock Island Seam, top . . . . F	. . . .	. . . .	52.50	2.0	White.	54.50	41.00	4.5	45.50	8047	1493.
211	Rock Island Seam, middle . . . . F	. . . .	. . . .	58.00	11.0	Red.	69.50	27.50	3.0	30.50	7461	1384.
212	Rock Island Seam, bottom . . . . F	. . . .	. . . .	50.00	8 5	White.	58.50	37.00	4.5	41.50	7473	1386.
213	Rock Island Seam, slaty bottom	. . . .	. . . .	49.50	12.5	Lemon.	62.00	34.00	4.0	38.00	7155	1328.
214	Rock Island Seam, cannel . . . . F	. . . .	. . . .	45.50	6.0	White.	51.50	42.00	6.5	48.50	7574	1405.
215	Cannelton, upper . . . . F	. . . .	. . . .	51.50	4.0	White.	55.50	41.00	3.5	44.50	7966	1478.
216	Cannelton, middle . . . . F	. . . .	. . . .	48.50	2.0	Brown.	50.50	43.00	6.5	49.50	7909	1467.
217	Cannelton, bottom . . . . F	. . . .	. . . .	45.50	3.5	Red.	49.00	46.00	5.0	51.00	7945	1474.
218	Clarke Brothers, upper . . . . F	. . . .	. . . .	48.50	2.0	White.	50.50	42.50	7.0	49.50	7863	1459.
219	Clarke Brothers, middle . . . . F	. . . .	. . . .	49.50	3.5	White.	53.00	40.50	6.5	47.00	7758	1440.
220	Clarke Brothers, bottom . . . . F	. . . .	. . . .	48.50	4.0	White.	52.50	41.00	6.5	47.50	7724	1433.
221	Heck's Mine, upper . . . . F	. . . .	. . . .	49.50	6.0	Blue.	55.50	40.00	4.5	44.50	7712	1430.
222	Heck's Mine, lower . . . . F	. . . .	. . . .	45.00	8.5	Red.	53.50	43.00	3.5	46.50	7626	1415.
223	McMahon, upper	. . . .	. . . .	48.50	4.0	Blue.	52.50	41.50	6.0	47.50	7770	1441.
224	McMahon, lower	. . . .	. . . .	50.50	5.5	Brown.	56.00	39.50	4.5	44.00	7746	1437.

Analyses of Coals, Pike County. Geological Report, Indiana, 1871, *E. T. Cox.*

225	Thomas Case	L ?	1.280	80.00	45.50	4.0	Faun.	49.50	47.00	3.5	50.50	8038	1491.
226	Bennett	K	1.268	79.25	45.50	3.5	Brown.	49.00	45.00	6.0	51.00	7852	1457.
227	Alexander's Seam	N	1.284	80.25	49.50	3.0	White.	52.50	41.50	6.0	47.50	7851	1457.
228	Alexander, another part of seam	N	1.259	78.69	52.00	4.0	White.	56.00	36.00	8.0	44.00	7542	1401.
229	Dr. Posey, upper	K	1.288	80.50	48.00	5.5	Blue.	53.50	40.00	6.5	46.50	7590	1408.
230	Dr. Posey, middle	K	1.275	79.68	48.00	4.0	Faun.	52.00	41.00	7.0	48.00	7683	1425.
231	Dr. Posey, bottom	K	1.244	77.75	50.50	6.0	Brown.	56.50	38.00	5.5	43.50	7607	1412.
232	Shandy's, upper	K	1.279	79.91	51.50	5.0	White.	56.50	37.00	6.5	43.50	7595	1409.
233	Shandy's, lower	K	1.270	79.37	49.00	3.5	White.	52.50	41.50	6.0	47.50	7810	1449.
234	DeBruler, upper	K	1.294	80.87	42.00	5.0	Blue.	47.00	45.00	8.0	53.00	7569	1404.
235	DeBruler, middle	K	1.271	79.43	44.50	5.5	Brown.	50.00	44.00	6.0	50.00	7679	1425.
236	DeBruler, bottom	K	1.268	79.25	50.00	3.5	Blue.	53.50	40.00	6.5	46.50	7752	1438.
237	Crowe's, upper	L	1.274	79.62	52.50	3.5	Faun.	56.00	35.50	8.5	44.00	7536	1398.
238	Crowe's lower	L	1.262	78.87	47.90	8.5	Gray.	56.40	35.10	8.5	43.60	7086	1315.
239	T. Smith's	N	1.279	79.93	53.50	2.5	White.	56.00	38.50	5.5	44.00	7896	1465.
240	Hawthorn & Gleason	L	1.269	79.31	45.50	14.0	Gray.	59.50	32.00	8.5	40.50	6646	1233.
241	Barrs	M	1.260	78.75	57.00	3.5	White.	60.50	32.50	7.0	39.50	7622	1414.
242	Falls, upper	N	1.274	79.62	47.00	5.0	Faun.	52.00	42.50	5.5	48.00	7742	1436.
243	Falls, lower	N	1.268	79.25	51.50	4.0	White.	55.50	37.00	7.5	44.50	7595	1409.
244	Owner unknown	K	1.268	79.25	48.00	3.0	White.	51.00	44.50	4.5	49.00	8008	1486.
245	DeTar, upper	A	1.444	90.25	41.50	14.0	Red.	55.50	37.00	7.5	44.50	6787	1259.
246	DeTar, lower	A	1.288	80.50	49.50	5.0	Red.	54.50	40.00	5.5	45.50	7712	1431.
247	Bees, coal	K	1.269	79.31	44.50	14.0	Brown.	58.50	37.00	4.5	41.50	7529	1378.
248	Moulton, upper	K	1.244	77.80	48.00	3.5	Blue.	51.50	43.00	5.5	48.50	7869	1460.
249	Moulton, middle	K	1.257	78.56	50.50	8.5	Red.	59.00	36.50	4.5	41.00	7468	1385.
250	Moulton, bottom	K	1.257	78.56	49.50	3.0	White.	52.50	41.50	6.0	47.50	7851	1456.
251	Thomas	K	1.280	80.00	48.50	4.0	White.	52.50	40.50	7.0	47.50	7677	1425.
252	Wells & Whitman, upper	L	1.294	80.87	52.50	2.5	White.	55.00	37.00	8.0	45.00	7676	1425.
253	Wells & Whitman, middle	L	1.278	79.87	50.50	2.0	White.	52.50	41.50	6.0	47.50	7932	1471.
254	Wells & Whitman, bottom	L	1.275	79.68	50.50	2.5	White.	53.00	42.00	5.0	47.00	7978	1480.

Analyses of Pike County Coals—Continued. *Geological Report of Indiana*, 1871, *E. T. Cox.*

	NAME OF MINE OR OWNER.	Specific Gravity.	Lbs. Weight of one cubic foot.	Fixed Carbon.	Ash.	Color of Ash.	Coke.	Gas.	Water.	Total volatile matter.	Units of Heat.	Steam Value. See page 10.
255	Massey, upper L	1.268	79.25	53.50	3.5	Gray.	57.00	34.50	8.5	43.00	7524	1396.
256	Massey, lower L	1.279	79.93	55.00	1.5	White.	56.50	36.50	7.0	43.50	7831	1453.
257	Martin, upper L	1.258	78.62	52.00	3.5	Gray.	55.50	37.00	7.5	44.50	7635	1416.
258	Martin, middle L	1.269	79.31	57.00	3.0	Gray.	60.00	33.50	6.5	40.00	7724	1433.
259	Martin, bottom L	1.275	79.68	55.00	2.5	White.	57.50	35.00	7.5	42.50	7692	1427.
260	Tevault . . . . K	1.245	77.81	49.50	3.0	White.	52.50	40.50	7.0	47.50	7758	1440.
261	Wood . . . . K	1.272	79.50	45.00	3.0	White.	48.00	47.50	4.5	52.00	8044	1492.
262	Ingham, upper . . . . K?	1.280	80.00	49.00	2.0	White.	51.00	41.50	7.5	49.00	7810	1449.
263	Ingham, lower . . . . K?	1.311	81.93	50.50	2.0	White.	52.50	41.00	6.5	47.50	7885	1463.

Analyses of Coal, Spencer County. Geological Report of Indiana, 1870–'71, *E. T. Cox.*

264	Priest coal	1.282	80.12	51.90	1.5	Cream.	53.40	43.10	3.5	46.60	8192	1518.
265	W.-L. Barker I	1.317	82.31	43.50	6.5	Brown.	50.00	47.50	2.5	50.00	7923	1470.
266	Brashear & Howard I	1.281	80.06	52.50	1.0	White.	53.50	43.00	3.5	46.50	8232	1527.
267	Barr & Bro., upper L	1.274	79.62	46.00	2.5	Brown.	48.50	48.00	3.5	51.50	8171	1515.
268	Barr & Bro., middle L	1.282	80.12	48.50	2.5	Brown.	51.00	45.00	4.0	49.00	8095	1502.
269	Barr & Bro., lower L	1.278	79.87	48.50	3.0	Light red.	48.50	47.00	4.5	51.50	8280	1536.
270	R. L. Crosley L	1.267	79.17	47.50	4.0	Red.	51.50	45.00	3.5	48.50	8014	1487.
271	Lewisport I	1.294	78.06	47.50	1.0	White.	48.50	47.50	4.0	51.50	8246	1529.

272	Rockport		1.275	79.68	49.50	4.0	White.	53.50	40.00	6.5	46.50	7712	1431.
273	L. G. Smith		1.232	77.00	45.50	1.5	White.	47.00	47.00	6.0	53.00	8038	1491.
274	Staal's coal	I	1.237	77.31	47.20	3.5	Gray.	50.70	44.30	5.0	49.30	7927	1470.
275	Staal's coal (Col. J. W. Foster)	I	1.243	77.68	54.00	1.6	White.	55.60	42.60	1.8	44.40	8307	1541.
276	Stocking's coal		1.267	79.18	46.60	3.0	Brown.	49.60	47.90	2.5	50.40	8212	1523.
277	Woods' coal	I	1.289	80.56	48.00	3.5	Brown.	51.50	45.50	3.0	48.50	8101	1503.
278	H. B. Kittaen	A	1.244	77.75	46.50	2.0	White.	48.50	47.00	4.5	51.50	8119	1506.
279	Kathman, upper	A	1.250	78.12	45.50	2.0	White.	47.50	48.50	4.0	52.50	8084	1500.
280	Kathman, lower	A	1.251	78.18	47.50	2.5	White.	50.50	45.00	5.0	50.50	8014	1487.
281	Abbott of St. Meinrod	F	1.265	79.06	50.50	5.0	Brown.	55.50	39.00	5.5	44.50	7690	1427.

Analyses of Coals, Sullivan County. Geological Report of Indiana, 1870, *E. T. Cox.*

282	Chambers	N	1.206	75.37	48.50	2.0	Brown.	50.50	45.00	4.5	49.50	8095	1502.
283	B. & L. Burk	M	1.210	75.62	51.00	1.5	White.	52.50	44.00	3.5	47.50	8204	1522.
284	Dicks, upper	M	1.258	78.62	50.50	1.5	White.	52.00	43.50	4.5	48.00	8117	1505.
285	Dicks, middle	M	1.252	78.25	55.80	0.5	White.	55.30	39.20	4.5	44.70	8144	1510.
286	Dicks, lower	M	1.278	79.05	52.00	2.5	Red.	54.50	42.00	3.5	45.50	8099	1502.
287	Hanna, Standard	L	1.281	80.06	54.00	2.5	Gray.	56.50	40.50	3.0	43.50	8122	1506.
288	Pigg's coal	M	1.271	79.43	49.00	2.5	Red.	51.50	42.50	6.0	48.50	7903	1466.
289	St. Johns	M	1.287	80.43	49.00	2.5	White.	51.50	45.00	3.5	48.50	8135	1509.
290	Henry K. Wilson	M	1.228	76.75	51.60	0.8	White.	52.40	45.25	2.35	47.60	8360	1551.
291	H. Wilson, Cass Tp.	M	1.249	78.06	52.00	2.0	Blue.	54.00	43.00	3.0	46.00	8192	1520.
292	Curryville Shaft	L	1.282	80.12	51.50	1.0	Red.	52.50	43.50	4.0	47.50	8198	1521.
293	Richards & Buckley, top	L	1.278	79.05	51.50	2.5	Red.	54.00	43.00	3.0	46.00	8152	1513.
294	Richards & Buckley, middle	L	1.284	80.25	50.25	2.0	Cream.	52.25	44.75	3.0	47.75	8213	1505.
295	Richards & Buckley, bottom	L	1.296	81.00	53.70	2.8	Red.	56.50	39.75	3.75	43.50	8011	1486.
296	Standard Coal Company	L	1.333	83.31	55.20	2.9	White.	58.10	40.10	1.8	41.90	8155	1513.

Analyses of Coals, Sullivan County. Geological Report of Indiana, 1871–'75, E. T. Cox.

	NAME OF MINE OR OWNER.	Specific Gravity.	Lbs. Weight of one cubic foot.	Fixed Carbon.	Ash.	Color of Ash.	Coke.	Gas.	Water.	Total volatile matter.	Units of Heat.	Steam value. See page 10.
297	Curryville, upper part	....	....	56.50	2.50	White.	59.00	36.50	4.5	41.00	**7952**	1475.
298	Curryville, middle	....	....	53.50	1.50	White.	55.00	40.00	5.0	45.00	**8035**	1490.
299	Curryville, lower	....	....	52.50	3.00	White.	55.50	40.00	4.5	44.50	**7954**	1476.
300	Dicks' coal, five years out of mine	1.239	77.43	55.00	1.5	White.	56.50	40.00	3.5	43.50	8114	1505.
301	Dicks' coal, fresh from mine	1.258	78.62	50.50	1.5	White.	52.00	43.50	4.5	48.00	8071	1497.

Analyses of Coals, Vanderburg County. Geological Report of Indiana, 1875, E. T. Cox.

302	Ingleside . . . L	1.275	79.68	53.50	4.0	Red.	57.50	39.00	3.5	42.50	7901	1466.
303	Ingleside, top . . . M	1.273	79.56	44.00	13.5	White.	57.50	39.50	3.0	42 50	7179	1332.
304	Ingleside, middle . . . M	1.275	79.68	48 50	6.0	White.	54.50	42.00	3.5	45.50	7772	1442.
305	Ingleside, bottom . . . M	1.336	83.50	46.00	11.0	White.	57.00	39.50	3.5	43.00	7341	1363.

Analyses of Coals, Vermillion County. Geological Reports of Indiana, 1869–'75, E. T. Cox.

306	Grove's mine . . . L	1.289	80.50	47.70	4.5	....	52.20	44.30	3.5	47.80	**7965**	1478.
307	Charles Moore	1.258	78.62	46.00	4.5	Flesh.	50.50	44.00	5.5	49.50	7751	1438.

Analyses of Coals, Vigo County. Geological Reports of Indiana, 1870–'75, *E. T. Cox.*

308	Foote's coal, Honey Creek		1.217	76.06	50.10	1.8	Brown.	51.90	44.40	3.7	48.10	8168	1515.
309	Titcomb's coal, Grant	L?	1.257	78.56	46.50	2.5	White.	49.00	48.00	3.0	51.00	8212	1523.
310	Roof of Titcomb's coal		1.493	93.50	39.00	32.0	Fawn.	71.00	25.00	4.0	29.00	5471	1013.
311	Arbuckle & Budd, Seelyville, top		1.211	75.68	48.00	3.5	White.	51.50	45.00	3.5	48.50	8007	1485.
312	Arbuckle & Budd, Seelyville, bottom		1.250	78.12	50.00	3.5	White.	53.50	43.50	3.0	46.50	8031	1490.
313	Barrick & Sons		1.192	74.50	48.20	4 3	Red.	52.50	44.50	3.0	47.50	8000	1484.
314	H. Brayton, Grant		1.216	76.00	44.00	8.5	Red.	52.50	44.00	3.5	47 50	7592	1409.
315	Foote's bore		1.217	76.06	50.10	1.8	Brown.	51.90	44.40	3.7	48.10	8123	1507.
316	P. H. Holloman		1.242	77.62	42.00	12.5	White.	54.50	42.00	3.5	45.50	7247	1344.
317	G. W. Mooreland		1.195	74.70	47.50	4.5	Red.	52.00	43.50	4.5	48.00	7829	1452.
318	A. McPherson		1.239	77.43	56.50	4.0	White.	60.50	37.00	2.5	39.50	7959	1477.
319	McQuilkins		1.210	75.62	47.50	3.5	White.	51.00	44.50	4.5	49.00	7921	1469.
320	F. Rhyan		1.226	76.62	48.50	6.0	Flesh.	54.50	43.50	2.0	45.50	7910	1467.
321	Somerset Coal Co		1.210	75.62	51.00	1.5	White.	52.50	43.00	4.5	47.50	8066	1496.
322	Webster & Bramwell, top		1.197	74.81	48.00	3 0	Purple.	51.00	46.00	3.0	49.00	8098	1503.
323	Webster & Bramwell, bottom		1.210	75.62	47.50	4.0	Red.	51.50	45.50	3.0	48.50	8013	1487.
324	Wyeth, Hartford, top		1.237	77.31	49.00	7.5	White.	56.50	41.00	2.5	43.50	7721	1432.
325	Wyeth, Hartford, bottom		1.216	76.00	51.00	4.5	White.	55.50	42.00	2.5	44.50	7974	1479.

Analyses of Coals, Warrick County. Geological Reports of Indiana, 1870–'75, *E. T. Cox.*

326	Locust Grove, No. 1	I	1.300	81 25	47.50	14.0	Brown.	61.50	34.50	4.0	38.50	7040	1306.
327	Locust Grove, No. 2	I	1.279	79.93	50.50	2.0	White.	52.50	44.50	3.0	47.50	8210	1523.
328	Locust Grove, No. 3	I	1.313	82.06	46.00	7.0	Brown.	53.00	45.00	2.0	47.00	7893	1465.
329	Locust Grove, No. 4	I	1.282	80.31	50.50	2 5	White.	53.00	44.50	2.5	47.00	8210	1523.
330	Chandler's, top	M	1.274	79.62	47.50	9.0	White.	56.50	40.00	3.5	43.80	7508	1392.
331	Chandler's, middle	M	1.282	80.12	49.50	5.5	White.	55.00	41.50	3.5	45.00	7808	1449.
332	Chandler's, bottom	M	1.283	80.18	45.00	16.5	White.	61.50	34.50	4.0	38.50	6801	1262.
333	Millersburg, middle	N	1.242	77.62	53.00	2.5	Blue.	55.50	41.50	3.0	44.50	8090	1501.
334	Millersburg, bottom	N	1.243	77.68	49.00	2.0	Brown.	51.00	45.50	3.5	49.00	8042	1492.

Analyses of Coals, Warren County. Geological Report of Indiana, 1873, E. T. Cox.

	NAME OF MINE OR OWNER.		Specific Gravity.	Lbs. Weight of one cubic foot.	Fixed Carbon.	Ash.	Color of Ash.	Coke.	Gas.	Water.	Total volatile matter.	Units of Heat.	Steam Value. See page 10.
335	John Briggs, coal	K	1.212	75.75	48.50	2.0	Flesh.	50.50	44.75	4.75	49.50	**8071**	1497.
336	J. T. Briscoe, upper	L	1.223	76.44	57.50	7.0	Gray.	64.50	32.00	3.50	35.50	**7616**	1413.
337	J. T. Briscoe, middle	L	1.267	79.18	54.70	8.0	Blue.	62.70	33.80	3.50	37.30	**7559**	1402.
338	J. T. Briscoe, lower	L	1.350	84.37	52.25	16.0	Blue.	68.25	28.75	3.0	31.75	**6890**	1278.
339	R. W. Claypool, upper	L	1.246	77.87	48.50	10.0	Red.	58.50	38.50	3.0	41.50	**7491**	1390.
340	R. W. Claypool, middle	L	1.204	75.87	55.50	2.5	White.	58.00	38.00	4.0	42.00	**8011**	1486.
341	R. W. Claypool, lower	L	1.205	75.31	54.50	8.5	Brown.	63.00	34.00	3.0	37.00	**6751**	1253.
342	R. W. Claypool	M	....	....	48.00	3.5	Brown.	51.50	45.00	3.5	48.50	**8050**	1493.
343	Goodrick	M	1.343	83.93	45.00	9.5	Red.	54.50	39.50	6.0	45.50	**7302**	1355.
344	Goodrick, upper	L	1.304	81.50	46.50	8.5	Purple.	55.00	42.00	3.0	45.00	**7655**	1420.
345	Goodrick, lower	L	1.262	78.87	46.00	4.5	Flesh.	50.50	46.50	3.0	49.50	**8032**	1490.
346	Hooper & Barringer, upper	L	1.238	77.37	59.00	2.5	White.	61.50	34.50	4.0	38.50	**7967**	1478.
347	Hooper & Barringer, lower	L	1.236	77.35	56.00	2.5	White.	58.50	35.00	6.5	41.50	**7773**	1442.
348	Harold & Co., upper	L	1.282	80.15	54.00	6.5	Red.	60.50	36.00	3.5	39.50	**7704**	1429.
349	Harold & Co., middle	L	1.290	80.62	49.50	7.5	White.	57.00	38.50	4.5	43.00	**7572**	1405.
350	Harold & Co., lower	L	1.252	78.25	56.00	3.5	White.	59.50	31.00	9.5	40.50	**7401**	1373.
351	Jarvis, upper	K	1.243	77.68	50.50	6.5	Red.	57.00	38.00	5.0	43.00	**7607**	1411.
352	Jarvis, middle	K	1.251	78.18	53.50	3.0	White.	56.50	40.75	2.75	43.50	**8104**	1504.
353	Jarvis, lower	K	1.348	84.25	51.50	12.0	White.	63.50	33.00	3.5	36.50	**7183**	1333.
354	Luppoldt, upper	L	1.222	76.37	49.00	9.5	Red.	58.50	37.00	4.5	41.50	**7386**	1370.
355	Luppoldt, middle	L	1.254	78.37	52.50	9.0	Red.	61.50	33.50	5.0	38.50	**7351**	1364.

356	Luppoldt, lower L	1.256	78.50	57.00	4.5	White.	61.60	35.50	3.0	38.50	7900	1465.
357	Schoonover, upper . . . . K	1.284	80.25	49.40	9.5	Red.	58.90	37.60	3.5	41.10	7480	1488.
358	Schoonover, lower . . . . K	1.229	76.81	55.25	6.25	Red.	61.50	34.00	4.8	38.50	7640	1417.
359	John Thomas . . . . M	1.415	88.43	49.50	12.5	Red.	62.00	33.50	4.5	38.00	7108	1318.
360	Tinker & Co., upper L	1.257	78.56	50.00	3.5	Red.	53.50	43.50	3.0	46.50	8077	1405.
361	Tinker & Co., middle L	1.282	80.12	47.00	3.0	Blue.	50.00	44.50	5.5	50.00	7927	1278.
362	Tinker & Co., lower L	1.244	77.75	50.50	5.0	Red.	55.50	42.50	2.0	44.50	8024	1489.

Analysis of Coals, Posey County. Geological Report of Indiana, 1875, *E. T. Cox.*

363	G. Heldfert, St. Wendells	1.327	82.93	51.00	5.5	Brown.	56.50	39.50	4.0	43.50	7745	1437.

Analyses of Peat, Northern Counties. Geological Report of Indiana, 1869–'70–'71, *E. T. Cox.*

364	Peat from St. Joseph county	. . . .	. . . .	26.50	9.5	Yellow.	36.00	55.50	8.5	64.00	7292	1353.
365	Peat from Lake county	. . . .	. . . .	21.50	23.0	Buff.	42.50	51.25	6.25	57.50	6493	1202.

Analyses of Indiana Coals, by Dr. David Dale Owen, in 1838.

								Car.	Bit.			
366	Fountain County, Sugar Creek Foundry	1.219	76.18	43.90	3.5	White.	47.40	75.00	20.00	52.60	7916	1468.
367	Fountain County, Coal Creek	1.260	78.75	44.60	15.0	Brown.	59.60	60.00	25.00	40.40	7168	1330.
368	Vermillion County, Brouillet's Creek	1.270	79.37	42.00	9.0	Yellow.	51.00	52.00	39.00	49.00	7821	1451.
369	Sullivan County, Lick Fork	1.240	77.50	54.90	2.0	White.	56.90	70.00	28.00	43.10	8254	1531.
370	Vigo County, Honey Creek	1.240	77.50	46.10	2.5	White.	48.60	70.00	27.50	51.40	8208	1523.

Analyses of Indiana Coals by Prof. Richard Owen in 1859–'60.

	NAME OF MINE OR OWNER.	Specific Gravity.	Lbs. Weight of one cubic foot.	Fixed Carbon.	Ash.	Color of Ash.	Coke.	Gas.	Water.	Total volatile matter.	Units of Heat.	Steam Value. See page 10.
371	Clay County, Brazil shaft	. . . .	. . . .	44.0	3.0	White.	47.0	48.0	5.0	53.0	8010	1486.
372	Clay County, Staunton	. . . .	. . . .	55.0	1.0	Gray.	56.0	39.0	5.0	44.0	8063	1496.
373	Dubois County, Portersville	. . . .	. . . .	50.0	5.0	Gray.	55.0	39.0	6.0	45.0	7659	1421.
374	Dubois County, Celestine	. . . .	. . . .	53.0	3.0	Gray.	56.0	39.0	5.0	44.0	7902	1466.
375	Dubois County, S. H. Jacobs	. . . .	. . . .	55.0	3.0	Gray.	58.0	34.0	8.0	42.0	7599	1410.
376	Fountain County, N. Thomas	. . . .	. . . .	51.5	4.5	. . . .	55.0	37.0	8.0	45.0	7595	1409.
377	Greene County, T. Hays	. . . .	. . . .	53.0	2.0	Gray.	55.5	36.0	8.5	44.5	7623	1415.
378	Harrison County, M. Smith's	. . . .	. . . .	54.5	4.0	Gray.	58.5	31.5	10.0	41.5	7327	1359.
379	Harrison County, A. Rosenberg	. . . .	. . . .	41.2	10.0	Red.	51.2	46.8	2.0	48.8	7674	1423.
380	Harrison County, Houghton's	. . . .	. . . .	48.7	12.0	Red.	60.7	30.3	9.0	39.3	6749	1252.
381	Harrison County, Leavenworth	. . . .	. . . .	40.0	20.0	Red.	60.0	29.0	11.0	40.0	5923	1100.
382	Orange County, Powell's	. . . .	. . . .	50.4	7.0	Gray.	57.4	35.6	7.0	42.6	7375	1368.
383	Parke County, W. G. Coffin	. . . .	. . . .	49.0	3.0	Gray.	52.0	42.0	6.0	48.0	7857	1457.
384	Parke County, J. W. Campbell	. . . .	. . . .	49.0	2.0	Brown.	51.0	42.0	7.0	49.0	7857	1457.
385	Perry County, Cannelton	. . . .	. . . .	50.0	3.0	Light.	53.0	39.0	8.0	47.0	7659	1421.
386	Pike County, Hughes	. . . .	. . . .	51.0	5.0	Dark.	56.0	38.0	6.0	44.0	7647	1418.
387	Pike County, Rhodes	. . . .	. . . .	54.5	1.0	Red.	55.5	30.0	14.5	44.5	7187	1333.
388	Posey County, Priest	. . . .	. . . .	42.0	19.0	. . . .	61.0	36.0	3.0	39.0	6734	1250.
389	Spencer County, Woods	. . . .	. . . .	48.0	3.5	. . . .	51.5	45.0	3.5	48.5	8054	1494.
390	Vermillion County, Bell & Groves	. . . .	. . . .	54.0	3.0	Red.	53.0	33.0	10.0	47.0	7426	1278.
391	Warren County, Burr's Mill	. . . .	. . . .	40.0	15.0	Gray.	55.0	40.0	5.0	45.0	6944	1289.
392	Warren County, Kiester's	. . . .	. . . .	51.5	6.5	White.	58.0	40.0	2.0	42.0	7873	1461.

Analyses of Ohio Coals by Prof. Womley. Geological Report of Ohio, " Vol. III, Geology."

393	Hocking Valley, Stallsmith Seam	1.254	. . . .	51.85	4.14	. . . .	55.99	36.41	3.8	40.21	**7566**	1403.
394	Straitsville, " Great Seam "	1.270	. . . .	59.61	3.04	. . . .	62.65	31.37	5.98	31.37	**7727**	1433.
395	Keith's Mine, Coshocton County	1.339	. . . .	54.70	5.10	. . . .	59.80	32.20	4.00	36.20	**7408**	1375.
396	Steubenville, Jefferson County	1.308	. . . .	65.90	1.80	. . . .	67.70	29.50	1.40	30.90	**8062**	1496.
397	Briar Hill or Mahoning Valley coal	1.284	. . . .	62.66	1.16	. . . .	63.82	32.58	3.60	36.10	**8086**	1500.

Jackson coal, Star shaft (Womley), specific gravity, 1.267; water, 7.50; ash, 4.10; volatile matter, 30.90; fixed carbon, 57.50; heat units, 7513.5; gallons of water from 100° to steam at atmosphere pressure, 1391.

Jackson coal, Star shaft (Levette), specific gravity, 1.270; coke, 64.50; volatile matter, 35.50; ash, 6.00; fixed carbon, 58.50; gas, 30.00; water, 5.50; heat units, 7510.8; gallons of water from 100° to steam at atmosphere pressure, 1391.

Analyses of Kentucky Coals by Dr. Peters. Geological Report of Kentucky, Vol. 1, 1875.

398	Boyd County, Buena Vista Furnace	1.328	. . . .	52.78	6.82	. . . .	59.60	33.90	6.50	40.40	**7408**	1375.
399	Carter County, Star Furnace, bottom	1.288	. . . .	54.64	4.40	. . . .	59.04	34.36	6.60	40.96	**7634**	1416.
400	Greenup County, Amanda Furnace	1.335	. . . .	53.34	9.00	. . . .	62.34	33.62	4.04	37.66	**7424**	1278.
401	Muhlenburg County, Airdrie Furnace	1.278	. . . .	58.50	6.50	. . . .	65.00	31.40	3.60	35.00	**7650**	1419.

Analyses of Pennsylvania Coals by A. S. McCreath. Pa. 2d Geol. Survey, Vol. M.M.

	NAME OF MINE OR OR OWNER.	Specific Gravity.	Lbs. Weight of 1 Cubic Foot.	Fixed Carbon.	Ash.	Color of Ash.	Coke.	Gas.	Water.	Total volatile matter.	Units of Heat.	Steam Value. See page 10.
402	Washington County, "Pittsburg bed"	....	....	51.46	8.89	Gray.	60.35	36.77	0.77	37.54	7569	1404.
403	Westmoreland County, "Pittsburg bed"	....	....	65.52	5.76	Gray.	71.28	25.20	1.27	26.47	7630	1415.
404	Tioga County, "Blossburg Coal"	....	....	71.69	5.34	Gray.	76.03	20.75	1.19	21.94	7718	1431.
405	Greene County, "Pittsburg bed"	....	....	59.05	2.60	Cream.	61.65	36.49	1.03	37.52	8151	1512.
406	Fayette County, "Pittsburg bed"	....	....	61.84	4.56	Gray.	66.40	31.84	1.20	33.04	7951	1475.
407	Westmoreland County, gas coal	....	....	59.29	2.89	Cream.	62.18	35.36	1.78	37.14	8066	1496.
408	Bedford County, "Broad Top Coal"	1.330	....	74.65	7.50	....	....	17.55	0.30	....	7660	1421.
409	Lehigh, anthracite	....	....	88.05	6.66	....	94.71	2.94	2.34	5.28	7387	1400.

Analyses of Missouri Coals by R. Chauvenet. Geological Survey Missouri, Broadhead.

	NAME OF MINE OR OR OWNER.	Specific Gravity.	Lbs. Weight of 1 Cubic Foot.	Fixed Carbon.	Ash.	Color of Ash.	Coke.	Gas.	Water.	Total volatile matter.	Units of Heat.	Steam Value. See page 10.
410	Barton County, H. Flack's	....	....	58.71	5.36	Purple.	64.07	34.04	1.89	35.93	7902	1466.
411	Vernon County, Cassell's	....	....	53.91	5.12	Gray.	59.03	38.39	2.58	40.97	7917	1469.
412	Bates County, Hecadon's	....	....	49.72	2.78	Pink.	52.50	44.93	2.57	47.50	8149	1511.
413	Sullivan County, Sodder's	....	....	50.03	4.92	Brown.	54.95	37.37	7.68	45.05	7507	1393.
414	Adair County, Williams	....	....	49.69	6.19	White.	55.88	38.99	5.13	44.12	7675	1423.

Analyses of Iowa Coals by Rush Emery. Geological Report, Iowa, White, 1869.

	NAME OF MINE OR OWNER.	Specific Gravity.	Lbs. Weight of one cubic foot.	Fixed Carbon.	Ash.	Color of Ash.	Coke.	Gas.	Water.	Total volatile matter.	Units of Heat.	Steam Value. See page 10.	
415	Monroe Co., Miller's mine . .	. . . .	. . . .	51.30	6.15	. . . .	57.45	37.84	4.71	42.55	**7556**	1402.	
416	Marion Co., Bousquest's mine.	. . . .	. . . .	47.54	3.32	. . . .	50.86	43.25	5.89	49.14	**7854**	1457.	
417	Mahaska Co., Burtis' mine . .	. . . .	. . . .	48.00	4.50	. . . .	52.50	42.27	5.23	47.50	**7801**	1447.	
418	Wapello Co., Inskeep's mine.	. . . .	. . . .	49.15	4.02	. . . .	53.17	42.96	3.87	46.83	**7969**	1478.	
419	Hardin Co., Buckner's mine .	. . . .	. . . .	44.72	4.82	. . . .	49.54	42.54	7.92	50.46	**7559**	1402.	
420	Average of sixty-four samples (Prof. White)	. . . .	. . . .	45.42	6.77	. . . .	. . . .	39.24	8.57	. . . .	**7341**	1362.	

Analyses of Illinois Coals.

	NAME OF MINE OR OWNER.	Specific Gravity.	Lbs. Weight of one cubic foot.	Fixed Carbon.	Ash.	Color of Ash.	Coke.	Gas.	Water.	Total volatile matter.	Units of Heat.	Steam Value. See page 10.	
421	Jackson Co., "Big Muddy" coal.	. . . .	. . . .	60.80	1.50	. . . .	62.30	31.20	6.50	37.70	**7808**	1448.	James Macfarlane.
422	Vermillion Co., Danville . .	1.357	84.81	46.78	8.64	Brown.	55.42	40.58	4.00	44.58	**7545**	1400.	Geo. Rep. Ind., 1870.
423	Peoria Co	1.243	77.68	58.60	2.80	Gray.	61.40	25.80	12.80	38.60	**7202**	1337.	Blaney, Econ. Geo. Ill., vol. 1.
424	LaSalle Co	1.243	77.68	55.00	7.60	Fawn.	62.60	27.40	10.00	37.40	**6989**	1297.	Blaney, Econ. Geo. Ill., vol. 1.
425	Grundy Co	1.259	78.48	58.20	1.80	Gray.	60.00	29.20	10.80	40.00	**7412**	1375.	Blaney, Econ. Geo. Ill., vol. 1.
426	Randolph	1.278	79.68	58.20	5.20	Lilac.	63.40	26.60	7.00	36.60	**7171**	1331.	Blaney, Econ. Geo. Ill., vol. 1.

Analyses of Coals from Other States and Territories.

	NAME OF MINE OR OWNER.	Specific Gravity.	Lbs. Weight of 1 Cubic Foot.	Fixed Carbon.	Ash.	Color of Ash.	Coke.	Gas.	Water.	Total volatile matter.	Units of Heat.	Steam Value. See page 10.	
427	Alabama, DeKalb Co	....	....	57.42	6.31	....	....	35.51	0.76	....	7935	1472.	Alabama 2d Geo. Rep.
428	Michigan, Eaton Co	....	....	45.00	2.00	....	....	49.00	2.00	....	8183	1518.	
429	Arkansas, Yell Co	....	....	80.40	5.20	....	....	11.40	3.00	....	7555	1402.	Dr. D. D. Owen.
430	North Carolina	....	....	70.48	6.46	....	....	21.90	1.16	....	7727	1434.	
431	Colorado, Golden City	1.320	....	45.57	3.85	Gray.	....	37.15	13.43	....	7129	1323.	W. P. Blake.
432	Colorado, Boulder Co	1.330	....	49.72	5.20	Gray.	....	33.08	12.00	....	7087	1315.	W. P. Blake.
433	Colorado, Canon City	1.279	79.23	56 80	4.50	Yellow.	61.30	34.20	4.50	38.70	7763	1441.	Geo. Rep. Ind., 1870.
434	Colorado, Fair Play	1.254	78.37	55.58	2.00	Fawn.	57.58	37.92	4.50	42.40	8010	1486.	Geo. Rep. Ind., 1870.
435	Colorado, San Miguel, Ouray Co	1.314	82.12	39.50	10.50	Brown.	50.00	40.50	9.50	50.00	6950	1290.	G. M. Levette, 1881.
436	Colorado, LaPlatte Co	1.296	81.00	45.75	5.25	Orange.	51 00	37.50	11.50	49.00	7177	1331.	G. M Levette, 1881.
437	Utah Territory, Evanston	1.300	....	49.90	6.30	....	....	35.22	8.58	....	7300	1354.	W. P. Blake.
438	Wyoming Territory, Carbon	1.330	....	49.72	8.00	....	....	35.48	6.80	....	7310	1356.	W. P. Blake.
439	West Virginia, Coalburg	1.257	78.56	56.00	1.50	White.	57.50	40.50	2.00	42.50	8283	1537.	Ind. Geo. Rep., 1870.
440	West Virginia, Campbell Cr'k	1.290	80.62	57.00	2.50	Red.	59.50	38.00	2.50	40.50	8131	1508.	Ind. Geo. Rep., 1870.
441	West Virginia, Peytona, cannel	1.322	82.62	59.50	3.50	White.	63.00	34.50	2.50	37.00	8009	1486.	Ind. Geo. Rep., 1870.
442	Texas, Robertson Co., lignite	1.232	77.00	45.00	4.50	White.	49.50	39.50	11.00	50.50	7260	1347.	Ind. Geo. Rep., 1875.
443	California, Mt. Diablo, lignite	....	....	46.84	4.58	....	....	33.89	14.69	....	6929	1286.	Dr. J. S. Newberry.
444	Oregon, Coos Bay, lignite	....	....	41.98	5.34	....	....	32.59	20.09	....	6417	1188.	Dr. J. S. Newberry.
445	Alaska, Cook's Inlet, lignite	....	....	49.89	7.82	....	....	39.87	1.25	....	7731	1434.	Dr. J. S. Newberry.
446	Vancouver's Island, Naminn.	....	....	46.31	18.55	....	....	32.16	2.98	....	7712	1430.	Dr. J. S. Newberry.
447	Newcastle, England	....	....	61.70	3.75	....	....	33.55	0.99	....	8090	1501.	
448	New Brunswick, Albertite	....	....	42.00	1.00	....	....	57.00	....	....	8683	1608.	
449	Crude Petroleum, Pa	Carbon, 84 per cent.; Hydrogen, 13.75 per cent.; Water, 2 25									11526	2134.	H. Wurtz.

COMPARISON OF INDIANA BLOCK COALS WITH ILLINOIS COALS.

The following exhibit of fuel values of Indiana coals and those of Illinois, prepared by Prof. E. T. Cox, in 1876, has never been officially published. The present State Geologist has pleasure in availing himself of the labors of his efficient predecessor:

H. G. Sleight, Indianapolis:

DEAR SIR—The following is the result of the analyses, made in the laboratory of the State Geologist, of the three samples of coal which you brought to me for that purpose:

No. 1. Block coal. Taken at random from a car load, shipped from Brazil, Clay county, Ind.

No. 2. From Wilmington, Ill., on the Chicago & Alton R. R. Sample taken from the delivery at Chicago.

No. 3. Minonk Coal, Ill., on the Illinois Central R. R. Also taken from the delivery at Chicago.

No. 1 is an ordinary sample of block coal. No. 2 is a glossy, jet-black caking coal, with specks and scales of pyrites. No. 3 is a very brilliant black caking coal, which, when broken, shows numerous markings of sulphide of iron.

A large lump of each sample was reduced to fine powder and kept, well stoppered, in separate bottles. From these bottles, which contained proper average samples of the coals, the quantities were taken necessary to complete the separate processes to which a coal must be subjected in order to point out its commercial value. For convenience, these coals will now be referred to by the numbers given above. The results are given in 100 parts of coal:

NO. ONE. INDIANA BLOCK COAL.

Specific gravity, 1.285. A cubic foot weighs 80.31 lbs.

Ash, white	2.50	Coke, 59.00 per cent.
Fixed carbon	56.50	
Volatile matter	32.50	
Water	8.50	
	100.00	

Iron	0.82
Alumina	1.20
Silica, lime and magnesia	0 48
Ash	2.50

Total sulphur. 1.43. The iron is combined with 0.947 of sulphur, leaving 0.483 of sulphur combined with the other constituents of the ash and carbon. This coal contains 7424 calculated heat units, and one pound will convert 11.4 pounds of water from 0° Cent. (32° Fahr.) into steam at 100° Cent. (212° Fahr.).

NO. TWO. WILMINGTON COAL.

Specific gravity, 1.248. A cubic foot weighs 78 lbs.

Ash, red	6.50	Coke, 52.50 per cent.
Fixed carbon	46.00	
Volatile matter	37.00	
Water	10.00	
	100.00	

Total amount of sulphur in this coal, 4.74 per cent. Iron 4.34 per cent.=9.298 of pyrites; this would be in excess of the sulphur, so that all the iron does not exist as sulphide. The ash is composed of iron 4.34; silica, 2.16.

This coal contains, by calculation, 6762 units of heat. One pound will convert 10.4 pounds of water from 0° Cent. (32° Fahr.) into steam at 100° Cent. (212° Fahr.).

NO. THREE. MINONK COAL.

Specific gravity, 1.232. A cubic foot weighs 77 lbs.

Ash, brown	5.50	Coke, 53.50 per cent.
Fixed carbon	48.00	
Volatile matter	35.00	
Water	11.50	
	100.00	

Total sulphur, 3.63 per cent. Sulphur combined with iron, 2.719. Sulphur combined with other mineral matter, 0.911.

Composition of ash.	Iron	2.38
	Alumina	0.80
	Silica	2.32

This coal contains 6756 calculated heat units. One pound will convert 10.3 pounds of water from 0° Cent. (32° Fahr.) into steam at 100° Cent. (212° Fahr.).

From this it will be seen that one ton of the Indiana block coal will convert into steam, from 0° Cent. (32° Fahr.) to 100° Cent. (212° Fahr.) 22,800 pounds of water, while the Illinois coals will only convert into steam, under the same conditions, 20,800; a difference of 2,000 pounds in favor of the block coal, or nearly eight barrels.

In addition to its superior heat-producing properties, the Indiana block coal contains a minimum quantity of sulphur and ash, while the other coals contain these injurious diluents in great excess.

I need hardly dwell upon the injurious effect which the sulphur exerts upon grate-bars, fire-boxes and boilers, where it is used for generating steam, since it is well known to all intelligent engine drivers that when sulphur is brought in contact with red-hot iron it causes it to fuse or lose its tenacity; thus, the sulphur from coal will destroy the grate-bars, fire boxes, and, sooner or later, the boilers themselves.

The pyritiferous ash of the Illinois coals will also give great trouble, since it will fuse into clinkers, which, by their rapid accumulation, stop the draft, and otherwise derange the perfect combustion of the coal, so that frequent stops must be made, or favorable moments taken, to remove them from the fire-chamber. On passenger trains, using such coals, much inconvenience is also experienced by the passengers, who are compelled to inhale the sulphurous fumes which escape from the smoke-stack and are wafted back into the coaches by the motion of the train.

No inconsiderable part of the commercial value of a coal depends upon its strength and resistance to atmospheric agencies, which cause it to crumble and waste when stocked. In this respect, again, the Indiana block coal will endure stocking for years without deterioration or loss from crumbling, while the Illinois coals will crumble into dust from the decomposition of sulphide of iron which it contains in such large quantities. It is given in Trautwine's "Engineers' Pocket Book," that 4.47 tons of water will carry a passenger train twenty to thirty miles, or even more if the grades are light. Then, assuming for the sake of comparison that the evaporation of 4.47 tons of water will run a given train twenty-five miles, one ton will run it 5.7 miles. Now, a ton of Indiana block coal will convert into steam one ton more water than the Illinois coal; consequently, it will, under like conditions, run a train 5.7 miles further than the Wilmington or Minonk coals—a difference of more than twenty per cent. in favor of Indiana coal. Indeed, so different is the Indiana block coal from the Illinois coals here reported on, chemically and physically, that they can not rightly come in competition for steam and house purposes, where a due regard is paid to economy of fuel, safety to machinery, comfort and health.

E. T. COX, *State Geologist.*

INDIANAPOLIS, March, 1876.

ECONOMIC GEOLOGY OF THE STATE.*

Indiana has been bounteously endowed by nature. In other regions rich in ore, coal and stone, the soil is usually thin and unproductive, or, *vice versa*, fertile lands are not rich in mineral treasure: but here in Indiana, a bountiful and inexhaustible supply of mineral wealth is overlaid by the richest of soils; and with cheap and abundant food, cheap homes, cheap wood and coal for fuel, and good clays, sands, and the finest of building material, she offers to the farmers, laborers, mechanics and manufacturers a share of her abundant blessings, resources richer and more useful to humanity than gold or silver or precious stones.

BUILDING STONE.

The rocks of the State contribute largely to her wealth, for they contain some of the finest building stone in the country, and the supply, comparatively undeveloped yet, is practically inexhaustible. The excellent qualities, durability and beauty of these Indiana stones are just beginning to be recognized for building purposes throughout the country, and the quarrying interests promise to become an important feature in the products of the State, in the near future. This stone is being extensively used in some of the most expensive and imposing buildings throughout the country, and the demand is increasing as it becomes better known. During the year 1880, the capital invested in the operation of quarries was $613,500, and the output of material was 8,413,827 cubic feet, worth $633,775, or about $20,000 more than the total capital employed. To effect this result required the labor of 1,788 men and 545 horses, and the use of 13 steam channellers in quarrying; 107 derricks and cranes in hoisting; 14 saw mills and 42 gangs of saws (3 per mill), in dressing; while 5,727,225 cubic yards of space were excavated, in doing which $2,300 worth of powder and dynamite was used.

As to the geographical division of the quarrying interest, Southeastern Indiana supplies a large quantity of stone for foundations and rubble masonry, from the bluffs along the Ohio River, and extending through Wayne, Union, Fayette, Franklin, Dearborn, Ohio and Switzerland, west to Clark county; besides being found to some extent in the counties adjoining these to the west, which are included in the Lower Silurian geological range.

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*Republished from my Report of 1882, by frequent request.

The close-grained, compact, magnesian limestones are largely quarried in the counties bordering the above on the west, forming a belt extending northward from the Ohio to the Wabash River in Carroll, Cass, Miami, Wabash and Huntington, and to some extent in the counties north and west of these. This stone, which belongs to the Upper Silurian age, lies in even beds, having a thickness of from a few inches to two or more feet, and is especially adapted to work in foundations, piers, abutments, and massive range work where great strength is required. The thinner strata of this stone furnish, at a low cost, excellent slabs, flags and curbstones, etc., since it comes from the quarries with bed and top ready dressed by nature. The economy in its use is apparent.

A very popular stone among engineers and bridge builders is the North Vernon blue limestone, a good sample of which, as a bridge building material, may be seen in the new bridge of the C. & I. Air Line across Broad Ripple, north of Indianapolis. This stone is quarried extensively in Jennings and Jefferson counties.

Quantities of blue and buff Oolitic stone of superior quality for building purposes are quarried in Monroe county. These strata are from six to twenty feet thick, from whence one firm alone, Messrs. Dunn & Dunn, has been shipping their entire output to Chicago and Joliet, Ill. It is there sawed into thin slabs, matched and polished, and finds a large and growing demand for mantels, table-tops, pilasters, wainscots, and interior ornaments and decorations where handsome neutral tints are required.

From Warren county, on the north, to the Ohio River, in a widening range, the valuable limestones of the Keokuk group, the sandstones of the Chester, and Oolitic limestones of the intermediate St. Louis group, are quarried; while the basal conglomorate sandrock, found in a wide belt from Warren county to the Ohio, contains an unlimited supply of strong, fire, water, and frost proof stone, very suitable for piers, foundations, etc.

But by far the most beautiful and valuable stone for architectural purposes is the Oolitic limestone of Lawrence, Monroe, Owen, Crawford, Harrison and Washington counties. The supply is simply inexhaustible, as it lies in massive strata of from twenty to seventy feet thick, over an area of more than fifty square miles.

These strata are homogeneous, equally strong in vertical, diagonal or horizontal sections. The stone comes from the quarry so soft as to be readily worked by saw, chisel or planing machine, while on exposure it hardens to a strength of from 10,000 to 12,000 pounds to the square inch—a strength amply sufficient to sustain the weight of the largest structure in the world. In use it presents a handsome, creamy brown appearance, gradually whitening with age. It is of almost unprecedented purity, containing an average of 96.8 per cent. of carbonate of lime, a purity rarely, if ever, surpassed, and scarcely equaled, in the world. Hence its advantage over the magnesian limestones, as it is not affected by decay in an atmosphere charged with the gases of burning stone coal. In natural outcrop it presents bold perpendicular faces to the elements, showing every scratch and mark, unaffected after the exposure of thousands of years, as no other stone or rock does.

It is quarried by steam channelers, which carve it out in prisms six by ten, fifty or one hundred feet long, putting to shame the boasted prodigies of Egyptian story and effort. It is then rapidly sawed into blocks and dimension forms, and steam-planers carve, mold and smooth it like clay or wood, and more accurately than mallet and chisel. It is now fit to be carved and polished into the freest kind of sculptured and ornamental work.

Ready for the mason or sculptor, it is alive and resonant, answering with a clear metallic ring each touch or blow. This resonance is an excellent test of the perfect unity of its particles, and as a result it is highly elastic, bending under pressure and rebounding to place when relieved from it. This elasticity enables Indiana Oolitic limestone to adapt itself without cleavage or disintegration to our changeable climate, where material will be frequently subject to a change of from 20° to 60° of temperature in a few hours; as in large buildings, the outside will be subject to a temperature of 25° below zero in winter, or 120° above it in summer, while the inside will remain at 60° or 70°—differences of 50° to 80° in the extremities of the same stone—with their accompanying effects in expansion or contraction. The strains of heat and frost will tear down buildings and sides of mountains, with their great expansive forces, and even steel and iron will give way before them. Here, then, is presented to the builder and architect a new and wondrous element in an "elastic stone," a potent quality which, united with its other sterling excellencies of strength and beauty, makes Indiana Oolitic limestone *the best in the world* for exposed work in buildings in localities subject to great climatic changes. It has been and is now being used in many of the finest public structures in the country—the new $2,000,000 court house at Indianapolis, the new Indiana State House, the postoffice, and many churches in that city; the custom house at Louisville; the city hall and the water-tables of Lincoln park in Chicago, many fine structures in St. Louis, the Cotton Exchange in New Orleans, and many public and private buildings in New York and Philadelphia, and the exposed parts of the new State House of Illinois.

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 Measures 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.

During the year 1882, there were quarried in Indiana nearly 1,000,000 cubic yards of sandstone.

COAL.

The Indiana coal fields are embraced in an area of about 7,000 square miles, and are entered from all directions by railroads, thus insuring a steady and inexhaustible supply of the best fuel at a low price. There are in all twelve seams at varying depths, from the surface to three hundred feet below, averaging a depth of eighty feet. Five of these seams are almost constantly workable wherever met, varying from one-half to eleven feet, and averaging four feet in thickness. The small seams are worked for local use by "stripping."

These coals range in quality from "fair" to "superior." The "block coal," pre-eminent as a metallurgic agent, is found in an area of about 600 square miles. Remarkably free from sulphur and phosphorus, it is rich in carbon, and admirably adapted to the manufacture of "Bessemer" steel, and for refining, as well as for rolling mill and locomotive use. It burns free, without caking, to a minimum of white ash, and with a ruddy flame.

Mr. J. J. Turner, Superintendent of the Indianapolis & Vincennes Railroad, made for some weeks a careful test of the comparative merits of Indiana coal (from Greene county) and the celebrated Pittsburgh coal, with especial reference to locomotive purposes, with the following results:

	Pittsburgh.	*Indiana.*
Wheels hauled one mile per ton coal	.97	.99
Gallons of water evaporated per ton coal	.53	.52
Average temperature during test	39°	39.9°
Total consumption	.40	.35

The enormous amount of power stored up in coal is thus set forth by Prof. Rogers: "The dynamic value of one pound of good steam coal is equivalent to the work of one man for one day, and three tons are equal to twenty years' hard work of 300 days to the year. The usual estimate of a four-foot seam is that it will yield one ton of good coal for every square yard, or about 5,000 tons per acre. Each square mile will then contain 3,200,000 tons, which, in the total capacity for the production of power, are equal to the labor of over 1,000,000 able-bodied men for twenty years."

Of course this contemplates that period in the future when inventive genius shall develop processes by which the full power of coal shall be economized, now so wasted in smoke and imperfect combustion.

During the year 1881 the coal mines of Indiana employed 5,000 men, to whom were paid wages amounting to over $1,500,000. In the mines was invested a capital of $2,500,000, while the product was 1,500,000 tons of coal, worth at the mines $2,500,000, a sum equal to the capital invested.

From a small beginning in a region where wood fuel was so abundant as to be a drawback, the excellent quality of our coal has promoted Indiana to the place of sixth in the coal-producing States of the Union, with a gain of 231 per cent. in the past decade, or over 23 per cent. per annum, while the future promises still larger outputs and triumphs.

How much influence the State Geological Department has had in producing the above results may be inferred from the fact that since 1869, when the first full report of the coals of Indiana was made by my predecessor, Prof. E. T. Cox, the business has increased about 250 per cent.

GLASS SAND.

Extensive beds of sand and friable sandstone occur in the counties of Madison, Parke, Clark and Harrison. It is of ocean-washed purity, frequently white as snow, and so pure as to cause the plate-glass of our State to rival, and in some respects to excel, the best European products. With fair encouragement Indiana can supply the nation with glass cheaper and better than foreign manufacturers, and can at the same time give employment to thousands of skilled and unskilled laborers, and bring additional capital within her borders.

GRAVEL.

This is so bountifully present over nearly all the State that it is as common as air *and as unprized.* Other countries make costly highways with broken stone; here nature presents the best of granite, imported during the great "Ice age," ready prepared for use. This is the best possible material, and in the future, with ordinary enterprise, our State will have the best roads in the world, with the consequent blessings of comfort, enjoyment and profit. During the year the sale of gravel in the State amounted to about 200,000 cubic yards, but probably ten times that amount was used without cost.

LIME AND CEMENT.

These necessaries of life are so abundant in the State as to escape attention. The whole northern, central drift regions and eastern and middle parts are underlaid with good limestone, suitable for calcining. The very best quality of lime is produced from these rocks, and in quantities not only sufficient for home consumption, but for an extensive trade in exportation also. To-day it is only used for mechanical purposes, but its full value will be appreciated when, in the near future, it becomes more generally used in agriculture for fertilizing purposes. The lime of the Upper Wabash, Central and Southern Indiana is unrivaled; the Delphi and Huntington and Utica limes are of a very superior quality.

Cement that meets all the requirements of the market is prepared from the native beds of Clark county, and is of fine quality; while large beds still undeveloped exist in Harrison county, waiting to reward him who will turn his attention to and bestow his labor upon them. From the lacustral clays and chalks of St. Joseph county is made, at South Bend, a fine "Portland cement," which is not rivaled even by the best European brands. During the year 1882 there was produced in the State 836,628 bushels of lime and 82,938 barrels of cement.

CLAYS AND KAOLIN.

Brick clay is as common as water throughout the State. Owing to the presence of iron, the clays of Delphi, Carroll county, offer a product of extra beauty, smooth and ruddy, and with colors so fixed that buildings which have stood for twenty or twenty-five years present the same cheerful, bright appearance as those erected last year. Our builders would do well to consider the color and quality of this material, permanently painted by nature.

Underlying all our coal seams are great beds of excellent fire clay. Good fire bricks are made in Clay and Vermillion counties, and the raw material is abundant in the southwestern regions. When the coming man builds, not for to-day, but for all time, he will require permanent fire-proof edifices, and will then avoid disastrous conflagrations by cheaply furnishing from this clay, window and door frames, roofs, cornices, etc., and ornamental brackets of terra cotta ware. The supply is sufficient to furnish the world, and, when common sense prevails, the clays of Indiana will be richer than the mines of Colorado and the golden sands of California. During 1882, 2,769 tons of fire clay were produced.

The kaolin mines of Owen and Lawrence counties have lately opened a new and prosperous field of labor. The product of these mines is used by the "Encaustic Tile Works" at Indianapolis, where are being produced tiles of rare beauty and excellence, rich in design, perfect in form, equally vitrified, and unrivaled by the best factories of England and France, over whose products they take precedence in the great public buildings in eastern cities. Large beds of kaolin, still undeveloped, invite exploration and examination in Owen and Harrison counties. The discovery of these kaolin beds has already resulted in the importation of large amounts of capital, and numbers of foreign skilled workmen.

NATURAL GAS.

In Harrison and other counties considerable areas present, from the deep bores, a flow of gas distilled by the internal heat of the earth from the bituminous beds of the Devonian age. This flow has been utilized for concentrating brine, and is of great economic value for driving engines, burning lime, crockery, etc., as well as for illuminating and culinary purposes. It invites and deserves attention.

SOIL.

The soil of Indiana is composed of materials from all the geological horizons. It contains the elements of all, spread as a broad alluvial plain along the ancient glacial bed. Being deep, it holds like a sponge the excess of winter and spring moisture to alleviate with dews, or water by springs, the surrounding country, avoiding excessive drouth. Posey county has shown to the State Board of Agriculture her great crop of corn, while Vermillion county comes to the front with 64.78 bushels of wheat and 110 bushels of oats to the acre. Other regions are equally rich, showing results in grains and grasses which rival these. Such crops are not accidents, but are the legitimate and natural results of a superior soil and its mineral constituents. When we consider that a soil composed of the decomposition of local rocks only is lean and soon needs manure, we can appreciate the effects of the deposition of the glacial drift over Indiana in the almost fabulous fertility of its soil, as instanced by the above examples.

GEOLOGY OF POSEY COUNTY.

Posey county is the extreme southwestern part of Indiana. The seat of justice, Mt. Vernon, is 198 miles, and the farthest point, at the mouth of the Wabash, over 200 miles southwest from Indianapolis.

It was organized in 1814, contains 420 square miles, or 268,000 acres, and is bounded on the north by Gibson, east by Gibson and Vanderburg, south by the Ohio River and State of Kentucky, and west by the Wabash and State of Illinois.

These boundary streams are stately rivers, of nearly equal size at low water. The Wabash comes from the rich alluvial loams and clays of Northern Indiana, and the prairies of Illinois, loaded with manurial sediment; the Ohio, at overflow, brings the calcareous washings of its tributary streams, and is red with angry waves. At ordinary stages the latter is the "Belle riviere" of the French—the beautiful river of the early traveler; bright and blue in its clear almost crystal waves and royally crowned by a swan-like fleet of steamers trailing their smoky banners against the clear sky, it is attractive. From the hill tops it is a scene of active beauty, clearer, brighter and fuller of progressive energy than even the "Silver Rhine." Each of these rivers is belted with broad, alluvial plains, ranging from a narrow strip to five or more miles wide, with a soil of unrivvaled fertility, excelling the boasted granaries of Egypt by the diversity of its productions. Corn, wheat and oats are cultivated, and produce crops never elsewhere equalled. All the fruits of a temperate clime are abundant, and textile plants have been and may be successfully grown. The forests comprise black and white walnut, red, white and burr oak, red and white elm, white and black gum, cottonwood, hickory, maple, willow, sycamore, cypress, pecan, etc., with many shrubs and vines.

The drainage of the northern parts is by Black River. This stream, almost insignificant in its present volume, shows evidence that once it was a mighty river, broad alluvial bottoms bordering its sides, so much wider than a stream of its volume required, that it is plain at some early time—probably about the close of the Lacustral period, Patoka, or creeks(?) tributary to Pigeon, were discharged by this way. Big Creek drains the central parts and was formerly a mill stream of importance. Small streams flow from the southern areas to the Ohio. Many of these creeks flow through flat level plains, and have the muddy beds characteristic of the Loess soils.

From the creek and river valleys we pass, sometimes by gentle ascents, along the tributaries, but often by abrupt bluffs, to the table lands. The latter, in the central and northern parts, attain an elevation of from 100 to 200 feet, and average a height of 125 feet above low water in the Ohio River; and being formed, as a rule, from lacustral fine sands or loam, the soil is compact and to a degree impervious to air and moisture, unless drained or well intermixed with vegetable matter. The flat areas are wet and predisposed to prairies or "openings," but the slightly uneven surfaces are clothed with a thick growth of timber. Of this, post-oak, persimmon and sweet gum are characteristic, if not peculiar. White, red and Spanish oaks, black gum, maple, white and black hickory are common. The rolling uplands, containing a generous admixture of red calcareous material, imported by fluviatile action, is richer, and has a corresponding growth of sugar trees, poplars, black walnut and ash, added to the former list. Both varieties of upland, when properly cultivated, produce fair to good crops of corn, wheat, oats and meadow grass. The hills and high ridges, by the modifying influence of their elevation, are exempt from the destroying effects of sudden changes of temperature, and admirably adapted to the growth of tender fruits and vines. Advantage has been taken of this situation by progressive farmers and gardeners, and the many extensive and profitable orchards and vineyards of this county are regarded sure sources of income by their prosperous owners. These areas, entirely elevated above the malaria of the valleys, are remarkably free from fevers attributed to that cause. Good cisterns for filtering and containing rain water for family use, would furnish an ample supply of purer water than can be obtained from wells or springs in this soil, and would probably, in a considerable degree, avert inflammatory diseases.

Dr. D. D. Owen describes this lacustral loam as a silico-calcareous earth, of pale, reddish gray, or ashen flesh tint, and says that, when in part composed of decomposed material of Coal Measure rocks, it gives rise to some of the best tobacco land. He gives the following analysis:

Combined moisture	1.35
Soluble organic matter	.30
Insoluble silicates	73.30
Carbonic acid	10.00
Lime	6.80
Magnesia	3.78
Alumina and peroxide of iron	2.80
Chlorine	.12
Loss and alkalies	1.55
	100.00

An analysis of water leached through this material is found to contain an excess of magnesia, and observation shows that it has a deleterious effect on the health of those who habitually employ it for domestic and drinking purposes. During the presence of cholera, Owen observes that those who habitually used this kind of water were apt to be more frequently and seriously attacked. In such localities, at times of drought, erysipelas and typhoid fevers are liable to prevail. Magnesia and its metallic combinations, rendered deliquescent by exposure to atmosphere, are not acute poisons, perhaps, in the small quantity which exists, but long continued use produces a chronic irritation which may tend to incite disease. Hence the use of pure, filtered rain water is earnestly urged.

RECENT GEOLOGY.

ALLUVIUM.

The "river bottoms," or alluvial "meadow lands," bordering the rivers and streams are due to causes now in action. Solid rocks, laminated or crystalline, compose the rock-ribbed crust of the earth. These, on exposure to frost, air and water, decompose or disintegrate, or, broken from their beds, are rounded, rolled, and, by the mills of nature, ground into clays, sands and pebbles by rushing water and waves. The finer particles, as clay and sand, combined with rich organic matter, form here the productive alluvial bottoms of a delta outrivaling the famous delta of Africa. This deposit is always found above or against the sides or excavated edges of older beds.

In deep shafts at Evansville, and at Henderson, Kentucky, a bed of fluviatile shells was found, at a depth of forty to seventy feet from the surface, so deposited as to indicate an era when the Ohio flowed at a bed that much below its present level; but, more wondrous, it showed an early period in the river's existence, reaching back to tell the story of life, and climate and time. These mollusks, then abundant here, were such as now are common in streams bordering the northern shore of the Gulf of Mexico; and as they could only exist in a sub-tropic climate, they prove that such climate prevailed here. They may be intimately connected with the following epoch.

LUCUSTRAL EPOCH.

The Loess or lacustral loams succeed in age. It was the epoch of great lakes or slow-flowing lagoons, with a warm climate succeeding the glacial time. These loams are an ash gray or brownish buff color, exhibiting, principally, an impalpable sand, with a small amount of clay. Sir Chas. Lyell, on his visit to this county, identified this deposit as the equivalent to the Loess of the Rhine, and he was enabled to know of the thermal conditions by the shells found abundantly at New Harmony as equivalent to that of Cuba or Mexico. These shells are listed in my report for 1870, on

Sullivan county, but here repeated for the benefit of those not having that report, viz.: *Macrocyclas concava*, Say; *Zonites arboreus*, Say; *Hyalina indentata*, Say; *Patula perspectiva*, Say; *Helicodiscus lineatus*, Say; *Pupa armifera*, Say; *P. fallax*, Say; *Strobila labyrinthica*, Say; *Stenotrema hirsuta*, Say; *S. monodon*, Rack.; *S. monodon var. fraterna*, Say; *Vallonia pulchella*, Muell.; *Succinea avara*, Say; *Valvata tricarinata*, Say; *Pomatiopsis lapidaria*, Say; *Helicina occulta*, Say.

Of these shells, *H. occulta* is of tropic life, and belongs to the latitude of Cuba and Mexico. Prof. Swallow remarks: "These lacustrine fluviatile and land species of mollusca indicate a deposit formed in a fresh-water lake, surrounded by land and fed by rivers; and refer back to a time when a large portion of this valley was covered by a vast lake, into which flowed various rivers and streams." The climate was tropic or sub-tropic.

The low, rounded hill-tops, constantly recurring, appear like tumuli, and are occasionally shaped by the Mound Builders for funeral purposes. The red, marshy clay, fat with shells of that epoch, forms a fertile soil along the shore line of the lagoon-like lake, characterized by a heavy growth of poplar, walnut, sugar tree, ash and post-oaks of giant size; the lower and more sandy member of the Loess, impervious to air and moisture, bears a growth of oak, hickory, gum, beach, dogwood, symbolic of the cold, close soil.

DRIFT.

Next in order of time succeeds the great ice age; a stratum of sand and gravel resting below the Loess, but upon or against the sides of older formations. It represents the sorting and sifting power of water in motion, each deposit being placed where the velocity of the current could no farther carry it; thus a ripple deposited gravel and bowlders, a slower current left banks of coarse sand, and, finally, slow eddy-currents made banks of clay and fine sand. At the base of the hills at New Harmony are beds of glacial material, indicating the sorting powers of the Wabash in its youthful vigor.

GENERAL GEOLOGY OF POSEY COUNTY.

The rocky formations of this county are classed as of the Upper Coal Measures. The surface outcrops exhibit two or three coal seams, with intercalated beds of limestone; above is the Merom sandstone, which, unconformable with the Coal Measure rocks, lies above them, and its coarse material demands a shore line of a mighty, surging sea for its formation. This rock is of later date and apparently of different conditions, and, perhaps, indicates that future students may find evidence to connect it with

Mesozoic times and possibly with the Triassic period. Cretaceous beds occur in adjoining regions of Kentucky and Missouri. Outliers are to be expected, and should be sought for, in Indiana.

GENERAL SECTION OF POSEY COUNTY.

The following general section is combined from the shafts, bores and explorations made from outcrops in eastern and northern parts or adjoining regions, and probably gives the unexplored strata of this county:

		Ft.		Ft.	In.
1.	Buff, brown, red and mottled shales	2	to	0	00
2.	Merom sandstone, soft, shaly, upper div.	20	to	25	00
3.	Merom sandstone, massive in quarry beds	10	to	30	00
3½.	Dark gray or buff shales and flaggy sandstones, with clay iron stones	10	to	20	00
4.	BROWN IMPURE COAL, 3d rash coal	1¼	to	00	00
4½.	Flaggy or thick-bedded sandstone, ripple-marked	9	to	4	00
5.	Hard, clinky, gray limestone, at bottom irregular and sometimes flinty, passing to the west to a calcareous shale	2	to	6	00
6.	Argillaceous shale and shaly sandstone	34	to	0	00
7.	Black slate, with fish spines and fossils	1½	to	0	00
8.	SECOND RASH COAL	0	to	0	03
9.	Fire clay	1	to	0	00
10.	Gray shale	6	to	0	00
11.	Limestone, yellow ferruginous	3	to	12	00
11½.	Gray shale	98	to	0	00
12.	FIRST RASH COAL and black slate	0	to	0	08
13.	Fire clay	1	to	2	06
14.	Soft, flaggy, blue, buff and gray sandstone, with much gray shale and beds of clay ironstone and nodules	60	to	121	00
15.	Yellow and gray sandstone, often giving good quarry beds	15	to	29	00
16.	Gray and buff alluminous, arenaceous or shaly, flaggy sandstone, with ironstone nodules and shaly concretions	29	to	8	00
17.	Black slate or clod, with fossils			1	00
18.	COAL N. Choice, gassy, caking			2	03
19.	Fire clay, at bottom shaly, with iron balls			5	08
20.	Buff or gray limestone, with *Chætetes*	8	to	5	00
21.	Gray or white shale, with nodules of ironstone and bands of sandstone	30	to	40	00
22.	Siliceous shale, passing to massive sandrock to south and west; Anvil rock? of Lesquereux and Owen	60	to	71	00
23.	Black slate and clod, with many animal and vegetable fossils	2	to	1	08
24.	INGLESIDE COAL M: Laminated coal, 1 ft. 4 in.; parting, 2 in. to 0; solid cubic coal, 2 ft. 8 in.			4	00
25.	Fire clay			4	00

26.	Fire clay, with pyrite balls			3	08
27.	Siliceous shale			11	09
28.	Argillaceous sandstone			5	00
29.	Gray shale and soapstone			64	05
30.	Soapstone, with plant remains			0	03
31.	COAL L: Impure cannel coal, 1 ft. 6 in			1	06
32.	Fire clay			2	06
34.	Siliceous shales and coarse massive ferruginous sandstone	90	to	120	00
35.	Bituminous limestone and black slate	2	to	8	00
36.	COAL K. Caking, pyritous	0	to	1	06
37.	Laminated fire clay	2	to	1	04
38.	Siliceous and black aluminous shales, with rich bands and pockets of nodular iron ore	10	to	30	00
39.	Conglomerate sandrock	110	to	180	00
40.	COAL A	3	to	0	00
41.	Dark or black shale, with iron ore	30	to	5	00
42.	Chester sandstone and Lower Carboniferous limestone.				
				833	11

PALEOZOIC TIME.

CARBONIFEROUS AGE.

Upper Coal Measures.

The following remarks (made after a careful and protracted study of the mines, outcrops, bores and shafts of Vanderburg county) are given here as the fullest show the writer has of the deep strata of Posey county, where, from the depth of the coal seams, extensive explorations have not been made. The section and deductions apply with full force to Posey county.

The beds Nos. 3 to 14 of the general section, including two or three thin seams of rash coal and two strata of limestone, each from two to eight feet in thickness, occupy the hill-tops in the eastern parts, and thence, dipping to the southwest, are found at or near the level of the streams in that part of the county. These beds are a notable horizon. Besides the advantage of the stone, which is burned for the lime, they form an unmistakable directrix from which to measure down to the probable level of the lower workable coals. The limestones Nos. 5 and 11, at their southeastern outcrop, are hard and clinky, and are frequently brought close together or found in contact. Going westward, they first become more plainly calcareous, are separated by a parting which widens at some points to a space of nearly fifty feet, and allows the introduction of a Rash Coal, becoming persistent to the west, but only represented by fire clays in the eastern parts. Persistent in the eastern parts they become somewhat inconstant in the western, and pass into calcareous shales. In all adjoining regions, these limestones contain a multitude of fossils in great variety, which have given rise to bitter personal quarrels and disputes between eminent scientists. Some of these fossils, as *Meekella*, *Syntrielasma*, a *Myalina*, *Bellerophon crassus*, *Pleurotomaria turbiniformis*,* etc., are closely allied to Permian forms of Europe. These fossils, with many others are not found, in my knowledge, below the Upper Coal Measures included by the numbers (5 to 14) under consideration. So many new fossils from this horizon have been described as of "the Coal Measures," that, deciding from such determination, the rocks, notwithstanding the introduction, in part, of a new fauna, are Coal Measures. As a compromise, equivalent beds in Kansas and Nebraska have been termed by eminent geologists "Permo-carboniferous," a designation which seems properly applied.

In this county, these limestones, often crowded or almost wholly composed of fossils, as *Athyris*, *Spirifer lineatus* and *Lophophyllum proliferum*, offer many and good cabinet specimens. The coals (Nos. 3, 8, 12) are generally absent and never persistent over considerable areas. Impure and thin, they are consequently of no great economic importance. The thin fire clays (Nos. 9, 13) are of even more value, for, generally unctous and plastic, they afford, as a rule, a clay which, purified by exposure to atmospheric agencies, will work well for crocks, coarse pottery and terra-cotta ware.

No. 14, a soft, flaggy, blue, buff and gray sandstone, interchanging with gray shale, carrying iron stones, is found in the eastern parts.

The yellow and gray sandstone (No. 15) is found well down in the Evansville shafts, and is not exposed in the county.

The black shale or clod (No. 17) is pretty constant, and differs from the slate usually found covering coals in the predominance of aluminous matter, rendering it soft. It usually carries a considerable number of fossils, most of which are pyritized, as *Productus cora*, *P. costatus*, *Athyris subtilita*, *Macrocheilus*, several species, *Bellerophon*, two species, etc., etc.

Coal N (No. 18 of the general section) is a choice, gassy coal, of excellent quality. From appearances it is believed that this is equal to the best western coal for gas and coking, and, although the seam will average but little over two feet, yet the purity and richness in volatile matter will justify removing the fire clay for potteries, and thus secure this valuable coal. It is passed in the Ingleside shaft, and was formerly worked by a shaft not now in use, on Stevens' land, northwest quarter section 7, township 6, range 9.† It is also pierced by Priest's bore, at West Franklin, in

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† These fossils have not been found west of the Wabash River, but are abundant in equivalent beds in Illinois, adjoining to the west.

* In Vanderburg county.

the extreme southwest corner of Vanderburg county, and by the Kentucky shafts at Henderson—in fact at every point at which this horizon has been explored. These facts indicate a general persistence throughout this region of Coal N., a seam that is characteristically inconstant and unreliable in all the basin, to the north and east. It is locally known as the "Little Newburg coal."

Below the fire clay of N. is found a buff or gray limestone (No. 20). This is not exposed in the county, but is met in all the shafts in regular position, and outcrops at Newburg. It contains a few specimens of *Productus* and *Spirifer*, but is remarkable for the wonderful size of *Lophophyllum proliferum* (some of the cups were seen from three-fourths to one and one-fourth inches in diameter), and a great profusion of the coral *Chætetes milleporaceus*. Next succeeds a gray or white shale, carrying bands and nodules of iron ore of good quality, but not in sufficient quantity to be of any great value.

The siliceous shale and sandstone, passing into massive sand rock along Green River and generally to the north and west, is a marked horizon at stations where exposed, forming quarry beds of economic importance and bold river bluffs. In this county, it is entirely below the surface and can be seen only in shafts.

The black slaty clod (No. 23) is generally persistent throughout this region,* and carries a large number of beautiful and well preserved fossils. Generally pyritized, they form desirable cabinet specimens, viz.: *Productus cora*, *P. longispinus*, *P. punctatus*, *Bellerophon carbonarius*, *B. Montfortianus*, *B. percarinatus*, *Macrocheilus inhabilis*, *M. fusiformis*, *M.* (sp?) *Pleurotomaria carbonaria*, *P. sphærulata*, *P. Grayvillensis*, *Orthoceras Rushensis*, *Nautilus decoratus*, *Aviculopecten rectilateraria*, *A.* (sp?) *Nuculana bellistriata*, *Nucula inflata*, with crinoid stems. These are only a partial list of its marine life. Comb-like spines of fishes and dermal plates, named *Petrodus occidentalis*, are not uncommon; while bones and corprolites are frequent, though crushed and fragmentary.

The Ingleside coal M., locally known as "Main Newburg" (No. 24 of the general section), is the probable mineral resource of this region. This seam has been pierced, by shaft or bore, at a great many different points in this county* and in regions immediately adjoining. At every station, with the single exception of the "Crescent City Park" bore, it has shown a thickness of not less than four feet. It is a strong coking coal, burns to a gray or red ash, and is an excellent fuel for steam or grate use, and commands, as it deserves, a ready market. It drives the wheels of commerce, pulls mighty railway trains, and gives energy to the thousand arms and fingers of iron which manufacture, with the strength of a million giants, the wealth of the city of Evansville. From absence of faults or barren places, indicated by bores conducted up to this time, we may infer

* In Vanderburg county.

that it underruns southern and eastern parts, at least two-thirds of the area of the county, with a possibility, if not a probability, that it may be found in the remainder. A coal of such continuity is unusual, not often met in our coal field, and combining so many good with but few bad qualities, it may be looked upon as a grand source of wealth for ages, and assures for this region an enviable prosperity and progress for the future. This coal has long been worked at Ingleside shaft, in Evansville, and at Newburg, Henderson and Green River, of Kentucky; a new shaft has been put down at Chandler Station, on the Boonville road; all of which find the seam regular in thickness, and differing but little in quality, as may be seen in the chemist's report of analysis.

The usual fire clay, below Coal M. (Nos. 25 and 26), in its upper member, is plastic, and in the future demand for fire-proof buildings, will be extensively used in terra cotta. Usually, it will be necessary to remove the diffused particles of pyrites by aeration. Strata of limestone are not reported in the sections to which access was had below N. and immediately above M., as was found to be the case in Gibson county; but in the new shaft at Henderson and in the bore at Ingleside, beds are found confirming the unexpected phenomenon of massive limestones in the Coal Measures, so unwillingly admitted in my report on Gibson and Knox counties.

The space represented by Nos. 27, 28 and 29 has been pierced only by the lower shaft, in Ingleside mine. It is highly argillaceous, hardly rising above the grade of clay shale; even the tough blue sandstone readily yields to air and moisture. This was to be expected, as similar material, in eight cases out of ten, characterize the horizon between Coals M. and L., in the counties I have visited in Indiana. Similar outcrops were seen at the same horizon, along Green River, especially at and near Cromwell Landing. A thin bed of soapstone (indurated clay) is ordinarily found succeeding, which is rich in leaves and stems of carboniferous plants, and is known as the "fern bed." Sometimes the soapstone is replaced by gray shale, full of kidney iron-stones, enclosing plants and fruits.

Coal L (No. 31 of section) offers the characteristic physical form and qualities usually presented throughout the Indiana coal field. It is a laminated semi-caking or free burning coal, rich in carbon, and yielding a gray or white ash, with little or no cinder. It is the most persistent coal of the Wabash basin in thickness, regularity and good qualities. In this vicinity it has been pierced by three bores, showing an average thickness of only about two feet, which may be regarded as the probable thickness of the seam along the southern and eastern part of the county. This will hardly justify mining at present.

Below Coal L., a hard ferruginous, laminated sandstone, passing into siliceous shales, has been pierced by bores, and occurs at adjoining regions in outcrops, filling a space of from 90 to 120 feet, at the base of which the limestone superimposing Coal K. is found; sometimes flinty, but on the

Kentucky side of the river carrying the usual fossils as *Productus costatus*, *P. longispinus*, *Lophophyllum proliferum*, *Spirifer cameratus*, *S. Lineatus*, *Athyris subtilita*, *Chonetes mesaloba*, *C.* (sp. ?) and *Crinoid* stems.

Coal K. is not seen in this region. In bores along the Ohio River it never develops a thickness of two feet and is generally thinner or barren. Typically, it is a strong caking coal, containing some sulphur, and burns to red or brown ash. A short distance below the horizon of K., beds of black shale occur, which are often, in bores, reported as coal. No thick or workable seams may be expected at this depth. The space usually presenting the block coals is here barren, as it is generally in the southern part of the State. It seems probable that at the central extreme depths of the basin the vegetable material, which if preserved pure would suffice for a coal seam, was largely intermixed with clay and argillaceous matter, and thus diffused and scattered, is represented by a black shale, and the ironstone (No. 38).

The conglomerate sandrock (No. 39) forms the bottom rock or bed of the Coal Measures. It is a coarse, red sandstone, heavy bedded or massive, containing, often, a few red and white quartz pebbles, conglomerated, but the latter are generally absent in the Indiana coal field. This sandrock is only pierced by the Crescent City Park bore in Vanderburg county, and in neighboring wells, but is typically exhibited in adjoining regions to the northeast and south.

The sub-conglomerate Coal A is only known by report. Its existence in this region is, to say the least, problematical, and certainly of no economic importance. The deepest bores report beds of limestone and sandstone, which are referred to the Chester beds of the Sub-Carboniferous period. These bores were put down during the oil excitement, and are not very reliable for minor details, but their steady concurrence, as to the underlying limestone, is regarded reliable.

The foregoing gives a connected view of the surface phenomenon and rocky structure of the county, as before stated almost wholly studied from out-crops, bores and shafts in Vanderburg and Pike counties, and in the Greene River regions of Kentucky. Details will be added for local information.

LOCAL DETAILS.

With low water in the Wabash, the following section was observed, following down the cut-off:

SECTION AT NEW HARMONY CUT-OFF.

	Ft.		Ft.	In.
1. Alluvium (river bottoms)	30	to	10	00
2. Loess	20	to	10	00
3. Clay, sand, gravel, etc., sorted from glacial drift	30	to	13	00

4.	Merom sandstone; massive in eastern parts, to the west laminated	50 to	20	00
5.	Limestone, with fossils	4 to	12	00
6.	Black shale			
7.	UPPER RASH COAL	10 to	0	00
8.	Shaly sandstone	10 to	40	00
9.	Concretionary iron balls	1 to	2	00
10.	Calcareous shale, with fossils	1 to	2	00
11.	Black, sheety shale, with coprolites and fossil remains.	1 to	2	00
12.	LOWER RASH COAL	0 to	1	06
13.	Gray shales, with plant remains to low water in river	2 to	4	00
			116	06

The lower sandstones of this locality present fossil casts of strong growing plants of the Permo-Carboniferous age, *Calamites*, *Sigillaria* and numerous beautiful ferns. A *Sigillaria* preserved by Mr. Sampson was of wondrous size. A part of the fossils seen in his collection were: *Lophophyllum proliferum*, *Bryozoans*, *Productus longispinus*, *P. punctatus*, *P. costatus*, *Orthis Pecosi*, *S. lineatus*, *Athyris subtilita*, *Myalina Missouriensis*, *Entolium aviculatum*, *Bellerophon carbonarius*, *B. percarinatus*, *B. Montfortianus*, *Peurotomaria carbonaria*, *P. tabulata*, *P. spherulata*, *P. Grayvillensis*, *Orthoceras Rushensis*, etc., etc.

This section does not reach down to the bottom of the Upper Coal Measures, and indicates that the horizon of the workable coals M., L. and K. are from 200 to 500 feet below.

Continued rains directed attention to the eastern part of the county. A section was taken near the county line, at M. Gluck's, southwest quarter section 32, township 6, range 11, where the upper limestones were well developed.

SECTION AT GLUCK'S.

	Ft.	In.
Loess loam	20	00
Red sand, Loess	4	00
Soft Merom sandstone	26	00
Shaly sandstone	12	00
Blue limestone . . . 3 feet to	1	00
Calcareous argillite, with plates of chert of 2 inches to 8 inches, and containing *Spirifer Lineatus*, *Orthis Pecosi*, *Bellerophon*, *Athyris*, *Productus*, and crinoid stems and arms	3	00
Gray and buff limestone, crowded with a crushed mass of above fossils	8	00
Gray shale in brook	2	00
	76	00

An outcrop of this flinty (hornstone) limerock was seen further on in the West Franklin road, which has been a noted curiosity with geologists who have made this region famous by their labors. At this point, although not well exposed, it would seem from the sloping outcrops that the whole thickness of this limestone had passed into clinky hornstone (flint). At southeast quarter section 6, township 7, range 11, the Merom sandstone is seen along the top of the hill, indicating a thickness of twenty to thirty feet.

On the slope of the hill, near the residence of F. Finney, are three sink holes, such as are so common in the region of the subcarboniferous limestone, from ten to thirty feet in diameter. Their size indicates an unusual development of limestone of this locality. These are the only sinks seen in our Coal Measures. A large spring discharges the water collected by them. At the southeast corner of the county, about a mile east of West Franklin, the bluffs expose a bold, precipitous face to the river. The limestones, here parted by a slight layer of slate and thin plates of the second rash coal, are elevated, with the Merom sandstone, by a local anticlinal ridge, with strike from northeast to southwest, and dipping slightly to the east, but rapidly, for a short distance, in the normal western direction. Much stone was formerly burned here, and at the village below, for shipment to the southern market, but this lime contained so much color and foreign ingredients that it could not successfully compete with the purer article from Subcarboniferous. At this bluff, Mr. George M. Priest (to whom I am indebted for section in bore and other favors), in November, 1859, put down a test well, which, with the outcrops, gives a good exhibit of strata, viz.:

PRIEST'S BLUFF SECTION, WEST HALF SECTION 19, TOWNSHIP 7, RANGE 11.

Outcrop.

		Ft.	In.
Covered		22	00
Yellow ferriferous Merom rock		15	00
Pyritous clay shale, with plates of sandstone		19	00
Black carbonaceous slate	1 ft. to	0	00
Blue limestone	1 ft. to	4	00
Parting, 2d rash coal			06
Buff clinky limestone		5	06
Blue and black shale, 1st rash coal	1 ft. to	0	00
Siliceous shales, with iron nodules		27	00

Bore—High-water mark.

Siliceous shale, with good iron ore in bands and nodules	36	06
Siliceous shales, with nodules	30	00
Hard concretions	2	00
Sandstone	44	03
Laminated sandstone and shale	13	00
Blue shales	27	00
Very dark shales	3	06
Coal (N?)	3	06
Fire clay	1	06
Total	254	03

By this it is seen that a coal of workable thickness exists at a depth of 157 feet below high water mark. Just across the line, in Posey county, the rash coals are better exhibited, although of no great importance. They are, at no locality in the State, of workable extent. Near this point, and below, the tops of the hills, 130 feet above the valley, afford a magnificent view, embracing a large extent of river and bottom fields, and have been employed as "look-outs," or residences, by the Mound Builders and other pre-historic races.

Going north along the county line, the Merom sandstone was noted at several localities, generally in Posey county, rising to the northeast and dipping to the west southwest. Much diagonal or false bedding was observed, with wave faces to west. At Andrew Keck's quarry (northwest quarter section 36, township 7, range 12), half a mile west of the county line, the massive member of the Merom sandstone is well exposed, and yields an excellent quarry stone, in large blocks, one of the best quarries in the vicinity. In the lower strata *Calamites* and worn trunks of coal plants were seen. Below the quarry is a band of black shale, with, locally, a thin seam of coal, from six to ten inches thick.

The same sandstone outcrops on the farms of Charles Keck, Lewis Hauschild and George Roseman (sections 30 and 31, township 6, range 11), soft and incoherent at the top, but presenting massive ledges, ten to twenty feet thick, in the ravines. A short distance east of this locality, the sandrock ascends to the summit of the hills, and the double limestone and rash coals are exposed in the valleys. Massive beds of sandstone are seen along the southern bluffs of Big Creek, some of which have been quarried for rough masonry. At Wm. Fauquher's, and vicinity (section 6, township 6, range 11), the Merom sandstone caps the tops of the hills, and a band of black carbonaceous shale, twelve to eighteen inches thick, is seen in the ravines, representatives of the second rash coal of general section, the limestones apparently being absent or having passed into a calcareous shale. A thin coal was formerly worked, for blacksmiths' use, on the Dow farm (northwest quarter section 1, township 6, range 12).

On the dividing ridge between east and west branches of Big Creek, on the farm of Henry Schift, 2½ miles southwest from St. Wendell, the Merom sandstone has not been eroded, and crowns an almost knob-like elevation. The lower strata is soft, micaceous, and readily yields to the action of the atmosphere and running water; the middle or massive member, more compact, often stands out 10 to 15 feet, overhanging the brook which rushes past its base, forming "rock houses" like those so often seen in the conglomerate hills. These have been used for shelter in storms by Indians, as well as wild animals. St. Wendell is a German village (section 7, township 5, range 11), and presents many characteristics of the fatherland, novel to Americans. The industry, thrift and prosperity of the citizens is proverbial. Well appointed farms, good gardens and comfortable or luxurious houses, filled with means for social comfort, enable them to enjoy life somewhat independent of the outside world. Coal has been stripped to a very small extent at several openings near the village, but it is impure, thin, and will not justify expensive work. On the farm of John Tenbarge (west half section 6, township 5, range 11), the second rash coal is found, eleven inches thick, of fair quality. At George Helfert's (southwest quarter section 7, township 5, range 11), several loads have been mined.

SECTION AT HELFERT'S, ST. WENDELL.

	Ft.	In.
Slope, Merom sandstone	70	00
Calcareous shale (limestone)	1	06
Black sheety shale	2	00
Coal, second rash	1	06
Laminated fire clay, in brook	1	00
	76	00

In the black slate covering this coal was seen dermal tubercles and spines of *Petrodus occidentalis*, *Nucula inflata*, *Cardiomorpha Missouriensis*, etc. The fish specimens above are probably termed "comb-like teeth of sharks" in former Reports.

The northeast part of the county is a prime agricultural region; perhaps, considering all the surroundings, the best in the country. The tableland is a broad, gently undulating or nearly level plateau, and offers the characteristics of a prairie opening. The soil produces good crops of grass, wheat, and a fair yield of corn in its natural condition; but many farms have been enriched by under-draining, which assures good crops in spite of unpropitious seasons, by fortifying plant life against flood or drought. In this vicinity, the valley of Big Creek proper is from two to three miles wide, and several of its branches have valley plains from one to two miles wide, with only brooks or wet weather streams flowing through them, in no way commensurate with the erosion necessary to excavate such water-ways, all pointing back to the time when temporary sluice-ways, discharging floods of ice-water from the northern and northeastern glaciers, swept across here to the Wabash, by way of Big Creek, now an insignificant stream. The rocks are deeply covered, and the only outcrop noted is a quarry of Merom sandstone on the farm of John Klaser (northwest quarter section 23, township 4, range 11). Well improved farms, comfortable houses and a thrifty people characterize this vicinity.

Continued rains and overflows concealed the beds of the stream, justifying the recall, condensed, of some of such sections, by Dr. D. D. and Prof. Richard Owen, given in their Reports.

Six miles north of New Harmony, near the residence of Jos. Calvin, a coal seam is exposed, about nine inches thick.

CALVIN SECTION.

	Ft.	In.
Covered top of hills	70	00
Limestone, without fossils	2	00
Shaly sandstone	5	00
Soft shales, with plants and shells	21	00
Coal	0	09
Fire clay	2	00
	100	09

On Mackadoo Creek, eight miles northeast of New Harmony, two thin seams of coal are seen.

On Big Creek, near the road from New Harmony to Mt. Vernon, a bed of coal eight, to ten inches thick, is exposed, and was worked for burning lime. The roof shales contain plant and fish remains, as well as fossil mollusca.

At the mouth of Rush Creek there is a thin bed of coal, ten to eighteen inches thick, overlaid by a bank of sandstone, four to six feet thick; and on the border of the Wabash, at low water, a bed of soft shales is exposed, containing a great abundance of plants. The black, slaty shales, here, contain many fossils.

SECTION AT BLAIRSVILLE.

	Ft.	In.
1. Alluvial soil and Loess	5	00
2. Shales and shaly sandstone	15	00
3. Coal—rash	0	03
4. Fire clay, with broken plants	6	00
5. Sandstone	6	00
6. Fire clay and trace of coal	0	03
7. Shales and shaly sandstone, to Creek	0	00
	32	06

In the sandstone (No. 5 of this section), remarkable fossil remains of standing trees were discovered by Dr. D. D. Owen. One of the largest specimens, preserved in the cabinet of this distinguished geologist (afterward destroyed at the fire of the State University), was two feet three inches high, perfectly cylindrical, and thirteen inches in diameter at the top, where it was broken off. A similar specimen was secured, and sent to the State Museum by the writer, in 1875.

Graysville, Illinois, opposite the northwest corner of the county, gives the following expose of the limestone and first rash coal:

SECTION AT GRAYSVILLE.

	Ft.	In.
Covered space	8	00
Bituminous fossiliferous shales	4	00
Fossiliferous limestone	1	00
Black, bituminous shales	0	03

Rash coal—plant remains	0	03
Slaty coals	0	03
Fire clay	1	00
Shaly sandstone—plant remains	12	00
	26	09

Many fine fossils have been found in the calcareous beds here, and some described by Norwood and Pratten.

The State Geologist is indebted to kindness of Prof. E. T. Cox, his able and meritorious predecessor, for the following facts on the "Geological Features of Posey County." Prof. Cox's long study of this vicinity, aided by the corps of distinguished laborers in this science, who rallied at New Harmony as the central home of geology, gives them high value.

LOCAL GEOLOGICAL FEATURES OF POSEY COUNTY.

The geological features of Posey county, though presenting many points of extreme interest to the paleontologist, are correspondingly uninteresting to the peterographic geologist, on account of the very uniform character of the rocks which present themselves to the view of the explorer.

We find the sandstone, which caps the hills in the northern part of the county and extending into Gibson and Vanderburg counties, spreading over the whole county where the land is elevated enough to catch it. This sandstone is sometimes thin-bedded, but is generally massive, has a reddish-brown color and coarse, granular structure, and is most probably a portion of the great sandstone so well pronounced in the Bluffs at Merom, Sullivan county, Hanging Rock, above Mt. Carmel, on the Wabash River at the latter city, and at Carnie's Bluff, below Mt. Carmel, on the Wabash. It is also seen as a massive rock, but not so thick, as found in the above mentioned localities, in the hills that border the western bottoms of Fox River, in Illinois, six miles west and almost opposite New Harmony, Indiana. A portion of this rock forms the Grand Chain, in the Wabash River, nine miles by land and twenty-two miles by water below New Harmony. The lower part of this sandstone also crosses the river at the Little Chain. At the latter locality, the reef across the stream is formed of a thin-bedded, bluish-gray, highly micaceous sandstone, with here and there impressions of stems of coal plants.

At the time of my visit the United States River Improvement engineers, under the direction of Major J. A. Smith, were engaged in dredging up this sandstone and building a breakwater or cribbed wall of rock, jetting down the stream for a distance of 4,000 feet or more. This dangerous obstruction had been removed for a width of fifty feet, which is as wide as the excavation could be made by once going over, it being the intention, next season, to take out fifty feet more and to make the channel one hundred feet wide, with a depth of six feet of water at the lowest stage. Captain Huston was in charge of this important work, and entertained us most hospitably on his dredge boat, the "Kwasind." I was surprised to see the lower Wabash River, from Mt. Carmel down, such a large and important stream. At New Harmony it is twelve hundred feet wide, and increases this width to the mouth, where, according to the engineer's report, this river discharges more water in time of drought than is found in the Ohio at its embouchere, ten miles above Shawneetown.

SECTION OF FORMATIONS AT NEW HARMONY.

	Ft.		Ft.	In.
Soil and sub-soil	1	to	6	00
Loess	6	to	30	00
Drift, yellow clay, with small crystalline bowlders	10	to	20	00
Hard, blue clay (hard-pan)	½	to	1	00
Merom sandstone; sometimes thick-bedded, yellowish red color and spotted with iron stains; often friable, and seldom suitable for building purposes	10	to	50	00
Argillaceous and siliceous shales	5	to	10	00
Coal	½	to	1	00
Fire clay	1	to	3	00
Limestone; earthy, and of accretionary structure, and without fossils	0	to	2	00
Argillaceous, jointed, bluish-gray shale	20	to	30	00
Thin-bedded and schistose sandstone, highly micaceous, and carrying stems and trunks of *Sigilliria Oweni* and *Asterophycus Coxii*	3	to	6	00
Banded limestone, with *Palæophycus Milleri*	0	to	0	02
Calcareous shale and limestone, full of fossils (West Franklin limestone)	2	to	25	00
Argillaceous shales, with some coal plants, black, bituminous, sheety shales, with fish teeth and *Coprolites*	0	to	2	00
Coal	0	to	0	06
Bluish underclay, full of fossil plants	0	to	3	00
Low water, Wabash River.				

Underneath the sandstone (which I have traced from Merom to the Ohio River, and which, for the purpose of convenience, and fixing the continuity in the mind of the reader, has been designated as the Merom sandstone), there is a massive bed of siliceous and argillaceous shales, with intercalated beds of fossiliferous, calcareous shales and earthy limestones. At West Franklin, opposite Diamond Island, the limestone is of very great thickness.

Prof. E. T. Cox is of the opinion that the West Franklin limestone has its counterpart in the Carthage limestone, which crops in the bank of the Ohio River, about one mile below Uniontown, Union county, Ky. On Big Creek, near the road from New Harmony to Mt. Vernon, this limestone is not so thick, and is of a black color, very close grained, breaks with irregular fracture, and has a strong fœtid odor. It contains a few characteristic Coal Measure fossils, very perfectly preserved, but difficult to procure on account of the hardness of the rock. The fossils are white and, when the rock is polished, they show white on a black background. If the stone could be had in dimensions free from cracks, it would be valuable as a marble for mantles, table tops and other decorative purposes.

At the Lower Hills, in Bethel township, the limestone seen in the shales above alluded to, is of an earthy, accretionary character, not at all resembling the West Franklin, and is without fossils. On the road from New Harmony to Evansville, and about five miles east of the Posey county line, the West Franklin limestone is seen in great force, cut through by the drainage ravines, and is extensively quarried for lime.

At the cut-off, in the edge of New Harmony, there is a beautiful exposure of the lower part of the Merom sandstone and the upper portion of the underlying shales. About ten feet of the sandstone, of a coarse-grained, friable nature, and reddish-brown color, has under it five or six feet of argillaceous shale, containing a seam of poor coal, eight inches thick, underlaid by a bed of fire clay that will answer well for coarse pottery; and, beneath the latter, is an earthy accretionary limestone of a reddish-brown color, and wholly barren of fossils. Under this limestone is a massive bed of bluish-gray, jointed, argillaceous shale, improperly called soapstone. Under this shale, there is a bed of sandstone, about thirty feet thick, in layers from two inches to twelve inches thick. The total thickness of this bed varies, and is best seen at the mouth of the cut-off, where it was quarried by the Old Harmony society for the foundations of its hall, and for the ornamental doorway, the lintels and other portions of the building. This doorway was carved by Frederick Rapp. It can not be considered a durable stone, though the blocks for the above purpose appear, so far, to have withstood the test of fifty-one years. Under this sandstone, at the site of the lower dam, in the cut-off, there is exposed, in the bed of the river and along its shores, another mass of shales, containing a band of flat ironstones, rich with remarkable fossilized ferns that are in bold relief. Some of the most remarkable have been figured and described by Prof. Leo Lesquereux, in the Report for 1875. The best preserved specimen was found on Brouillet's Creek, in Vermillion county, and obtained from the cabinet of Mr. J. F. Miller, Superintendent of the Pan-Handle Railroad, Richmond, Indiana. While on a visit to this place with Mr. James Sampson, of New Harmony, he found and gave to the State Museum some of the very best and most interesting specimens that have yet been discovered. The name given by Prof. Leo Lesquereux is *Palæophycus Milleri.*

These shales and schistose rocks are found throughout the county, and may be seen in most of the streams in times of drought or extreme low water. On Macadoo Creek, near the road leading from New Harmony to the Hume settlement, they are quite siliceous, and contain casts of many fossil shells, conspicuous among which is seen *Monopteria longispina*, Cox.

At Blairsville, on Big Creek, they contain upright trunks of trees, *Sigillaria Oweni*, Lesq. From this famous locality Dr. David Dale Owen obtained many specimens, from six inches to a foot and more in diameter and three feet high from the branching roots to the top of the broken body. Sir Charles Lyell, when on his second visit to this country, accompanied by Dr. Owen, made a careful examination of this locality. Not only has it been examined by the above mentioned parties, but during the years before it had received the attention of William Maclure, Thomas Say, C. A. Leseuer and Dr. Troost; subsequently by Norwood, Shumard, Pratten, Worthen, Lesquereux, Cox, and many others. Below the roots of these standing trees is a bed of argillaceous shales, containing some fossil ferns, and other coal plants, and a thin seam of coal.

The calcareous beds which underlie this member of the general section were best exposed on the bank of the Wabash, just above the mouth of Rush Creek, but they had been so extensively worked for fossils by the very many geologists who congregated at New Harmony, that the subsequent freshets of the Wabash have filled up the excavation to such a depth that it would be a vast and expensive undertaking to excavate it so as to again expose the fossil bed. At the cut-off the fossil bed is not so thick; but it was crowded with fossils that have gone to enrich the cabinets of the country.

I should have stated that the two massive blocks of limestone, above alluded to, in the cut-off and the Rush Creek locality, furnished the fossils for the excellent monograph on carboniferous fossils published by Norwood and Pratten, also a subsequent publication by J. H. McChesney.

Any one wishing to study the fossils of these famous localities must visit the extensive collection made and owned by Mr. James Sampson, of New Harmony. Every available part of his residence contains cabinets that are filled with fossils and other objects of natural history. But it is when you enter what he calls his "sanctum sanctorum" that one is bewildered with the vastness of his labors in bringing together the natural history of this renowned region of the State. There are two rooms to this temple of science. The first one you enter contains his work bench, around which is to be found a multitude of tools suitable for all kinds of work. In the center is a round table for books, papers, etc. The ends are filled with cabinets and shelves, crowded to their utmost capacity with choice specimens. The ceiling overhead is completely covered with prepared specimens of fishes, cheloniæ, snakes, etc., etc. The next room has its sides and ends filled with cabinets from top to bottom, and in the central space, leaving a narrow walk on each side, is also a string of cabinets. Here are to be seen Indian relics of all kinds, among which are a great many that are rare and precious. In others are the prepared skulls of all the birds and quadrupeds of the district, feet of birds, etc. There are rows of bottles filled with reptiles. Here, again, every available spot on the ceiling is covered with heads and skins of animals.

When you have finished looking through this vast museum, you will not fail to be impressed with the amount of labor required, through the single exertions of one man, to hunt them up and clean the fossils from their rock matrix, more or less difficult to remove, and place everything away in admirable order. Mr. Sampson is now 77 years old, and is still a hale and hardy man, and just as full of enthusiasm for collecting as in his younger days. He walked with me to visit many localities and, on returning in the evening, showed no signs of the least fatigue—in fact, was not nearly so tired as I found myself.

Mr. Sampson is not the only collector and naturalist at New Harmony, for this is also the home of Prof. Richard Owen, the former State Geologist of Indiana, and for many years Professor of Geology and Natural History in the State University, at Bloomington. At the time of my visit, this distinguished scientist and author was absent, with his wife, on a visit to the Southern Exposition, at Louisville. I met him on the cars as they were returning home, but, being on the way to Griffith Station, I was sorry that I could not accept his kind invitation to pay him a visit.

I found that Mr. John Chappelsmith had, on the death of his wife, returned to England. He lived for many years in New Harmony, and drew all of the fossils that were described by Prof. E. T. Cox, and figured in the 3d Kentucky Report. He was a skilled artist and engraver. I spent an afternoon at Mrs. Thomas', looking over several scrap books that contained specimens of drawings and steel-plate engravings. They were admirably drawn and showed great skill.

The calcareous shales of the cut-off and Rush Creek are also seen in the bank of the Wabash River, at Grayville, Illinois, twelve miles above New Harmony. At the latter locality, it is highly fossiliferous, and there is a band of ironstone just above it, which has furnished a large number of remarkable *Cephalopoda*, *Lamellibranchiata*, *Brachiopoda*, *Gasteropoda*, *Pteropoda*, *Bryozoa*, and corals. Like Rush Creek and the cut-off, this also has been a place of great resort for the New Harmony naturalists, and has furnished specimens that were new to science.

William Maclure, who purchased one-half of the town of New Harmony from Robert Owen, in 1825, for the purpose of promoting a love for natural history, was, himself, one of the earliest workers in geology, and, indeed, might properly be classed as one of the founders of the science. He crossed the Alleghany Mountains many times on foot, to study their rocky structure, and lived long enough to see his conclusions, which were published in book form, verified by the research of modern students. Associated with him at New Harmony was Thomas Say, styled the great American naturalist; C. A. Leseuer, the great artist and ichthyologist of the expedition of La Peruse, fitted out under the auspices of Napoleon I, to explore Australia; D. Troost, the eminent geologist and mineralogist, who afterwards moved to Nashville, where he died, leaving a cabinet of great scientific value. These eminent men were followed by the late David Dale Owen, M. D., and his brother, Prof. Richard Owen, who came to New Harmony in 1832, fresh from the schools of Europe. Dr. D. D. Owen commenced at once to arrange a chemical laboratory and museum of natural history on a scale that, in those days, had no superior in this country. William Maclure turned over to him his vast collection of rocks and minerals that had been made in Italy, Spain, Portugal, West Indies, Mexico and France, at a great cost. So vast was this valuable collection that many boxes remained unopened up to the time of their removal to the State University at Bloomington. In 1837, D. D. Owen was appointed United States Geologist, with headquarters at New Harmony. He was instructed to make a reconnoisance of what was then the Great Northwest, now Minnesota, Wisconsin, Iowa, and the northern part of Illinois, in order to point out, for preservation by the Government, the salt springs, lead and other mineral-bearing rocks, previous to offering the lands for sale. This herculean task was accomplished in two months, and the report laid before Congress at the opening of the next session. Several hundred men were employed in making the survey. They were divided into companies, having an intelligent head to look after the work, and each company was allotted a district, in which every section was to be visited and samples of the rocks collected. At stated points, Dr. Owen would meet each camp, and study the work accomplished. The country was almost without settlements, and each camp had to be supplied with hunters, whose duty it was to furnish game for subsistence.

In looking over Dr. Owen's report, one can not fail to appreciate the skill and fidelity with which this great geologist performed this survey under immense difficulties and in such a short time. He carried with him on the trip up the Mississippi a suite of rocks and minerals, which were exposed on a table in the cabin of the steamboat, and he would daily give his men instruction in geology and point out the characteristic rocks of the leading formations and the minerals that it was likely would be found in them. In this way, by the time they reached the place to disembark, they had been made acquainted with the first principles of geology. In after years, this great region was more systematically surveyed by Dr. Owen.

The headquarters of the United States Geological Survey continued at New Harmony up to 1856. Among the geologists connected with these surveys, who spent more or less time at New Harmony, were Dr. J. G. Norwood, B. F. Shumard, Dr. Litton, Col. Charles Whittlesy, the veteran geologist, Dr. Locke, F. B. Meek, the eminent paleontologist, and others.

After the completion of the Smithsonian Institution building at Washington, the headquarters of the Government surveys were established in that city.

Dr. Owen was placed in charge of the Kentucky survey and the Arkansas survey, with Dr. J. G. Norwood in charge of the Illinois survey, and Prof. Richard Owen in charge of the Indiana survey, all of whom had headquarters at New Harmony, where the advantages of comparison could be found in the extensive cabinets of the Owen collection. New Harmony, then, became the resort of a great many geologists, some of whom made it their home. I may mention among these, as connected with the Kentucky survey, Maj. Sidney Lyon, Prof. E. T. Cox, Leo Lesquereux, Mr. Nicholson, civil engineer and topographist. In the Arkansas survey, E. T. Cox, Leo Lesquereux, Dr. Elderhorst (author of "Elderhorst on the Blowpipe"), and Joseph Lesley; on the Illinois survey, J. G. Norwood, chief; Henry Pratten, J. H. Wolfers, Dr. Varner, A. H. Worthen and J. H. McChesney. In the Indiana survey, Richard Owen and Leo Lesquereux. From this, it will be understood why New Harmony became a kind of Mecca for geologists and naturalists. Subsequently, A. H. Worthen became State Geologist of Illinois, and the headquarters was moved to Springfield. Prof. E. T. Cox was appointed State Geologist of Indiana in 1869, and the headquarters of the survey was established at Indianapolis.

ECONOMIC GEOLOGY.

The survey is indebted to the favor of Gen. Alvin P. Hovey for the following paper on the common sense interests of Posey county, and it is so reliable and pointed that it is given verbatim:

Posey county was organized in 1814 and named in honor of one of our Territorial Governors, Gen. Thomas Posey.

It lies in the extreme southwestern part of the State, and is bounded, on the south and west, by the Ohio and Wabash Rivers, for the distance, by their sinuosities, of at least one hundred and forty miles.

The topography of this part of the State is but very imperfectly known abroad. The great body of the county is gently undulating. Large tracts of rich black soil are found in level lands or flats of Black River, Big Creek and Point townships, which are above all overflows of the Ohio and Wabash Rivers.

There is a general misapprehension as to the "bottom land" of the rivers. Commencing where the southeastern line strikes the Ohio River, following it down to the Wabash, and, thence, up the Wabash, to the northwestern corner of the county, near Grayville, Illinois, a strip of land on the margins, not exceeding a half a mile in general width, forms the celebrated "bottoms," or corn lands, of Posey. These bottoms have given the travelers on the river the general idea that the whole of the county is a level swamp. Commencing at Mt. Vernon, and running north to Cynthiana, it can be safely said, that no finer or better land can be found in this State, or any other part of the United States. The best of water is found in every locality, and a failure of any crop is unknown to the oldest inhabitant. There are many fine fields of wheat which have been cultivated for fifty years, and producing more now than they did in former years. It has a rejuvenating subsoil, that seems to be exhaustless and improves on continued cultivation. In wheat, it is the banner county of Indiana, the "Banner State," and produces over 4,000,000 bushels of corn, or maize, with a capacity, when fully developed, of almost doubling its present productions. Below is given an abstract taken from the office of the Auditor, for 1883—that for 1884 is not yet complete, and may be increased by at least ten per cent.

1883.

Acres of wheat	60,693
Acres of corn, up-land	79,641
Acres of corn, bottom land	13,372
Acres of oats	3,615
Acres of barley	101
Acres of rye	104
Acres of Irish potatoes	760
Acres of sweet potatoes	99
Acres of timothy hay	5,042
Acres of clover	12,087
Acres of blue grass	1,234
Drain tile, rods	89,346

I will only observe that our wheat averaged about eighteen bushels per acre, which would amount to about 95,000 bushels; corn land at least forty-five bushels per acre, or over 4,000,000 bushels; besides other grain. There are probably about 20,000 acres of good land held by their owners out of cultivation as timber land, which is of the best quality.

There are outcroppings at West Franklin, ten miles above Mt. Vernon, and on the Grand Chain, on the Wabash, of sandstone and bastard lime-rocks, but of no considerable quantities. There can be but little doubt that the whole county is made land, with the usual coal formation in this locality; and vein M., worked at Evansville, Shawneetown, Henderson, and other surrounding localities, clearly prove the existence of the same formations here. There are eight or more spots in the county, at different points, where coal, in the upper or thinner veins, crop out. The working vein at Mt. Vernon will, probably, be found at about 200 feet below the surface, and a company is about to be formed to sink a shaft on the Ohio, near Mt. Vernon. The highlands, commencing at the upper part of the city of Mt. Vernon, and extending about eight miles below, are above the highest water of the Ohio River, and are destined, at no distant day, to be covered with manufacturing establishments. There is no other locality on all the banks of the Ohio River, from Pittsburgh to its mouth, where eight continuous miles of high banks, above all high water, can be found. It will be the foundation for a future great city; for as the drainage of all the table lands of the Ohio valley are speedily thrown into the river, by the hundreds of thousands of miles of tiling and artificial ditches, the river will be annually subject to increasing overflows, until manufacturers will be compelled to abandon all overflowed localities and seek positions above the swelling waters.

Without doubt, there is a bright future for Posey. No other county of the same number of square miles has the same agricultural advantages. Every part of her one hundred and forty miles of river, and her eighty miles of railroad running through her lands, offer to the agriculturist markets for the vast quantities of grain grown upon her soil. The rivers compete with the rail, and the rail with the rivers, for low freights, and the agriculturist, instead of being at the mercy of one kind of transit for his produce, has his option to select another.

ARCHÆOLOGY.

Posey county was the center of mechanical skill in the time of the Mound-Builders. Copper was beaten into thin plates, for buttons, gorgets and tiny bells; obdurate flint was polished as are Danish flints; shells from the ocean were pierced and polished for ornaments; beautiful vases and vessels were made in perfect symmetry; and the native pearls of the Wabash were prepared and pierced to serve as beads.

Several good-sized mounds were seen on the bluff, one hundred and seventy feet above the Ohio, at West Franklin, giving a wide out-look over the beautiful river and its rich valley lands.

A clump of mounds on the bluff overlooking New Harmony attracted the attention of our early scientists. One was opened and described by Leseuer. At the same town the old German burial ground is dotted with mounds, showing the taste of our predecessors for beauty in aspect and situation.

TABLE OF ALTITUDES AND DISTANCES,

With Elevation at Low Water above the Level of the Sea, on Wabash River between Terre Haute and Mt. Carmel, and on White River between its mouth and Hazelton. Distances taken in steamboat channel at low water from maps made from recent surveys.

WABASH RIVER.

LOCATIONS.	Miles from Wagon Bridge at Terre Haute.	Miles from Wagon Bridge at Vincennes.	Elevation of Low Water Above the Sea in Feet.
Main Street Bridge, Terre Haute	0.00	90.00	447.73
Foot of Island	1.60	88.40	446.32
Sugar Creek	2 50	87.50	445.88
Old Terre Haute, Ferry	4.55	85.45	445.41
Musgrave's Ripple (head) (Fall, 1.04 ft.)	7.20	82.80	444.12
Eight Mile Island (head)	7.80	82.20	442.93
Eight Mile Island (foot)	8.10	81.90	442.49
Hawk's Creek	10.95	79.05	442.11
Goose Nest Island (head)	12.70	77.30	441.92
State Line, Corner Stone	14.65	75.35	440.60
Strain's Ripple (head) (Fall, 1.20 ft.)	16 35	73.65	440.27
Turkey Reach, Ferry	18.10	71.90	438.71
Big Creek	18.70	71.30	437.70
Creek at Head of Aurora Bend	20.95	69.05	436.55
Foot of Aurora Ripple (Fall, 1.16 ft.)	21.70	68.30	434.75
Darwin Ferry	23.60	66.40	433.78
Darwin Landing	23.80	66.20	433.60
Bowen's Ripple (head) (Fall, 0.66 ft.)	25.50	64.50	432.68
Prevo's Landing (warehouse)	26 45	63.55	432.00
Little Sycamore Bend (head of bar)	27.90	62.10	431.57
Bridge Piers, Chenowith's Reach	29.15	60.85	431 26
Prairie Creek	30.40	59.60	430.95
Niles' Landing	32.10	57 90	430.15
Devil's Elbow Ripple (head) (Fall, 1.54 ft.)	35.40	54.60	429.56
Mill Creek, at York	36.40	53.60	427.71
Green's Ripple (head) (Fall, 0.66 ft.)	38.10	51.90	427.29
Raccoon Creek	39.35	50.65	426.46
High Water Cut-off, Hackberry Bend	41.10	48.90	425.84
Foot of same	43.20	46.80	424.69
Hutsonville Ferry	43.50	46.50	424.63
Hutson Creek	44.10	45.90	424.30
Head of Island	45.25	44.75	423.77
Turman's Creek	46.20	43.80	422.68
Harney's Landing	47.80	42.20	422.17
Merom Island (head)	50.05	39 95	420.88
Merom Ferry	51.00	39.00	420.81
Eagle Island (head)	53.00	37.00	419.41
Narrow Gauge Bridge	53.80	36.20	418.78
Greer's Ripple (head) (Fall, 1.09 ft.)	55.20	34.80	418.43
Palestine Landing	57.75	32.25	416.71
Turtle Creek	60.75	29.25	415.10
Hite's Ferry	61.85	28.15	414.71
McCutcheon's Slough	63.45	26.55	414.00
Shaw's Landing	65.70	24.30	412.70
Longtown Landing	67.70	22.30	411.42
Foot of Cut-off, Johnson's Ripple	70.30	19.70	409.49
Horse-shoe Cut-off (head)	71.20	18.80	409.79
Doe Creek	71.60	18.40	409.69
Swan Island	74.00	16.00	407.46
Goose Bar	75.15	14.85	406.75
Russellville Sawmill	77.20	12.80	405.28

WABASH RIVER -Continued.

LOCATIONS.	Miles from Wagon Bridge at Terre Haute.	Miles from Wagon Bridge at Vincennes.	Elevation of Low Water Above the Sea in Feet.
Belgrade Landing	81.50	8.50	403.42
Seven Mile Island (foot)	84.00	6.00	401.96
Massey's Bend Ripple (foot) (Fall, 0.35 ft.)	85.00	5.00	401.32
Fort Knox	86.30	3.70	401.09
Soap Creek	88.40	1.60	399.81
R. R. Bridge, Ohio & Mississippi	89.55	0.45	398.97
Wagon Bridge, Vincennes	90.00	0.00	398.81
Embarras River	95.75	5.75	394.85
Nine Mile Island (head)	98.45	8.45	394.61
Nine Mile Ripple (head) (Fall, 1.40 ft.)	98.85	8.85	394.45
R. R. Bridge	99.50	9.50	392.83
St. Francisville Landing	102.90	12.90	391.46
Raccoon Creek	106.90	16 90	389.91
River Deshee, Head of Cat-fish Bend	109.30	19.30	387.96
Little Rock Ripple (head) (Fall, 1.80 ft.)	112.00	22.00	387.66
Beadle's Dam Ripple (head) (Fall, 1.30 ft.)	114.75	24.75	385.40
Buchannan's Ferry	116.40	26.40	383.40
Hanging Rock (Fall of Ripple, 1.25 ft.)	118.75	28.75	382.55
Grand Rapids Dam (Fall of Ripple, 4.50 ft.)	121.10	31 10	378.68
Hurd's Ferry	121.50	31.50	376.76
White River, "The Point"	122.55	32.55	376.55
R. R. Bridge, Louisville, New Albany & St. Louis	123.70	33.70	. . . .

WHITE RIVER.

LOCATIONS.	Miles from Mouth of White River.	Miles from Hazelton Ferry.	Elevation of Low Water Above the Sea in Feet.
Mouth	0.00	18.30	376.55
Ferry	2.95	15.35	376.73
Kelley's Ripple (foot)	3.30	15.00	378.07
Kelley's Ripple (head) (Fall, 1.80 ft.)	3.70	14.60	379.95
Bingham Place	5.05	13.25	379.46
Outlet Spring Lake	7.00	11.30	379.72
Slough, Foot of Bar	9.00	9.30	380.16
Field's Ferry	10.75	7.55	380.94
Ripple (foot) (Fall, 0.20 ft.)	14.00	4.30	383.34
Worth's Ripple (head) (Fall, 0.80 ft.)	16.00	2.30	385.69
Hazleton Ferry	18.30	0.00	387.05
R. R. Bridge, E. & T. H.	20.80?	. . . .	388.82

NOTE—The first three of the low water elevations given above for White River, are taken from a survey made in 1879; the others from a survey made in 1880. Distance from mouth of White River to Mt. Carmel R. R. Bridge is 1.15 miles.

The above distances and elevations have been carefully compared and corrected by Jared A. Smith, Major of Engineers, U. S. Army, to whom thanks are returned.

GEOLOGY OF MORGAN COUNTY.

BY RYLAND T. BROWN, A. M., M. D.

GEOGRAPHICAL AND HISTORICAL NOTES.

Morgan county covers an area of 409 square miles, lying in an irregular square, the eastern and southern boundaries being unbroken section lines, while the northern line has an offset of two miles, and the western one an offset of three miles, and an irregularity at its northern extremity caused by Mill Creek forming a part of the line. Morgan county is bounded on the north by Hendricks and Marion, on the east by Johnson, on the south by Monroe and Brown, and on the west by Owen and Putnam counties. It was organized in the spring of 1822 by the appointment of Benjamin Hoffman, Jonathan Williams and Larkin Reynolds, County Commissioners, George H. Beeler, Clerk, and Benjamin Cutler, Sheriff. These appointments were made by the Governor, and the commissioners proceeded to divide the county into civil townships and complete the organization by ordering an election for the remaining county and the township officers.

The first permanent settlement of white inhabitants in Morgan county was made in the spring and summer of 1819, on the southeast side of White River, between the mouth of Crooked Creek and the bluff, where the village of Waverly now stands.

Soon after the ratification of the treaty of St. Mary's (in the autumn of 1818), extinguishing the Indian title to all the land lying in the central portion of the State, an idea became prevalent that the four sections of land donated to the State for a capital by the act of Congress admitting it into the Union, would be located near the bluffs of White River. This brought a number of adventurers into the wilderness, even before the land was surveyed. This settlement before the close of the year 1819 had swelled to the number of about a dozen families, which served as a kind of center of distribution for subsequent immigration.

Cyrus Whetzel, who located his cabin near the mouth of Bluff Creek, had opened a trace through the forest from the older settlements on White Water, and for several years afterward "Whetzel's trace" was an institution familiar to all emigrants from the east to Central Indiana. Hiram

T. Craig and James and Robert Stott, who settled at the mouth of Crooked Creek, two miles below Whetzel's, had also opened a trace from Vernon, by the mouth of Flat Rock, now Columbus. This opened a communication with the southern settlements of Indiana, and gave this early pioneer colony a prominence, and, indeed, made it the parent of numerous other backwood settlements.

The county, at present, is divided into fourteen civil townships, arranged in four tiers, north and south, beginning at the north end of the eastern tier, as follows: First, Madison, Harrison, Greene and Jackson; second, Brown, Clay and Washington; third, Monroe, Gregg, Jefferson and Baker; fourth, Adams, Ashland and Ray. These are quite irregular, both in size and form, several of them having White River for one boundary, which gives a very irregular margin.

The principal towns are Martinsville, in Washington township, the county seat; Mooresville, in Brown; Brooklyn and Centerton, in Clay; Waverly, in Harrison; Morgantown, in Jackson; Paragon, in Ray; Alaska, in Ashland; Eminence, in Adams; Hall, in Gregg, and Monrovia, in Monroe.

DRAINAGE AND TOPOGRAPHY.

White River traverses Morgan county diagonally from northeast to southwest, and, with its tributaries, furnishes ample drainage for the whole county, with the exception of Adams and a part of Ashland townships in the northwest corner of the county, which are drained by tributaries of Eel River. On the southeast side, White River receives Bluff Creek, Crooked Creek, Stott's Creek, Clear Creek, Indian Creek, Little Indian Creek and Bryant's Creek. From the opposite side, it receives White Lick, Sycamore Creek, Highland Creek, Lamb's Creek, Burkhart's Creek, Fall Creek and Butler's Creek. Running westwardly into Eel River, we have Lake Creek, Mud Creek and Rhoades' Creek. These complete a most perfect system of drainage, and, at the same time, supply the country with water from numerous springs which break out along their several courses. White River is a large stream, having been declared a public highway for navigation by act of Congress before the land was surveyed.

In the early years of the settlement of this county, flatboats loaded with produce, were occasionally floated to New Orleans, at the time of spring freshets in White River, and in the spring of 1824 a stern-wheel steamboat made its way up this stream as far as Indianapolis. But since the forests have been cleared away, the streams have greatly diminished in size and persistence of volume, though, if there was a demand for it, White River could still be used for flatboat navigation at the time of spring floods; but railroads having supplied the demand for transportation, the river is no longer used for that purpose. The general course of White

River through Morgan county is more direct than it is above this, and a number of short curves and "horse-shoe bends," which existed when the bottom lands were covered with timber, have been relieved by the wâter making a new channel or "cut-off" since the forests were cleared away. A cordon of rocks form rapids in the river in section 32, range 1 east, township 12 north, in which the river has a fall of four feet in half a mile.

Several of the tributaries of White River, above named, were, formerly, regarded as valuable mill streams, but at present they are nearly dry during the summer and fall months, and are, therefore, practically worthless for mill purposes.

In its general surface, Morgan county is more diversified than most other counties in the State. A belt of country along the northern border of the county, embracing Madison, Brown, Monroe and Adams townships, is quite level, or, at most, not so broken as to materially interfere with cultivation. It is covered with a deep deposit of drift material, forming a soil more largely mixed with sand than the clay soil of the regions further north. It is, therefore, a friable, mellow soil, easily cultivated and very productive. Adams, and the western half of Monroe township, present large tracts of black-muck swamp lands, that were originally covered with water a great part of the year; but ditching and underdrainage is converting these swamps into the best of farm lands, especially adapted to the production of corn. This region was originally covered with a heavy forest of white oak, burr oak, ash, beech, sugar maple, black walnut, yellow poplar (tulip tree), hickory, etc. But little of this, however, remains. Much of it was displaced to make room for cultivation, and the recent demand for walnut, poplar, ash and oak lumber has thinned out most of the choice timber from the forests that remain.

Directly south of this belt, and embracing the greater part of Clay, Gregg and Jefferson townships, lies a region of knobs, but little of which is level enough for profitable cultivation. The hills, in some places, rise to the altitude of three hundred feet above the level of the river, and are frequently so steep as to make the ascent difficult, even on foot. The surface soil of these knobs is generally clay, with but a very thin coat of vegetable loam covering it. It, however, produces a good growth of grass, and both peach trees and apple trees make a vigorous growth on it, and appear to be long-lived. These knobs, therefore, may be utilized for pasturage and fruit culture. The forest on these hills was originally a rather small growth of white oak, jack oak, black hickory, with an occasional grove of sugar maple. Much of this timber has been sold—the oak for railroad ties and the hickory for wagon timber.

West and southwest of these knobs lie Ashland and Ray townships, the uplands of which consist of an elevated plain of clay lands, interspersed with an occasional spot of very rich loamy soil. In places it is broken by numerous funnel-shaped depressions, familiarly known as sink-holes.

Some of these are thirty feet deep and embrace half an acre of surface. The hills bordering the streams are in many places abrupt bluffs of limestone. The timber here very nearly answers to that on the northern tier of townships, with the absence of the burr oak. Some of this land will be improved by underdraining, when it will produce well.

The uplands in the townships of Harrison, Greene, Jackson, Washington and Baker, lying on the southeast side of White River, are more uniform in their character than those on the opposite side of the river. In the vicinity of White River, the surface in many places is quite hilly and the general elevation of the country is about two hundred feet above the level of the river. But these hills are seldom so steep as to materially interfere with cultivation. The soil on them is generally a sandy loam.

After passing back from the river hills two or three miles, the surface becomes gently undulating, and in many places quite level, while the soil changes from a sandy loam to a compact clay loam, resting on a rather hard clay subsoil. These lands will require tile drainage to develop their full producing capacity. Under proper treatment there are but few soils that will be more productive or more pleasant to cultivate than the land on the eastern border of Morgan county.

White River, in its course, developes a very wide margin of bottom land, about two-thirds of which lies above the reach of freshets, and that which is subject to overflow is seldom visited by this catastrophe except in the spring months, and the crop on these lands being generally Indian corn, can be planted after the freshet has subsided, and a heavy yield secured, for these lands are inexhaustively productive. While the bottom lands are distributed pretty uniformly along the river (for the hills are seldom less than a mile apart), yet the large districts of bottom lands may be considered in three groups, to-wit:

The Centerton, or White Lick, bottom, is about five miles long, and in several places, more than two miles wide. Lamb's bottom extends from the rapids of White River, nearly opposite to Martinsville, to a point some distance below Paragon, giving an area of about twenty-five square miles, most of which is above high water. Indian Creek bottom, on the southeast side of the river, extends from Martinsville to the west line of Washington township, a distance of about six miles, with a width of from one to three miles. In this bottom, in section 17, range 1 east, township 11 north, there occurs the curious phenomenon of a "lost hill," as it is familiarly called. This consists of a hill about one hundred feet high, nearly a mile long and a quarter of a mile wide, detached from the main upland by a strip of bottom land half a mile wide, more or less. The hill consists chiefly of a mass of heavily stratified sandstone. Indian creek bottom is much of it subject to overflow—more, however, from the freshets of Indian Creek than from the floods of White River. Like all other alluvial lands, these bottoms are generally built on a substratum of gravel, which gives perfect underdrainage to these broad, level plains, that renders them exceeding productive. I observed a spot in the Centerton bottom, and one or more in Lamb's bottom, that were exceptions to this rule. These are composed of a sedimentary deposit of a very fine, light-colored clay. The bricks used in the construction of the new State Capitol are made from this Centerton deposit and it proves to be an excellent material for the purpose. The manner in which these large districts of bottom land were formed, and the nature of the forces operating in their formation, will be considered in their proper place; at present we speak of them only in their economical relation, as furnishing an area of more than fifty square miles, in this county, of land which has no superior in points of productiveness, durability and adaptation to a variety of crops.

GEOLOGY.

The underlying rock of nearly the whole of Morgan county is the knob sandstone, which is now generally regarded as the lowest member of the Carboniferous formation. Measuring its outcrop from its junction with the Devonian shale on Bluff Creek, in Johnson county, along the line of strike to the point of its disappearance under the Keokuk limestone, near the corner of Owen county, and allowing it a dip of twenty feet to the mile, we may assume the thickness of the knob sandstone at this point to be about five hundred feet. This corresponds very nearly to the register of the boring at Reelsville, in Putnam county, where a thickness of four hundred and eighty-eight feet was reported. The base of this formation consists of a clay shale, thinly laminated but not distinctly stratified. This shale, when moist, has a pale blue color, but when dry it is ash colored. When exposed to the weather, it crumbles into a mass of sandy clay, with scarcely enough iron in its composition to tinge it red when burned. This shale has occasional bands of a hard, blue rock, from three to ten inches thick, interposed at irregular distances. These rocks are siliceous, though they have not the mechanical structure of sandstones. They are generally smooth and parallel on their faces, but, lacking elasticity, they endure change of temperature badly. Their hardness and firm appearance have often misled builders to use them in preference to the softer but more durable sandstones. The entire absence of fossil remains is a rather remarkable feature of this shale, for though it had, probably, neither lime nor silica in a proper state to produce petrifactions, yet it appears to have been an excellent material to receive impressions and retain them in the form of moulds or casts; but a diligent search revealed no such marks of organic remains. A few crinoid stems and an indistinct impress of a coral, found near Waverly, was the only evidence of life which I observed in this extensive deposit of shale. This is the more remarkable as it is in a shale corresponding to this, and nearly on the same horizon, that the noted crinoid beds of Crawfordsville are found. At a point, however, five miles below this, on the southeast side of the river, near the mouth of Clear Creek, a bed of argillaceous sandstone occurs, which abounds in fossils, though the species are not numerous. We obtained *Taonurus Colletti*, *Zaphrentis Dalei*, *Spirifier Carteri*, *Productus semi-reticulatus*, *Productus costatus*, and fragments of several unidentified species were also observed.

The upper members of this formation present a distinctly stratified sandstone, generally of a gray, or light drab color, sometimes showing a distinct shade of buff. The lower members of this series are often so largely mixed with clay as to destroy their value as a building material. This clay gives a more or less distinct blue shade to the stone; and though it is generally harder than the purer sandstone, yet, on exposure to the weather it disintegrates rapidly. In selecting building stone from this formation *it will be safe to reject all that have the blue or lead colored shade*. Higher in the series, and generally crowning the highest elevations, we find a fine-grained sandstone, in strata ranging from one foot to five feet thick. This stone is quite soft in the quarry, and this feature of its character has deterred architects from adopting it as a building stone. But when it loses its quarry moisture, and is once thoroughly seasoned, it becomes very firm and hard, and absorbs but little water when exposed.

The chief defect I observed in this rock, as a building material, is the occasional occurrence of small specks of oxide of iron that may produce unsightly stains; but these are small, and, in the thicker strata, of rare occurrence. Care must be observed in quarrying this rock. Like most sandstones, the grains cohere with but little force in the quarry condition, and even a very moderate blast will shatter the firmest rock in these quarries for a distance of fifteen feet or more, so as to render it practically worthless. Blocks may be taken out very rapidly and neatly with a channeling machine, or with steel wedges, even without drilling.

The outcrop of this rock occupies the summit of the hills on the southeast river front, from the mouth of Bluff Creek to Martinsville with but two or three interruptions, the widest of which is at the mouth of Stott's Creek. But few quarries, however, have been opened, and these have not been worked to any considerable extent, and generally with but little skill or science.

Mr. S. J. Mandeville has opened a quarry at Peach Orchard Hill in section 6, range 2 east, township 11 north, and is taking out a good quality of stone, and exhibiting both science and skill in the operation. The strata in this quarry now exposed range from two feet to five and a half feet thick, and the stone is very uniform in its texture. It shows but few iron specks and no petroleum stains that disfigure many of the Ohio and Pennsylvania sandstones.

This is the only point in the county where the working of the quarry gave me a fair opportunity to judge the quality of this stone as a building material, and, after examining it, both in the quarry and in its dressed and seasoned condition, I have no hesitancy in saying that it will fairly compete with the best Ohio sandstone, both in point of beauty and durability. Mr. Mandeville's quarry is eight hundred and sixty-two feet above tide water and two hundred and sixty-five above Martinsville.

It is not improbable that stone of a quality equally as good as this at the Peach Orchard quarry may be found at other points in the county, and more convenient to railroad transportation than this is; but the quarries are not opened, or have been so imperfectly worked that it is difficult to form such a judgment of the stone as if it were exhibited under more favorable circumstances.

One mile east of Mooresville a quarry has been worked by an Indianapolis company for the last five years, and a large amount of stone, of a fair quality, has been taken out. This quarry is too low in the formation to yield the best quality of stone. The strata do not exceed eighteen inches thick, and in some of the strata there is too much clay in the composition to be entirely reliable in exposed situations. This quarry is the nearest workable outcrop of rock to Indianapolis; and with a railroad switch to the quarry, and proper care in selecting the rock, this quarry may be very profitably worked. A mile west of Waverly an outcrop of sandstone appears in several places, which gives promise of valuable quarries, but they have not been worked sufficiently to determine fully the character of the rock. The strata, where exposed, are from twelve to twenty inches thick, and generally of a drab or light buff color, and of a very fine grain.

From the exposure of this rock at "The Bluffs" (now Waverly), the material was obtained for the foundation of the former court house, the abutments of the National road bridge over White River at Indianapolis, and the basement of the old state house. In the last, the blue stone was unfortunately selected, and its speedy decay brought the stone into bad repute. The bridge abutments and the court house foundations proved reasonably durable.

Nearly all the higher knobs of Clay, Gregg and Jefferson townships are capped with sandstone, though it does not always appear on the surface, and in many places, no doubt, quarries may be opened and worked with profit. This remark, however, can apply only to localities favored with railroad transportation.

The summit of the high hill (known by the local name of Mount Ætna) about a mile southwest from Brooklyn is worth a careful examination. It is proper to say, in this connection, that the exposed rocks on the northwest side of the river, lying nearer the summit of the formation, are more highly charged with iron oxide than those nearer its middle.

SUB-CARBONIFEROUS LIMESTONE.

At the mouth of Rhoade's Creek, near the northwest corner of Ashland township, the Keokuk member of the sub-carboniferous limestone makes its appearance on the eastern bank of the Mill Fork of Eel River. At this point it is thinly stratified and rather argillaceous in its composition, but near Alaska, three or four miles southeast, it is well developed and presents its characteristic fossils. These are quite numerous in the individuals, but embrace only a few species. (See Appendix.)

Three miles south of this, at Porter's Cave, immediately on the Owen county line, the St. Louis member crowns the hill above the cave, while the gorge below is excavated in the Keokuk. Immediately at the junction of these members of the sub-carboniferous limestone, there occurs a single stratum of dolomite, five feet thick. It is quite soft, and has the peculiar unctuous feel, characteristic of magnesian rocks.

PORTER'S CAVE

Is formed by a considerable stream of water, which has cut away the soft magnesian rock, and has worn its way some two feet into the Keokuk strata which forms the floor.

The opening of the cave looks to the southeast, and is twenty-five feet wide, with an average height of seven feet. The roof, for the first one hundred feet, is smooth, and appears to be composed of a single slab of St. Louis limestone. In this distance, the cave narrows to an average width of sixteen feet, with an elevation of five feet six inches. From this point the roof breaks and is irregular, reaching in some places an elevation of from twenty-five to thirty feet. At the same point the walls abruptly recede, and display a room thirty feet wide, with irregular walls, incrusted with adhering stalactites. For the next reach of one hundred yards, the width gradually narrows to ten feet and the roof becomes a gothic arch by the jutting forward of the strata, which are now, in most places, covered by the stalactite formation. The floor is tolerably smooth, and quite free from loose stones. A brisk current of water, from four to ten feet wide and two or three inches deep, runs on the floor, varying its position from side to side, making the frequent crossing of it a necessity. I extended my observation for about four hundred yards, when the water (covering the bottom from side to side) became so deep as to demand waterproof boots, which I had not with me. As far as I explored, the roof continued so high as to permit of walking upright, though I am informed that, further on, it is, in some places, so low as to require the explorer to stoop. The cave has an opening on the opposite side of an elevated ridge, three-quarters of a mile from the outlet I examined. At the first room, one hundred feet from the entrance, there is exposed several strata of limestone, ranging from one to four feet thick, which show a decidedly ōolitic structure. The stone is much harder than the Bedford or Ellettsville stone, but this may be owing to its having been long exposed. Immediately below the cave, the water coming from it forms a cascade by making a leap of thirty feet from the floor of the cave into a wild and romantic glen.

Porter's Cave is directly on the line between Morgan and Owen counties, five miles northwest from Paragon.

The region of country along Butler's Creek, below the cave, including the ridge between that stream and Fall Creek, on the east, gives a remarkable instance of the influence of the geology of a country on its topography and soil. Passing westward over the knobs of Sycamore Creek, Lamb's Creek, Burnett's Creek, and Fall Creek, we observe the sterile soil, with its stinted growth of white oak and black hickory, but, suddenly, on reaching a hill capped with St. Louis limestone, immediately we enter a forest of sugar maple, black walnut, yellow poplar, blue ash, wild cherry, etc. But these rich hills are badly broken by sink-holes.

GLACIAL PHENOMENA.

The drift deposits of Morgan county, like its topography, is varied and very irregular. On the southeast side of the river, the surface deposit is more uniform than on the opposite side. In a few instances, we find the usual deposit of clay, gravel, and bowlders replaced by a heavy deposit of sand, evidently derived from the denudation and destruction of the knob sandstone of the immediate vicinity. This is not distributed uniformly over the surface, making a level plain, as is common with drift deposits, but it gives a surface broken into rounded hills, from fifty to one hundred feet high, suggesting their deposit, by eddies, on the margin of great currents of water. A good opportunity to study these sand hills occurs a little way east of Martinsville, along the northern margin of the Indian Creek bottom. At a large spring, about three-fourths of a mile northeast of Martinsville, I observed the base of the sand deposit resting on the blue clay which generally constitutes the lowest member of the foreign drift. Beyond this, as we recede from the river hills, the drift resumes its usual appearance of clay plains, with occasional bowlders of granite or gneiss distributed over the surface; though these are neither so frequent in occurrence, nor so large, as they are further north.

On the northwestern side of White River, in the northern tier of townships, the drift is deep and continuous, with its base of blue clay, and its upper member of yellow clay, with water-worn pebbles interspersed and an occasional bowlder of granite on the surface. Some of these are very large. On section 4, range 2, township 12, I measured a bowlder of flesh colored granite, with these dimensions: length, 15 feet 4 inches; greatest breadth, 13 feet; height above ground, 11 feet 9 inches. It is an irregular oblong, with the corners well rounded off. It shows no indications of decay. South of an irregular line from Brooklyn to Eminence, the bowlders almost entirely disappear, and, with them, the upper drift also, leaving an irregular deposit of blue clay, constantly broken by the deep ravines which lay bare the underlying strata and cut the country into knobs.

The glacial period has left its footprints on the surface of Morgan county in a manner that time will hardly efface. Beginning at the Mill Fork of Eel River, a little north of Eminence, there is a valley about five miles wide, extending in a northeasterly direction; crossing the valley of White Lick Creek a short distance north of Mooresville, it passes into Marion county between West Newton and Friendswood, and, thence to the valley of White River. From its western origin, to a point in section 1, range 1, township 13, near Monrovia, the valley gradually narrows to a width of about one mile. Originally, this section of the valley was a continuous lagoon, or swamp, locally known as "The Lake"; but now it is drained westwardly into Eel River, by a public ditch, which has become quite a large creek. On the northern side, the depression of this valley seldom exceeds forty feet below the general level of the country, and the descent is commonly quite gradual. On the opposite side, the country rises from fifty to one hundred feet, and sometimes pretty abruptly. From the water-shed near Monrovia, the drainage is eastward, by McCracken's Creek, to White Lick. In this section, the descent gives a rapid current to the water, though the valley maintains a width of a mile or more, with well defined margins, the south side still maintaining the greater elevation. East of White Lick, the outline of the valley is less distinctly marked, yet, on close observation, its course is plainly visible. The topography west of White Lick indicates that this valley was the southern margin of the ice-field for a long time, and received the drainage floods from the disappearing glacier. South of this, I observed no gravel beds, or other evidence of rapid currents that mark a dissolving glacier.

The valley of Indian Creek gives evidence of having been the bed of a glacial river, bearing the same relation to the knobs in Washington township and Brown county that the one above described does to the knobs of Gregg and Clay townships. Several smaller valleys of erosion, that properly may be referred to this period, were observed, but they are not of sufficient importance to require special notice.

The broad valley of White River, in this county, however, is a geological phenomenon that demands careful study. It is evidently a valley of erosion, for the strata in the hills bordering the valley on either side have their natural dip undisturbed, and the several members correspond correctly on opposite sides of the valley. This lies from 250 to 300 feet below the general level of the drift plain forming the adjacent uplands;

and of this depth, at least 200 feet is cut through the rock strata of the Knob sandstone. The area denuded to this depth in the county is not less than 150 square miles. This amount of erosion since the Carboniferous period, by a stream no larger than White River, would be almost incredible; but there is conclusive evidence that, at the close of the Drift epoch, a volume of water passed down the valley of White River vastly larger than that which now flows there, or than that which filled its channel when Congress declared it navigable.

But there is another circumstance which must be taken into the account when estimating this erosion. From fifty to one hundred feet of the lower portion of this rock is a soft clay shale, easily cut away, and, being very fine material, would be transported by even a very gentle current. A torrent of water would rapidly undermine the overlying sandstone, and, falling into the surging current in its soft state, it would be readily ground to sand and carried away. The sand hills in the vicinity of Martinsville give evidence of the burden of sand which that flood carried.

METALS AND ORES.

The base of the Carboniferous formation is frequently rich in iron ores, but in Morgan county it is peculiarly barren in this respect. A few nodules of iron ore were observed in two or three localities, associated with the clay shale so common here, but in no place is it found in such quantities as would promise valuable deposits of ore. Detached fragments of both lead and zinc ores (sulphide) have been picked up in several places in the knob districts; and, at least, in two localities, I observed specimens of galena, in quartz nodules imbedded in sandstone, but in no place could I find a well defined vein, or lead, of sufficient promise to encourage further search for these metals.

In the year 1850, some returned California gold miners observed the characteristic black sand in the ravines, among the knobs of Brown and Morgan counties, and immediately commenced "prospecting." They found gold in most of the ravines of Bean Blossom Creek, in Brown county, and in the tributaries of Sycamore Creek and Lamb's Creek, in Morgan county. Some of the more skillful miners were able to wash out two or three dollars' worth of gold per day for several weeks. But the excitement of an actual "placer mine" in Indiana brought together so many fortune hunters, that every ravine was directly occupied and the sands were soon washed out, and the "gold fever" subsided. Within the last few years the excitement has been revived, and gold-washing, to a limited extent, has been resumed, paying from fifty cents to a dollar per day. The gold is in very thin scales or in almost invisible grains, and is remarkably free from alloy of any kind.

The origin of this gold is a geological problem of some importance, as the underlying rock is of comparatively recent date and shows no indications of trap dykes, quartz veins, or other geological disturbances. The only rational solution of the problem appears to be that which refers the gold to the blue clay, which is the lowest member of the drift. Where the clay forms the summits or sides of the hills, it is washed into gulches by the rains. The lighter and finer particles are borne onward with the current, while the heavy black sand and gold lodge among the rocks in the bottom. But as the lower blue clay is the ascertained matrix of the gold, still the question, How came gold to be mixed with this particular clay, in this special locality? remains to be answered. Two methods of solving this problem have been proposed. The first assumes that the gold-bearing clay of Brown, Morgan and Montgomery counties, in Indiana, certain localities near the Vermillion salines, in Illinois, and a few local spots on the Des Moines, in Iowa, indicate a line of early drift, from regions of gold-bearing quartz, which, being crushed and broken down in its passage, liberated the gold in the form we now find it. The other hypothesis assumes that the lower blue clay contains minute quantities of gold everywhere, and that it accumulates, in appreciable quantities, only in the sands of ravines where the country is hilly and extensive surfaces are washed into streams that are sufficiently rapid to carry away the lighter material and leave only the gold and heavy sand to accumulate, it may be for centuries, till we can detect the presence of the precious metal. But either of these solutions will involve that more difficult question, From whence came the material that now covers thousands of square miles with a talcose clay to a depth varying from ten to five hundred feet? The discussion of this question would be out of place here; and here for the present I leave it, adding, however, the practical caution, that fortunes will never be made by gold-mining in Morgan county.

OTHER MINERALS.

There is a pretty well authenticated tradition that the Indians made salt from water of a spring, or shallow well, on the border of the lake valley, about two miles north of the village of Eminence. I examined the locality with some care, and though I found a large bog spring of common chalybeate water near the location of the traditional saline, yet I found no traces of any excavation, nor of even brackish water. The occurrence of brine, in this locality, however, is not an improbability. In boring through the Knob sandstone at Reelsville and at Terre Haute, brine of fair strength was found; and as the whole depth of that formation lies below this locality, any deep fissure in the rock would be likely to reveal brine. But salt is now so cheap, that its manufacture could hardly be made profitable here.

On the southern border of the town of Monrovia, is a deposit of magnesian clay of a very fine quality. It is quite free from iron, and when burned has a light cream color, similar to Milwaukee brick. It is at present used in the manufacture of drain tile.

Two diamonds have been found in the drift of the Indian Creek valley. One is now in possession of Mr. Harry Craft, a well-known jeweler of Indianapolis. It is cut and set. It had a weight of three carets in its rough state. It was found near Morgantown. The other is somewhat larger, and is uncut. It is in the possession of Mr. Maxwell, who resides three miles south of Martinsville. It was found on his farm. Both of these stones appear to have had an original connection with the drift of Indian Creek valley.

ARCHÆOLOGY.

The Mound Builders have left no remarkable monuments of their occupancy of the territory now included in Morgan county, yet it is quite certain that the large districts of bottom land did not fail to attract the attention of these primitive cultivators of the soil. That a dense settlement —probably a large town—of this race once existed near the mouth of White Lick, is an inference from the numerous small burial mounds in and near the town of Centerton, and from the stone implements, such as axes, chisels, knives, arrows and spear-heads, etc., that are frequently found in this vicinity. But few specimens of pottery have been detected in this county. A large vase, however, was recently found in a gravel pit near Waverly, by a company of workmen who were constructing a road. It was associated with a male skeleton, buried in the sitting posture. It was finely proportioned, richly ornamented, and had a capacity of two or three gallons. Unfortunately the workmen broke it into fragments so small that it was impossible to reconstruct it. I saw a collection of these fragments, which indicated that the original had been a fine work of art. This discovery proves that the Mound Builders did not always bury, even their distinguished dead, in mounds.

About a mile northeast from the town of Paragon, on the point of a high hill which projects into the bottom land, is a lookout mound, commanding a wide view to the southwest. A beacon fire on this mound could be distinctly seen on the range of hills west of Gosport, ten or twelve miles distant. On a similar hill, two miles due north from Paragon is another lookout mound, commanding an extensive prospect to the southeast. Near Brooklyn, on the east side of the Indianapolis & Vincennes Railroad, is a large mound, constructed on the south end of a gravel ridge one hundred yards long. The mound has a base of about one hundred feet in diameter, and rises twenty feet above the ridge on which it stands. It is constructed entirely of gravel, which suggests a doubt of its artificial character. But its regularity, and the depression in the ridge, indicating the place from whence the material was taken that was used in its construction, confirms the opinion that it is the work of human hands, though it may be more recent than the age of the primitive Mound Builders. Passing over a newly-plowed corn field, about a mile west of this, I picked up a stone axe which weighs seven pounds. It is made of a fine-grained gray stone—perhaps a fine granite.

Morgan county was a favorite hunting ground of the Delaware Indians, a principal town of which tribe was located on the west bank of White River, a few miles above Waverly. Game was abundant in the dense forests that covered the broad river bottoms, and the hills furnished winter food in the acorns, beech nuts and other native seeds. Deer, bears and turkeys were abundant, and White River was well supplied with an excellent quality of fish. These, together, furnished the Indian an easy living, which he left with many regrets.

RAILROADS.

The Indianapolis & Vincennes Railroad traverses the county from northeast to southwest. Its road bed and bridges are permanently constructed, and its trains are run with regularity, safety and comfort.

The Martinsville, Franklin & Fairland Railroad is an auxiliary to the Cincinnati, Indianapolis, St. Louis & Chicago Railroad. It furnishes a direct line to Cincinnati, and makes connection at Franklin with the Louisville line. It is in contemplation to extend this road westward, up the valley of Lamb's Creek, to the coal fields of Owen and Clay counties.

The line of a coal road from Indianapolis to the Eel River coal fields has been located through the great glacial valley in the northern part of the county, but adverse circumstances have hitherto interfered to prevent its construction. However, this is but a question of time, for Indianapolis must, before long, have a direct supply of coal, and this line will reach good coal in the shortest distance, on a line of easy construction and low grades. It will, moreover, open a region of agricultural capabilities second to none in the State, and forests of hard wood, which will be invaluable to the manufactories of Indianapolis.

LIST OF FOSSILS IN MORGAN COUNTY.

I collected the following fossils in the strata of Morgan county:

Taonurus Colletti	Knob sandstone.
Zaphrentis Dalei	Knob sandstone.
Spirifer Carteri	Knob sandstone.
Productus semi-reticulatus	Knob sandstone.
Productus costatus	Knob sandstone.
Plurotomaria (Sp.?)	Knob sandstone.
Spirifer Keokuk	Keokuk limestone.
Spirifer Grimesi	Keokuk limestone.
Productus punctatus	Keokuk limestone.
Productus Cora	Keokuk limestone.
Palæacis cuneatus	St. Louis limestone.
Rotalia Baileyi	St. Louis limestone.
Aulopora gigas	St. Louis limestone.
Zaphrentis spinulifera	St. Louis limestone.
Cyathocrinus (Sp.?)	St. Louis limestone.
Fenestella Shumardi	St. Louis limestone.
Archimedes Wortheni	St. Louis limestone.
Orthis dubia	St. Louis limestone.
Athyris subquadrata	St. Louis limestone.
Athyris hirsuta	St. Louis limestone.
Terebratula formosa	St. Louis limestone.
Euomphalus Spergenensis	St. Louis limestone.
Dentalium venustum	St. Louis limestone.

CONNECTED SECTION.

Alluvial (bottoms)	10 to 20 ft.
Second bottom	15 to 30
Lacustral—Loess	5 to 15
Glacial drift, about	100
St. Louis limestone	30
Keokuk limestone	50
Knob sandstone	500
Devonian shale	00
Total	745 ft.

GEOLOGY OF RUSH COUNTY.

BY MOSES N. ELROD, M. D.

GENERAL DESCRIPTION.

Rush county has an area of twenty-three miles, north and south, by eighteen miles, east and west; equal to four hundred and fourteen square miles; and, according to a recent report of the Bureau of Statistics, has 255,315 acres of land returned for taxation. The aggregate taxable property is given as $12,473,020, which, considering that it has no large city within its limits, ranks it as one of the very wealthiest counties in the State. Its *per capita* wealth of $652.18 is second to but one county.

It is bounded on the west by Shelby and Hancock counties, on the north by Hancock and Henry counties, on the east by Fayette and Franklin counties, and on the south by Decatur county.

The title of the Delaware Indians to the territory comprising Rush county was ceded to the United States, by treaty at St. Mary's, October 2 to 6, 1818. The United States' surveyors completed their work July 23, 1819, and April 29, 1820, and the land was offered to purchasers October 1, 1820, at the Brookville land office. Up to the year 1822, the land embraced in Rush county, was attached to Franklin county for judicial purposes. This year the county was organized and the first County Commissioners' Court convened on the first Monday in March. The county was named, at the suggestion of Dr. Wm. B. Laughlin, Government surveyor, in honor of the famous Dr. Benjamin Rush, of Philadelphia. June 17, 1822, the county seat was located, and, by July 29, following, the town was surveyed and lots offered for sale, thus showing that push and energy of the early settlers which still characterizes their descendants.

Rushville, the county seat, is beautifully situated on the right bank of Big Flat Rock River, near the center of the county, thirty-six miles east, and eleven miles south of the Circle Park of the State Capital, and is thirty-nine and three-tenths miles by rail from Indianapolis. It is a handsome city of 4,000 inhabitants, and is rapidly growing in wealth and population. The south, and business part, of the city, including the court house, is located on the river terrace, above high water mark; the residence part of the city lies to the north, on the low uplands, and contains many fine buildings and highly ornamented front yards. The streets are wide and regular, smoothly graveled, paved, lighted with gas and lined with beautiful maple shade trees. The water supply is drawn from inexhaustible wells. The city government is complete, with a uniformed police force, fire department, and everything to indicate a thriving, vigorous town.

Carthage, on Big Blue River, the second place in point of size in the county, is a good town of 600 inhabitants, surrounded by a fine agricultural region.

Milroy is the third town, in size, and, since the completion of the Vernon, Greensburg & Rushville Railroad, has grown rapidly. Its location, nearly equidistant between Greensburg and Rushville, and a good farming community supporting it, promise well for its future.

Moscow, Richland, New Salem, and Raleigh are thriving, pleasant villages, off the railroad lines. Manilla, Homer, Marcellus, Glenwood, Falmouth, Gings, and Arlington are railroad villages, of three hundred inhabitants and less. They are active trading and shipping marts, the outgrowth of the commercial wants of the finest farming and pasture lands in the world.

Rush county is well supplied with railroads, all centering and crossing at Rushville. The Cincinnati, Hamilton & Indianapolis Railroad runs through the central part of the county, from the east to the northwest; the Cambridge Branch of the Jeffersonville, Madison & Indianapolis Railroad (forming a connecting link in the "Pan-Handle system"), crosses the county from the southwest to the northeast; the Vernon, Greensburg & Rushville Railroad (a branch of the "Big Four," Cincinnati, Indianapolis, St. Louis & Chicago Railway) and the Louisville Branch of the Cincinnati & Fort Wayne Road, traverse the center of the county, from north to south.

All pikes and other roads leading out of Rushville are graveled to the out townships, and many of them to the adjoining county lines. The experiment of building free pikes is being tested in some parts of the county. The ordinary dirt roads are good, especially for Indiana, and in summer nothing could be much nicer, but in winter they are fearfully muddy. I was struck with the almost total absence from the road side of the rank and vile weeds so commonly seen in a neighborhood of slovenly farmers.

TOPOGRAPHY.

TABLE OF ALTITUDES, RUSH COUNTY.

Cincinnati, Hamilton & Indianapolis Railroad.

Miles from Indianapolis	POINTS AT WHICH THE ELEVATIONS WERE TAKEN.	Feet above Ocean.
	Indianapolis, East and New Jersey streets	720
1.21	Cincinnati, Hamilton & Indianapolis shops	751
2.8	Belt Railway crossing	784
4.6	Irvington	832
7.2	Morehouse	871
11.0	Julietta	843
14.8	Palestine	844
18.5	Reedville	847
20.8	Fountaintown	854
22.8	Lardona	865
	Big Blue River bridge, grade level	844
	Big Blue River, bed of stream	822
25.4	Morristown	858
28.3	Gwynne's	924
	Beaver Meadow Creek, bed of stream	895
32.3	Arlington	933
	Little Blue River bridge, grade level	927
	Little Blue River, bed of stream	905
	Mud Creek, bed of stream	945
34.9	Brandon	955
	Summit	1,016
39.3	Rushville, level of grade	983
	Flat Rock River, bed of stream	957
44.3	Farmington	1,045
45.4	Griffin	1,062
47.4	Glenwood (Vienna)	1,092
	Summit, natural level of surface	1,116
51.8	Longwood	1,011
	Summit, natural level of surface	1,059
54.7	Tyner's	936
55.9	Salter's Switch	919
57.1	Connersville	844
	Summit, natural level of surface	951
61.5	Lyons	896
	East Fork White Water River bridge	802
	East Fork White Water River, bed of stream	773
65.3	Brownsville	806
	Summit, natural level of surface	1,020
71.4	Liberty	992
	Summit, natural level of surface	1,043
74.3	Lotus	1,055
	Summit, natural level of surface	1,090
76.5	Cottage Grove	1,054
79.4	College Corner	1,002
	State Line, Ohio and Indiana	998
84.9	Oxford, Ohio	930
98.9	Hamilton, Ohio	839

TOPOGRAPHY—Continued.

Cambridge Branch of Jeffersonville, Madison & Indianapolis Railroad.

Miles from Columbus, Indiana.	POINTS AT WHICH THE ELEVATIONS WERE TAKEN.	Feet above Ocean.
	Columbus Depot, base of rail	642
23.86	Shelbyville crossing Cincinnati, Indianapolis, St. Louis & Chicago Railroad	779
	County line, Shelby and Rush, base of rail	905
32.86	Manilla, base of rail	907
	Mud Creek bridge, base of rail	922
	Mud Creek, bed of stream	908
35.11	Homer, base of rail	923
37.72	Goddard's Station, base of rail	952
39.79	Summit of grade, base of rail	1,002
42.19	Rushville station, base of rail	979
	Crossing Cincinnati, Hamilton & Indianapolis railroad, base of rail	983
	Flat Rock River bridge, base of rail	983
	Flat Rock River, bed of stream	966
	Turkey Creek bridge, base of rail	1,002
	Turkey Creek, bed of stream	976
48.31	Ging's Station, base of rail	1,013
49.68	McMillan's Station, base of rail	1,025
	Plum Creek bridge, base of rail	1,029
	Plum Creek, bed of stream	1,016
52.68	Falmouth, base of rail	1,061
55.12	Highest point on Cambridge Branch, base of rail	1,084
63.20	Cambridge City, junction Pittsburg, Cincinnati & St. Louis Railway	952

Vernon, Greensburg & Rushville Railroad.

Miles from Greensburg.	POINTS AT WHICH THE ELEVATIONS WERE TAKEN.	Feet above Ocean.
	Greensburg Depot, Cincinnati, Indianapolis, St. Louis & Chicago Railroad	954
8.8	Williamstown, county line	954
	Little Flat Rock Creek bridge	958
	Little Flat Rock Creek, bed of stream	935
11.8	Milroy	963
15.3	Bennett's	982
19.0	Big Flat Rock River bridge	951
19.5	Rushville junction with Cambridge Branch Jeffersonville, Madison & Indianapolis Railroad	955

The striking geological facts bearing on the topography and surface configuration of Rush county, deduced from the above tables and others before published in connection with the Geological Survey of Indiana, is the limitation of a part of the western border or crest of the ancient upheaval of the bed of old ocean that has given origin to the Cincinnati arch of the Lower Silurian rocks. The western border of the Cincinnati arch can be readily traced from the summit, near Pearceville, in Ripley county, north, through McCoy's Station and Clarksburg, in Decatur county, through Richland and Noble townships, Rush county; thence, north on the boundary line, and through the western part of Fayette county. The summit of the crest, one and one-half miles east of Glenwood (Vienna), taken at the natural level of the surface of the country, has an elevation of 1116 feet above tide water, which ranks it in altitude as the second highest point yet reported south of Indianapolis, and second only to the celebrated Weed Patch Knob of Brown county, which has an altitude of 1173 feet above the ocean.

The next highest point (1084) reported in this connection, is taken at the base of the rail on the Cambridge Branch Railroad, two and a half miles northeast of Falmouth. This line of elevation is not a high ridge in the sense of an abrupt elevation above the common level of the country; the so-called hills of Fayette, Union and Franklin counties are really not hills, the unevenness of the country being due to valleys cut below the surface. The top of the Lower Silurian outcrop in Indiana, in its early history, was a level plain. From the western border of this arch or plain the land falls away in a gradual slope to the west, and so gradual is the descent that it is not noticed by the casual observer. A reference to the table of altitudes, however, shows a marked difference in the elevations on the east and west sides of the county. The Glenwood summit, it will be seen, is 159 feet above the bed of Flat Rock River, at Rushville, and more than 100 feet above the common level of the country in the central part of the county. From Rushville, west, to the bed of Beaver Meadow Creek, the descent is eighty-eight feet, equal to a difference of 221 feet between the summit and the bed of the creek last mentioned. The Falmouth summit is 101 feet higher than Rushville, and 179 feet higher than the base of the rail at the point where the Cambridge branch crosses the Shelby and Rush county line. The elevations on the Vernon, Greensburg & Rushville Railroad show that there is but one foot difference between the level of Williamstown, at the Decatur county line, and the junction with the Jeffersonville, Madison & Indianapolis Railroad, and that the highest point on the road (Bennett's Station) is twenty-seven feet above Rushville. Two and a half miles west of the Rushville depot, on the Cambridge Road, the top of the grade is twenty-six feet higher than at the depot, and on the Cincinnati, Hamilton & Indianapolis road the difference is twenty feet.

Stretching away to the west, on a gentle slope, rests the broad and fertile acres of Rush county. Over the surface of an otherwise level expanse of country are short, low ridges, and slight mounds of gravel and sand, intermingled with a greater per cent. of clay. None of these elevations exceed twenty feet above the common level, and very few of them reach that figure—there is just enough rise and fall of ridge or mound to relieve the eye of the monotony of a dead sameness. An apparent exception to the above is seen in Anderson and Orange townships, where portions of the country are cut into bluffs and valleys by Big Flat Rock River and its tributary creeks and branches.

DRAINAGE.

The western border of the Lower Silurian (Cincinnati arch), besides its bearing on the topography of the county, determines the course of its rivers and creeks, causing those east of the border, or divide, in Richland and Noble townships, to flow into the White Water River, and those of the rest of the county to unite, as tributaries, with the east fork of White River. With the exception of Big Blue River (which flows through Ripley township, in the northeast corner of the county), all the rivers and creeks of the county have their origin within its limits or near the boundary lines. From this fact, it is manifest that the greater number of its streams are small. Flat Rock River is the most important stream of the county, and, with its many tributaries (the largest of which is Little Flat Rock Creek), drains the northeast, central and southwest portions of the county. The northwest and western portions of the county are drained by Big Blue River and its branches, Little Blue River and Mud Creek.

The flow of its streams to the west and southwest is determined by the general lay of the land already described and the increasing depth and lower level, from the north to the south, of the Collett Glacial River valley, of which Rush county forms an integral part.

In all drift regions, especially where the drift is heavy, as is the case in the north half of Rush county, the rivers and creek channels seldom reach down to the country rock. Below Hungerford's dam, section 4, township 12, range 9, the bed of Big Flat Rock River is generally rocky, and the same is true of Little Flat Rock Creek, below Milroy. With these exceptions, and appearance of stone in the bed of the river, four miles below Rushville, and in Little Blue River, below Arlington, the bed and banks of the streams are clay, gravel, or sand. Flat Rock River, where its bed lies wholly in the drift, has well-marked, level terrace banks, or second bottoms, ranging in width from one-half to one mile, with an average width of three-fourths of a mile in the vicinity of Rushville. The average width of the river-bed, or first bottom, is about 300 feet; height of bank is 10 feet; and the difference between low and high water is 8 to 11 feet. The bluff banks of the second bottoms vary in height from 10 to 50 feet, and, in a few places, may reach even 80 feet. The second bottoms of Big Blue River at Carthage, vary in width from one-half to one mile, with bluffs from 20 to 50 feet high. Here, the river banks average 10 feet in height, and the difference between low and high water is 10 to 12 feet. In the early history of the county, most of the streams, having their origin in the ponds and swamps of the flat lands, were everlasting brooks and branches, which wound their sluggish way beneath the protecting shadows of a dense forest, but, under the improving hand of man, many of them have been changed into artificial ditches that are dry one-half the year. In this fast age, even the creeks and rivers are required to do their work in a hurry; the barriers that once held back the waters have been removed, the very soil, by tilling, deprived of its superabundant moisture, and the floods sent rushing down to the ocean.

GENERAL GEOLOGY.

All the native stone, found in place, in Rush county, belongs either to the Niagara epoch of the Niagara group, Upper Silurian division of the Silurian Age, or the Corniferous epoch of the Corniferous group of the Devonian Age.

CONNECTED SECTION.

QUATERNARY AGE.

ALLUVIAL EPOCH.

Black soil and river deposits . . . . 4 ft.

DRIFT PERIOD.

Bowlders, gravel, sand, yellow and blue clays . . . . 60 ft.

PALÆOZOIC TIME.

DEVONIAN AGE.

CORNIFEROUS PERIOD.

Buff-colored magnesian limestone, lower division of the Corniferous epoch, used for making lime . . . . 30 ft.

UPPER SILURIAN AGE.

NIAGARA PERIOD.

Waldron shale	2 ft.
Gray or blue limestone, building rock	25 ft.
Total	151 ft.

The thickness of each stratum, as given above, is an average of several measurements, made at different points. At some places, the Corniferous group stone has a thickness of less than one foot, at others it exceeds that given. In *time* but two ages are represented, and the country rock underlying the drift forms but a small part of the great geological series. The top members of the Devonian, the whole of the Carboniferous, Reptilian and Tertiary ages are wanting; either they were never deposited over the surface of Rush county, or they have been removed by agencies that have worn away and comminuted their rocky substance to coarse gravel, sand and impalpable clay.

A practical inference from the absence of the rocks of the Carboniferous age, is that no true coal bed will ever be found within the limits of Rush county.

PALÆOZOIC GEOLOGY.

UPPER SILURIAN TIME.

NIAGARA PERIOD.

Commencing with the Niagara group, this limestone is, geologically, the oldest rock seen in the county. I found it an even bedded, crystalline stone, of a drab blue, or gray color, outcropping along the banks of Big Flat Rock River, below Moscow, and from Milroy, south, on Little Flat Rock Creek, in Orange and Anderson townships. It does not seem to form an exposed part of the bluffs on either side of the valleys, and, if it is ever discovered in them, will be found at their base, covered by a heavy stratum of the Corniferous group. As the drift, gravel, sand or clay covers all the stone of the rest of the county, with but a few exceptions in Posey and Rushville townships, it is not possible to exactly define the surface and boundary of the Niagara stone. From the reported results of borings made in the vicinity of Rushville, and the outcrop seen in Flat Rock River, below the city, it is safe to say that wells sunk through the drift in Richland, Noble, Union and Washington townships, will reach the Niagara limestone.

In the central tier of townships — Anderson, Rushville, Jackson and Center — the prevailing stone will depend largely on the irregularity of the surface underlying the drift. The Niagara will probably be found in the low places, and the Corniferous capping the higher, with a preponderance of the latter. Mr. Geo. C. Clark, of Rushville, reports that three-quarters of a mile from the city, up the mill-race, the freshets have exposed a gray limestone, on a level with the bed of Flat Rock River, that is referred to the Niagara group. Driven and other wells, put down in the central part of the county, have struck a similar, if not identical, stone.

No outcrop of the Hudson River group, Lower Silurian, was seen, nor has any been reported, but, possibly, it may be found in some of the ravines or creek bottoms, on the east side of Richland township, under the thinned edge of the Niagara.

No opportunity offered to measure the dip, but the general topography of the county clearly indicates that it is to the southwest, at a rate of not less than sixteen feet to the mile.

In the region of St. Paul, Decatur county, the Niagara limestone has a thickness of not less than forty feet, and, in places, more; but it seems highly probable that, on the south line of this county, it thins out as it approaches the Cincinnati arch. Near the western crest of the arch, the lithological characters of the top members are changed from cherty rubble to an even-textured stone, or the cherty portion has been eroded away; the former is the case with the outcrops seen in Rush county.

Chemically, the Niagara limestone is a carbonate of lime and magnesia, in variable proportions, together with alumina, silica, and oxide of iron in much smaller quantities. The reddish color of weathered specimens of the stone is due to a change of the oxide of iron from a lower to a higher oxide, by exposure. The percentage of silica is greatly increased in the flinty or cherty portions of the top strata, and is aggregated into irregular masses, nodules, and rough tables, that cause the stone, on exposure, to break into fragments. The Rush county stone seen by me is comparatively free from cherty matter, as I have before mentioned; and, hence, the upper ledges are more valuable than the outcrops at some other places. Uniformity of structure is an important element in a durable limestone for building purposes—hard and soft places differ widely in the amount of water the stone will absorb, and so, by freezing, subject it to very unequal strains and cause it to shell and break. Mr. Geo. C. Clark called my attention to the gradual crumbling, to fine fragments, of the court house foundation in Rushville, where, frequently, as much as an inch has been worn away. Whether this erosion was due to atmospheric waste, acting on a stone deficient in the cement that holds the particles together, or irregularity in density, it was not possible to say with certainty, but probably the former; and it may be that the durability of a limestone, aside from the homogeneity manifest to an ordinary quarryman, can be thoroughly tested only by time and exposure. And while but few ledges of this stone seen in Rush county will come up to the high standard required of a first-class building rock, for use in expensive structures, all of it will be found valuable for the thousand-and-one uses to which stone is now applied. It can be economically worked in road-making, to form a base on which to spread gravel. This experiment is being made on the Milroy and Andersonville pike with every prospect of it proving a success. In time, the south part of the county will be fenced with stone walls taken from the Niagara beds of Big and Little Flat Rock; and, but for its nearness to the quarries just south of the Decatur county line, it would now be in demand for fence posts and bases. At present what stone is taken out is mainly used for foundations and other purposes about light buildings.

It is evident that the Niagara limestone was formed at the bottom of a sea free from sediment, but subjected to currents sufficiently strong to reduce the crinoidæ and other organic remains found in it to fragments; and as corals do not flourish below the influence of the waves, their presence in the top ledges indicate a shallowing of the waters near the close of the period.

In this State the base of the Niagara is made up of shale, in strata ranging from a few inches to eight or nine feet in thickness. None of these beds are exposed in Rush county, but, as they outcrop northeast of Clarksburg, in Decatur county, they may be found near the surface in the southeast corner of Rush county.

The upper Niagara shale (or soapstone, as it is frequently called) is seen at Moscow and Milroy. This formation is generally known as the Waldron shale, for the reason that the outcrop, on Conn's Creek, in Shelby county, is largely made up of magnificent fossils that have given the locality a world-wide reputation. It does not seem to have an exact equivalent in any of the adjoining States, and in Indiana, so far as reported, the outcrops are confined to Flat Rock River, Clifty Creek and their tributaries. It is seen frequently from Moscow and Milroy, south, to Hartsville, and from Milroy and Sandusky, west, to Waldron. Aside from the fossils found in it and its marking the junction of the Upper Silurian and Devonian Ages, it has no special geological import on economic value. In this county, the Waldron shale contains more than the usual per cent. of argillaceous matter, nowhere showing imbedded nodules and flat pieces of limestone. Perhaps it was due to a want of carbonate of lime that no fossils were found in it, aside from a few fragments. In structure, the beds are made up of thin laminæ of friable shale and indurated clay. When not exposed the color is some shade of blue that weathers to yellow or ochrey, and the broken-down, disintegrated beds are scarcely distinguishable from the overlying yellow clay of the Drift period.

The conditions under which the Waldron shale was formed were in part a continuation of those of the shallow sea of the cherty Niagara limestone. The essential change in the conditions was the addition of currents loaded with a clay sediment. It has been suggested that, to the northward, the Waldron area was a more shallow sea, but, so far as yet reported, these beds are local, and, as indicated above, of no very great area, and it seems possible that the clay sediment also may have been of local origin. At this time in geological history the Lower Silurian limestone and shale of Indiana and Ohio, on the southeast, was either dry land or a wave-washed bank that may have furnished the alumina of the Waldron shale.

DEVONIAN AGE.

CORNIFEROUS PERIOD.

Geologists teach that the Devonian Age is the record of an invasion of the dry land, then in existence, by the sea. The Devonian sea was bounded on the southwest by the islands of the emerging Cincinnati anticlinal; on the west, the nearest land was the Lower Silurian mountains of Missouri; away to the north, the highlands of Canada were a part of a great and growing continent; on the east, in the States of New York and Pennsylvania, an extended area of dry land was exposed. Doubtless changes in the relative level of the land and sea were more frequent and well marked in their influence on the east, where the Devonian shales and sandstones have a total thickness of more than 15,000 feet, than in Central Indiana, where the formation is for the most part limestone of an aggregate thickness of 300 feet or less. But over all the interior space a warm sea prevailed, even its northern margin being studded with coral reefs and islands, and its shores having a tropical vegetation (Newberry).

The surface, extent and limits, east and west of the Corniferous group stone in Rush county, may be defined by reference to the description already given of the area covered by the Niagara epoch. Roughly stated, if all the drift materials were removed from the west half of the county, the exposed surface would be found to be buff-colored, magnesian limestone of the base or lower division of the Corniferous. Exceptions to this general rule are found in the valleys of the creeks and rivers. The stone exposed in the mound southwest of Rushville, section 24, township 13, range 9, and near Swayne's mill, on Little Blue River, and in the vicinity of Arlington, are all outcrops of the Corniferous stone.

In the banks of Big Flat Rock, near Moscow, it has the same general character as the strata further south. It is a coarse, argillaceous stone, having much the physical appearance of a sand-rock, and is frequently so called by the quarrymen; but the ease with which it is burned to lime proves that it is not a sandstone. Near the bridge over Little Flat Rock Creek, just west of Milroy, the Corniferous is the only stone seen in the outcrop, and has the same earthy color and appearance, but is in thinner strata that break into wedge-shaped pieces with feather edges. In general appearance it is identical with the outcrops of the same formation in the vicinity of Greensburg, and contains a higher per cent. of carbonate of lime than the equivalent beds on Big Flat Rock. In its western exposure, at Moscow, the bedding is from medium to heavy massive, breaking into angular blocks that are rounded at the corners by weathering, and under certain conditions of constant moisture, disintegrate to a fine powder. One mile below Milroy, on Little Flat Rock, the Corniferous outcrops above the Waldron shale and has local characteristics that distinguish it from either of the two varieties before described. Here it is a thin-bedded, shelly, blue or drab, crystalline limestone apparently free from admixture with earthy matter. In lithological appearance, it is the equivalent of the middle division of the Corniferous group that lies just under the North Vernon stone in many other parts of the State. Nowhere in the adjoining counties have I seen a stratum of so highly crystalline stone as this at the base of the group. These varieties, occurring within a radius of a few miles, indicate that they were formed under local conditions acting near the margin of a surf-beaten coast.

LIST OF FOSSILS FOUND IN RUSH COUNTY.

UPPER SILURIAN.

NIAGARA GROUP.

Favosites Forbesi (var. *occidentalis*) . . . . Hall.
Favosites spinigerus . . . . Hall.
Streptelasma radicans . . . . Hall.
Streptelasma borealis . . . . Nicholson.
Cyathophyllum radicula . . . . Rominger.
Eucalyptocrinus crassus . . . . Hall.
Eucalyptocrinus cœlatus . . . . Hall.
Lyriocrinus melissa . . . . Hall.
Lichenalia concentrica . . . . Hall.
Anastrophia internascens . . . . Hall.
Retzia evax . . . . Hall.
Rhyncotreta cuneata (var. *Americana*). . . . . Hall.
Rhynchonella Whitii . . . . Hall.
Rhynchonella Indianensis . . . . Hall.
Meristina Maria . . . . Hall.
Meristina nitida . . . . Hall.
Atrypa reticularis . . . . Linneus.
Spirifera crispa . . . . Hall.
Platyostoma Niagarensis . . . . Hall.

Strophostylus cyclostomus	Hall.
Gyroceras Elrodi	White.
Orthoceras annulatum	Hall.
Orthoceras crebescens	Hall.

DEVONIAN AGE.

CORNIFEROUS GROUP.

Cyathophyllum corniculum	Rominger.
Cyathophyllum rugosum	Edwards & Haime.
Acervularia Davidsoni	Edwards & Haime.
Favosites hemisphericus	Yandell & Shumard.
Favosites limitaris	Rominger.
Favosites epidermatis	Rominger.
Stromatopora tuberculata	Nicholson.
Zaphrentis gigantea	Rafenesque.
Athyris vitata	Hall.
Atrypa reticularis	Linneus.
Spirifera Oweni	Hall.
Spirifera euruteines	Hall.
Spirifera mucronata?	
Strophodonta demissa	Conrad.
Conocardium trigonale	Hall.

All the sedimentary stone of Rush county is fossiliferous, but not highly so; and no localities are known that offer attractions to the professional specimen collector. Just below the Decatur county line, on Big Flat Rock, Mr. Shaw showed me several fine fossils, found in the Niagara limestone of his quarry. One of them is, probably, an *Eucalyptocrinus* of very large size; another appears to be a large cystidian. He, also, has a fine specimen of *Orthoceras strix*, the only one I have seen from any of the Indiana beds. This locality is mentioned, with the hope that some good collector may visit and give it a thorough examination. The Waldron shale, so far as seen, is nearly destitute of good specimens, and fragments by no means common. The Corniferous fossil beds present nothing specially different from those of other localities. Mr. Geo. C. Clark has some nice specimens of *Spirifera mucronata* (?) and corals, found in the Drift gravel near the Little Flat Rock Christian Church. I visited the locality, but did not find anything of interest.

LOCAL DETAILS.

Following the banks of Big Flat Rock, north from St. Paul, the height of the bluffs gradually grows less, until, at Moscow, they are less than twenty feet. Generally, after crossing the county line, but one side of the stream shows a full bluff outcrop, the other side having been eroded away by the forces that, in ages gone by, excavated a valley many times greater than the rain storms of this day ever fill. Underlying some of these low bottoms, quarries can be opened and worked economically; the quarrymen will find but little stripping necessary, nature having done this part of the work for him.

SECTION AT MOSCOW, ORANGE TOWNSHIP.

Covered space	
Corniferous limestone, massive earthy stone	2 ft. 0 in.
Waldron shale (clay), Niagara group	0 ft. 10 in.
Flag, even-bedded Niagara limestone	0 ft. 2½ in.
Flag	0 ft. 3 in.
Flag	0 ft. 3 in.
Flag	0 ft. 4½ in.
Flag, or dimension stone	0 ft. 10 in.
Flag, or dimension stone	0 ft. 9 in.
Flag	0 ft. 5 in.
Flag	0 ft. 4 in.
Flag	0 ft. 3 in.
Flag	0 ft. 4 in.
Flag	0 ft. 2 in.
Flag	0 ft. 2 in.
Flag	0 ft. 4 in.
Dimension stone	0 ft. 5 in.
Dimension stone	0 ft. 4 in.
Dimension stone	0 ft. 6 in.
Dimension stone	0 ft. 10 in.
Stone to the level of river bed	6 ft. 0 in.
Total	15 ft. 7 in.

This quarry is opened in the east bank of Flat Rock River, on the point of an angle formed by a ravine. The amount of work done has not been sufficient to develop the exact quality of the stone, that taken out being changed by exposure and atmospheric waste. So far as the quarry has been developed, the stone is very free from chert, so common in the top strata of the Niagara at other places. The bedding is loose, even, and generally free from vertical seams, and of sufficient thickness to make excellent flag and general-purpose building stone. The facilities for working the quarry are confined to an ordinary outfit of drills, bars, hammers, etc. At the time of my visit, Mr. J. H. Jones, lessee of Jos. Owens, the owner of the quarry, and two employes, were engaged in prospecting and preparing to take out stone in quantities. With a good gravel road from Moscow to Milroy, a local demand, at least, might be developed that would pay good returns on a quarry investment. That the citizens of Milroy and vicinity are a wide-awake, enterprising people, is shown by the money they have spent in building the Milroy and Andersonville free pike; a continuation of the same spirit will macadamize a road west to Big Flat Rock. Let the proprietors of the quarries show what they have on hand, and those in need of stone will get it away.

SECTION ON LITTLE FLAT ROCK CREEK, ONE MILE SOUTH OF MILROY, ANDERSON TOWNSHIP.

Covered space, drift, clay and gravel		
Thin-bedded, crystalline limestone, lower division of the Corniferous group, fossiliferous	3 ft.	0 in.
Waldron shale, Niagara group, weathered to ochery-colored clay, and thin calcareous plates, very sparingly fossiliferous	1 ft.	6 in.
Thin-bedded Niagara group limestone, to the bed of the creek	3 ft.	0 in.
Total	7 ft.	6 in.

This section was taken in the bend of the creek, on the east side, where the wash of the stream has removed the crumbling Waldron shale, and left the Corniferous limestone projecting over the bank. Quite a number of fossils were seen in the overhanging rock at this point, and in the equivalent stone further down the creek. The Waldron shale is here intercalated with very thin calcareous laminæ that, when found thicker, as is the case at other points, are invariably fossiliferous. Here, the amount of carbonate of lime and magnesia appears to have been insufficient to preserve the organic remains buried in it. Only fragments and crinoid stems of the species general to this horizon were found. The underlying Niagara limestone is in thin strata, so far as could be seen, and much less massive than at the Moscow quarry. The same remark applies to the quarry of Captain Rice, located a little lower down the creek. That better stone could be had by opening back into the bank or bluff, is very probable, but, from what I have seen of this stone further south, it is not likely that the bedding will be heavy. The Niagara beds in this vicinity will yield good, light flagging, fence posts, bases, and light building-stone. Nowhere, in hundreds of examinations of the base of the Corniferous, where it forms a junction with the Waldron shale, have I found the stone so highly crystalline and so nearly a pure limestone as here. Doubtless it will make excellent "hot" lime, but, on account of its tendency to shell, will not prove of value for any other purpose.

QUATERNARY AGE.

DRIFT PERIOD.

In Rush county, covering alike the Upper Silurian on the east and the Devonian on the west, to a depth ranging from ten to one hundred feet, and thus largely concealing them from view, is found a mixture of clay, sand, gravel, pebbles, angular, subangular, and rounded stones, generally unassorted, unstratified and unfossiliferous. Out of this apparently heterogeneous mixture, a careful study evolves a degree of order that, in its history, has been governed by the same invariable laws of antecedents and sequences as in the other domains of nature. The general arrangement of the drift materials is illustrated in the following sections:

SECTION IN FAIR GROUND WELL, ON THE LOW BLUFF ONE MILE EAST OF RUSHVILLE.

Soil	6 ft.	6 in.
Hard, yellow, gravelly clay, with hardpan at the bottom	38 ft.	0 in.
Hard stone	16 ft.	0 in.
Total	60 ft.	6 in.

SECTION OF MR. J. C. PARKER'S WELL, NORTH OF THE C., H. & I. RAILROAD DEPOT, RUSHVILLE.

Soil	9 ft.	0 in.
Clay and black carbonaceous soil (?)	25 ft.	0 in.
Black sand, slightly water-bearing	8 ft.	0 in.
Mixed gravel and clay, no water	16 ft.	0 in.
Total	58 ft.	0 in.

SECTION IN MR. GEORGE C. CLARK'S WELL, ON THE EAST BLUFF ADJOINING RUSHVILLE.

Yellow hardpan, similar to the blue clay hardpan only in color	36 ft.	0 in.
Bed of fine gravel and water	6 ft.	0 in.
Stone	9 ft.	6 in.
Total	51 ft.	6 in.

AVERAGE OF ARTESIAN CHALYBEATE WELLS, WEST END OF RUSHVILLE.

Soil, yellow clay, and gravel	6 to 8 ft.
Blue clay, hardpan	14 to 15 ft.
Fine white sand and water	.. ..
Total	20 to 23 ft.

SECTION IN THE WELL OF JOHN F. MOSES, TWO MILES NORTH OF RUSHVILLE, IN JACKSON TOWNSHIP.

Soil, yellow clay, and blue clay hardpan	91 ft.	0 in.
Stone, probably Corniferous group; whitish, soft, sandy clay, Waldron shale (?); stone, probably Niagara group; total of stone	15 ft.	0 in.
Total	106 ft.	0 in.

This bore, one of the deepest reported in the county, was put down on the table-land back of the highest bluff. Water was found in the lower stratum of stone, and rose about sixty-seven feet in the bore.

AVERAGE OF WELLS IN CARTHAGE, RIPLEY TOWNSHIP.

Soil and yellow clay, mixed with large gravel	5 ft. to 5 ft.
Gravel	4 ft. to 6 ft.
Blue clay hardpan	10 ft. to 25 ft.
Quicksand and water	.. ..
Total	19 ft. to 36 ft.

SECTION IN THE WELL OF LOUIS J. OFFUTT, SECTION 21, TOWNSHIP 14, RANGE 9, POSEY TOWNSHIP.

Soil	6 ft. 0 in.
Yellow clay, and very little gravel	32 ft. 0 in.
Hardpan, blue clay	18 ft. 0 in.
Stone	0 ft. 10 in.
Total	56 ft. 10 in.

AVERAGE OF WELLS IN ARLINGTON, POSEY TOWNSHIP.

Soil, free from gravel	2 ft. 6 in.
Yellow clay, free from gravel	8 ft. 0 in.
Blue clay, hardpan	25 ft. 0 in.
Total	35 ft. 6 in.

SECTION IN WELL AT MANILLA, WALKER TOWNSHIP.

Soil	3 ft. 0 in.
Yellow, loamy clay	7 ft. 0 in.
Loamy sand	10 ft. 0 in.
Blue clay	47 ft. 0 in.
Fine quicksand	3 ft. 0 in.
Snow-white sand	1 ft. 0 in.
Gravel and sand	2 ft. 0 in.
Total	73 ft. 0 in.

AVERAGE OF WELLS AT MOSCOW, ORANGE TOWNSHIP.

Soil	1 ft. to 2 ft.
Yellow clay, slightly mixed with gravel	10 ft. to 10 ft.
Blue and hardpan clay	10 ft. to 20 ft.
Fine sand and water	.. ..
Total	21 ft. to 32 ft.

AVERAGE OF WELLS AT MILROY, ANDERSON TOWNSHIP.

Soil	1 ft. to 2 ft.
Yellow clay, uniformly found in the village and surrounding country	10 ft. to 10 ft.
Blue clay, sometimes replaced by a stratum of sand	8 ft. to 10 ft.
Gray clay and hardpan, usually mixed with fragments of chert and pebbles	6 ft. to 8 ft.
Gravel, sand, or muck, water-bearing, and, from two wells, fair specimens of peat	3 ft. to 5 ft.
Total	28 ft. to 35 ft.

In one well dug at Milroy, 150 yards from Little Flat Rock, sand was reached five or six feet from the top; after going through ten feet of sand water was found, which filled the well so it could not be walled. In one of the village wells a bowlder fifteen inches in diameter was found in the muck stratum, and they are reported as of frequent occurrence in other wells. Along the southern border of Anderson township there is a stratum of red clay that seems to replace the lower blue clay, as it comes from the bottom of the wells. The average of the wells above given is taken from wells dug on the uplands, above the first terrace or second bottom of the creek.

Sections taken in the wells at Richland, Richland township, and at New Salem, Noble township, show very nearly the same strata and thickness as the average of the wells at Milroy.

From the foregoing sections, it will be seen that there is an orderly succession of strata, from the bottom to the top of—(1) sand, quicksand or gravel; (2) blue plastic clay or gray hardpan, and, occasionally, buried timber, muck or peat; (3) yellow or red clay; and (4) soil. Another conspicuous member (5) of the Drift, not mentioned above, is the frequent occurrence, in places, of bowlders—exotic stones, derived from the Archæan rocks found native in the high land of Canada and on the south shore of Lake Superior. In some of the sections it will be noticed that one or more of the generally found strata are wanting; either they were never formed, or, by the action of local causes, they have been removed, or altered and blended, until it is impossible to identify them as the equivalent of any particular stratum; but however altered and changed, the *order* of succession remains the same in the Rush county Drift.

In the southern townships, Orange, Anderson and Richland, the average thickness of the Drift will not vary much from thirty feet. On the east side of the county, in Richland, Noble, Union and Washington townships, near the water-shed, the deposit grows thinner, and will not generally exceed twenty feet. At Rushville, Henry Ormes & Co., who have made many borings and wells, give forty-eight to fifty feet as the average depth of stone. North, northwest and west of Rushville the general depth will reach sixty feet and over. At Manilla, the well above reported passed through seventy-three feet of Drift; and another, bored on an adjoining farm, is said to have been put down one hundred and twenty-three feet before reaching the bottom of the blue clay.

The sand, glacial sand or gravel stratum resting on the country stone is not alike constant over high and low ground, but seems to occur in greatest force in the surface depressions. Its component materials range in size from fine siliceous sand to gravel and angular chert fragments; in color, from snow-white to dark or black quicksand. Generally it is a water-bearing bed of fine sand, but is occasionally replaced by dry, hard pieces of stone, that, from lithological and fossil evidence, are probably the debris of the eroded Carboniferous and Niagara group limestones. It is suggested that the agencies that reduced the flinty portions of the stone in one case to fine particles or sand, and in the other to coarse gravel, were not uniform in their action. Occasionally, as in some of the wells at Milroy, this and the next succeeding stratum are blended together.

The blue, plastic clay, bowlder clay, glacial clay, or hardpan, is a very generally diffused member of the Drift, occurring universally, except in the valleys south of Rushville, where the rivers and creeks reach down to, or near, the bed-rock. Wells and borings sunk in the first river terrace on Big Blue River, at Carthage, and on Big Flat Rock, at Rushville, pass through the blue clay, showing that the forces which have excavated the valleys ceased to act at these points before reaching the bottom of the blue hardpan. Taking the average depth to stone of the Rushville wells at forty-eight feet, and comparing it with twenty feet, the average height of the bluff part of the city above the bed of Flat Rock, it will be seen that many of the wells go twenty-eight feet below the river channel before reaching stone. The exposure of stone, before mentioned, on the west bank of the river, at the head of the millrace, on a level with the bottom of the stream, shows that Flat Rock does not reach down to the bed of the ancient valley. During the Drift period, the valley was filled with clay and gravel, and the channel of the present river subsequently formed near the close of the period. The well at the northeast corner of the court house yard (dug eighteen feet in the surface clay and gravel without striking the blue clay), indicates that the bed of the river may have shifted from the north to the south at a still later date in geological history, or the bed of the modern Flat Rock may formerly have been much wider and gradually contracted, by silting, to its present limits. In physical appearance it is a blue or lead colored clay, where protected from atmospheric change; where exposed, of a lighter shade. It usually occurs in compact beds, ranging from a soft, laminated, plastic, putty-like mass, to a dry, impervious hardpan, that can only be excavated with a pick. That these differences in consistency are largely due to moisture may be shown by subjecting different specimens to the same drying process. Chemically, it is an alumina silicate, mixed with fine, impalpable sand and salts of iron; its color is due to the latter. At Rushville, Mr. Geo. C. Clark describes this stratum, by saying that "It is not properly blue clay, but a hardpan of dark bluish cast, very gritty, filled with coarse sand and pebbles or gravel, intermixed like grouting. It has a very disagreeable smell, and, when it forms the wall of a well or the well is walled inside of it, the water has an offensive smell and taste for some months, but, finally, becomes palatable. In some places this bluish hardpan is forty feet thick, but generally less." "Southwest of the city, four or five miles, a well, bored sixty feet deep, did not strike stone, but found real blue clay, tough and resisting the drill by elasticity." In some places, fair-sized bowlders of northern origin are found in this stratum, but, as a rule, they are small, worn, and occasionally striated. Not infrequently it contains intercalated beds of sand.

The occurrence of buried timber, or a bed of soil and carbonaceous matter, is intimately connected with a description of the blue clay. In this portion of Indiana it usually occurs at the top of the stratum, but at Milroy was found at the bottom. Buried soil or timber is reported in nearly every neighborhood in the southern townships of the county. The soil bed, where it forms the top of the blue clay, is frequently overlooked in digging wells, or only remarked as a bed of black earth or clay, while the finding of a stick of wood or the root of a tree twenty or thirty feet below the surface, is something out of the usual line, and is reported; and the same is true of the muck beds. I am thoroughly convinced that the less conspicuous soil bed is of much more frequent occurrence.

The yellow or orange colored clay is found everywhere overlying the blue clay, except in the valleys and upland gravel ridges. Over the east side of the county, and in the vicinity of New Salem and Richland, it is so intimately associated with the top soil that it is not possible to separate them. Near the Fayette county line, the color is a reddish orange, and especially so in parts of Washington township. Generally, it is comparatively free from gravel in the uplands on the east and north sides of the county. Isolated points, low mounds and slight ridges, are not infrequent in which the proportion of gravel and sand is increased. This increase is, in part, due to the clay having been dissolved out by the rains. The gravel, pebbles, and bowlders distributed through the mass are identical in composition with those of the blue clay, but are less worn; especially is this true of the bowlders that are larger, seldom sub-angular, striated or flattened on one side by attrition. In structure it is a heterogeneous, friable clay, much more pervious to water than the blue clay, and yet so tenacious as to be improved by tiling. The percentage of lime is quite large, as indicated by a vigorous growth of sugar maple. The calcareous matter and very fine sand incorporated with the orange clay, in parts of Richland, Noble, Union and Washington townships, give it many of the physical characters of loess. Ten feet will cover its average thickness in Anderson township, that gradually grows heavier on the north, until it will measure thirty feet or more. Near the southeast corner of the county, the yellow clay is very thin; and over the line in Franklin county it fails as a factor of the Drift period, and leaves the blue clay exposed as the surface clay.

On the crest of the river bluff, west of Big Flat Rock, for five miles below Moscow, is a continuous ridge of imperfectly stratified gravel unmixed with clay. The stratification is seldom parallel with the horizon, but more nearly conforms to the surface slope of the ridge. A transverse section shows the alternating strata of sand, gravel, sand and gravel, or sand, gravel, and pebbles, running in irregular, increasing, and vanishing lines, that may or may not be conformable. The composition of a stratum is not uniform. It may be made up of sand in one place, that gradually changes to gravel within a few feet. Here and there, pockets are found, filled with clean, unstratified sand, or well-rounded metamorphic pebbles and bowlders. Occasional blocks of water-worn Niagara limestone occur, that seem to increase in size and number below the Decatur county line. By infiltration of water charged with carbonate of lime, in favorable localities, the thin beds of polished gravel and pebbles are cemented into a mass of conglomerate. This ridge contains enough good road gravel to macadamize Rush county. Other beds of upland gravel are reported as occuring east of Moscow, but were not examined; and it is probable that some of the low gravel beds on the east side of the county are similar in origin and structure to that described.

Along the banks of the principal streams, as already shown, are terraces or bottoms, averaging something over one-half mile in width. These terraces are the direct result of the wash or scouring action of the river flow that has removed the previous deposit of yellow clay.

Borings made in the bottoms pass through what is left undisturbed of the original Drift series, and show the same general section or borings on the uplands, minus a part of the yellow clay bed. In other places, the erosive action has been carried down to the blue clay, and sections show a partial replacement of the yellow clay by gravel or coarse sand. The terrace gravel beds are usually stratified, but not always so, and present the same alternating strata of fine and coarse materials, with increasing and vanishing layers, as the upland beds, but differ from the latter in having the strata nearly horizontal, more continuous, and showing less evidence of having been acted on by currents coming from two or more directions. The stratified terrace beds, when unmixed with large fragments of Niagara or Corniferous stone, yield good road gravel. Frequently, however, a few feet away from the channel of the stream, the gravel does not show stratification, and is too fine for macadamizing purposes. Well-marked second terraces were not observed in Rush county, but something of that kind shows near the southern boundary line, above the confluence of Big and Little Flat Rock, where the latter stream cuts across the ancient flood plain. These terraces are supposed to be evidence of a greater flow of water, some time in the past, together with a gradual elevation of the land on the north, that gave greater velocity to its rivers and, hence, more power to scour deep channels.

The extension of the yellow clay and gravel layers over the summit of the divide between the White Water and White River valleys, east of Rushville, and much above the level at which the equivalent beds are wanting in other places not many miles distant, is suggestive of some curious speculations on the geology of Indiana. If the yellow clay deposit is due to a submergence, it seems probable that these high lands must have been relatively lower than at present. Observations bearing on the history of the Cincinnati arch of the Lower Silurian, and the geological period or epoch in which its western border was uplifted to the present level, are omitted as too technical for presentation here.

Bowlders are scattered throughout the mass of the yellow clay and gravel beds, but the vast majority seem to lie on or near the surface. In size, they range from a few inches to two or three feet in diameter. In shape, they are angular and very seldom show a worn surface; especially is this true of the isolated specimens. On the side of the bluff bank, below Moscow, lies much the largest one I have seen in Southeastern Indiana; it will probably weigh over twenty-five tons. They are not common over the whole county, but are principally found in the southeast and west parts, and seem to occur as the continuation of a line of bowlders that reaches south, nearly to North Vernon. They are Archæan rocks, generally of the gneissoid variety.

RECENT PERIOD.

SOIL AND ALLUVIUM.

The soil of Rush county is almost wholly derived from the Drift deposits. Scarcely any of it is due to decomposition of the country stone found *in situ*; it is the combined result of the Quaternary Age acted on by the fertilizing agency of animal and vegetable life. In color, it ranges through various shades from black to pale yellow; the former is locally known as the black land, and the latter as the clay land. The black loamy soil covers the greater part of the surface of the county, and is general over the central and western parts. The great body of the black lands were formerly wet and swampy, and the dark color is due to the humus and carbonaceous matter derived from the decayed vegetation that grows luxuriantly over its surface. The yellow clay beds form the subsoil, except in the terrace bottoms, where the clay is sometimes replaced by gravel or sand. Outside the black lands, the distinction between the top and subsoil is not marked; the pale yellow surface clay grows brighter as it gradually grows deeper, and has more the character of a true tenacious clay. The tenacity of the subsoil explains why all the lands of the county are improved by tiling. A happy blending of calcareous matter, sand and clay in the subsoil, renders it peculiarly susceptible to the aerating influences of under-drainage. Exposed to the fertilizing influences of air and rain, charged with carbonic acid, the calcareous matter locked up in the clay and fine limestone gravel is unloosed, the salts of potash and soda set free, organic matter taken up, and, directly, it supports a vigorous growth of vegetation. The yellow clay subsoils of Indiana universally contain all the inorganic and a large per cent. of the organic elements of fertility; those of Rush county, in consequence of their fine state of division, readily yield their elements in a bountiful harvest, the substantial foundation of all wealth. Practically, they are inexhaustible; they may deteriorate under continuous cultivation and non-rotation of crops, but rest soon restores them to pristine productiveness.

ECONOMIC GEOLOGY.

AGRICULTURE.

The wealth of Rush county is essentially agricultural, together with such commercial relations as necessarily grow out of the wants of a great farming community. Originally covered with a dense forest, and, in places, wet, the husbandman has nobly done his work of turning an unbroken wilderness into splendid farms. The virgin soil, without a rival, has been constantly growing more productive. The bountiful gift of nature has been carefully utilized, until, to-day, instead of a wild waste, the eye wanders over well-inclosed farms of growing grain, pasture fields dotted with blooded horses and cattle, huge barns and fine residences. A moment's attention directed to agricultural statistics and land drainage will more forcibly and eloquently show, than mere words, what has been done for the farming interests of the country.

In 1882, the assessors of Rush county reported 446,000 rods of tiling against 442,000 rods in Shelby, 477,000 rods in Marion, and 693,000 rods in Decatur; giving to Rush the third place in the State in the number of rods of tile put down. Before a people can expend money in improvements they must first produce a surplus. That surplus is easily accounted for. In the number of bushels of corn produced per acre, Rush outranked any other county in the State, and was third in aggregate yield, with 2,223,414 bushels grown on 57,669 acres. The two leading corn counties were Tippecanoe and Benton, both including extensive tracts of Wabash bottoms within their limits. With 55,070 acres sown in wheat, producing 997,772 bushels, it ranks fifth in the State, and is led by Gibson, Daviess, Posey and Shelby counties. In clover lands, it had 20,369 acres against 21,310 acres in Wabash county. No more direct proof could be adduced than the last item, of the attention paid to the rotation of crops and keeping the land up to its high state of fertility. In 1881, 59,891 hogs were fatted for market, which is nearly thirty per cent. more than was produced in any other county in Indiana. The number of horses, mules and cattle owned in the county is well up with the best. In the leading farm products and stock raising, Rush is found at the head of the list. A very few counties may exceed it in a single farm product; but, when the whole list is taken into consideration, it stands without a rival. The mines of California may be exhausted, manufacturing may be overdone, banks may break and securities decline in value, but, with proper care, the Rush county farmer need not have any fears for the future. The peculiar adaptability of its soil to the growth of any of the cereals or to stock raising gives a variety of resources, that, in all human probability, render a total failure an impossibility.

The general remarks of Prof. Collett on the soils of Indiana are especially applicable to the black land, clay soil and yellow clay subsoil of Rush county. A heavy forest of sugar maples and walnut, supported by experimental evidence, is proof of its calcareous nature and adaptability to the growth of blue grass.

"The surface of the drift was left nearly level, but has since been modified by fluviatile and lacustral agencies, sorting the clays, sands, etc., so as to form, generally, a loose calcareous loam, deeply covering the gently undulating wood lands, plains and valleys. The great depth of the Drift deposit allows it to act as a gigantic sponge, absorbing excess of moisture in the spring or winter, until the long sunny days of summer, thus insuring against any prolonged drouth, and constituting a superior grazing district. For the perfect growth of grasses, a rich soil and perennial moisture is required, conditions which do not prevail in many other States. Indiana is the native home of "Blue Grass," *Poa pratensis*—the glory of our rich calcareous soils—an infallible gold-finder. It forms a permanent sward, thickening with age, so that, within ten or twenty years, the sod will withstand the hoof of heavy bullocks, even in wet weather. It grows slowly under the snow of a cold winter, but bursts into new life with the first genial day of spring, carpets the earth with productive beauty through the summer, and, if reserved for winter, cattle, horses, sheep, etc., may be well kept, except in time of deep snows, on this food alone."*

"Among the blue grass trotters," America over, is understood to mean more than the accidental relationship of the queen of native grasses to the fast horse. Muscle is necessary to the thorough development of the horse; "blood will tell," and the blue grass wood lands tell on the blood. The elastic sward, over which the high-steppers range, gives ease and grace

*First Annual Report of the Bureau of Statistics and Geology, Indiana, page 9.

to his proud movements, while he is protected from the blazing sun in "pastures green" that are charmingly undulating and invite trials of speed. Everything in nature and the loving care of man conspire to give life and strength to the noble animal. The Blue Bull and Jim Monroe farms of the late James Wilson, of Noble township, attest what can be done. These farms have turned out trotters and pacers that take rank with the best in America. The Blue Bull strain has second place in the trotting list for horses that have made better than 2:30; and Monroe Chief, from the Monroe farm, has a trotting record of 2:16¾.

It has been remarked that the possession of a fast horse curiously gives a kind of vicarious merit to his proprietor; he is esteemed as something of a high stepper and flyer, and as likely to run his factory, his newspaper, or his farm, or whatever it may be, a little better than other people. It is the best advertising medium known. And, in a degree, the same is true of the breeders of all kinds of pedigreed stock. Of the many proprietors who prove the truth of the above in Rush county, that are engaged in stock raising, and especially interested in producing improved strains of horses, cattle, etc., only a few can be mentioned here. Mr. Richard Wilson, of Rushville, and Mr. Samp. Wilson, of Noble township, as breeders of trotting horses, maintain the well-merited reputation of their father. Mr. John T. McMillan and Mr. Cal. Bates are well known owners of thoroughbred Norman horses. Mr. S. Frazee, of Noble township, breeds, and exhibits at the State and county fairs, complete herds of full-blooded short-horn cattle. Mr. George W. Thomas, of Homer, is another breeder of short-horn stock; and Mr. J. H. Beabout, of Rushville, of Jerseys. Mr. Leonard McDaniel, of Posey township, and Geo. W. Mauzy, of Union township, are well-known producers of full-blooded Cotswold, South Down, Canada, and Merino sheep Of course, in a county so largely engaged in hog-raising, especial attention is paid to the production of all the leading varieties.

FRUIT.

All the various kinds of orchard and small fruits are successfully grown, but not so extensively as in some of the adjoining counties. A rich sugar tree soil will undoubtedly produce the very best kind of orchard products. Winter-killing seems to be the great draw-back. With care in selecting varieties of trees that are known to be hardy, and good under-drainage, this trouble might be obviated. Wheat, corn, and stockraising chiefly occupy the attention of farmers, but some fine orchards were seen, showing what might be done for the whole county.

LIME AND SAND.

The soft magnesian stone found at the base of the Corniferous group, at Moscow and Milroy, makes a lime that is highly prized by masons and plasterers, and especially by the latter, on account of its working easily and smoothly under the trowel. The Moscow stone, having a considerable percentage of earthy matter, will yield a "cool" lime that slacks slowly; while that produced from the Milroy stone, on account of its more crystalline character, will rank as intermediate between a "cool" and "hot" lime. Typical "hot" lime is produced from the hard Niagara stone. It was formerly thought that the dark, rotten, Corniferous rock, having much the appearance of a decomposing sandstone, that occurs abundantly on the banks of Flat Rock and its tributaries, was utterly worthless for making lime. Experience shows that the darkest stone will burn perfectly white, and that the alumina, or earthy matter, mixed with it, adds greatly to its value for builders' use. The equivalent of the stone under discussion is used in making lime at Adams and Greensburg, in Decatur county, and at Geneva, in Shelby county. The ease with which the Flat Rock stone can be quarried, and the less amount of fuel required to reduce it than the hard Niagara stone, are questions of expense that indicate that the business might be made to pay in this county.

Sand for masonry and plastering, of the best quality, is common in the bars and banks of the rivers and creeks. No beds of bluff sand, free from gravel, were seen.

BRICK AND TILE CLAY.

Any of the yellow or blue clay of Rush county, when free from gravel, can be readily moulded and burned into brick or tile. Brick buildings are common in the towns and country; and farmers usually make what they need out of the clay found on the farm. Messrs. Patten and Caldwell, of Rushville, have a steam tile factory and kiln, with a capacity to turn out from 18,000 to 20,000 tile at a burn. There are a number of other factories of less note in the county.

GRAVEL.

Road gravel is found in the terrace bottoms of all the creeks, but not abundantly on the smaller streams. In Orange, Anderson, and Noble townships, upland gravel ridges occasionally occur that are free from clay, but the main supply for the county comes from the banks and bars of Big Blue and Flat Rock Rivers.

BOG IRON ORE.

Bog iron ore, in considerable quantity, has formed on the borders of the marshy tracts of land five miles east of Rushville. These deposits of ore are the result of the organic acids, derived from decomposing plants, acting on the salts of iron that occur in the drift clay, thereby rendering them soluble. By exposure to the air oxidation takes place, generally at the margin of the marsh, and the iron, in the form of hydrated peroxide, is again thrown down. Such accumulations are not infrequent, and some day may have a commercial value.

VEGETATION.

In 1879 and 1880, the assessors for this county reported more gallons of maple syrup made than were reported from any other county in the State. A soil that supports a mighty growth of sugar maple, *Acer saccharinum*, will abound in majestic specimens of black walnut, *Juglans nigra;* yellow poplar, *Liriodendron tulipifera;* white oak, *Quercus alba;* white ash, *Fraxinus Americana;* shellbark hickory, *Carya alba;* dogwood, *Cornus Florida*; red bud, *Cercis Canadensis;* iron wood, *Carpinus Americana;* paw-paw, *Asimina triloba*, etc. Beech, *Fagus ferruginea;* burr oak, *Quercus macrocarpa;* elm, *Ulmus Americana;* swamp maple, *Acer dysacarpum*, etc., are the most common varieties of timber growing on the wet, black lands. On the east side of the county, huge yellow poplar were once common; and one cut a few years ago, growing in Union township, is said to have been the largest reported in the State. The great body of the primitive forest has been removed in preparing the land for the plow, and the wood lands left have been culled of their best trees. A casual examination of a Rushville saw-mill yard, containing over three hundred logs, showed only beech, maple and elm.

MINERAL SPRINGS.

The artesian chalybeate wells of West Rushville have attracted attention for years, and are curious examples of subterranean streams or sheets of mineral water, held down by the impervious blue clay. The wells are dug in the usual manner, or dug a few feet, and then bored through the clay. The water is found in the fine gravel or white sand overlying the bed rock. Pump logs were placed in some of the wells and tamped with clay until the water was forced to flow through the log. The quantity of water discharged was never great, and additional wells seemed to weaken the flow of those previously dug, indicating that the water probably comes from a compact, saturated bed of sand that slowly gives up its superabundant moisture. Other mineral springs of note are found in the vicinity of Homer, and at the Soldiers' Home, south of Knightstown. Small ferruginous springs are rather common in all parts of the county, and, so far as I could learn, are nearly identical in composition. Their chemical nature is shown by the brown or ochery deposit of hydrous peroxide of iron seen near the spring. Before reaching the surface, the iron is held in solution as a ferrous carbonate, that is rapidly changed to the insoluble peroxide by oxidation on exposure to the air; hence, to get the medicinal effects of the water it should be used fresh from the spring. It will be found beneficial in all diseases where a mild preparation of iron is indicated.

WATER SUPPLY.

There is a wide-spread belief among physicians as well as the laity, that sheets of water found in or confined to the sand or gravel beneath the clay are continuous, and that the pollution of one well will contaminate many. That there is some truth in this, I am free to admit, but not to the extent generally believed. That the water supply of the city of Rushville has nothing to do with the level of Flat Rock River has already been shown. The varying depth of wells to water, and failures to find water, are proof that the water-bearing sand under the city is not continuous, nor on a common level. Two wells were put down just west of Main street and north of Ruth street, respectively twelve and eighteen feet to water; and two others near by, one on the west twenty-seven feet deep, and the other on the east thirty-seven feet deep, and no water. Southeast of the latter well, in court-house square, water was found at eighteen feet. Mr. J. C. Parker's well, north of the Cincinnati, Hamilton & Indianapolis depot, was put down fifty-eight feet, no water; another, near the point where the Jeffersonville, Madison & Indianapolis road crosses Main street, failed to find water at eighty-seven feet; while water was found in the triangle formed by the Jeffersonville, Madison & Indianapolis Railroad, Main street, and the Cincinnati, Hamilton & Indianapolis Railroad, at thirty-eight feet. These differences in depth are not due to inequalities of the surface, as the city is built on comparatively level ground.

Throughout the county, potable water for culinary and drinking purposes is almost wholly obtained through wells, and, as might be expected, springs rarely occur in a country so uniformly level. Wells sunk to the gravel or sand stratum, under the blue clay, reach an abundant supply of water; in localities where the clay rests on the country stone, a vein has to be found in the rock, or the well proves a failure—failures, however, are not common. Well water contains more or less mineral matter, even where it percolates through sandstone, and the water found in or beneath the calcareous drift deposits is universally "hard." That this hardness is not wholly due to calcic and magnesic carbonates is shown by its not being rendered "soft" by boiling, that changes the bicarbonates held in solution into insoluble carbonates, with consequent precipitation. The hardness remaining after boiling is probably due to calcic sulphate. Notwithstanding a hard water does not answer for all kinds of household use, it is perfectly healthful, sparkling and delicious.

The Rivers' Pollution Commissioners of England, in their sixth report, make the following classification of water in respect of wholesomeness and general fitness for drinking and cooking: *Wholesome*—(1) Spring water; (2) deep well water; (3) upland surface water. *Suspicious*—(1) Stored rainwater; (2) surface water from cultivated land. *Dangerous*—(1) River water to which sewage gains access; (2) shallow wells. In this county wholesomeness and safety lie in the use of water from deep wells that reach the glacial sand or gravel or a vein deep in the stone. Some facts have come to my attention indicating that the well water may be unwholesome that has percolated through the ancient forest bed or buried muck and carbonaceous soil. Especially does this seem to be true where the stratum rests on the native stone, and the water supply comes from it or from the stone just beneath. Organic matter in water, no difference what the source may be, supplies the conditions necessary for the development of microzymes. Every source of organic contamination should be rigidly excluded by digging deep, and protecting the mouth of the well from surface wash or soakage. A supply of soft water is had by storing rain and snow water in cisterns that are easily made in the clay.

ARCHÆOLOGY.

Burial mounds of a race of people who lived prior to the advent of the modern Indians not infrequently occur, and, so far as reported, are most common in the southern part of the county. I visited the site of a large mound on the farm of Mr. Louis J. Offutt, northeast quarter of section 21, township 14, range 9, that, in the early settlement of the country, is said to have been one hundred and six feet in diameter and fifteen feet high, and connected with a smaller mound, on the northeast, by a ditch. Fifty-three years ago, the large mound was covered with a heavy growth of beech timber, some of the trees measuring eighteen inches in diameter. Since the timber has been cut away and the mound plowed into, it has been nearly leveled with the ground. A few years ago Mr. Offutt dug into the larger one, near the center, and found parts of several skeletons, copper bands encircling the bones of the arms, wrists and ankles, bone beads, and two curiously perforated pieces of jawbone with a single, tusk-like tooth. The perforations were cut through the bone into the hollow of the tusk, and gave it somewhat the appearance of a whistle, but its use is not very evident.

Dr. S. H. Riley, of Milroy, has assisted in opening several mounds in the county, and reports that they all contained ashes, charcoal, and red or burnt clay. Relics were found in three of them. In one (section 12, township 13, range 9), were found an arrow point, copper needle, beads, and block of mica of an oval shape, seven by eleven inches in diameter and three-eighths of an inch thick. Two nearly perfect skeletons and parts of a third were found in another (section 27, township 12, range 9), buried with the heads turned toward a common center; also copper and bone beads. Some bones and copper bracelets were found in the third one (section 12, township 13, range 9). A large mound in section 27, township 12, range 9, about ten feet high and forty feet in diameter, has not yet been explored. From the fact that shells peculiar to the Atlantic ocean, copper from the shores of Lake Superior, and mica from the mines of South Carolina have been found in the mounds along the banks of Little Flat Rock Creek, it is presumed that the commercial relations of their builders were much more extensive than their limited means of travel would seem to indicate.

THANKS.

I am under obligations to all whom I met for favors and information, and especially so to Mr. George C. Clark, of Rushville, for information bearing on the history of the Drift period, etc.; to Messrs. Henry Ormes & Co., for depth of wells, etc., in Rushville and vicinity; to Dr. Henry Charles, of Carthage; Mr. J. Morton Clark, of Arlington, and to Dr. S. H. Riley, of Milroy.

GEOLOGY OF JOHNSON COUNTY.

BY DAVID S. M'CASLIN, A. M.

Johnson county lies south of the geographical center of Indiana. It comprises an area of 320 square miles, or 211,206 acres of land. In form it is a true parallelogram, measuring, from east to west, sixteen miles, and, from north to south, twenty miles. This county is bounded, on the north, by Marion; on the east, by Shelby; on the south, by Bartholomew and Brown, and on the west, by Morgan county. Franklin, the county seat, is twenty miles south of Indianapolis.

The county organization was effected in 1822, the territory previously having been a part of the extensive tract known as Delaware county, the original purchase from the Delaware Indians, which was effected at St. Mary's, Ohio, in 1818. It was known as the "New Purchase," and included nearly all the land now comprised in the central counties of Indiana.

Previous to 1818, the influx of population had been mainly to the southern portion of Indiana Territory. The organization of the State of Indiana, in 1816, was followed by a great increase of population—from 63,897, in 1816, to 147,178, in 1820. This tide of immigration flowed rapidly into this newly opened territory, coming in from both the south and the east. As early as 1817 pathways had been made through the unbroken forest—from the east, it was known as "Whetzel's trace," and from the south, the old Indian trail, running north to the villages on the Wabash, was the highway of the pioneers of Johnson county. The pathway previously trod by herds of buffalo and wild red men became the chosen highway of commerce, traveled by the iron horse on his path of steel. Southern and eastern people were thus early mingled and united. This social amalgam has produced a citizenship of more than usual excellence and stability. Virginia, North Carolina, Massachusetts and New Jersey are, here, all blended into an organic structure of morality and culture that flowed into this beautiful region through those humble avenues of civilization, "Whetzel's trace" and the old Indian trail.

Originally, the whole county was an unbroken forest, with a dense undergrowth, much of it regarded as worthless, being wet and swampy.

Other portions were supposed to be so broken as to prevent successful cultivation. Under energetic and progressive agriculture, these difficulties have been annihilated; every marsh has been made a marvel of fertility, and every hillside a mine of wealth.

The river bottoms and the higher plateaus are unsurpassed in the production of corn and wheat. The clay uplands and the higher ridges of the southern part afford a great variety of timber and the best capacity for fruit production. This county produced, in 1880, 582,469 bushels of wheat, 1,315,283 bushels of corn, and 143,697 bushels of oats. Great numbers of cattle, horses, hogs and sheep are raised. These statistics are large, as might be expected from the production of grain and grass. There were in the county, in 1880, horses, 8,760; cattle, 11,670; sheep, 11,865. In other lines of production, the figures are proportionately large, making very favorable comparison with any other county in the State, indicating fertility in the soil and intelligent agriculture.

Franklin, the flourishing county seat, located a little east of the center of the county, has a population of 3,116, according to the census of 1880. It lies on level land, at the junction of Hurricane and Young's Creeks. It is beautifully laid out, with well-paved streets, having excellent drainage in two directions. The streets are shaded with majestic maples, two or three species having been planted, both the white and red varieties. In many places their branches meet over the thoroughfares, making an arch of living green. The homes of the people are handsomely and substantially built, and many are surrounded with beautiful lawns. The business houses and public buildings are commodious and convenient. The court house is an elegant structure, occupying a square in the central part of the city. The city school building is large and well arranged. Several handsome churches adorn the city, their capacity and costliness indicating the Christian character of the citizens.

Two railroads intersect at this point—the Jeffersonville, Madison & Indianapolis and the Cincinnati & Martinsville—giving direct commercial contact with the great centers of trade—Indianapolis, Louisville and Cincinnati. The Cincinnati & Martinsville Railroad does a very large freight business. Passing, as it does, through a region as yet without good roads, it carries to market the produce of a wide extent of territory. It furnishes transportation for the southwest part of Johnson county, the southeast of Morgan, and is nearly the only railroad accessible to Brown county, as yet entirely without a railroad. Large quantities of timber, hoop-poles, grain, and fruit are brought to Morgantown, and shipped thence by way of this road.

A study of the map shows the fact that a wide region of very productive land in the western part of Johnson county is without a railroad. It has had many promises, but, as yet, none have been realized. Should the line be built from Indianapolis to Evansville, as recently proposed, it will pass through this county, and be of immense advantage to the people and of untold profit to the railroad. Such a railroad is one of the urgent needs of both Brown and Johnson counties, and it will, doubtless, be built at no distant day.

Edinburg, in the southeast part of the county, is located in the sandy valley of Blue River, and surrounded by a magnificent farming country. It has an energetic, enterprising population of about 2,000.

Other towns and villages of importance are Greenwood, Trafalgar, Wheatland and Nineveh, all of which present evidence of thrift and culture among its citizens.

The population of the county in 1880 was 19,537, being a little more than sixty-one to the square mile.

TOPOGRAPHY.

The surface features of Johnson county are very simple. A bird's-eye view of its whole extent would reveal a general outline as follows:

A broad, high ridge, beginning in the northern part and gradually growing higher as it extended to the south, would be observed in the central part of the county. It would appear to be a sort of flattened ridge, in a crescent form, with the convex side westward. From this elevated center, a gentle slope would be observed on both sides, in the northern part of the county; but, as it extended towards Brown county, the slope would appear more abrupt and precipitous. On the eastern side, this descent, in places, as in Nineveh township, would be quite abrupt, making the boldly escarped hills of that township. On the western side, the descent has caused the streams to cut deep channels, rendering much of the land very broken. To the east and south, would be stretched away, as far as the eye could reach, a broad alluvial plain, covering the whole area of Clark, Needham and Blue River townships. To the west and south, would be seen the bold bluffs of White River, running sheer up to the eroded channel of its waters. West of the northern extremity of this ridge, would be seen a broad valley, extending to the White River, threaded by Honey Creek and Pleasant Run. This surface outline reveals the hydrography of the county.

The ridge is the watershed, and upon its summit all the streams originate. The flattened ridge, in the north, forms broad plateaus that were originally swamps, but now, thanks to thorough drainage, they are so no longer. These swamps are, really, the highest land in the county, and not the lowest, thus facilitating their reclamation. Many of the ditches made to drain them continue to cut deeper channels, instead of filling up. From this summit region the streams all flow either southwest or southeast, emptying into Blue River or White River, according to their relation to the ridge. White River touches the county on the northwest, cutting off about 1,000 acres, and Blue River touches the southeast corner, cutting off about 1,400 acres. It will be seen, thus, that the whole of Johnson county is a watershed, lying between these two rivers.

The streams that flow down its slopes, or plunge down its descents, are numerous and beautiful. Sugar Creek is the main stream of the eastern slope. It receives, in Needham township, through Little Sugar Creek, nearly the whole of the drainage of Clark township. Young's Creek, with its tributaries, Indian, Moore's, Burkhart's and Hurricane Creeks, drain the concave side of the crescent ridge. Gathering, thus, the whole volume of water from this level basin, it finally empties into Sugar Creek, near Amity, in the northwest part of Blue River township. From the southern and highest part of the ridge, Nineveh Creek sweeps down a narrow ravine, excavated by its plowing waters. Its channel is simply a gorge, with high and precipitous clay banks. On the western side of this ridge Indian Creek begins, with its various tributaries. These streams, like all running in that direction, descend to the valley of White River, through deep channels, not all of them, however, of recent origin, for some of them have evidently adopted the channels of ancient glacial streams.

The other streams are Stott's Creek, with its tributaries, and Crooked and Coot's Creeks. These last streams are small; and, indeed, none on the western side of the county are large enough to afford mill power. Occupying, as they do, rocky gorges, they are quite dry during most of the year. Some, at points where there are springs flowing, make a rill, useful only as a supply of water for stock. Sugar Creek is the only stream of the county that furnishes adequate mill power, and along its banks a number of large mills have been erected.

This topographical outline puts before us the various topographical features of this county. We have the form, and are now ready for the structure and constituents.

Observations throughout the county, with measurements of many widely separated exposures and outcrops, give the following:

CONNECTED SECTION.

QUATERNARY AGE.

Alluvium	00 ft. to 40 ft.
Loess	00 ft. to 30 ft.
Lacustral silt	00 ft. to 25 ft.
Bowlder drift	25 ft. to 100 ft.
Total	195 ft.

CARBONIFEROUS AGE..

KNOBSTONE GROUP OR EPOCH.

Knob shales and sandstone	25 ft. to 150 ft.

DEVONIAN AGE.

HAMILTON GROUP.

Black slate (Genesee shale)	00 ft. to 30 ft.
Grand total	375 ft.

RECENT GEOLOGY.

It being the fact that all geological formations are the results of successive depositions of material, the lower deposits, if undisturbed, are the older, and the rocks are later, successively, until we reach the surface, where the latest formations are found. These later deposits, as seen by the section given, are very heavy in Johnson county, and present many features of interest.

All these deposits of recent time are included under the one term, Quaternary. They are, generally speaking, alluvial, lacustral, and glacial. Of these three, the alluvial is latest, and its material is gathered from all the rest, being the deposits along the streams. Sand, clay, and organic matter are mingled together, and, as distributed through the river bottoms, produce soils of great fertility. Some of the low, level lands, above the line of overflow, are covered with from one to five feet of alluvium, almost entirely of vegetable origin. This material, mingled with sand, produces the black loam so valuable for farming purposes. A great portion of the northern and eastern part of the county is covered with this soil. The lacustral deposits are found in the southern and western portions of the county. They, generally, date from the latter part of the Champlain period, an era of surface depression. Bodies of fresh water were then confined in shallow basins, over a great part of Indiana, particularly in the northern and southern parts, the central part of the State seeming to be a sort of high dividing line between two great lake basins. The deposits in these lakes would be, usually, a fine sediment, with very little of sand and gravel. In many instances, the deposits contain fresh-water shells, though but few are observed in the lacustral of Johnson county.

These formations present three varieties in Johnson county. The ridges of the southern part, in Nineveh and Hensley townships, are capped with Loess, a yellow or buff-colored sediment. It has much siliceous material, but little coarse sand, and is easily removed by currents of water. The hills are accordingly cut into gullies and gorges, with abrupt sides. The valleys in many places are filled up with the lacustral from the hills. The Loess bed extends, in a wedge-shaped tract, almost to Trafalgar. In the western point of Hensley and Union townships, a large extent of light gray soil was observed, which is also assigned to this period. Slight changes were observed in several localities, where these fine-grained sedimentary deposits are replaced by silt, a sandy deposit made by slowly moving currents of shallow water. These lacustral deposits are simply fragments of a great area of Loess that covered several counties of Indiana, thus cut up into isolated areas, in later transformations of surface, by erosion and denudation. The ancient lake bed is thus the level of the highest ridges, and the soil that caps them the sedimentary deposit of its quiet waters. Underneath these alluvial and lacustral beds, throughout the county, is found the glacial Drift. It is either obscurely unstratified or modified, and in one form or the other, or both, it covers the rocky substratum of the whole county. The alluvial of Sugar Creek valley rests upon modified drift. But the lacustral deposits of the high southern ridge as far as observed, lie above deposits of undisturbed Drift, the latter being, in general, compact blue clays filled with angular, fragmental rocks. This formation is evidently the foundation of the primeval glacial deposits.

This glacial Drift varies greatly in thickness, ranging from only a few feet to over a hundred, wells that deep not having reached its base. The probability is that its thickness over this region was quite uniform, and that what remains in place is the undisturbed portion of a great mass of Drift material. As far as seen, this part of the Drift, throughout the county, was quite uniform. The variations of the surface are very marked, being lacustral, fluviatile, or alluvial, but the identity of this blue clay that superimposes the sandstone is clearly apparent. Dig where you will on the great central ridge of the county, this blue clay will be found at varying depths. It, like the others, gets its name from its origin. The alluvial is formed by the wash and overflow of streams; the lacustral by the slow accumulation of sediment in quiet waters; the glacial Drifts were formed by the action of great masses of moving ice.

The dynamics of this period need only an elemental discussion for the benefit of readers unlearned in geological science. All the phenomena of this period have not yet been fully explained, but the fact as to the prevalence of an era of glaciation is an integral part of accepted science. It is the only theory explaining a multitude of problems in physical geography. It answers the questions as to the presence of the bowlders, and explains the discovery of buried timber at the bottom of deep wells and a variety of inquiries originating in the mind of every observer.

Wide investigation has revealed the fact that the glacial Drift does not extend far, on an average, below the 39th parallel. In Indiana, the Drift scarcely reaches to the Ohio River, some of the southern counties having little or none. In many other localities, deep grooves or striations are seen upon the stratified rocks, and many of the bowlders are scratched or grooved, as are some observed in Johnson county. Moving ice alone could leave such a record.

The facts observed show that this moving mass was a mighty glacier, covering vast areas of the northern latitudes. As it accumulated, it moved southward, thus passing, gradually, into lower and warmer latitudes. In its progress over the rocky formations of the north, it displaced, by its weight and motion, vast quantities of material. These substances, in the form of sand, gravel, and bowlders, were carried along in its icy embrace, to be released in other latitudes by the dissolution of the glacier. The broken fragments of metamorphic rocks of the north would lodge in the soil, and remain as bowlders of granite and feldspar that are so familiar to all, yet so mysterious in their origin. The material eroded, by the glacier, from sandstone and limestone formations constitutes a large proportion of the soil, being pulverized and distributed by the waters of the melting glacier. The local details of the Drift in Johnson county furnish a good exposition of glacial phenomena. The primeval glacier extended over the whole of Johnson county, there being evidence that it covered the whole of Brown county, save the summit of "Weed-patch Hill," the northern ridge of Brown county became a great barrier in the pathway of the glacier. The first advance of the ice may have easily surmounted the obstacle, passing on and over, with resistless depth and power, the whole region becoming a glistening expanse of icy solitude. Bye-and-bye, an epoch of spring-time followed this era of wintry cold. The changed climate came on slowly. The melting ice causes the gradual recession of the glacier. Its dissolution sets new agencies into operation. Torrents of water begin the re-assortment of the drift. As the glacier withdrew, its detritus of bowlders, sand, and clay is subjected to the action of these fluviatile floods. The original deposit of the glacier is unstratified bowlder-drift; the foundation is of blue clay or hardpan that underlies the surface deposits.

The glacier did not recede uniformly. Its progress backward was varied with periodical advances. Nor was its retreat equal in every latitude. Surface elevation and the nature of the underlying formations would affect the dissolution of the ice mass. Tongues of the glacial ice would extend southward. Along elevated ridges, waters, rushing down, would conspire in the construction of deep, broad channels where the excavation was the easiest. That would be the locality where the surface was lowest and the underlying formations most susceptible of erosion.

This was the process of glacial action in Johnson county. The great central ridge of the county was covered with ice after it had wholly disappeared in the eastern side of the county. Indeed, it appears, from conditions observed, that the whole valley of Sugar Creek was a portion of what is now definitely known to science as "Collett's Glacial River."

Through this region, comprising three townships, there is evidence of deep erosion. There is no outcrop of the sub-stratum, save one exposure of the black shale. The deposits are all fluviatile, modified bowlder drift, either as a pebbly clay, with pockets of sand, or large and wide-spread deposits of obliquely stratified sand and gravel. Throughout this region, large bowlders are rarely found. The western shore of this ancient channel is well defined. In the southern part of the county are boldly outlined hills of the Knobstone formation. Some of them are plainly terraced, as particularly one on "Montrose farm," in section 34, Nineveh township. From the top of this hill there is a magnificent view of this ancient valley. Its eastern shore, the highest lands in Shelby county, stands out in distant outlines. This hill is one hundred and forty feet above the valley at its base and two hundred and seven feet above Edinburg, six miles to the east, and located on the alluvial and fluviatile deposits in the bed of this ancient river. In the northeastern part of the county, this outline is not less distinctly, though not so abruptly and grandly, defined. On the map, it coincides almost exactly with the course of Hurricane Creek. Observation revealed the striking fact that this stream, with an almost due south course, followed the eastern limit of the modified bowlder drift. This is seen in the fact that the western bluff of the stream is the higher for a distance of seven miles, and that this higher bluff, throughout this whole extent, is full of bowlders, while none were observed on the eastern side. West of Hurricane, the bowlder clays are thick and undisturbed; but on the east, the soil is sandy and loamy, with local gravel deposits, just as observed elsewhere throughout this ancient valley. This shore line, beginning thus in the northern part of this county, continues, with this general southern course, to the southern part of the State.

Prof. John L. Campbell has conjectured that at the time of greatest flow in this channel, the southern terminus of the glacier was not far south of Indianapolis. There is evidence of this, not only in the fact that the western shore disappears in this region, but that the crescent-like ridge of this county sweeps around to the east with a sharp curve, outlining, to the observer, a mighty mass of drift material that is a notable feature in the northern part of Pleasant and Clark townships. It extends from Greenwood, eastward, with its axial line running a little south of east. It is a ridge, well marked by the hundreds of bowlders that are strewn along its surface. Near Greenwood, the railroad crosses this ridge at an elevation of 840 feet above the sea, this being the highest point on the railroad between Indianapolis and Louisville. The eastern terminus of this ridge is in section 4, Clark township, at which it is rounded by Leatherwood Creek. Throughout its course, no deposits of gravel were seen. The bowlders are everywhere thickly studded in a solid matrix of clay. Near Rocklane, a multitude of unusually large ones were seen, sometimes hundreds of them in an area of a few acres, many of them ten to fifteen feet in length and weighing many tons. On the farm of Mr. W. F. Kimuck, in section 36, Clark township, one was measured, showing the following dimensions: Length over top, 18 feet, 1 inch; circumference 41 feet, 10 inches; height above ground, 5 feet. Near this monster were a number of immense proportions.

It was noticeable that there was a striking similarity in the bowlders of this ridge. They were mainly a coarse, gray granite, appearing as though they came from the same locality, as, doubtless, they did. The reason of their exposure so numerously upon the surface is, probably, that the ridge, being much more elevated originally, has been lowered by the washing down of its clays, thus exposing its buried bowlders and leaving them thickly strewn upon its flattened surface. Bowlders are thus a measure, oftentimes, of erosion.

There are a number of localities where a heavy removal of clay is revealed by the abundance of bowlders exposed, notably in Nineveh township, section 16. The whole mass of undisturbed bowlder clays of the central part of this county are more or less filled with these massive, erratic rocks.

Most of them are granitic. Occasionally a feldspathic or schistose bowlder is seen. A few large fragments of limestone, usually filled with Devonian fossils, were noted; one weighing several thousand pounds was seen in a deep ravine, near Barnes' Creek, in Hensley township, section 17. These massive erratics, thus strewn throughout this whole region, suggest the extent of the glacier. The whole region was covered with ice, by which alone these bowlders could have been transported.

Originally, the drift was deeply deposited on the eastern side of the county, also; but, there, it has been subjected to complete modification and erosion. That this re-assortment should take place there, and not in the central part of the county, is explained by the fact that the elevated regions held their ice-coverings the longest; that while the receding glacier's volume of water was deepening its channel northward, defining the course of the great glacial river, this ice-foot extended across Johnson county to the higher lands of Brown county, thus preventing the deep erosion that would have re-assorted the glacial drift, had it not been thus protected. But, in process of time, the whole mass melted, and there came volumes of water, overflowing everything, silting up portions of the old channels, and re-covering large areas of the glacial deposits, with sorted sands, clays and gravel. These floods moved with rapid and resistless current. They cut deep sluiceways through the clay barriers, casting up, in various places, heavy bars of sand, gravel, clays and bowlders. These channels may be traced by the deposits of gravel in many places, notably in a series of sluiceways having a general southwestern direction, found mainly in the southern part of the county. One is observed passing through the southwestern part of Franklin township, and connecting in Union township with the channel in which Stott's Creek now flows. Along the line of the Franklin and the Trafalgar gravel road, it is well defined, being a broad, deep channel, now obstructed with alluvium, and only occupied by a rill wholly unequal to the task of its excavation. Another similar depression passes near Trafalgar, showing an analagous relation to Indian Creek.

Proof that large volumes of water, at one time, flowed through these passage-ways of this glacial ridge, is found in the fact that, in the deep channels of the creeks in Hensley township, deposits of gravel are found. In many places they occupy positions with reference to the clay and sandstone that show the direction of flow as being from the northeast. Two beds of gravel on Barnes' Creek were examined, having the usual oblique and alternating stratification of such fluviatile deposits. Both were on the west bank of the valley, the one in section 17 facing a bluff with an exposure of sandstone capped by about 30 feet of clay. The current that cast up this sand bank came down this valley from the northeast. Similar conditions were observed in other valleys, many of the low points in these deep gorges being simply deposits of the post-glacial streams.

Where the region to the northeast of this central ridge is examined, it reveals the fact that these fluviatile waters wrought wonders in re-assorting the drift. North and east and south of Franklin, extensive deposits of sand and gravel exist. In their arrangement there is a general trend to the southwest. The sand ridge beginning at Franklin runs southwest, without interception, for several miles, where it is intersected by a small stream, but it appears again in the west, in sections 29 and 30, Franklin township. The sand and gravel at Mount Pleasant Church is a continuation of the ridge south of Franklin.

Another conspicuous deposit of sand and gravel, and probably the most remarkable, is the "Donnell Mound," section 8, Franklin township. It is an illustration of the effect of fluviatile waters, and it shows well their southwestern course. The northeast side of this mound is abrupt; and the southwest side, sloping gently toward Young's Creek, presents a talus, showing the direction of the current. The sand and gravel at Hopewell and vicinity is all of the same origin. The "Donnell Mound" presents a section of alternate layers of sand and clay and gravel, showing well the "flow and plunge" structure. The mound is about ninety feet above the bed of Young's Creek. From its rounded summit there is an interesting view of a region of wondrous fertility and beauty. While these floods were re-assorting portions of the glacial drift in the central part of the county, the eastern parts were wholly submerged. Clark township was a broad flood-plain, and in Sugar Creek valley the waters had more current; hence the casting up of the great sand deposits, characteristic of this region. The elevated portions of Needham township, notably on the land of L. Waggoner, in section 18, and of W. Duckworth, in section 15, are excellent examples of these fluviatile deposits. They overlie large areas in Blue River township.

All of these deposits bear a marked resemblance throughout the county, and all are contemporaneous in origin.

The only departure from this rule, that was observed, was a gravel deposit in section 20, Hensley township. This formation is apparently near the base of the glacial drift, being overlaid by from thirty to forty feet of bowlder clay and Loess deposits. From observation, this bed of gravel is present through quite an area of drift, and is not a mere pocket of sand and gravel, as such deposits usually are in unstratified drifts. The formation is, on an average, about ten feet thick, and, as far as seen, shows a regular, horizontal stratification. The alternating layers of fine sand and gravel are from six to ten inches thick, and all are charged with various mineral solutions, that give the whole deposit a variegated appearance. The bands are reddish-brown, ash-gray, blue, and yellow, features of chemical discoloration not seen in any gravel deposits elsewhere in the county. In many, the ordinary coloring of red oxide of iron was seen, but nothing with these features of color and stratification. This deposit, probably, antedates the general fluviatile modifications of the drift, and was formed at the first advance of the glacier, under the action of waters attending its periodic advance and retreat, and, as thus deposited, finally deeply covered with drift, when the glacier reached its culmination. The contrast of condition between this gravel bed and the one on Barnes' Creek, just one mile west, is very striking. The one lies above the drift, with oblique stratifications; and the other below it, with regular layers. The covering of the gravel pit on Barnes' Creek, is black alluvium; of this one, the covering is of the most compact clay, so hard and firm that it could only be removed by blasting. The relative antiquity of these two adjacent deposits is thus suggested. An epoch of geological history probably intervenes them.

Along the bluffs of White River, the peculiar phenomena of the glacial and post-glacial periods are observed. On this side of the central ridge of the county, the fluviatile floods apparently had not the advantage of long continued erosion. Instead of filling up a wide valley, already excavated, the great flood performed the Herculean task of cutting a channel through the sandstone ridge that extended, in bold outlines, across its course. This fluviatile erosion of the ancient valley of White River is thus seen to be a later event in geologic history than the formation of the "Collett Glacial River," which was the product of glacial action previously. This sandstone formation was probably capped with a heavy drift deposit. Through this barrier the water found its way, having, as the shore of its channel, the bold bluffs of White River at Waverly and Far West. The bluffs mark the eastern limit of the Knobstone formation.

Instead of following the outline of the outcrop, as in "Collett Glacial River" valley, the waters are compelled to cut directly across the barrier, because of the ridge on the east. North of Smith's valley there is a broad level plain, covered deeply with alluvium. Parallel with the present channel of White River, there are, in many places, detached ridges of sand and gravel, the axial lines of which lie northeast and southwest, coincident with the course of the ancient river. Some of these sand deposits are very thick. In several places they are piled directly upon the sandstone, all the clay having been removed. The sand and gravel gradually disappear as we go east from Far West, showing that these deposits were limited to that ancient channel. The high lands of section 9, 16, etc., of White River township, are the eastern shore of glacial drift, of superimposing sandstone strata. From the county line, one mile south of Far West, this elevation affords a magnificent view of the ancient valley, now threaded by the comparatively diminutive and meandering channel of White River. Observation and inquiry in various parts of the county reveal the fact that buried timber and leaves are frequently found, under such conditions as to position and distribution as to indicate a glacial and not "forest-bed" origin. The wood was apparently that of cone-bearing species, and found usually imbedded, at irregular depths, in clays. In section 21, Franklin township, at the bottom of a well twenty feet deep, leaves and twigs were found in the clay; and in section 20, three-fourths of a mile west, fragments of wood were taken out thirty-five feet below the surface. These remains all seem to be isolated and fragmentary—not a portion of a buried forest, but particles of wood and debris, dislodged and ground up by the moving glacier, and deposited finally with its detritus.

In section 12, of Hensley township, just south of Trafalgar, on the farm of J. J. Moore, is a formation of tufa that is quite extensive and interesting. There is above it a deposit of gravel, much of it cemented firmly together; beneath it lies a mass of calcareous tufa, or "honey-comb limestone." It contained perfectly preserved outlines of sticks, grass, moss, and leaves. The formation is produced by the filtration of water through the soil, which is highly charged with mineral ingredients, in this instance particularly, calcareous matter. The water becoming thus charged with lime, deposits a thin layer upon any object that it may cover; hence, the leaves and moss lying where such waters issue will, sooner or later, have their material re-placed with carbonate of lime, and, so, perfect casts are preserved and these curious formations are produced. For this reason these tufaceous deposits are usually observed in the vicinity of springs.

PALEOZOIC GEOLOGY.

The substrata of Johnson county comprise two different formations—one of the Carboniferous Age and the other Devonian. The Subcarboniferous period is represented by the Knobstone group or epoch, that underlies the drift throughout the western portion of the county. The Devonian is represented by the black shale of the Hamilton period, which is seen at a single exposure in Blue River township, but, probably, underlies the drift throughout the eastern third of the county.

The first for consideration, in the order of investigation, will be the

KNOBSTONE GROUP OR EPOCH.

As previously intimated, this formation underlies the glacial drift in the western portion of the county. As traced by outcrop, it enters the southern line of the county in the southeast quarter of section 34, where it appears in force, forming the precipitous slopes of Woodruff's Hill, near Nineveh. From this point it extends northwest in a waving line, having a heavy outcrop in section 10, Nineveh township, at Pritchard's Hill; thence, northwest through sections 4 and 5, Nineveh township, and section 31, Franklin township. In all the deep channels of the streams in Hensley, Union and White River townships, there are uniformily exposures of strata of this formation. Generally, the exposures are continuous to the very source of the small streams, showing that this formation lies well up in the central ridge of the county. It was seen at the head-waters of Nineveh, Indian, Stott's, Crooked, and Bluff Creeks. This elevation of strata suggests the possibility of their continuance underneath a portion of the eastern extension of this ridge, through Pleasant and Clark townships. This can only be determined by a deep bore in those regions. The probability of this extension is increased by the consideration that erosion did not occur here so deeply, because of the overlying ridge of compact bowlder drift. This whole region was more or less protected while the denudation of the formations southward was in progress.

Originally, the Knobstone formation extended eastward much farther than at present. Indeed, such an extension is demanded by the present position of the strata. They lie in position with an undisturbed and almost horizontal stratification, and with only a gentle dip to the west, yet, six miles west of Edinburg, they have an altitude of more than two hundred feet above the level of Blue River. There are no sufficient data to prove that this difference of altitude is produced by oscillations of surface: the ledges show no signs of any sort of disturbance. The main cause of change has, apparently, been the deep erosion of the eastern portion of the Knobstone toward the older and more elevated formations of Shelby and Decatur counties. The precipitous wall of the Knobstone formation in southern Johnson county indicates that it was caused by erosion. The very constituency of the lower portion of the Knobstone group favors the idea of their general denudation in the eastern part of Johnson county.

The characteristic of these ledges is that the lower are the more argillaceous; hence, loose, fine-grained clay shales are found, generally toward the base of this formation, with an increase of sandstone toward the top. The whole group in Johnson county exhibited these features.

The easily disintegrated clay shales are lowest and eastward, and the heavier ledges of massive freestones are found, as we rise, in series toward the limestone of the next formation. This feature indicates not only the probability of extensive erosive action along the eastern outline of the Knobstone, but suggests also the fact that the physical condition of the lower parts of the Knobstone conditioned the course of the Collett Glacial River, and contributed not a little to the formation of this glacial valley. The natural tendency of water is to follow the line of an outcrop, especially when an outlet with the dip is not easily secured, as was the case in this instance. The glacial deposits, westward, overlaying massive sandstone formations, made the natural channel coincide with the outcrop of the soft clay shales of the Knobstone. These favored deep and rapid erosion. All the data have, as yet, not been gathered to establish its depth and extent. It certainly swept away the whole part of the clay shales, and a greater part of the black shale of the next period. It is possible that the drift deposits, in some localities, rest upon the Corniferous limestone—the final bed of the deep flowing river of the misty past.

The Knobstone formation is quite uniform throughout the county. A section from White River township would coincide, in general features, with a section in Hensley.

Everywhere, the blue clay shales are filled with ironstone concretions, of all sizes and shapes. They are particularly abundant in the deep ravines of Nineveh and Hensley townships. They contain a large per cent. of iron, but the quantity is not sufficient to give them economic importance. Near the top of the outcrop at "Pritchard's Hill" (section 10, Nineveh township), two beds appear that are quite rich in iron, the mineral not being in nodules, but mingled with the shale, and, under exposure, showing a reddish-brown color.

The aluminous shale, while persistent through the whole section, nevertheless, varies in appearance. In one locality, on the land of Alfred Vandevier, in section 5, Nineveh township, it was a fine micaceous clay. The outcrop is about ten feet thick, underlying layers of freestone about six inches in thickness. In character, it was very soft and friable, but, on exposure to the air, it soon hardens, and, if it is rubbed, it takes a smooth polish and turns white. The early settlers of the neighborhood used it as a finishing mortar in "daubing" their houses. Its qualities demand some test of its practical value. No other exposures of this aluminous shale were observed, with the peculiarities of this outcrop. Elsewhere, they are more of a drab color, and usually with more or less of arenaceous material.

Along the course of Indian Creek, in Hensley township, the peculiarities of this formation are well displayed. One branch of the stream rises in the northern ridge of Brown county and the other starts from high land south of Trafalgar. Each one passes down a deep gorge, in part the work of its own waters. The South Fork presents the best exhibit of the Knobstones. Along its whole course they present a precipitous bluff, ranging from seventy-five to one hundred feet in height. At the junction of the two branches of Indian Creek, in southeast quarter of section 27, the following section was taken:

Soil	2 ft.	00 in.
Loess	20	00
Clay, about	30	00
Sandstone	00	10
Arenaceous shale	12	00
Freestone	00	06
Clay shale	10	00
Sandstone	00	08
Blue clay shale	12	00
Paving stone (bed of creek)	00	00
Total	88 ft.	00 in.

This alternation of shale and sandstone is very marked as we go down the stream. The sandstone becomes more massive, but the shales are persistent. The floor of the stream, at the point of the section given, is a layer of ferruginous sandstone. It is in broad slabs from three to six inches thick. It quarries easily, is regularly seamed in one direction and breaking with a square fracture in the other, thus being well adapted for pavements. The verticle partings through this layer all trend east and west.

This layer is exposed in Union township, under similar conditions, in the bed of the Middle Fork of Stott's Creek. The dip of the strata is down stream. It was observed that they rapidly thickened as they continued westward; a stratum of freestone, six inches thick, increased to about two and one-half feet in less than two miles. The increase of thickness was very uniform through the whole distance. Its continuous outcrop along this creek is a very noticeable feature of the scenery. The ledge juts out in massive shelves over the water. Where it finally passes below the bed of the stream, it is nearly three feet thick. At this point the overlying deposits are comparatively thin, and the conditions are favorable to the successful removal of this excellent building stone. It is a durable rock, hardening with exposure and not affected by climatic changes. Ledges that had been exposed for an indefinite period preserved the sharp angles of the first fracture.

No fossils were found in any part of this formation, though constant and careful search was made. Ripple marks were occasionally seen, though usually in faint outlines. One slab of brown ferruginous sandstone on "Woodruff's hill" had its surface covered with raindrop-like impressions; another was found in Hensley township, with outlines of "fucoids or seaweed." The absence of fossils is explained by the conditions of the ancient sea in which these shales and sandstones were deposited. The turbulent and shallow water of its shore may have been fatal to their existence, or, if they existed, its deposits were not adapted to their preservation. In some of the ravines of White River township, geodes were found quite numerously, but, generally, smaller than those abounding in Brown county. The hollow concretions are characteristic of the Keokuk beds, the next higher formations, and appearing in outcrop some distance westward. Their presence in this distant and isolated valley may be explained by the decomposition of some outlier of the Keokuk. The calcareous matter of limestone being removed, these siliceous concretions would remain, and would naturally find their way to the beds of small streams.

In the valley of Indian Creek, a geodized goniatite was found by Hiram Porter, who kindly presented it to the State Museum.

THE BLACK SHALE.

(GENESEE SHALE.)

There is but one outcrop of this well-known and much studied formation. It is well exposed in the bed of Sugar Creek, in Blue River township. The outcrop begins just below the railroad bridge, in section 9, and extends down the stream to the iron bridge, over Bradley's Ford, in section 17. It is a fine exposure, the formation composing both the bed and the banks of the stream. The shale is jet black, breaking usually, on exposure, into small pieces, the fracture being quite as ready in one line as another. Other ledges exist in broad slabs that are quite massive; these are usually studded with quantities of iron pyrites in flattened concretions. When broken, the illusive yellow suggests the common name, "fool's gold," and, therefore, is simply sulphide of iron.

This exposure of the black shale seems to be an isolated one, there being no other observed nearer than Valley Mills, in Bartholomew county, nearly seven miles south. It seems to be an island of shale, capped with a heavy deposit of modified drift. If any of this bed exists in any place in this locality it is at a much lower level. In this outcrop, the shale ascends well up on the bluffs of the creek; and in the adjacent regions the alluvial and fluviatile deposits are very heavy, the deepest wells never reaching the shale.

Only one fossil was found in this outcrop. Though this group, in other localities, has furnished quite a number of species, the specimen found was the impression of a fossil plant on a large slab of the shale. It was fully six feet long, and was apparently a rush-like plant, with a jointed stem, which, when growing, must have been a gigantic *Equisetum*, allied to the genus *Calamites* of the Carboniferous Age. It had jointed stems, the joints being from two to four inches apart. In process of preservation these joints seem to have been separated, and, in the interstices, was found a layer of coal that was as hard and irridescent as anthracite. This black shale is full of carbonaceous matter.

The rocks of this period, in other localities, are rich in oil, but these shales contain only about ten per cent. of combustible matter. For this reason, they burn with a bright flame for a few minutes, when placed in a hot fire, but, aside from this they have no other resemblance to coal; nor have they any relation to the coal-bearing rocks, being far below them geologically. These beds probably underlie the most of the surface of the eastern part of the county. It has been subject to great erosion, and, as it readily decomposes on exposure to air and water, it is not unlikely that the broad belt of black loamy land in Clark and Needham townships derive their color and fertility from the decomposition of the black shale. Its clayey, carbonaceous matter, mingling with alluvial deposits of organic material, produces a fertile soil.

ECONOMIC GEOLOGY.

SOIL.

The diversified topography and varied geological structure of this county affords a great variety of fertile soils. They range from the firm compact clays of the central ridges to the loamy alluvium of the level plains.

The clay lands are all susceptible of a high state of cultivation. Even the white clay of portions of Hensley and Union townships is rich in the mineral ingredients that are the basis of a good soil, which constitute the vital elements of plant food—the product of decomposed rocks, mingled with more or less of matter of vegetable origin. These stiff, heavy clays are really not "poor" land. They are rich in the elements of productiveness. A cold, clammy soil only needs to be opened and warmed. This can readily be done, not so much by costly fertilizers; for the soils of Johnson county do not need so much the introduction of plant food as they need the production of the conditions in which they can use what they already have in store as a part of their constitution. Manures might, doubtless, benefit old and worn out soils, but the need of so-called "poor white clays" is not the putting-in, but the bringing-out process. The elements of fertility are inherent in the vast store of phosphates, carbonates, etc., that are held unused in these cold, compact clays. The two agents are clover and drainage; the former, in connection with a judicious rotation of crops, and the latter contemporaneous with thorough subsoiling. These introduce the effects of light and heat. The clover roots penetrate deeply—they tap the store of plant food. The roots and leaves, dying, introduce a new element of fertility. The drains carry off the water that formerly had no outlet. The soil becomes porous and open. In wet weather, it loses its superfluous water, and in dry weather the loosened earth gives the rootlets access to the deeper moisture. This process will develop the capacity of these cold clays. Not only will it develop their capacity, but it will preserve them in increasing fertility.

The greater portion of the soil in Johnson county is a rich, black loam. The only condition of productiveness is thorough under-drainage. This condition has been almost universally met, hence, the almost unequaled fertility of the land. There are numerous tile factories in constant operation, and thousands of dollars are expended annually in this most profitable investment.

The direct benefit of the extensive and thorough drainage is the hygienic blessing of pure water. Malaria was the curse and terror of this county, three decades ago. The shallow, stagnant marshes generated the poison which was introduced into the human system, probably not so much by atmospheric communication as by the infiltration of its impurities into the shallow wells and surface springs from whence the people procured water for potable and culinary use. Drainage dries the swamps that feed the shallow, surface wells. The remedy is a deeper well to the purer waters below, that have not a marsh for a fountain; or, what is better still, the construction of cisterns, and thus securing the purest of all waters, from the clouds. The importance of a pure water supply can not be overestimated. Medical authorities affirm that many epidemics of typhoid fever originate in a contaminated water supply.

Johnson county is naturally well supplied with an abundance of pure water. Numerous springs issue from the hillsides, some of them charged with mineral ingredients. The finest and most noted mineral springs are found in section 7, Nineveh township. They are known as the "Vickerman Springs," after the name of the original owner of the land. They are three in number, all close together and issuing from the base of a boldly escarped bluff of bowlder drift. The springs flow out at the top of the sandstone strata at the base of the clay. They are quite similar in character, though the one farthest to the west exhibits the most decided mineral character. Its analysis was not obtained. The water is said to have medicinal properties, and many have testified as to its efficacy in certain disorders. It has a pleasant taste. The rocks over which it flows are colored bluish black, as is the whole bed of the stream into which it flows, for some distance below. Bubbles issuing occasionally, indicate the presence of a free gas. The "Big Spring," at Hopewell, is well known. Here, the water issues from the base of a sand and gravel deposit overlaying the blue clay. Other springs have been utilized in the arrangement of fish ponds. The supply of German carp has taken fish culture out of the domain of pleasure into the region of practical industry. Fish may be reared as easily as poultry, and are more profitable.

LIVE STOCK.

The abundance of running waters and excellent grass land make this county a great stock region. These natural advantages, coupled with the noted enterprise of the people in securing and breeding to the best breeds of animals, has made this county famous for its fine stock. Herds of short-horn and Jersey cattle are numerous, with horses of the finest character, while flocks of Cotswold sheep and droves of Berkshire and Poland China hogs are found everywhere. To individualize merit would be to discriminate against equal excellence in a myriad of instances.

ROADS.

Johnson county was one of the first counties to move in the matter of improved means of transportation. Under the old gravel road law, numbers of excellent roads have been built, the material being the excellent gravel that abounds in every part of the county, save a narrow strip along the central ridge. This region, however, is not so extensive but that material is accessible in the adjacent more highly-favored localities. The gravel usually cements into a solid mass, and becomes very durable, needing only a fresh coat now and then to keep it in excellent condition.

The provisions of the new road law are stimulating the construction of many free gravel roads, notably in Hensley and Union townships. The distance from any shipping point make them doubly desirable. Difficulty in securing adequate supply of gravel in those localties was anticipated, but closer investigation indicates an adequate amount is accessible. The beds of the larger streams will produce a small amount continually, probably enough to keep the roads in repair. A larger and more reliable supply will be found in hidden deposits along the points of the ridges running down into the deep valleys of Indian, Barnes' and Stott's Creeks. The gravel is found in the "second bottoms," and sometimes under several feet of soil. The efficiency of the new road law will depend upon its proper enforcement, and that will hinge upon election of honest, intelligent and energetic men to the office of road superintendents.

FRUIT.

The "Brown edge" of Johnson is well adapted to the production of fruit of all kinds. The native fruits of this soil are Nature's plain hint as to its capacity. They grow luxuriantly. Persimmons, blackberries, raspberries and grapes all abound. Grape vines of wonderful length and size clamber among the branches of tall trees. Where Nature's suggestion has been followed, excellent fruit is produced in abundance and in the greatest perfection. While the orchards elsewhere in the county were dead and dying, the apple trees on these ridges were thrifty and fruitful. Mr. J. M. Woodruff states that in sixty years his peach trees on this high land have only failed to produce fruit four times, an average of but one failure in every fifteen years! Such success should warrant the planting of this land in all varieties of fruit. Cereals have but a scanty and uncertain growth in these soils, but fruit would be a sure investment, with early profit. The region south of Trafalgar and west of Nineveh could be made the orchard of Central Indiana. Other regions, equally as productive, are too remote from the railroad. This region is near, with excellent facilities for transportation, and could easily distance all competitors.

ARCHÆOLOGY.

Traces of the pre-historic people, while not abundant, are of such a nature as to interest the antiquarian. Only two small mounds are known to exist in the county, and they are small habitation tumuli. They are on the land of William Sanders, in section 10, Blue River township. They are about one hundred yards from each other. The land is under cultivation, and they have been almost obliterated. Some of the sand ridges in the county greatly resemble mounds, as the "Donnell Mound," and many others; but they are natural elevations produced by the fluviatile agency previously described.

The western half of the county is by far the richest in archæological relics. One of two reasons may explain their comparative absence on the eastern side: either the locality was too wet and marshy, or the alluvial deposits have buried all traces of their residence below the present surface. On almost every farm in Hensley, Union and White River townships, the various implements of the pre-historic and aboriginal people may be found. They are generally the grooved axes, pestles of Greenstone, and pieces of pottery. A fine Syenite axe was presented to the State Museum by Mr. Hiram Porter, of Hensley township. This gentleman is an enthusiastic collector of specimens, having in his house many of rare interest. Another handsome grooved axe, or "celt," was presented by George Holman, of Hensley township.

In this township are frequently found slabs of sandstone, having one or both sides full of shallow round holes, about large enough to fit the larger end of an average hen egg. They are smooth and symmetrical, evidently having been fashioned for some purpose. Many conjectures have been advanced as to their probable use. Some have suggested that they were "Anvil stones"; but the character of the stones prohibits such use, being in rather thin slabs and easily broken. One of these stones was seen, having both sides full of holes. On one side there were twenty-three, and on the other twenty-five. Such a number seems to oppose another explanation that has seemed very plausible—that these holes were worn by constant use in cracking nuts for food, which constituted a large portion of their subsistence.

On the land of Calvin Fletcher, in section 18, White River township, a skeleton was found in a gravel pit, having a vessel of pottery closely fitted upon the skull, which was well preserved. Both the skull and the pottery were broken into fragments by the thoughtless workmen. Associated with this skeleton were found a number of flint arrowheads and pieces of fresh-water shells. These specimens are in possession of Mr. W. M. McKinzie, of Waverly, Morgan county.

In section 32 of this township, on the land of Mr. J. H. Throckmorton, portions of an immense pair of antlers were found, in digging a ditch. They were four feet below the surface, lying at the base of the alluvial deposits or at the top of the clay. They were worn, doubtless, by the great post-glacial deer, which ranged this region as a contemporary of the Mastodon. Of this latter animal no relics have been reported in any part of the county.

Flint arrowheads, chisels, bodkins, scrapers, knives, etc., are frequently found. Mr. W. H. Barnett, of Franklin, has an interesting collection from various parts of the county—among them one eight-grooved axe, one flint bodkin three inches long, and a fine flint dagger six inches in length. He has in his possession, also, two iron tomahawks, to which is attached peculiar interest. The smaller one was picked up on the old Indian camp ground on the bluff of Young's Creek, west of Amity, the spot on which the Indians had their last camp-ground within the limits of this county, in 1824; the other is a larger axe, of very hard steel, made in the old Spanish fashion, and was dug up near the buildings of Franklin college.

EDUCATION.

Franklin College is located at Franklin, and is under the control of the Baptists of Indiana. The institution is in a flourishing condition and is doing a grand work in the cause of education. The able and efficient faculty are thoroughly devoted to their work. It is confidently hoped that the endowment of this institution will soon be increased largely, and the college put in position to surpass in usefulness even the grand record of the past. The curriculum of studies is complete in all departments, and the standard of scholarship is high. The surroundings of student life are most delightful and favorable to all the interests of the pupil—moral, mental and physical. The location is a pleasant one. The buildings are commodious and convenient, and the campus extensive and shaded by majestic trees, mainly of native forest growth. The library, laboratory and cabinet are all well supplied with the references, appliances and specimens that enable the successful prosecution of any branch of study.

The public school houses of Franklin, and of all the larger towns, are well constructed and supplied with all the desiderata of first-class graded schools; and, throughout the county, the old-fashioned, barn-like school houses have been almost universally replaced with handsome and well-arranged structures that are a credit to the intelligence of the people.

Large and commodious churches abound in the county as well as in the towns. Some of the rural churches, as Hopewell, Pleasant Hill, and Union, rival the cities, in both the costliness of the houses of worship and size of the congregations.

The population, everywhere, is cultivated and Christian, progressive in spirit, ready for every act of benevolence and every movement for public good.

THANKS.

The personal kindness received from those who aided in this survey has been highly appreciated, special acknowledgment being due the following generous and public-spirited citizens of various townships: Wasson McCaslin, David A. Leach, N. H. Barnett, Herman Porter, J. M. Woodruff, Alfred Vandevier, George Holman, Andrew S. Wood, W. F. Kinnich, Prof. D. A. Owen, W. H. McKinzie, T. J. Byer, John H. McCaslin.

GEOLOGY OF GRANT COUNTY.

BY A. J. PHINNEY, M. D.

GEOGRAPHICAL AND TOPOGRAPHICAL NOTES.

Grant county is situated not far northeast of the center of the State, about midway between Ft. Wayne and Indianapolis. It embraces 418 square miles in its area.

The principal Indian inhabitants of the county, in the early part of the century, were of the Miami tribe; in later years they were reduced to the Meshingomesia band. Their most noted village was Meshingomesia, situated about three miles south of the Wabash county line, near the Mississinewa River. The Indians still hold this land, the title never having passed to the Government.

The first settlers were principally Quakers, who located at and in the vicinity of Jonesboro; and, to-day, fine farms, school-houses, and modest churches are evidences of the thrift, intelligence, and moral status of these people. The northern portion was settled by emigrants from Ohio and the Middle States.

Grant county formed part of Delaware county until February 10, 1831, when the Legislative Act for the organization of the county was approved.

Marion, the seat of justice, is named in honor of Gen. Francis Marion, a noted leader in the Revolution. This city has a population of about four thousand. It is an enterprising place, busy with the various industries that give prosperity and happiness to its people. It is situated in the valley of the Mississinewa River, and is surrounded by high table lands, rendering the scenery quite picturesque. The court house is a magnificent structure, built of Indiana's famous oolitic limestone.

The other principal towns are Jonesboro and Fairmount, each having about one thousand inhabitants. The smaller towns are Upland, New Cumberland, Van Buren, Jalapa, Mier and Sweetser.

The county is crossed by the Pittsburgh, Cincinnati & St. Louis, the Cincinnati, Wabash & Michigan, and the Toledo, Cincinnati & St. Louis Railways, and, as the course of each is somewhat circuitous, ample facility for communication is afforded all parts.

SURFACE CONFIGURATION.

The surface was originally one vast plain, with only occasionally slightly rolling tracts to break the monotony; now, the valley of the Mississinewa River is the most marked topographical feature. On the east, is a slight divide, separating the waters of Black Creek from the Mississinewa, while on the west, is another, which turns the waters of Pipe Creek to the westward. Its course, after leaving the county, is nearly parallel with the Mississinewa. The drainage from Green township is almost due west, Wildcat Creek having its source here. There are no hills, strictly speaking; the broken surface along the river is due to erosion, as the summits of the so-called hills are not higher than the plain a few miles back from the river.

The fall of the Mississinewa is rapid. Throughout its entire course in the county, it has cut its channel from fifty to one hundred feet below the level of the plain; as a result of this, all the small streams tributary to it have excavated deep gorges through the heavy clays, giving a very broken surface. The southern portion of Monroe township is usually considered rolling, especially along Walnut Creek, but this is due, also, to erosion. Walnut Creek may seem totally inadequate for the excavation of so deep and broad a valley as the one it now occupies, but the explanation is easy, after determining that it was crossed by a great glacial river, flowing to the southwest. Overflows from this river, probably, contributed much toward the excavation of the valley and the erosion of the surface of the plain adjacent to it.

The Mississinewa River enters the county near its southeast corner, and, after traversing it diagonally, leaves it on the north side, about six miles east of its western boundary. Its valley is quite broad in places, though, north of Marion, it is narrow, owing to the river having cut its channel through limestone strata. No one, from the present size of the stream, would infer that it was ever navigable, yet such has been the case. In early times it could be crossed at Marion by ferry only, for nearly half the year; flatboats carried the produce of the farmers, by way of the Wabash, to New Orleans, where it found a ready market; but with the clearing of the forests, the draining of the wet lands and the building of dams, the river has dwindled until this is no longer practicable, and the construction of railroads has rendered it no longer a necessity. The river, however, at present, affords valuable water power, which is utilized to its fullest capacity.

Pipe and Grassy Creeks drain the western part of the county, and Black Creek the northeastern portion. The principal tributaries of the Mississinewa, from the east, are Walnut, Lugar's, Hummel's and Lake Creeks, and Barren Back, Deer and Boot's Creeks from the west. These are all small streams, and serve only to furnish a supply for stock.

Water is usually obtained in wells, at a depth varying from ten to forty feet, thirty feet being the average depth in the eastern part of the county, while in the west and south it is frequently obtained within fifteen or twenty feet of the surface.

In the southeastern part of the county, passing through Monroe, Jefferson and Fairmount townships, with direction from north northeast to south southwest, is the partially silted up channel of one of those Glacial Rivers that were once so common in Eastern Indiana. It is marked throughout its course by a series of swamps, lakes, beaver dams, and, near section 18, Fairmount township, by a deep gorge, one-half mile long, unoccupied by any stream. The drainage of the swamps has made many of the prairies. Some of them are of considerable size, as Bird's prairie, in Monroe township. In section 14, Fairmount township, is quite a large lake; its area is now about ten acres, but it formerly covered nearly thirty. This is gradually filling up, but is still a favorite fishing place for people in that vicinity. In section 12, Jefferson township, is another large, but shallow lake, now nearly dry from drainage. Although this lies considerably to the south of the course of the stream as marked on the map, it is probably a part of the old channel, as the Glacial River was, at times during the overflows, a wide stream. This old channel is quite clearly marked, and can be traced into Blackford county on the east and Madison county on the south. The course of the stream was such that it probably passed through Marion county, near the site of Indianapolis, and either joined the Collett Glacial River in Johnson county, or continued on in a southwesterly direction near or in the valley of White River.

The city of Marion is supplied with water from an artesian well, which was sunk on the west side of the river near Boot's Creek. It was commenced twenty-five feet in diameter and carried to a depth of twenty-seven feet, when, not finding water, a drill was sunk forty-one feet, when a vein was reached which filled the well and overflowed at the top.

SECTION IN THE MARION WELL.

Black muck	1 ft.
Blue clay	2
Gravel and sand	9
Blue clay	15
Blue clay, in bore	41
Total	68 ft.

Water works have been built at a cost of about $50,000, and afford ample protection against fire, as well as furnishing the people an abundance of good pure water. From an analysis of the water, given by Prof. Cox in the Geological Report for 1878, it is found to contain twenty-eight grains of mineral matter to the gallon.

ANALYSIS OF WATER FROM THE MARION WELL.

	Grains.
Silica, insoluble in acids	1.610
Alumina	.350
Magnesia	3.705
Lime	9.319
Oxide of iron	.849
Soda	.154
Carbonic acid, combined	9.314
Sulphuric acid	2.298
Chlorine	.236
Loss	.343
Total	28.200

Many people in the adjacent counties think that the well furnishes soft water, but this is a mistake, as shown by the analysis.

The source of the water is a question frequently asked, but difficult to answer positively. The direction of Massey and Hummel's Creeks and the swampy tracts, extending northeast through Van Buren township into Huntington county; a continuation of the same line, embracing Boot's Creek, the upper portion of Pipe Creek, and the chain of swamps, now prairies, extending through the northwest corner of Green township, into and through Tipton county, passing a little east of Tipton, render it probable that this line represents the course of another of those glacial rivers, or, perhaps, one of the pre-glacial lines of drainage, incompletely filled. Marion, besides its situation in the valley of the Mississinewa, is located between two rocky ridges, the one on the northwest about one-half mile from the city and the other, two and one-half miles to the southeast. Between them is a deep valley three miles wide. Wells have been sunk at Marion one hundred feet without reaching the rock, and this may not be one-half its depth. Where the river cuts across the ridge southeast of the city, it may find a passage under the heavy sheet of clay filling the valley, and, the well being sixty-eight feet deep, the fall between this point and the bottom of the well may be sufficient to cause an artesian flow. The subterranean currents of the old valley, probably, come from the northeast, and may be reinforced by veins from the east and southeast, as well as by water from the river. The well is located in a wet, swampy tract, which was once the channel of the Mississinewa River.

GENERAL GEOLOGY.

CONNECTED SECTION.

QUATERNARY AGE.

Alluvium	1 to 10 ft.
Drift	10 to 200 ft.

UPPER SILURIAN.

Guelph, or Cedarville beds, yellowish, massive limestone, with chert.	16 ft.
Springfield beds, bluish limestone, upper portion argillaceous, in places a calcareous shale, variable	25 ft.
Total	251 ft.

QUATERNARY AGE.

These deposits are of vital interest to the farmer, because they have contributed largely to the formation of fertile soils. Without them the farms would not be worth near their present value, and much of the surface would be covered with shallow lakes, to breed pestilence and death instead of yielding, as now, glorious harvests.

At the close of the Glacial epoch, the many slight depressions of the surface were filled with water; but, with the spread of vegetation and the wash from the higher lands, most of these have become swamps, filled with peat, muck, or humus, waiting only for the farmer's bidding to give up their wealth. The prairies are only lakes that have been filled with vegetable accumulations. The aquatic vegetation has only covered the surface of the deeper ones, and beneath the ten or fifteen feet of peat and muck will be found subterranean lakes. This will explain why railroad embankments built across these prairies are frequently swallowed up, as the mass of vegetation gives way. All the townships in the county have more or less of this deposit, but the eastern, western, and southern portions are best supplied. Much has been done, by ditching, to complete the work begun by nature, namely, to render the swampy tracts dry; but more is needed, if an increase of the fields of magnificent corn and wheat is expected. Vegetable mould or humus is found on every farm, as indicated by the rich black soil.

ALLUVIUM.

This deposit is necessarily limited in extent, for the valley of the Mississinewa is deep, but narrow, and none of the tributaries, except Walnut Creek, have alluvial bottoms of any extent. Formed by the material left on the flood-plain during high water, it is composed of fine sand (silica), clay, and vegetable debris, finely comminuted. The uniformly good crops show that this deposit has high rank, judged from an agricultural standpoint.

DRIFT.

This name is given to all those beds of sand, gravel, clay and bowlders which have not been deposited by forces still in action. They are due to causes which have long since ceased to act in this latitude. They cover the whole county, the depth ranging from ten to two hundred feet, the last only found in the pre-glacial valleys.

Gray clay is the principal surface deposit over the eastern portion of the county. Its thickness is about thirty feet. Beneath this is the water-bearing bed of sand and gravel; under this lies the blue bowlder clay, so nicely exposed in the bank of the river east of Marion. The bed of sand and gravel is not as constant as the clays. In the western and southern parts, gravel and sand is found in pockets; as wells, sunk only a few feet apart, show, in one, nothing but clay, while the other may strike gravel within a few feet of the surface, and afford an unfailing supply of water. In places, thin beds of gravel are passed through, in digging wells, at a depth of ten or fifteen feet, but water is obtained principally from deeper beds, and is thus freer from impurities. Many of the swamps, bogs and round sink holes or ponds are underlaid with gravel and sand. A pike was being built in Fairmount township, the gravel for which was taken from a swamp. It was necessary to use a pump to keep the pit free from water. At Jonesboro, the bluffs are composed of sand and gravel; elsewhere observed, they are formed of heavy blue and gray clays. In the southern part of the county, along the river, the gray clays have become yellowish or rusty colored from oxidation or the iron in the limestone, which forms a good portion of the drift, being thoroughly mixed with the clays. South of Marion is a deposit of gravel, below the old bed of the Mississinewa; but this was deposited by the melting glacier, not by the river. It supplies the city and railroads with an abundance of this valuable material.

Bowlders, although common in the county, are not numerous, except in a belt near Jalapa, where are found many large ones. They are principally granites, gneiss, greenstones and quartzites. They were evidently torn from the under surface of the glacier, as it passed over the ridge of rock exposed in the bed of the river. Limestone bowlders were once numerous along the river, between Jonesboro and New Cumberland, and were burned for lime.

MASTODON.

Some years ago the tooth of one of these extinct animals was found in one of the marshes south of the lake in Fairmount township, showing that the ponds and lakes along the course of the ancient river was frequented by them.

Beaver dams were numerous when the county was first settled, but the beavers had disappeared before the coming of the white man. Whether they were of the giant species (*Castoroides Ohioensis*), and were contemporaneous with the mastodon, or whether they were of existing species, is hard to determine in the absence of their skeletons.

PALEOZOIC GEOLOGY.

The only rocks exposed in the county belong to the Niagara period, Upper Silurian Age. No outcrops occur between Jonesboro, and New Cumberland, though the rock is probably but a few feet below the bed of the river. North of Marion, the Mississinewa has cut its channel through limestone nearly the whole distance north to the county line. It is a magnesian limestone, varying in color, hardness and durability. In places, the argillaceous layers have more resemblance to a shale than to a limestone, and indicate a muddy condition of the seas at the time of their deposition. The better layers produce good building stone, but they must be selected with care, as the strata are subject to great variation—a good layer frequently changing so, in a few rods, that it may be of inferior value. Sufficient stone is quarried to supply the wants of the county, and considerable is shipped away. Near Marion, the quarry of Mr. D. R. McKinney gave the following:

SECTION AT MCKINNEY'S QUARRY.

Gray, argillaceous limestone, charged with iron; strata from 2 to 4 inches thick	4 ft.	00 in.
Bluish gray or light drab limestone; strata 2 to 4 inches	4	00
Blue limestone; lower part resembling a pudding-stone, but due to concretionary structure	0	8
Blue limestone	0	4
Blue limestone	0	10
Blue limestone	0	8
Blue limestone	0	7
Blue limestone; 2 strata	0	6
Blue limestone	0	8
Blue limestone	0	7
Blue limestone	0	6
Total	15 ft.	7 in.

Below the lowest strata worked, the rock becomes argillaceous, of a bluish green color, and rapidly disintegrates upon exposure to the atmosphere. All the strata given in the section become similarly changed, further down the river. The middle layers are the most durable, as the lowest strata are softer, and gradually change until they become worthless. Any of the strata are liable to be split into two or more layers, within a few rods. The dip is to the northwest, and quite marked. Mr. McKinney sells, annually, from 6,000 to 10,000 perch, a portion of which is shipped to other counties.

In the upper portion, specimens of the trilobite (*Calymene Niagarensis*) have been found. In the lower part, large cephalapod mollusks are the prevailing forms of life. The large coiled fossil is a *Lituites* (new species); the curved forms are *Phragmoceras ellipticum*. The larger ones are

Phragmoceras Nestor. The long straight ones are *Orthoceras crebescens* and *Orthoceras strix*—the latter easily distinguished from the first by the longitudinal markings. The short form, with eight or nine transverse septa, is *Gomphoceras subgracile.* Occasionally, the half-coiled *Cyrtoceras Dardanus* is met with. All the above are internal casts. Some of the strata contain calc-spar, chert and crystals of quartz; but it is an idle dream to expect to find silver or any other valuable mineral here. Silica, in one form is soluble in waters slightly alkaline; and its presence here is due to its deposition from solution, either as quartz crystals or as chert, which is only another form of quartz. In some cases, chert and flint, related forms, are probably due to aggregation, around some foreign body as a nucleus, of the solution of the spicula of sponges and the siliceous shells of infusoria. As sponges existed in the seas of the Niagara period, they were probably one of the sources of the chert so abundant in some of the strata.

Across the road, Mr. S. R. Frankbone is working a quarry which gives the following:

SECTION AT FRANKBONE'S QUARRY.

Soil	5 ft.	0 in.
Gray, argillaceous limestone, strata 2 to 3 inches thick	5 ft.	0 in.
Bluish limestone, strata 2 to 3 inches thick	4 ft.	0 in.
Bluish limestone	0 ft.	4 in.
Blue limestone	0 ft.	6 in.
Blue limestone	0 ft.	2 in.
Blue limestone	0 ft.	12 in.
Blue limestone	0 ft.	10 in.
Brownish slate, varying to black or blue calcareous	0 ft.	2 in.
Blue limestone	0 ft.	4 in.
Blue limestone	0 ft.	10 in.
Blue limestone	0 ft.	2 in.
Blue limestone	0 ft.	6 in.
Blue limestone	0 ft.	6 in.
Blue limestone	0 ft.	8 in.
Total	20 ft.	0 in.

About three thousand perch are quarried here, annually. Some of the thinner strata are, in places, quite slaty, and ring under the hammer like a clinkstone. Both these quarries yield some good flagging.

One and one-fourth miles below this point, on the east bank of the river, Mr. S. Secrist quarries about one thousand four hundred perch, yearly. The strata, here, are thicker than at McKinney's but softer, and the argillaceous layers have been removed by erosion.

SECTION AT SECRIST'S QUARRY.

Soil	4 ft. 0 in.
Bluish limestone	0 ft. 8 in.
Bluish limestone, in 4 layers.	0 ft. 14 in.
Bluish limestone, argillaceous	0 ft. 12 in.
Bluish limestone	0 ft. 18 in.
Bluish limestone	0 ft. 16 in.
Bluish limestone	0 ft. 18 in.
Total	11 ft. 2 in.

This rock hardens on exposure and becomes a durable building stone. Efforts have been made to produce a hydraulic cement, but without success. It is said, however, to make a very fair firestone.

A short distance below here, Dr. Lewis Williams is working a quarry which corresponds to the one just given, except that the upper layers produce fine flags, their rough surfaces showing nicely the jointed suture.

Three and one-half miles below Marion, Mr. C. W. Bowman is working an outcrop which resembles the one near Marion, but only about four and one-half feet of the lower strata are suitable for buildings. Portions of the upper layers are used for wells. The strata are quite cherty, and the stone from the lower beds hard and refractory. About ten feet is the depth to which this is worked.

A short distance north of here, near the summit of the hill, is an outcrop of a yellowish, massive limestone, very unevenly bedded and overlying the blue rock and argillaceous limestone. It forms the summit of the rocky series exposed in the county, and shows a change from the muddy sea, in which the strata beneath were deposited, to one of clear waters, filled with corals and other forms of life; but, like a coral reef exposed to the waves from a deeper sea, their forms have been reduced to a condition of fine sand, and then cemented, forming a massive lime rock. It is probable that the exposures near Mier and in Franklin township belong to this rock, though differing in color at the place last named. Some lime has been burned from this outcrop, but the kilns are all abandoned. Probably, with care in the selection, avoiding the chert, good lime might be produced. Here were found the trilobites *Calymene Niagarensis* and *Illænus Ioxus*, *Receptaculites hemisphericus*, *Alveolites Niagarensis*, *Eridophyllum rugosum*, *Favosites Niagarensis*, *F. obliquus*, *Halysites catenulatus*, *Heliolites interstinctus*, *Atrypa reticularis*, *Meristina nitida*, *Meristina Maria*.

This place affords a complete section of the rocky series exposed in the county, for, across the river, is the best exposure of the blue limestone seen.

GENERAL SECTION.

Yellowish limestone, unevenly bedded, siliceous	6 ft.
Yellowish-gray limestone, silecious, massive, looking like a sandstone at a distance	10 ft.
Across the river, and beneath the last, a bluish argillaceous limestone, more properly a calcareous shale	15 ft.
Bluish green limestone, strata from 2 inches to 3 feet in thickness	10 ft.
Total	41 ft.

The lower twenty-five feet, although representing the same strata that are exposed in the quarries near Marion, have their upper portion so heavily charged with alumina that they rapidly disintegrate upon exposure to the atmosphere. No marked line can be drawn separating the upper fifteen feet from the lower ten feet, as the change from the shaly upper strata to the lower harder and more massive beds is gradual. The lower portion has a conchoidal fracture, as shown in the talus. Certain of the strata would, no doubt, be desirable for architectural purposes, if it were not for the thickness of the overlying mass of worthless material. The current of the river is such that the talus is removed nearly as fast as formed, and a vertical face is thus presented.

These beds of blue or bluish-green limestone form one of the most persistent and valuable portions of the Niagara group exposed in Indiana. It everywhere presents nearly the same characteristics—heavy, massive beds below, gradually changing to a calcareous shale or an argillaceous limestone above. The variations observed in the color of the different strata is due, in great part, to oxidation of the iron which they contain. The lower strata have almost invariably a bluish-green color, occasionally changed to a light drab or stained with iron, while the upper layers are of a gray or whitish color, only occasionally bluish. The upper portion has very little economic value, as only occasionally are the beds of sufficient thickness or of such a quality as to render them fit for even the lighter purposes of masonry. In Delaware county, portions of the upper strata are sufficiently free from silica and alumina to make a lime of fair quality; in fact, all the lime burned in that county comes from the upper layers. The lower strata afford nearly all the building stone of Eastern Indiana. They are undoubtedly the western extension of the famous Springfield beds of Ohio, and I have given them, in the General Section, that name, as they are the same strata to which Prof. Orton assigned that name in Ohio. Everywhere throughout Eastern Indiana these beds yield a good building stone, and in some localities in Marion, Decatur and Franklin counties it is hardly surpassed, either in beauty or durability, by Indiana's famous oolitic limestone. It is almost an inexhaustible mine of wealth.

The upper portion of the section last given is the probable equivalent of, at least, the lower part of the Guelph limestone of Canada, or the Cedarville beds of the Ohio geologists. Although cherty at this locality, this portion of the Niagara is as noted for the excellent lime which it produces as the Springfield beds are for building stone. It has not yet been identified south of Delaware and Madison counties. In Decatur and Madison counties, the Devonian rocks immediately overlie the Springfield beds. Throughout Northeastern Indiana, south of the Wabash River, it is the surface rock over a greater part of Randolph, Jay, Wells, Blackford, Grant, Huntington, Miami and Wabash counties. This portion of the Niagara is its only true coral-reef formation. The change from the muddy sea, in which the upper portion of the Springfield beds were deposited, to the clear seas of this coral-reef epoch, is marked. The rock is one mass of broken and pulverized shells and corals. North of Grant county it is probable that this part of the Niagara is thicker, as a white limestone is said to overlie it along the Wabash River, and forms the summit of the Niagara group of Indiana.

So far as at present determined, the Niagara group of Central Eastern Indiana is composed of the following:

Guelph or Cedarville beds	20 ft.
Springfield beds	40
Niagara shale	10 to 15

The last named forms the base of the Niagara group, as determined by Dr. Elrod in his Report of Decatur county, in the Geological Report for 1882. This section would, probably, require some modification in the construction of a General Section of the whole Niagara group of the State, as the character of the strata vary somewhat along the Ohio River, and it is, at present, difficult to tell whether the Waldron shale belongs to the Springfield beds or to the Guelph. No exposure of the Niagara shale occurs in this county, as the bottom of the quarries barely reach the base of the Springfield beds.

It will be of interest to most readers to learn that the quarry rock exposed north of Marion, along the river, is probably the westward extension of the strata over which the torrent flows at Niagara Falls (there ninety feet thick, and the shales, below, sixty feet).

I have thought best to digress somewhat from the Report of this county, in order to give an explanation of the relation the rocks of this county sustain to the Niagara group as a whole.

About one mile below Mr. Bowman's quarry, Mr. John Mellott is taking out a fine building stone. The shaley layers have mostly been removed by erosion, and the thick and valuable beds are easily accessible. Stone from this quarry was used for the abutments of the bridge which spans the river at this point, and it shows no evidence of disintegration as yet. The fossils found here are the same as those at Mr. McKinney's quarry.

SECTION AT MELLOTT'S QUARRY.

Gray argillaceous limestone, uneven bedded, varying from 2 to 8 inches thick; breaks into irregular blocks; worthless	7 ft. 0 in.
Blue limestone	0 ft. 8 in.
Blue limestone	0 ft. 12 in.
Blue limestone	0 ft. 13 in.
Blue limestone	0 ft. 11 in.
Blue limestone	0 ft. 12 in.
Blue limestone	0 ft. 12 in.
Blue limestone	0 ft. 12 in.
Blue limestone	0 ft. 14 in.
Total	14 ft. 11 in.

Below this point, rock is exposed at intervals in the bed of the river, but is not quarried to any extent.

About one-half mile south of Mier is an outcrop, near Pipe Creek. It is, here, a yellowish limestone, in thin layers and unevenly bedded. Some of the lower strata furnish the principal building stone used in this vicinity. Rock is near the surface over quite an area, as it is frequently struck in digging wells. In section 9, Franklin township, is an exposure of a whitish rock, in strata from one to four inches thick. Preparations are now being made to work this quarry on an extensive scale, as the rock has proved durable. Trials show that it produces lime of an excellent quality. This is the purest limestone seen. Being free from silica and alumina, it would probably yield a superior lime, and there need be but little waste, as that not suitable for architectural uses could be calcined, and the quarry thus be very profitable.

Limestone is frequently found near the surface for a number of miles south of here. An exposure occurs about midway between Marion and Jonesboro', but it is the blue rock, and similar to that below Marion.

The drift has brought many Devonian and Niagara fossils here, either from rock which once covered the county or from the destruction of that formation to the north and east. Among them were *Acervularia Davidsoni*, *Cystiphyllum Americanum*, *Diphyphyllum cæspitosum*, *Eridophyllum rugosum*, *Favosites Emmonsi*, and *Lyellia Americana*. These corals are the petrified wasps-nests, honey-combs, roots, etc., of common parlance.

ECONOMIC GEOLOGY.

TIMBER.

In common with all the counties of Eastern Indiana, timber is abundant, and, if the growth of a dense forest is an indication of strength of soil, there need have been no apprehensions on the part of the first settlers. The dense forest has been a detriment, so far as the early settlement of the county is concerned. People would rather go further west, and locate on the prairie, than spend so much time and labor clearing it up. But, now, with the development of the county and the demand for lumber, our forests are a source of profit. All the more common varieties are found here, about equally represented.

LIME.

Very little of this material is burned at present, most of the limestone containing too much silica or alumina; however, with care in the selection of the rock, it may be produced of fair quality. Possibly, some of the argillaceous limestone would make hydraulic cement, if carefully tested.

CLAY.

An abundance of this material is present in every township, suitable for brick and tile. Many kilns are in operation, and miles of tile are already laid, with more in the fields ready. Probably, few counties in the State are doing more in this direction, compared with what is needed.

ROADS.

Pikes are always good highways, and, if this were true of the dirt roads, a great deal of hard labor would be saved. Some of the richest lands are nearly inaccessible during portions of the year. Money spent in the the construction of pikes, here, will be returned in the increased value of the farms. Quite a number have been built, but more are needed. Sufficient gravel can be found in every township, if carefully looked for. Many of the swamps are underlaid with gravel, and, even if pumps have to be used, it will pay better than to haul gravel far, or to go without the pikes.

AGRICULTURE.

The soils are all derived from the alluvial, lacustral, or drift deposits; the latter are mostly clays mixed with vegetable humus (mold), and constitute by far the greater part. The alluvial soils, formed by streams, are principally fine sand and clay, mingled with organic matter. The lacustral soils consist of the black muck and peat of the swamps, with the finer material washed from the higher lands. Every farm has more or less of these different soils.

The principal productions for 1881 were—Wheat, 482,035 bushels; corn, 1,218,049 bushels; oats, 149,499 bushels; flaxseed, 31,907 bushels; potatoes, 24,020 bushels. The prevalence of black soil in the eastern, western, and southern portions of the county, renders corn a profitable crop, as the yield is large.

The county is capable of largely increasing all its productions, but ditches must be dug, and tile laid, in order to redeem the wet lands. The farms most recently brought under cultivation produce the best crops, while many fields, long cultivated, show a marked deterioration in production. There is a reason for this, that ought to be plain to every farmer; for as surely as crops are harvested, and nothing or little returned, so surely will there be a decrease in the fertility of the soils. No skillful rotation of crops, underdraining or subsoil plowing will save the soils of Indiana from deteriorating, unless attention is given to the use of fertilizers. We have only to look to the older settled States and portions of Indiana, where once the soil was equal to our own, to see thousands of acres that fail to yield the farmer a fair remuneration for his labor. The potash, lime, soda and phosphoric acid has been, in great part, removed either in the wheat, corn, oats, rye, potatoes, hay, flax, or as beef, pork, or fine horses, and but little returned to the soil. To-day, in every county, are hundreds of acres that are fast losing their mineral and organic material, and they can not yield more than one-half a crop. Portions of New Jersey was once a barren waste, but a judicious use of marls and other fertilizers has rendered them among the most productive lands in the State. Observations made where dairying or stock raising is carried on, show that even closely pastured lands will lose their strength, and that the attempt to restore lost fertility to worn out soils, by returning them to pastures, is neither very effective nor profitable. The soils of Indiana are a source of immense wealth, and, as yet, we have hardly begun to draw upon their resources, but, as deterioration has already begun, it is time to sound the alarm. Fertilizers ought to be used now, for it is easier and better to maintain fertility than to restore it when lost.

An average of many analyses show that the grain, chaff and straw of one bushel of wheat weigh 136 pounds, but when reduced to ashes, 5¾ pounds, which is mineral matter absorbed from the soil. Every bushel of wheat grown removes nearly three-quarters of a pound of phosphoric acid, nine-tenths of a pound of potash, one-fifth of a pound of magnesia, and one-fifth of a pound of lime. Oats contain a large amount of silicic acid, far exceeding any of the other grains. Potatoes double the amount of potash. Lime, potash and magnesia predominate in tobacco. Flax and buckwheat are the most exhaustive crops raised, as they extract from the soil more potash, lime, magnesia and phosphoric acid than either wheat, corn, oats or grass; hence the fallacy of attempting to redeem poor and worn-out soils by raising a crop of buckwheat simply because it leaves the ground mellow and black. No plant has the power to manufacture any of the elementary substances; it can only select such as are in the soil. And one plant succeeds better than another, other things being equal, because it has greater power of selection, or because the physical condition of the soil is better adapted to its growth. But since plants have the power of selection, in a state of nature, they choose such as are best adapted to their wants; even then, when the soil deteriorates, others less choice in their food will take their place. A familiar example of this may be seen in meadows where the white daisy, fleabanes, *Erigeron annuum* and *strigosum* have run out the meadow grasses.

Most soils have all the elements necessary for the supply of mineral matter for the growth of crops, but the physical condition must be such that heat and moisture find easy access, thus not only favoring chemical change in the soil, but hastening the growth of vegetation. It is of great importance that the ground should be relieved of its surplus water in order for the above conditions to be present. This leads to the subject of underdraining, the beneficial effects of which are no longer doubted, as it has, over and over again, been demonstrated that nearly all soils are benefited by the judicious use of tile. Every farmer realizes the benefits derived from draining the swamps; for no matter how rich a soil may be, it can not produce good crops if saturated with water the greater part of the year. Where the excess of water in the soil finds an easy escape, the season of growth is lengthened (sooner worked in the spring and later in the fall); besides, crops are not so liable to winter-killing, because, without moisture, ice does not form, and cold, without ice, seldom injures the roots of plants.

The principal mineral ingredients of all soils are silicate of alumina, with varying amounts of potash, lime, magnesia, iron, phosphoric acid and organic matter. They may have all the mineral substances necessary, but if they lack organic material they will be unproductive. Carbon dioxide is as necessary for the growth of plants as mineral matter, and the decomposition of organic material produces it. It also renders the soil mellow, and enables the roots to penetrate deeper and give access to the atmosphere, and thus favors those chemical changes in the mineral substances which renders them soluble, besides replenishing the supply by decomposition of the comminuted rocky material, ground in the glacial mill. All soils possess more or less of the proper mineral substances necessary for the growth of plants, but as they are supplied with only a limited amount of each, it is easily seen, where but little is returned and the cropping successive, that the loss is constant, and finally detrimental to the vigorous growth of crops. There are occasionally patches of soil that seem to produce, year after year, with but little diminution of fertility; but they are the exception, not the rule.

Where farmers harvest annually from fifty to one hundred acres of grain, it is not probable, even with the most careful saving of the manures from the barn, that enough can be obtained to supply the waste from the fields, and it is necessary that other means be used to restore lost fertility—plowing under green crops, the use of lime, ashes, or guano. A great part of the value of organic fertilizers depends on the amount of potential ammonia they contain, as produced in their decomposition, but the mineral fertilizers evidently supply deficiencies in the soil, as well as bring into activity chemical actions. In limestone regions, lime can usually be obtained for the burning, at very little expense. Peat or muck is easily accessible in most localities, though, owing to the salts of iron in it, it ought to be exposed to the atmosphere for a while before spreading on the land. Guano or hen manure is one of the most valuable of fertilizers, being rich in phosphoric acid and ammonia. Wood ashes applied to the land show their beneficial effects for years.

ARCHÆOLOGY.

A little north of Jonesboro', on the bluffs of the river, are two or three small tumuli, which contained a few beads, along with the bones, ashes, and charcoal, so common in this class of works. Quite a number of axes, arrow-heads, etc., have been found in the vicinity.

In section 33, Monroe township, and in Van Buren township, near Black Creek, are a number of small mounds similar to those described. One or two small ones are situated on the bluffs, east of the river, near Marion. The largest in the county, however, were situated near where the court house now stands, and in the city cemetery.

Relics are found in nearly all parts of the county, and, through the kindness of Mr. L. A. Wallace, the State cabinet received some fine specimens.

THANKS.

The writer is under obligations to Mr. D. R. McKinney, who allowed him to take such fossils as he wished. Mr. Wm. Neal, County Surveyor, gave information in reference to all parts of the county, such as only an intelligent person, with a life-long experience and familiarity, could give. Mr. L. A. Wallace has already been mentioned as a donor of relics. Mr. E. L. Goldthwait rendered great assistance. Thanks are due to all the people of the county who gave information cheerfully.

A GLOSSARY

OF

TERMS COMMONLY USED IN GEOLOGICAL REPORTS.

SUGGESTED AND LARGELY PREPARED BY

W. T. S. CORNETT, M. D.

ACCRETION. The process by which inorganic bodies grow larger, by the addition of fresh particles from the outside.

ACOTYLEDON. A plant in which the seed-lobes (cotyledons) are not present, or are indistinct, like the fern, lichen, and most of the coal plants.

ACROGENS. Plants which increase in height by additions made to the summit of the stem by the union of the bases of the leaves. The highest tribe of *Cryptogams*, such as *Sigillaria*, *Lepidodendria*, *Calamites*, *Ferns*, etc.

AEROLITE. A stone or other body which has fallen from the air, or, more correctly, has come to the earth from distant space; a meteorite.

AGATE. A semi-pellucid, uncrystallized quartz.

ALGÆ. Marine plants, comprising the seaweeds and many fresh-water plants.

ALLUVIUM. Earth, sand, gravel, loam, vegetable mould, etc., washed down by streams and floods, and deposited upon formations not permanently submerged.

ALUMINA. A characteristic ingredient of common clay.

ALUMINOUS. Pertaining to or containing alum, or alumina. The clay slates are very frequently impregnated with alum, and are then called alum-slates or alum-shales.

AMMONITE. An extinct genus of *Cephalopoda*, like the Nautilus, found in the Secondary or Mesozoic rocks; so called from the resemblance of its shell to the horns of Jupiter-Ammon.

AMORPHOUS. Bodies devoid of regular or determinate form. A name sometimes used to designate the sponges.

AMPHIBIA. Animals capable of living either in water or on land, like the frogs, newts, lizards, turtles, certain serpents, etc.

AMYGDALOID. A rock in which crystallized minerals are scattered in almond-shaped cavities.

ANTICLINAL. The crest or line in which strata dip in opposite directions.

ARGILLACEOUS. Clayey; composed in whole or in part of clay.

ARTICULATA. Animals characterized by the possession of jointed bodies or jointed limbs.

AURIFEROUS. Containing gold.

AZOIC ROCKS. Rocks formed before the existence of organic life, or, at least, of animal life, consequently destitute of fossil remains.

BASIN. An isolated or circumscribed formation, particularly where the strata dip inward, on all sides, toward the center. Especially applied to the coal formations, called "coal-basins" or "coal-fields."

BATRACHIA. The order of reptiles which includes the frog and related animals.

BELLEROPHON. A genus of *Gasteropoda*, having a univalve shell, found in the Paleozoic rocks.

BITUMINOUS SHALE. Shale impregnated with bitumen; usually of a dark brown or black color.

BIVALVE. Consisting of two plates or valves, hinged together with an elastic ligament.

BOWLDERS. Rocks, rounded or otherwise, which have been transported from more or less distant localities by natural agencies, especially during the Drift period.

BOWLDER CLAY. The stiff, unlaminated clay of the Drift period.

BRACHIOPODA. A class of marine mollusks, characterized by two fleshy arms, continued from the sides of the mouth, and which served to create currents to bring them food.

CALAMITE. Extinct plants, with reed-like stems, sometimes attaining a diameter of fourteen inches and the height of trees, found almost entirely in the Coal Measures.

CALCAREOUS. Consisting of or containing carbonate of lime.

CALCITE. Crystallized carbonate of lime. Common limestone, all the white and most of the colored marbles, calc-sinter, calc-spar, calc-tufa, stalactites, and stalagmites are so classified.

CARAPACE. A protective shield. The upper shell of the tortoise, turtle, crab, lobster and other *Crustacea*.

CARBONATE. A salt formed by the union of carbonic acid with a base.

CARBONIFEROUS. Producing or containing carbon or coal.

CARBONIFEROUS AGE. The one immediately following the Devonian Age, or *Age of Fishes*, and characterised by the vegetables which formed the coal beds. This Age is divided into the Subcarboniferous, the Coal Measure and the Permian epochs.

CARBONIFEROUS PERIOD. The second, or middle, division of the Carboniferous Age.

CARINATED. Shaped like the keel of a ship. Applied to flowers consisting of two petals, either separate or united, inclosing the organs of fructification, and which have a longitudinal prominence like a keel.

CARPOLITE. Petrified fruit. Literal meaning, "stone fruit."

CENOZOIC. Belonging to the Tertiary period, and means "recent life."

CENTIMETRE. A French measure of length, equal to .39368 of an inch.

CEPHALOPODA. A class of the *Mollusca*, comprising the cuttle-fishes and their allies, and characterized by a distinct head, surrounded by a circle of long arms or tentacles, which they use for crawling and for seizing objects.

CHERT. An impure, massive, flint-like quartz, or hornstone, of various dull shades of color.

CHONETES. A genus of fossil bivalve shells, of the class *Brachiopoda*.

CINCINNATI GROUP. The upper division of the Lower Silurian system. Same as *Hudson River Group*.

CLEAVAGE. That peculiar structure in rock which admits of its division into scales or layers.

COAL BASIN. Depressions formed in the older rock formations, in which coal-bearing strata have been deposited.

COAL MEASURES. Strata of coal, with the attendant rocks.

CŒLENTERATA. Proposed by Frey and Leuckhart, in place of the old term *Radiata*, for animals having "hollow bowels," which this term literally means.

CONCHIFERA. A species of the *Mollusca* having shells with a dorsal hinge, like oysters, clams, mussels, and other ordinary bivalves. Literal meaning, "to bear a shell."

CONFORMABLE. Parallel, or nearly so; said of strata which lie in contact.

CONGLOMERATE. A rock, composed of pebbles cemented together by another mineral substance, either calcareous, siliceous or argillaceous.

CONIFERA. The order of the firs, pines and their allies, in which the fruit is generally a "cone" or "fir-apple"; literally, "I carry a cone."

CONTORTED. Strata which have been bent or twisted while in a soft and yielding condition.

COPROLITES. Fossilized excrements of animals.

CORAL. The solid secretion of zoophytes, produced within the tissues of the polyps, and corresponding to the skeleton in higher animals. It consists almost purely of carbonate of lime.

CORALLINE ZONE. That zone of marine life which extends from about 90 feet to 300 feet in depth.

CORALLUM. The coral or solid part of a zoophyte, whether composed of stone or horn.

CRAG. A partially compacted deposit of the older Tertiary formation, consisting of sand and shells.

CRETACEOUS. Having the qualities of chalk; the uppermost or last of the Secondary formation.

CRINOIDEA. An order of lily-shaped marine animals, belonging to the sub-kingdom *Radiata*. They generally grow attached to the bottom of the sea by a jointed stem, though some are free.

CRUSTACEA. One of the classes of the *Articulata*, comprising lobsters, shrimps, and crabs, characterized by the possession of a hard shell or crust, covering the body, legs, etc.

CYATHIFORM. In the form of a cup or drinking-glass, a little widened at the top.

CYATHOPHYLLUM. Cup-shaped, rugose corals, very abundant in the rock formations of Indiana.

DEBRIS. Broken and detached fragments of rocks, taken as a mass or collectively.

DEGRADATION. A gradual wearing down or wasting, as of rocks, banks, and the like, by the action of water, frost, etc.

DENUDATION. The laying bare of rocks by the action of running water, or by removing earth, etc.; also, the excavation of rocks by running waters or by the action of waves.

DEPOSIT. Matter precipitated from suspension in water.

DETRITUS. Small portions of matter worn off from rocks by attrition.

DEVONIAN. Applied to rock strata lying next above the Silurian.

DICOTOMY. Dividing regularly by pairs.

DIP. The downward inclination of strata.

DRIFT. A collection of loose earth, sand, rocks, or bowlders, distributed over a large portion of the earth's surface, especially in latitudes north of 40°, and which have come from the northward, brought thence, mainly, by glacial action.

ENCRINITE. The lily-shaped radiate; crinoid.

EOCENE. The lowest division of the Tertiary rocks, in which but few specimens of existing shells are found.

EOZOIC. A term used for the oldest fossil-bearing rocks yet known, such as the Laurentian and Huronian of Canada.

EPOCH. The period during which a formation was produced; thus, geologists speak of the Millstone Grit epoch, etc.

ESCARPMENT. The steep face presented by the abrupt termination of strata.

FAULT. A sudden interruption of the continuity of strata or veins in the same plane, caused by a crack or fissure.

FAUNA. The animals of any given area or epoch.

FAVOSITES. A kind of fossil coral, having a prismatic structure closely resembling that of a honey-comb.

FERRUGINOUS. Containing iron; also, partaking of the quality of iron.

FIRE-CLAY. Any clay capable of sustaining intense heat without vetrifying. Abundant in the Coal Measures, beneath each coal seam.

FISSILE. Capable of being split, cleft, or divided in the direction of the grain.

FLORA. The system of vegetable species native in a given locality, region, or period; as the Flora of the Coal Measures, etc.

FLUVIATILE. Belonging to rivers; formed by rivers, as fluviatile strata.

FLUVIO-MARINE. Formed by the joint action of a river and the sea, as in the deposits at the mouths of rivers.

FOLIATED. Having leaves or leaf-like projections, as foliated shells; composed of thin laminæ or layers, as mica schist, schistose, and the like.

FORAMINIFERA. A minute genus of the *Protozoa*, characterized by having a calcareous shell perforated by numerous pores, or foramina.

FORMATION. The series of rocks belonging to an Age, period, or epoch, as the Silurian formation, and the like.

FOSSIL. That which may be dug up; the petrified form of a plant or animal in the strata composing the surface of the earth.

FOSSILIFEROUS. Containing fossils or organic remains, as fossiliferous rocks.

FUCOIDS. Fossils resembling sea-weeds.

FUSIFORM. Shaped like a spindle; tapering at each end.

FUSILINA. A spindle-shaped *Foraminifer*.

GASTEROPODA. A univalve mollusk, having a fleshy ventral disk, which serves to take the place of feet, as the snail.

GEMMATION. The formation of a new individual by the protrusion of any part of an animal or plant, which may then become free or remain connected with the parent stock; budding. Polyps and some other animals reproduce by buds.

GENUS. An assemblage of species possessing certain characters in common, by which they are distinguished from all others.

GEODE. A rounded nodule of stone, containing a small cavity usually lined with crystals, sometimes with other matter; the cavity in such a nodule.

GEOLOGY. A science which treats of the materials which compose the earth, the methods in which those materials have been arranged, and the causes and modes of origin of those arrangements.

GLACIER; GLACIAL RIVER. A field or immense mass of ice, or snow and ice, formed in the region of perpetual snow, and moving slowly down mountain slopes or through valleys, usually bearing along bowlders and fragments of rock.

GNEISS. A crystalline rock, consisting of quartz, feldspar and mica, but, unlike granite, having these materials arranged in planes, so that it rather easily breaks into coarse slabs or flags.

GRANITE. A crystalline rock, of the same materials with gneiss, but differing therefrom in these materials being grainy and not stratified.

GYPSUM. Sulphate of lime. Plaster of Paris is made from this mineral by calcination.

HABITAT. The natural abode or locality of an animal or plant.

HÆMATITE. Sesqui-oxide of iron. So called because of the red color of the powder.

HEMIPRONITES. A fossil bivalve shell, sometimes known as the genus *Streptorhynchus*.

HETEROCERCAL. A fish having the vertebral column continued into the upper lobe of the tail, which lobe, on this account, is larger than the lower one. Literal meaning, "A diverse tail." This form prevailed in Paleozoic times.

HOMOCERCAL. A fish in which the vertebral column terminates at the commencement of the tail, the lobes of which are symmetrically equal. Literal meaning, "Common tail."

HUDSON RIVER GROUP. An upper division of the Lower Silurian formation. Same as Cincinnati Group.

HUMUS. A dark brown substance formed in the soil by the action of air on solid animal or vegetable matter. It is a valuable constituent of soils.

ICHTHYOLOGY. The science of the systematic arrangement or classification of fishes.

IGNEOUS ROCKS. Resulting from the action of fire, such as lavas, basalt, trap, and the like.

IMBRICATED. Lying over each other in regular order, like the scales of a fish and those on the leaf-buds of plants.

INFUSORIA. Microscopic animals found in water and other fluids, multiplying by gemmation.

INORGANIC. Devoid of an organized vital structure. Rocks, minerals and all chemical compounds are inorganic substances.

IN SITU. In its original situation. Said of rocks which remain where they were formed.

INVERTEBRATA. Animals without a spinal column.

LACERTIAN. The lizard species.

LACUSTRAL. Pertaining to lakes or swamps.

LAGOON. A marsh, shallow pond, or lake, especially one into which the sea flows.

LAMINATED. Consisting of plates, scales or layers, one over another.

LAND-SLIP. The sliding down of a considerable tract of land.

LENTICULAR. Having the form of a double-convex lens.

LEPIDODENDRON. A genus of fossil cone-bearing trees, belonging to the Carboniferous Age, and so-called from having their stems marked with scars or scales, produced by the falling off of the leaves.

LIGNITE. Mineral coal showing the texture of wood, and found in the Tertiary formation.

LINE OF BEARING. The direction of the strike, or outcrop.

LINE OF DIP. The line of greatest inclination of a stratum to the horizon.

LITHOLOGY. The science which treats of the characteristics and classification of rocks.

LOAM. A soil composed of siliceous sand, clay, and carbonate of iron, with more or less oxide of iron, magnesia, and various salts, and also decayed animal and vegetable matter.

LOESS. A division of the Quaternary System, Lacustral Age. Common along the Mississippi and many of its tributaries.

LOWER CARBONIFEROUS PERIOD. The first, or earliest, division of the Carboniferous Age.

MAMMALIA. Vertebrate animals that suckle their young.

MAMMOTH. An extinct elephant, fossil remains of which have been found on both American continents.

MARL. A mixture of carbonate of lime, clay, and sand in varying proportions. A valuable fertilizer.

MASTODON. An extinct gigantic mammal, resembling the elephant, so called from the conical (nipple-shaped) protuberances on its molar teeth (grinders).

MATRIX. The earthy or stony substance in which metallic ores or crystalline minerals are found.

MESOZOIC. The Secondary period. Literal meaning, "Middle life."

METAMORPHIC. Rocks or minerals which have undergone changes in form or shape since their original deposition; usually applied to changes made by heat.

METEORITE. Same as Aerolite; which see.

METRE. A French measure of length, equal to 39.368 inches. (See, also, Centimetre and Millimetre.)

MICA SLATE. A schistose rock, consisting of mica and quartz, with, usually, some feldspar. The lowest stratified rock except gneiss. It bears no fossils.

MILLIMETRE. A French measure of length, equal to .039368 of an inch.

MILLSTONE GRIT. A hard, gritty, sandstone, a kind of conglomerate, found under the Coal Measures, sometimes containing quartz pebbles.

MIOCENE. The middle division of the Tertiary rocks, in which the minority of the organic fossils are of recent species.

MOLLUSCA. Invertebrate animals, having a soft, fleshy body (whence the name), which is inarticulate, and does not radiate internally. Includes the shell-fish proper.

NAUTILUS. A fossilized and living genus of the Molluscan Cephalopods.

NIAGARA GROUP. A division of the Upper Silurian system.

NODULE. A rounded mass of irregular shape.

NUCLEUS. A kernel; a central mass or point, about which other matter is gathered.

OOLITE. An epoch in the Jurassic Age. A variety of limestone, consisting of round grains like the roe of a fish. Name is derived from two Greek words, which mean "Eggstone."

OOLITIC. Resembling Oolite.

ORGANIC REMAINS. Fossilized remains of animals or plants.

ORTHIS. A genus of *Brachiopoda*, named in allusion to the straight hinge-line.

ORTHOCERAS. A family of the *Nautilidæ*, in which the shell is straight, or nearly so.

OUTCROP. That part of an inclined stratum which shows at the surface of the ground.

PALEONTOLOGY. The science of the ancient life of the earth, or of the fossils which are the remains of such life.

PALEOZOIC. Applied to the older division of geological time and the fossil-bearing rocks of the Silurian, Devonian, and Carboniferous Ages.

PEAT. Accumulation of vegetable matter, on and near the surface of the earth, in moist places. It is intermediate between pure vegetable matter and lignite, 80 parts in 100 being combustible, and is, therefore, often dried, and then used for fuel.

PERMIAN. The epoch following the Coal Measure epoch, and regarded as closing the Carboniferous Age and the Paleozoic era.

PLEISTOCENE. Quaternary. Pertaining to the epoch or to the deposits following the Tertiary, and immediately preceding man. Compounded from two Greek words, meaning "most new"

PLIOCENE. The upper division of the Tertiary period. Meaning, "more new."

Plutonic Rocks. Those deriving form from igneous action.

Polypi. Radiates, having many feet (whence the name) or feelers.

Polýzoa. The lowest order of *Mollusca*, in which many animals are united in one structure. A compound group among the *Bryozoa*.

Primitive (or Primary) Rocks. Rocks supposed to be first formed, being irregularly crystallized,aggregated without a cement, and containing no organic remains, such as granite, gneiss, and the like.

Primo-Carboniferous. Upper Coal Measures (?). See "Coal Measures," *ante*.

Productus. An extinct genus of *Brachiopoda*, in which the shell is "eared," or has its lateral angles drawn out.

Protozoa. The lowest division of the animal kingdom.

Pterodactyl. A winged saurian; a fossil reptile which had the little finger of the hand greatly elongated, for the purpose of bearing a membraneous wing. Meaning, "wing-finger."

Pteropoda. A class of *Mollusca*, which swim by means of fins attached near the head. Meaning, "wing-foot."

Pudding Stone. A coarse conglomerate, composed of siliceous or other pebbles, united by a cement.

Pyrites. A combination of sulphur with iron, copper, cobalt, or nickel.

Quaqua-versal. Dipping toward all points of the compass from a central point, as beds of lava around a crater.

Quartz. Pure silex, occuring in pellucid, glassy crystals, having the form of a six-sided prism, terminated at each end by a pyramid. The crystals are usually clear, but sometimes are variously colored, more or less transparent, and even opaque.

Quartzite. Granular quartz; sandstone that has been changed, by metamorphic action, to a hard quartz rock.

Quaternary. Later than the Tertiary; equivalent to the English Pleistocene.

Radiata. One of the great sub-kingdoms of animals, in which all the parts are arranged uniformly around the longitudinal axis of the body, such as star-fishes, corals, crinoids, etc.

Rash Coal. An impure coal.

Recent. Of a date subsequent to the creation of man.

Reniform. Kidney-shaped; applied to certain minerals.

Receptaculites. An extinct genus of *Protozoa*. Meaning, "A stone receptacle."

Reptilia. The class of *Vertebrata* composing snakes, lizards, tortoises, turtles, etc. From Latin verb *repto*, "I crawl."

Reticulated. Having sets of parallel fibres or lines crossed by others, likewise parallel, so as to form meshes resembling those of a net.

Rhynchonella. A small bivalved Brachiopod, having a *rynchos* (nose or beak).

Rhynchonella Osagensis. Same as *R. Pecosi.*

Rhynchonella Pecosi. Same as *R. Osagensis.*

Rock. Any natural deposit of stony material.

Rugose. Wrinkled; full of wrinkles.

Saurian. Any lizard-like reptile.

Seam. A layer of substance, more or less wide, parallel with the stratification of surrounding material.

Sedimentary Rocks. Those formed from materials precipitated from suspension in water.

Seismology. The science of earthquakes and their characteristics.

Serrated. Notched on the edge like a saw.

Shale. A fine-grained rock, having a slatey structure; an indurated clay, deposited in thin layers.

Shell Marl. A deposit of shells, which have been disintegrated into a gray or white pulverulent mass.

Sigillaria. Fossil trees, the bark of which is covered with impressions as if by a seal. Found in the Coal Measures.

Silex. Silicic acid, generally impure, as it is found in nature, constituting flint, quartz, and most sands and sandstones. Literal meaning, "Flint."

Siliceous. Composed of silex.

Silt. Mud or fine earth deposited from running or standing water.

Silurian. The earliest of the Paleozoic formations; so called from the country of the Silures, who anciently inhabited a part of England and Wales, because the strata was most plainly developed in that country.

Siphuncle. A tube of a membraneous or calcareous nature, transversing the septa of a chambered shell.

Slate An argillaceous stone which easily splits into plates.

SOAPSTONE. A soft magnesian mineral, usually gray, white, or yellow; so called from its soapy or greasy feel; steatite; pot-stone.

SPIRIFER; SPIRIFERINA. Extinct species of *Brachiopoda*, with large spiral supports for their "arms."

STALACTITE. Icicle-like encrustations and deposits of lime, which hang from the roof and sides of caverns hollowed out of limestone.

STALAGMITES. Encrustations of lime formed on floors of caverns hollowed out of limestone.

STIGMARIA. Stem-like, fossilized vegetation, often traversing the under clay of the coal, and supposed to be the roots of *Sigillaria*; which see *supra*.

STRATUM (pl. STRATA). A bed of earth or rock of any kind, formed by natural causes, and usually consisting of a series of layers.

STRATIFIED. Formed in regular beds or layers.

STREPTORHYNCHUS. Often called *Hemipronites*.

STRIKE. The horizontal direction of the out-cropping edges of tilted rocks, which is always at right angles to the dip.

SUBCARBONIFEROUS PERIOD. Same as Lower Carboniferous Period.

SUTURE. The line of junction of two parts which are immovably connected together, like the line where the whorls of a univalve shell join, or the lines made on the exterior of a chambered shell by the margins of the septa.

SYNCHRONISM. Concurrence in time of two or more events; contemporary; simultaneousness.

SYNCLINAL. Formed by strata dipping toward a common line or plane, as a synclinal trough or valley. The opposite of *Anticlinal*; which see, *supra*.

TALUS. A sloping heap of rock fragments lying at the foot of a precipice.

TERRACE. A shelf or bank of earth having an uniformly level surface.

TERTIARY. Third in order. Applied to the first period of the Age of Mammals, or Cenozoic time; also, to the rock formations of that period.

TEST. A shell, as of a mollusk.

TESTACEA. Mollusks are sometimes so called.

THERMAL. Hot, warm. Applied to springs which discharge water heated by natural agencies.

THIN OUT. Applied to beds or strata which grow gradually and continually thinner in one direction, until they entirely disappear.

TRANSITION ROCKS. The lowest uncrystalline stratified rocks, supposed to contain no fossils, and so called because thought to have been formed when the earth was passing from an uninhabitable to a habitable state.

TRAP. A heavy, igneous rock, of a greenish-black or grayish color, generally composed of feldspar, augite, and hornblende; so called because the rocks of this class often occur in large tabular masses, rising above one another like *treppe*, steps.

TRILOBITE. Three lobed. An extinct family of *Crustacea*, and derives its name from its body being so divided.

TUFA. A soft or porous stone, formed by depositions from water, usually lime-bearing, in which case the result is called calcareous tufa. Also, a volcanic sandrock, rather friable, formed of agglutinated volcanic earth or scoria.

UMBO. The beak (the point immediately above the hinge) of a bivalve shell is so called, from its fancied resemblance to the "boss of a shield."

UNCOMFORMABLE. Not lying in a parallel position; applied to rock strata.

UPPER COAL MEASURES. Upper strata of the coal system.

VEIN. A seam or parting of any substance, more or less wide, intersecting a rock or stratum, and not corresponding with the stratification.

VENTRAL. Belonging to the belly, or the surface opposite the back, or dorsal side. Sometimes used to designate the interior surface of the body.

VERTEBRATA. The division of the Animal Kingdom which is furnished with a spinal column.

WHORL. The spiral turn of a univalve shell.

ZAPHRENTIS. A genus of rugose (wrinkled) fossil corals.

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PART I.

ERRATA.

PART I.

Page 104, twelfth line from top, for *Carboniferous* read Corniferous.

PART II.

Page 127—Note, for *d'Orbigney*, read d'Verneuil.

Page 66, line 15, for *Wolfers*, read Ulfers.

Page 55, for *Peurotomaria*, read Pleurotomaria.

INDIANA.

REPORT OF THE STATE GEOLOGIST,

No. 13.

1883.

PART II.

PALEONTOLOGY.

PRINCIPLES OF PALEOZOIC BOTANY

AND THE

FAUNA OF THE COAL MEASURES.

PALEONTOLOGY

Paleozoic Flora and the Fauna of the Coal Measures.

INTRODUCTION

In former years the object of a Geological Survey was limited to explorations of the mineral riches of the land and to the study of the fossil remains, which, found in the rocks, serve as guides for the determination of Geological Periods, or Formations. Now that the field which the human mind is called to explore has been widely expanded by discoveries of every kind, giving origin to many new industries, Geological Surveys are called upon to give an account of all that may be valuable to the inhabitants of a country and of all that may interest the world at large. The characters of the land, its chemical components, its adaptation to culture, the divers kinds of minerals, the plants and animals of the present epoch as well as those which have lived in former periods, the remains left by former races of human beings, those of animals and vegetables left in the strata composing the crust of the earth; all have to be carefully studied and recorded. For if the present inhabitants have the need and the right to know about the material value of their land, the world at large has a right to know all that pertains to natural history, in order to gather the facts that constitute the history of the world from its origin, through the different periods of its existence.

In my e orts of the past years, I included as a contribution to science, a description of some of the fossil remains of animals especially marine shells, corals, etc., found in the rocks of Indiana and serving as characters to recognize the succession of the Geological Formations of the State. This part has been generally received with great favor. As the greatest riches of the minerals of Indiana, lie in its coal beds which are entirely composed of plants, I have thought it advisable to give an exposition of the vegetable remains, which found in connection with coal beds, indicate the nature of their compounds. The plants of the coals of North America have been already described in many valuable works or Geological Reports, especially in those of Pennsylvania, Illinois, Arkansas, Ohio, etc. And, therefore, the number of new or not yet known species is probably limited, and few could be furnished from Indiana. But until now, we have no kind of book servicable to direct the study of the fossil plants, no manual of the Principles of Vegetable Paleontology which, in my opinion, would be very useful to the students of all the Scientific Institutions of our State and country.

The only man deeply versed in that part of Natural History, is Prof. Leo Lesquereux, of Columbus, Ohio, who, as an intimate friend and fellow-citizen of Professor Agassiz, was encouraged by him to come to America, and who, since his arrival here in 1848, has given the most of his time to the study of the fossil plants of North America. His studies published in numerous State and Government Reports fill many volumes, and as a Paleontologist, Lesquereux is as widely known in Europe as he is in this country. I have, therefore, proposed to him to prepare for this Report, a Manual on the Principles of Vegetable Paleontology, and I now offer it to the State as a work which will be of great value to the students and colleges of Indiana, and to those of the United States, and which at the same time may be read with pleasure and profit by all persons interested in the coal beds. It will enable every one to study and analyze the beautiful specimens of fossil plants abundantly found in our Coal Measures.

The work forcibly limited to the plants of the Paleozoic times has been prepared with the greatest care. It illustrates in beautiful plates the characters of the plants which facilitate the understanding of the descriptions. I consider it, therefore, as a publication that will greatly enhance the value of the Geological Reports of Indiana.

The foregoing Vegetable Paleontology is followed by descriptions and figures of the characteristic animal remains of the same period, by Dr. C. A. White, Paleontologist of the United States Geological Surveys, of the Smithsonian Institute, and former State Geologist of Iowa.

The best specimens have been selected for this purpose by Dr. White, and the work has been done with his usual fidelity and ability. These shells, etc., designate the horizon of stone coal—of the Coal Measures—they are not found except within a short distance above or below Coal seams; hence are indicators of minerals to be expected, as emphatic and plain as if the rocks in which they are found were labeled in black letter English.

The drawings of the animals, shells, corals, etc., are by Dr. McConnel, of Washington City, and will bear comparison with similar work prepared in any age, State, or Nation.

The State Geologist admits that he is glad to present this work, and its illustrations, prepared by the best experts in the Special Departments of Science, to the citizens of Indiana—to some extent a contribution to science throughout the world.

JOHN COLLETT,
State Geologist.

PRINCIPLES OF PALEOZOIC BOTANY.

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PRINCIPLES

OF

PALEOZOIC BOTANY.

BY LEO LESQUEREUX.

§1. EXPOSITION.

Vegetable or phyto paleontology (*phuton*, a plant, *palaios*, ancient, *logos*, word), a branch of science intimately related to geology, considers the vegetation of our globe during the different epochs anterior to the present times, directing its researches and study to the plants which, found in a fossil state, are known to have inhabited the earth or the sea from the first apparition of vegetation until now. This, of course, implies the well known fact that this world of ours has not remained the same since its origin; that it has been subjected to great and gradual changes; that the plants which inhabited it in former times are not the same as those of the present.

It is the history of the ancient vegetation that vegetable paleontology is trying to decipher and interpret. From mere fragments of wood, bark, and leaves, all transformed into stone or imbedded in the rocks, paleontology is able to gradually reconstruct some kinds of plants, and to discover not only their nature by a more or less distinct relation to the vegetables living now, but the physical circumstances which have fostered their growth. It thus explains the atmospheric variations of the long series of ages preceding the advent of man, and is able, at the same time, to trace, in connection with animal paleontology, the succession of the series of layers which constitute the crust of the earth, and the relative age of each of them. Thus a mere leaf, or the mere fragment of a plant, indicates the age and nature of what is called a geological formation; a series of deposited materials, for example, like those interstratified with coal (the carboniferous), or those containing oil or other kinds of minerals.

I do not intend to give here a description of all the characters of the plants which are known to have inhabited the earth at different epochs;

still less could I now interpret the natural phenomena which have influenced successive modifications in the vegetable kingdom. I wish only to trace the first principles of a science which opens to the mind a most pleasant and attractive prospect and explains the work of the Great Creator of Nature in gradually building the habitation of man. Not as a work limited or dwarfed by fallacious theories of the human mind, but as it really is, an exposition of the sublime wisdom, the prescience and providence of the Great Architect, traced by the plants of the ancient ages or by their remains in the rocks, quite as evidently as his eternal, infinite, and divine essence is demonstrated by the Heavens.

§2. THE CONSTRUCTION OF THE CRUST OF OUR EARTH, OR, IN GEOLOGICAL PARLANCE, THE FORMATIONS.

The most true and sublime passage written by Moses, in exposing his system of the cosmogony of the world, is that in the first and second verses of the first chapter of Genesis: "In the beginning God created the heaven and the earth. The earth was without form, and void; darkness was upon the abyss and the Spirit of God moved upon the face of the waters." The word *move* here implies action, work—the same sense as given to the words of Christ when he says: "My Father worketh hitherto and I work." (John v., 17.)

Like the innumerable bodies scattered in the heavens, some of them brilliant, some others darkened by a vail of opaque matter, our planet was originally a nucleus, a fiery furnace of molten matter, surrounded by a compact mass of vapors. These vapors, in coming near or in contact with the burning mass, were for a long time immediately dilated by heat, expanded and forced upward, so that no water could be permanently deposited upon the surface of the earth, and no ray of light could reach it. It was only after the surface had been gradually cooled, when, like a boiling semi-fused bed of lava, it had been upheaved at some places, traversed in various directions by wide undulations, cleft in deep fissures or crevasses and rendered somewhat solid, that the surrounding vapors could reach the earth like torrents of rain and fill more or less wide and deep basins where the waters were gathered. Thus land and water became separated; thus the rarified vapors of the atmosphere gave passage to light; thus the rain, falling on the still heated crust of the earth, began decomposing, loosening and scattering particles of matter, which, gathered by water, were transported by their course and spread at the bottom of the basins. Thus gradually the thickness of the crust was increased, the surface became gradually more cooled, the separation between land and water was more distinctly fixed, and, after a long period of time, the earth became prepared for the habitation of plants and animals.

Of course the earthy materials, either in the water or scattered on the surface of the primitive still heated rocks, were not fit for the life of highly organized beings. But, judging from what we see at the present times, vegetation has appeared in its most simple representatives as soon as the water could be permanently gathered into basins, or at a degree of heat slightly lower than that of the boiling point. In the hot springs of Arkansas and those of the Yellowstone, plants named *Confervæ*, long, green, thread-like filaments, fill basins of water of a temperature of near 100° Cent., the point of ebullition where water is forcibly vaporized. Hence we can surmise that in the first layers of sediments of matter, transported and deposited by water, one may expect to find the first traces of plants preserved by fossilization. It is therefore from this point that we may begin explorations for the discovery of remains of plants and researches upon their nature and their gradual development.

Before coming to this, it is advisable to further consider the mode of increase in the thickness of the crust of the earth, the origin, the succession and distribution of the materials which have entered into its composition and the changes which have occurred in the gradual construction of the great building from its origin, when nothing could live in the water but a film of green confervæ, to its completion, when, as man's habitation, it became covered with a multitude of beings, plants and animals, all contributing to the advantage of the human race. The following short explanation is merely an exposition of the first principles of Geology.

§3. COMPOSITION OF THE CRUST OF THE EARTH

The primitive rocks are composed of materials originally in fusion, either exposed after cooling from the nucleus of the earth or thrown out by eruptions of the volcanoes like lava. These rocks, like the first layers of materials deposited upon them, which were transformed either by heat in their contact with the molten mass (metamorphic rocks) or by amalgamation of their elements with those of the surrounding vapors, do not contain any remains of animals and plants. They constitute in their thickness and distribution the first group of stratified rocks, named by geologists the *Archæan* or *Azoic* (*a* without, *zoös* life). This formation is necessarily omitted in the present remarks on the ancient vegetation of the earth, as it is only in the later strata or layers composed of deposits of transported materials that remains of organized beings have as yet been found.

The work of building up the thick crust of earth by successively deposited materials being continued at the present epoch, it is easy to have an idea of the means employed by nature for the construction of the more ancient layers, which serve as the base of the great edifice.

Atmospheric influences, the alternation of cold and heat, the winds, the rain, etc., tend to produce a continual disintegration of the rocks into more or less minute particles of matter, which, falling into the water, are transported by its movements, sometimes to long distances, and strewn either along the borders of the currents from streamlets to streams, then to the rivers which throw them and heap them in banks into the sea. The waves of the sea constantly driven by winds and currents against the shores, break and grind into powder even the hardest rocks, and the debris drifted around are deposited somewhere at the bottom, the heaviest nearest to the shores, forming banks of pebbles, sand, mud, or other materials. The ice also breaks the rocks by gradual disintegration or by the movement of the glaciers, and the crumbled debris is either transported by floating banks of ice, cast forth and scattered to the bottom of the sea, or is pushed upon the surface of the land, sometimes in wide deposits of rounded blocks, pebbles, gravel or sand. As the largest heaps of transported materials have been deposited in the sea by the course of the great rivers, or by the movement of the waves, most of the formations are marine and have the greatest thickness and the widest extent. But land has also contributed its share in the construction of the earth's crust, either directly by its vegetation, forming heaps of combustible mineral, coal, lignite, peat, humus, or layers of iron ore by the work of infusoria, minute beings observable only by the microscope; or indirectly by the accumulation of particles of matter deposited in fresh water basins, forming especially beds of clay, or by condensation of the elements held in solution in the water, and by atmospheric action transformed into lime, silex, etc. In the deposits of the sea, remains of marine animals and of marine plants are more or less abundantly found, while land and fresh water plants and animals are mixed in the clay and other land materials. We have thus already two distinct kinds of strata, representing first, the marine, and second, the fresh water formations.

The superposition of the layers of matter is a result of their mode of deposition. In the sea, the constant movement of the water, especially the currents, displace the materials at the bottom, transporting them and strewing them along their courses, heaping them in some localities, while they are taken from others which are left waste. The same action is seen in the bottoms of large rivers, where gravel, sand and mud are constantly displaced and deposited again here and there, new materials upon the old ones, and gradually pushed farther down by the movement of the water. Naturally it is near the mouths of large rivers like the Mississippi, the Nile, the Amazon, that the materials are more abundantly carried, and successively deposited near the land or farther into the sea, according to their size or density. There the currents vary each year, either in force and velocity, or in direction; and each year, also, the layers of drifted matter are differently distributed around and superposed.

One year sand comes along one of the branches of the river; later, the outlet is closed and for a time nothing may pass through the channel; it becomes a bayou whose bottom is gradually covered by a bed of dark mud composed of remains of plants, shells, etc. Later, in a period of very high water, the channels are opened again and over the first deposits of sand and mud a bed of gravel may be spread, thus producing alternate layers of different natures.

On another side, local swellings and depressions of the crust of the earth were extremely frequent and active in the first ages of the world, when the crust, still thin, was under the more direct influence of the internal heat. These local upward and downward movements, though much less marked now, are, however, observed in different countries where the shores are gradually upheaved, the sea receding from them, while at other localities they are gradually depressed, and thus invaded by the ocean. It is to these movements of the crust that are due formations covering wide surfaces, sometimes whole continents.

There has been on the surface of the earth a succession of local changes of level, sometimes persistent for ages, which have naturally greatly modified the local deposits, very thick at some places, totally absent at others, and have produced local differences in the nature of the layers, and in their direction or angle of stratification, which correspond to the angle of superposition.

The deposits successively made on the surface of the earth, either above or under water, and for a countless number of ages, have been gradually hardened and modified in their compound and transformed into beds of sandstone, limestone, clay, siliceous or ferruginous rocks, according to the elements of which they are composed. They have thus formed the so-called stratified rocks whose study is the province of geology.

§4. GEOLOGY, ITS PURPOSE AND ITS WORK.

Geology is a complex science. A thorough comprehension of it requires a knowledge of divers subjects which, separately considered, necessitate long and difficult study. For it has to search and determine the nature and relative position of the series of all the stratified rocks, which, if they were heaped at the same locality, would show a thickness of twenty miles or more. It has been said above that the age of the strata is attested by the remains of plants and animals which, either marine or of fresh water or of land origin, are found imbedded into the rocks. It will be seen hereafter that the beings which have at successive epochs inhabited the earth, either plants or animals, have become more and more highly organized from the oldest times to the present, and therefore geology is able to fix the characters and the relative age of the different layers from the study of the remains of organized beings discovered in them. This, of course, necessitates for the geologist an acquaintance with animals and plants living at our time as points of comparison for the anatomy of fossil remains.

Geology has also to study the constituents of the rocks, by chemical analyses, in order to recognize the nature of their compounds, which, like some minerals, may be used for the advantage of man. Hence its domain is immense. It bears upon the interest of all the conditions of the existence of man, and though of difficult access, some of its more valuable and productive divisions are accessible to every man of intellect. For the analyses necessary for the determination of a bone, of a plant, or of any kind of mineral, are made by competent specialists, and therefore every one has the means of ascertaining the value of the discovered materials and the mode of pursuing the researches with advantage and pleasure.

From the characters of the remains of organized beings preserved in them, the strata of the earth have been divided into three great periods of time: First, the Paleozoic, which follows the Azoic or Archæan; second, the Mesozoic (*mesos*—middle), and the Cenozoic (*kainos*—new or recent).

The Paleozoic time has three essential ages: The Silurian, or the age of invertebrate animals; the Devonian, the age of fishes; the Carboniferous, the age of plants. Each of the ages is subdivided into periods. The Mesozoic time, or reptilian age, has three periods—the Triassic, the Jurassic and the Cretaceous. The Cenozoic has the Tertiary age, and at its end the Quaternary and the Era of Man.

In this memoir, and for the present, the vegetable paleontology of the Paleozoic times only has to be examined.

§5. MODE OF PRESERVATION AND FOSSILIZATION OF VEGETABLE REMAINS.

Plants are fossilized for ages, and preserved: First, by entombment; second, by carbonization; third, by impressions or casts; fourth, by infiltration or impregnation of foreign substances generally held in solution by water.

a. Entombment or Burial.

Vegetable remains covered or surrounded by compact impermeable materials before their decomposition, have been sometimes preserved without any modification of their original structure. For example, leaves, flowers, or small fragments of plants are now found imbedded in pieces of amber. Subjected to microscopical examinations, remains of this kind are determined as easily as specimens of living plants. This process of fossilization is explained by that of the deposition or formation of amber. In some cases, observable upon the peat bogs of the North, the resinous matter exudes, from the trunks of low conifers, in such profusion that the ground at their base is covered with a coating of resin. All the small fragments falling upon this matter are soon imbedded in it and secured against atmospheric influences. The northern part of Europe, during the tertiary period, was covered by vast forests of this kind, which have been buried along the shores of the Baltic Sea, where amber is now gathered.

In other cases, deposits of woods, like forests prostrated by some catastrophe, have been buried by the eruptions of volcanoes under layers of ashes and lava, or other impermeable matter. These vegetable deposits are now found in their original state, the wood perfectly preserved. Some of these beds of lignite, rendered accessible by shafts, are worked like coal mines, and the materials used for fuel. Deposits of this kind are rare, and as yet found like amber in tertiary formations.

But in older formations, even in the carboniferous, isolated fragments of wood, whose structure is still unimpaired, are sometimes found imbedded in very compact rocks. They have preserved, to a certain extent, their primitive nature, the flexible texture of the wood, the bark, even the epidermis.

b. Slow Burning or Carbonization.

Plants growing in swamps or damp places are shielded by immersion in water, or by great atmospheric humidity, against the rapid decay produced by the oxygen of air. The plants do not escape decomposition; but the process, rendered very slow under peculiar chemical modifications, is like that of the burning of wood in closed ovens for its transformation into charcoal. It is in that way that remains of a luxuriant vegetation, heaped each year upon the surface of the swamps, have been gradually transformed first into peat, as in the peat bogs of our time; then into lignite, by a more prolonged action of the same process, which tends to render the matter gradually more compact; then into coal, from the deposits of vegetable materials of more ancient periods, and to anthracite when the gases have been driven out of the coal by heat.

The plants preserved in this way are generally so mixed and compressed that, after a time, losing their original forms, they constitute a more or less compact mass, and become indeterminable. The coal, for example, when cut in thin lamellæ and examined with the aid of a microscope, exposes to view a fibrous or cellular compound, recognized as pertaining to vegetable tissue; but of course the determination of the characters of the plants which have entered into the composition is not possible. Sometimes, however, thin layers of charcoal, bearing impressions of leaf-scars, are observed between layers of compact coal. These impressions indicate the kind of trees from which they are derived, as *Lepidodendron*, *Stigmaria*, or *Sigillaria*, or even this dry charcoal, as it is named, distinctly preserves the impressions of leaflets of ferns. These remains give a vague insight into the characters of the plants which have entered into the composition of the coal; but the representations are too vague, and rarely interesting to the paleontologist.

c. Impressions or casts.

This process of fossilization is the more interesting to the phyto-paleontologists, who owe to it the preservation of the outlines or surface of fragments of plants of every size. Vegetable remains, leaves, branches, trunks of trees falling into the muddy water of swamps or upon the sand at the bottom of ponds or slow rivers, have been gradually covered by the deposits of soft materials, mud, clay, sand, etc., which have prevented access of the oxygen of air. Gradually, however, the original texture and compounds of the plants have been destroyed, but the impressions of their surface have been moulded upon the imbedding matter, which after the process of hardening has preserved them, often so distinctly, that their characters, the shape, even the nerves of the leaves, the scars of the bark of trees, etc., are easily recognized. Those who have seen specimens of fossil plants taken from the roof of coal beds know how admirably nature has preserved her works; how beautiful are those branches of ferns or other plants with their leaves flattened and compressed as if they had been prepared by drying for an herbarium, with the veins, the minutest teeth, even the hairs of the leaflets distinct, as if the plants were still living.

The trunks and the stems, by this mode of petrification, are generally flattened to a more or less great degree; the original compounds of the plants have been gradually destroyed and replaced by the imbedding matter, sand or clay; but the bark with its surface or merely the impressions are left as distinct as if they had been sculptured upon the rocks. I say that in some cases the mere impressions of the surface are left without any trace of the bark. There is generally an intermediate thin pellicle of coal representing the bark of the trunks in sandstone, but it is reduced to powder and detached on the contact of the atmosphere; thus one finds, especially in sandstone, large trunks of trees, *Lepidodendron*, for example, forty to sixty feet long and two feet in diameter, whose scars of leaves are distinctly marked from the base to the top without any remains of organic matter to cover them.

Generally, the casts of the leaves show only one of their faces. It is the case in those of the coal, and as there is sometimes a difference in the characters of the upper and lower faces, this may cause some difficulty in the analysis and determination of the leaves. The difficulty is still more marked in casts of leaves of the Cretaceous, which, thick and coriaceous, have the impressions of both faces separated by a thin space, or a thin crûst of matter, in such a way that by cutting the specimens vertically we may get a double impression of the leaves, the upper strongly, deeply nerved, the lower with veins far less marked, or with a *facies* sometimes very different.

I may mention here, as indirectly referable to the same kind of fossilization, the preservation of vegetable fragments in iron-stone concretions. These concretions, especially abundant at Mazon Creek, Illinois, and near the Little Vermillion River, Indiana, are round or oval generally flattened pebbles, varying from one to forty cm. long or more, the nucleus being either a leaf or a fragment of plant or animal. The concretions are the work of *infusoria*, small animalcules, some species of which living in water charged with carbonate of iron, congregate around fragments of organic matter and gradually surround them with a thick coating of compact iron-stone or clay derived from their organism. In splitting these nodules in the plane of stratification, the imbedded bodies are found fossilized in a perfect state of preservation, and therefore, the most beautiful specimens have been obtained from these concretions, which are strewn in the roof clay, of some coal beds. The specimens are generally of small size; but they, sometimes, contain remains of delicate plants or animals, which, imbedded by the work of infusoria before decomposition, or while they were still fresh, have escaped the deterioration and destruction forcibly produced by oxygen in shale whose matter is less compact and has been more slowly deposited. Mazon Creek has thus supplied paleontologists with specimens of many species which have not been found elsewhere in the Coal Measures.

d. Fossilization by Infiltration.

In this kind of petrifaction, the vegetables impregnated by water having in solution some kind of mineral substances, like silex or lime, are gradually transformed into stone. Generally the impregnation does not destroy, nor even alter in any degree, the internal structure of the plants. The woody tissue remains unimpaired—only the bark is destroyed.

The anatomy of wood fossilized by this process is made, as for that of living trees, in cutting thin sections or plates both vertical and horizontal, which, reduced to thin slides by the work of the lapidary and polished, may then be studied under the microscope, exposing the tissue to its most delicate fibers or cells.

Trees have oftener been subjected to this kind of petrifaction while still standing than when prostrated. In Colorado, standing fossilized trees have often been formerly observed; they are now mostly destroyed by the work of collectors of specimens. Near the Yellowstone Park, there are whole forests of silicified trees imbedded in sandstone; but many of the standing trunks have been bared by disintegration and erosion by water of the matter in which they have been buried. Trees fossilized in that way are, however, rarely found in their original integrity of size, for, as soon as separated from the imbedding matter, they break, mostly transversely, in fragments of various ength, which are strewn on the surface or buried in the sand. Such are the trunks of tree-ferns abundantly found on Shade River, near Athens, Ohio. As shown by their fragments, the trees from which they are derived had mostly a diameter of 15 to 30 cm. Few are smaller, some much larger. An exactly cylindrical trunk of a tree-fern, a fragment measuring 60 cm. in diameter and of the same hight, was dug out of a creek near Shade River and transported to the Museum of Comp. Anatomy of Cambridge, Mass. This mode of breaking is, however, not always the same, for near Gallipolis, O., there are some prostrated silicified trunks protruding from a bed of sandstone. They are solid in the whole exposed length, without appearance of transverse breakage, with this peculiarity, however, that a part of the wood has been fossilized into limestone, another part into silex, and this without distinct transverse separation. The parts silicified and petrified are here and there horizontally intermixed with other materials, as if the trees when prostrated had been impregnated in places by water containing different elements in solution.

The process of infiltration into the wood, of mineral matters soluble in water, presents so many apparent deviations from a common law that it can not be fully explained. At the present time, the water of some hot springs charged with carbonate of lime or other mineral substances in solution covers with a crust of hard deposits every kind of solid materials, organic or inorganic, which are immersed in their basins. The same phenomenon happens by the percolation of spring water charged with lime, made soluble by carbonic acid, upon leaves or other organic remains. The carbonic acid being set free by contact with air, the carbonate of lime is deposited. Materials of this kind named tufa are observed at different epochs. But the process is not a true petrification; it doės not change into stone the compounds of the encrusted bodies, but only covers them with a hard stony deposit. The fossilization by infiltration is more like the impregnation of wood produced by aspiration of the inner texture, a kind of capillary suction, which forces a fluid matter to ascend and penetrate whole trunks when they are immersed in it by their base, or like the movement of the water ascending the inside of the stems of the flowers when their base is immersed.

It has been supposed that the water charged with minerals in solution was derived from hot springs in the vicinity of volcanoes and widely distributed over the surface of the land, a fact which might be corroborated by the silicified forest of the Yellowstone, but which is contradicted by the silicified trunks so abundant in the south of Ohio, where no trace of disturbances of surface resembling the influence of subterranean heat has ever been observed.

Marine plants have been sometimes, not preserved, but traced or delineated by infiltration. When deposited upon sand or permeable rocks, the cellular tissues, becoming softened or fluid by decomposition, impregnate the surface of the sand or of the rock, marking upon it some indistinct design or outline of the vegetable form. Of course the specimens bearing impressions of this kind are of little value, as they offer but a vague representation of the original forms of the plants.

§6. HOW TO SEARCH FOR, AND COLLECT, SPECIMENS OF FOSSIL PLANTS.

The plants, like the animals of the ancient epochs, have left only fragments of their bodies in the numerous layers composing the crust of the earth. Not a single plant has been found preserved fossil in its full integrity with stems, leaves, flowers and fruits attached to their supports. Therefore, often, only one or two of their organs can be found. Thus, pieces of petrified wood, leaves especially, and hard fruits, are generally all that can be obtained for the study and the determination of a plant. Everybody knows how far different, even upon the same plant, are the organs which compose it. Taking only the leaves, for example; a single tree has them all more or less different, in shape and size, even in the disposition of the nerves (the nervation), which is of great importance for their determination. It is therefore easily seen that a paleontologist has more chance of coming to a better understanding of the characters of a plant in proportion to the number of specimens which represent it. If the collectors for show cabinets select especially specimens of fine appearances, the collections for study should always have as large a number of specimens known, or supposed to belong to the same species, as possible. Therefore, in cutting stones for specimens, great care must be taken to preserve all the vegetable fragments derived from the same piece of rock; or, when search is made in mines, it is always advantageous to select and compare plenty of specimens around the same place, in order to find, if possible, the different fragments which may belong to a plant or represent it. When large portions of plants, branches with their leaves and fruits, have fallen to the surface of the bogs and entered into decomposition, their parts gradually separate; first the leaves, then the fruits, then the small branches, and, after all, the large stems; but this separation generally leaves the different parts in proximity and therefore the researches upon the same place offer more chances of obtaining a whole subject, or a large portion of it; and it is not only the leaves of separate fragments which have to be studied, but their mode of attachment, the mode of division of the branches, the bark, the scars upon it, which are all of importance for determination.

No positive directions can be given on the probability of obtaining specimens in the rocks according to their different components. Limestone and sandstone formed at the bottom of the seas, have mostly animal remains, sometimes mixed with marine plants. Even land plants, like floated trunks or branches, may be found in rocks of this kind. But this is very rare. Brackish shells are, however, mixed with remains of plants in the roof shale of some coal beds. For, sometimes, after the heaping of woody debris, the surface of the deposits has been slowly invaded by the water of inland straits or bayous, inhabited by shells, which have, of course, been gradually brought with it. As the surface of the bogs was for a time covered with some kinds of plants of the coal age which had continued their vegetation in the water or above it, supported by hillocks, at the base of the trunks, remains of plants and animals have been there mixed together. But generally the best specimens of fossil plants are found where plants have lived alone, and this is generally the case in the carboniferous formation. It is, therefore, by splitting in the line of stratification the schist or slates of the roof of the coal beds that the finest specimens of fossil plants are found in this country. For this, a hammer pointed on one side and sharpened on the other, like a small hatchet, is the more valuable instrument, even the only one needed. And whenever one interested in the discovery of specimens and in their collection has his habitation in the vicinity of a worked coal bed, or still better, when one is the proprietor of a seam of coal, he may easily interest the miners in researches and obtain very valuable specimens from them. A proprietor in Pennsylvania has thus procured from a single bed of coal, and with the assistance of his miners, an immense amount of materials, representing not less than one hundred and eighty species of coal plants.

§7. THE NUMBER OF FOSSIL PLANTS KNOWN FROM THE ANCIENT FLORAS OR WHICH HAVE BEEN FOUND AT LOCALITIES REPRESENTING THE SAME AGE, AND THEIR VALUE IN RELATION TO BOTANICAL SCIENCE.

The plants preserved fossil are always very few in comparison with those which were living at the time when some of them were imbedded in the mud, sand, or soft materials, to be thus guarded against decomposition. The present flora of the borders of a lake or swamp, represents a mere, generally unimportant part of the vegetation of a whole country. Of any local group of plants, a few only may fall as debris into the mud or the imbedding matter, and of the imbedded fragments, a limited number only are discovered by researches; for the discoveries are rare and depend on peculiar casualties, or on peculiar kind of works like quarries, tunnels, etc. The chances of obtaining a tolerably good representative of an ancient flora are thus very few, except perhaps for that of the carboniferous. It is, therefore, difficult to make a comparison between the floras of the ancient formations and that of the present epoch.

The number of fossil plants known until now from all geological formations does not represent more than six thousand species, while the flora of the present time, taken in its whole, would probably, if entirely known, comprize more than one hundred and fifty thousand species; the phænogamous plants alone described until now amounting to eighty thousand species. The difference is enormous and at first sight seems to imply an immense superiority of the richness of the flora of this epoch over that of the ancient ones. If, however, the comparison is restricted, as it ought to be, to plants inhabiting local areas of reduced space, to the number of plants now growing at certain localities which may be supposed of a superficial extent equal to that where a number of fossil plants have been discovered, the differences will appear of far less importance. For example, a recent catalogue of the plants known as living in and around the District of Columbia, published in 1881 by the Department of the Interior, enumerates eleven hundred species of phænogamous plants. Another catalogue of the species observed around Buffalo, in a circle whose radius is more than fifty miles, has twelve hundred and seventeen species; while a third catalogue, that of Yale College, enumerates twelve hundred and thirty-three species, growing within thirty miles of the College. From these enumerations, and from a number of others published of different localities, one may admit that in the United States, eleven to twelve hundred species, inhabit a surface of thirty square miles, or about fifty species per square mile.

Calculations of this kind are always hypothetical in a great degree, as the vegetation varies in different localities, according to the local circumstances, nature of the soil, temperature, etc. They may serve, however, to show that, against the assertion made to the contrary, the fossil floras of the ancient epochs are sometimes locally represented by a number of species indicating a richness of vegetation equal or surpassing that of our present time. In an introduction to a work on Paleontological Botany, considered in England as reliable authority,* it is asserted that each coal bed has had a very limited amount of species of plants contributing to its composition. "Their number, it is said, particularly in the ancient beds, is rarely more than eight to ten species. In other cases it is more considerable, but rarely above thirty or forty." In the coal beds of Cannelton, Penna., which is worked on a very limited area, one hundred and forty species have been described from a very large number of specimens obtained there by systematic researches. The specimens here positively indicate the components of the coal, for they are derived, not from the top shale, where the vegetation might have been modified by peculiar circumstances after the deposits of combustible materials, but from the bottom, a hard compact cannel shale passing above to Cannel coal by a gradual

* Introduction to the study of Paleontological Botany by Balfour, (1872).

diminution of the muddy matter originally deposited with the vegetable remains. In the nodules of Mazon Creek, Illinois, derived from a bed of soft clay overlying the coal of that locality, one hundred and fifty species have been obtained already, and from the same shale, above the coal of Morris, eight miles distant, where the same bed of coal is thick and worked, sixty more have been found, of which fifty have not been as yet observed in the concretions of Mazon Creek. Adding both numbers it is seen that from what is known now, two hundred species of plants have contributed to the composition of a single bed of coal, and this in an area of less than ten square miles. If we would add to this the species of plants discovered at Murphysborough, Illinois, and Clinton, Missouri, where the same bed of coal is worked, the number of species would amount to two hundred and fifty.

The formation of coal is comparable to that of the peat bogs of our time and both materials have been produced under peculiar circumstances, especially superabundance of humidity, and with peculiar kinds of plants. For, as far as can be judged from the observations made in France, there was at the carboniferous epoch a flora inhabiting dry land, different in its characters from that of the bogs, where the coal was in process of formation. At the present time the flora of the peat bogs, well known to be limited in its characters as in its habitat, is composed of one hundred to one hundred and fifty species of plants, according to the localities where peat bogs have been formed. Pursuing our comparison on this new ground we must recognize here in the flora of the carboniferous epoch a far greater richness than in the flora of the peat bogs of our time; for as yet, more than nine hundred species of plants are known from the carboniferous formation mostly found in connection with beds of coal.

And now, still taking for another point of comparison the plants which at the present epoch have been found in such a state, where either imbedded in clay, or entombed in lime deposits, or heaped and covered with sand, they may seem prepared for fossilization, we are still surprised to find an inferiority of the representatives of the present flora as compared with the ancient vegetable fossil remains. The leaves of a single swamp, found still recognizable in the muddy deposit, do not represent more than twenty species. In the tufa, produced by the deposits of carbonate of lime, I have never found more than a dozen species; this, however, in deposits of limited extent. Near the mouth of the Ohio River, between the Cumberland and Tennessee Rivers, there is a very thick accumulation of leaves and fruits, materials heaped along the borders like a wall, four to eight feet high, mixed with sandy mud and in a very good state of preservation. They represent of course, by floated remains, the present arborescent and bushy vegetation of the borders of the river, a number of species amounting to one hundred to one hundred and twenty-five, when certainly from the heaped fragments no more than forty species could be determined.

Though great may have been the richness of the ancient floras, their study is rendered difficult by the deficiency of the fossil specimens. As it has been said above, the remains of plants of the ancient epoch are all more or less fragmentary. Of all, we have mere parts, representing one or two organs of the plants, all the others being destroyed. For this reason, the study of paleontology is not only discouraging, but its conclusions are uncertain and more or less unreliable. As it will be seen hereafter, however, there are often, even in the smallest fragment of a plant, some peculiar marks—characters, which indicate, if not its specific, at least its generic affinities; and certainly now, although still in its infancy, vegetable paleontology has procured, on the nature of the plants of the ancient epochs, on their relation to those living at our time, on the atmospheric circumstances which have governed the earth and influenced the vegetation at divers periods, data of such high value that it is now generally acknowledged as the faithful and reliable assistant of geology. Another important service rendered to science by paleontology is its positive exposition of the gradual development of the vegetable types, from the first apparition of the plants until now. This will be put in evidence in the following chapter.

§ 8. THE PRINCIPAL DIVISIONS OF THE VEGETABLE KINGDOM AND THEIR GENERAL DISTRIBUTION IN THE GEOLOGICAL PERIODS.

The plants inhabiting the earth, either on the land or in the water, are considered first in five principal divisions. First series. The Cryptogamous or acotyledonous cellular plants. Second. The vascular acotyledonous or Acrogens. Third. The Gymnosperms (phænogamous). Fourth. The Monocotyledonous. Fifth. The Dicotyledonous. These great branches are subdivided into classes, orders, or families, genera and species. The most essential subdivisions only can be mentioned here.

First. The Cryptogamous or acotyledonous cellular are the *Fungi* (mushrooms) the *Lichens*, both land plants, of which few have been preserved, fossil, and the *Algæ*, either marine or fresh water plants.

Second. The Cryptogamous vascular plants or acrogens, omitting the *Characeæ* and the mosses which are not represented in the old formations, have the *Equisetaceæ* (the Horsetail family), the *Filicites* (Ferns), and the *Lycopodiaceæ* (Club moss family).

Third. The phenogamous gymnosperms have the *Cycadeæ* (mostly now tropical or equatorial plants), and the *Conifers*, which include the great family of the Pines.

Fourth. The Monocotyledonous plants which have generally long ribbon like leaves, with parallel nerves, like the grasses. To them belong the great family of the Palms.

Fifth. The Dicotyledonous plants, whose leaves are of various forms, generally falling in winter, at least in the northern climate, and which constitute the essential part of the present vegetation.

According to their distribution, that is their great degree of prevalence at different periods of time, the plants represent in their successive development four principal epochs or reigns.

First. The reign of the Thallassophites (*Thallasso*, the sea, and *phuton*, a plant). The marine Algæ are already abundant in the Silurian. Some of them are represented Pl, 1, Figs. 1–8. But though only indistinct remains of vegetables have been recognized in the Cambrian, the presence of graphite in the rocks of that age, that also of carbonaceous substances which have blackened whole beds of slates, seem to indicate that some kind of vegetation was already then predominant and entered into the compounds of that oldest geological formation.

The reign of the Thallassophites, as referable to the times when the Algæ were the only representatives of the vegetation, has been until now extended to the middle Devonian. But recently remains of land plants have been discovered in the middle and upper Silurian, and therefore the first epoch has to be much reduced in time. This, of course, will not say that the *Algæ* have ceased to exist in the Silurian or the Devonian. They have continued their life until the present time in all the localities appropriate to it, and even they have probably greatly increased, if not in the number of their representatives, at least in diversified specific and generic forms. But until the middle of the Silurian, as far as we know, they reigned alone without land plants.

The second epoch, that of the vascular cryptogamous plants, includes the Devonian, the Carboniferous, and the lower part of the Permian. The vegetation of that epoch was composed essentially of Ferns, *Lycopodiaceæ* and *Equisetaceæ*, with some phenogamous gymnospermous plants, which by some paleontologists are referable to the Cycadeæ, by others to the Conifers, but which seem to represent an intermediate group partaking of some of the characters of both these families. Large fossilized trunks are found imbedded in the black shale of the Devonian, in Indiana and Ohio especially. By analysis of their internal structure the woody tissue is seen composed partly of dotted ducts or vessels, like the wood of some Conifers. It is probable, however, that these trunks are derived from *Cordaites*, a genus abundantly represented in the Devonian and the Carboniferous by large trees which, as it has been recently found, have in the texture of the wood the same kind of perforated ducts. Hard fruits distributed, sparingly in the Devonian already, but abundantly in the Carboniferous, are mostly derived from these *Cordaites*, and by their characters also they indicate a relation to the *Cycadeæ* as well as to the Pine family, as we shall have occasion to see in the examination of their remains.

The third epoch, known as the age of the Gymnosperms, is counted from the middle of the Permian, continuing through the Trias and the whole Jurassic period, represented as it is especially by the *Cycadeæ* and the Conifers with ferns and already a few Monocotyledonous plants. But already in the lower Permian some Gymnospermous and traces of Monocotyledonous plants are found.

Through the immense number of ages occupied by divers formations of this vegetable epoch, the vegetation has been subjected to gradual modifications which may be recognized in examining the characters of the plants and which gives occasion to a number of more or less important subdivisions. But it suffices to say now, merely to give an idea of the length of time represented by that period, that in some parts of Europe, for example, the Jurassic formations have a thickness of not less than fourteen thousand feet of successive strata, some of which are composed mostly of remains of animals, especially shells.

The fourth epoch apparently begins with the Cretaceous. It is that of the Angiospermous or Dicotyledonous plants, which gradually increase in development through the Tertiary to the present time, when they constitute the essential part of the vegetation. They, with the Conifers, mostly compose the flora of the temperate regions of the earth. Oaks, maples, poplars, hickory, willows, etc., belong to the great branch of the Dicotyledons.

The appearance of these plants in the Cretaceous is a remarkable phenomenon. In the lower strata of the formation in Greenland a single species of Dicotyledons, a Poplar, has been found mixed with the remains of ferns, Conifers, and other vegetables of the third epoch, and already in the middle Cretaceous of North America, named the Dakota group, the Dicotyledons are found in a predominance quite as marked, if not more, as it is at the present time, and representing a number of types still remaining in the North American flora, like Poplar, Plane trees, Beech, Oak, Magnolia, Tulip trees, Sassafras, Persimmon, etc. This vegetation, so different from that of the third period, seems like a spontaneous apparition, or creation, and has greatly interested paleontologists. But it is evident that from the Jurassic to the middle of the Cretaceous, a long succession of ages have passed, all with their successive groups of vegetation of which we know nothing as yet. The gradual modification of these groups may be hereafter opened to the study of the paleontologist by new discoveries. For vegetable paleontology is still in its infancy. Its progress, formerly very slow in this country, is now rendered more active by the prodigious abundance of fossil remains discovered in the strata of most of the formations of North America, and by the impulse given to researches by the numerous scientific institutions and associations lately founded. Thirty years ago the coal flora of this Continent was known only by about twenty species sent for determination to Brongniart, the celebrated French Paleontologist; now the North American coal flora counts more than seven hundred species. Fourteen years ago nothing was known of the Dakota group flora, of which more than two hundred species have been now described, or examined from an immense number of specimens. It is the same with the tertiary flora, of which also five to six hundred species are known. Hence, the progress is very rapid, and shows what may be expected from future explorations, which are now greatly facilitated and encouraged by the geological surveys.

§ 9. THE HISTORY AND THE CHARACTERS OF THE PLANTS KNOWN IN THE PALEOZOIC FORMATION OF THE UNITED STATES.

First and Second Class. Fungi and Lichens.

It is scarcely worth mentioning these classes of vegetables, as very few, if any, of their remains have been found fossil in the paleozoic times, or even in the recent geological formations. Both these classes of plants, the first especially, are very numerously represented now. They inhabit the ground, the bark of trees, the vegetable in process of decomposition, even the hardest stones. Of mere cellular tissue, they have been destroyed easily by atmospheric action. *Fungi* of a certain order, generally very small, are now found everywhere attached to the leaves or the decaying wood, etc., resembling small spots, round points or variously curved lines. These have been sometimes observed upon plants of the cenozoic formations, and also, but very rarely, on fossil remains of the Mesozoic. The stems of the coal also are perforated by small round or oval depressions, which may be taken for fungous impressions. But they have not been as yet, distinct enough to afford positive determination. Perhaps the organism the more positively referable to a Mushroom in the carboniferous, is that which I have discovered under the bark of a *Sigillaria*, in Pennsylvania. Its characters recognized by competent botanists are those of *Rhyzomorpha*, a kind of plant represented by long intertexed filaments, stems or radicles, of an adventive vegetation formed under the bark of trees, and from which, certain species of Mushrooms are derived. These peculiar remains, *Rhizomorpha Sigillariæ*, has been described and figured in the United States Coal Flora, p. 3, pl. 13, f. 2.

Of the Lichens scarcely any species has been described fossil, except from fragments imbedded in amber.

Third Class. Algæ.

These plants, mostly water plants, named Thalassophytes, when they live in the sea, Hydrophytes, when they inhabit fresh water, are extremely variable in their forms, and therefore, numerous in their species.

The fresh-water Algæ are of a soft tissue, generally in thin filaments, easily decomposed after death, either in water or under atmospheric influence. Their remains are, therefore, rarely preserved, and it does not appear that any of them have been discovered in the paleozic formations. These plants live in shallow ponds, canals, or any other kind of basins of stagnant water. Their part in the economy of nature, though unapparent it may be, is not without appropriate value; for, by their growth, they cleanse stagnant waters of a part of their impurities, allaying their miasmatic influence; they feed by their vegetation an immense number of small molluscs and other animals, and by their detritus constitute a kind of clayey mud, rapidly deposited at the bottom of the basins and gradually forming layers, sometimes of great thickness. In some countries canals or basins of wide extent prepared by man for ornaments in parks or by nature in land depressions, are filled with half a foot of muddy deposit in one year. This mud, by compression and the introduction of some mineral elements soluble in water, becomes a siliceous compound, a kind of clay, like that which underlies most of the peat bogs, rendering the basins impermeable and appropriate to the growth of the plants which enter into the composition of the peat. As most of the coal beds are underlaid by a bottom clay of the same appearance as that under the peat bogs, it is probable that the origin of that matter is partly due to the vegetation of fresh-water Algæ of the carboniferous times. As no fragment of these plants is preserved in the mud deposits of the present epoch, we can not be surprised if none of them are found in the clay of the old formations.

The marine Algæ, though generally of a soft tissue, are less rapidly destroyed by maceration. Some even are hard, coriaceous, and of these many have been fossilized. These plants are extremely numerous and varied in their forms. Some were simple cells, microscopical in their size; others very long, linear and simple; others divided into an inconceivable multiplicity of branches; others still, very large with trunks of a foot or more in diameter or with stems hundreds of meters in length. Either regular or irregular in their divisions, always elegant in shape, of a most pleasant and attractive aspect, being diversely, often brilliantly, colored, they form in the bottom of the sea like floral gardens of admirable beauty, or sometimes compose at the surface of the ocean immense carpets of a vegetation, which, of great thickness, covers thousands of square miles of surface. Such is the Sargasso Sea, between the

Canary Islands and Terre Nova, where the progress of ships is often retarded and even stopped by the compact tissues of the inter-woven plants. The floating prairies between the Kurile Islands and Japan are also of this kind.

It is certain that the marine Algæ have in the economy of nature a part which, though still somewhat unrecognized, can not be less important than that assigned to land vegetation. They feed an immense number of marine animals, they keep the water of the seas clear and pure, they give to man fertilizers for the land, food, coloring matters, a number of valuable compounds for domestic use, like soda, and others obtained by chemical agency. But they are useless for fuel, their texture being merely cellular, not fibrous and woody.

This fact of course eliminates the hypothesis of some naturalists who have supposed that the marine Algæ had in the ancient epochs contributed to the materials of the coal beds, by the deposits of their remains. When rapidly decomposed under atmospheric influences, the marine plants pass to a fluid state, or when coriaceous, they are dissolved under the alternate action of dryness and humidity. The heaps of wrack, or of hard species of marine Algæ thrown upon the beach by the waves, do not become compact or dry, and can never be used for fuel, like peat; they gradually pass at the base of the banks into a half fluid matter, which percolates through the sand. But it is very probable that the Algæ of ancient formations may have, by the decomposition of their debris, contributed to the formation of mineral oil, and filled the vast reservoirs of this precious matter now so greatly used and no less important for the progress of the civilization of our age than have been the deposits of land plants, which have formed the coal. For the remains of marine Algæ are sometimes found in paleozoic strata in prodigious abundance. Whole and thick beds of the Devonian are filled with these, and in some rocks where marine shells have been left in small cavities, and where marine plants appear to have been decomposed, the casts of shells are filled with mineral oil.

§ 10. DESCRIPTIVE PART.*

FIRST SERIES—ALGÆ.

The examination of the fossil Algæ is forcibly restricted to short descriptions of the few genera and species more definite and more interesting in their characters.

Soft plants, like Algæ, have been generally badly disfigured by compression and partial decomposition, and nothing has been left for their analysis but impressions of their outlines, which are very rarely marked by peculiar recognizable characters. For this reason Brongniart and other phytopaleontologists had admitted for the species of the marine Algæ the common generic name of *Fucoides*, which signifies a plant more or less like a *Fucus*. Though the genus is still preserved, for some more recent species, authors, among others Schimper, in his Vegetable Paleontology, have modified the genus to a more or less great degree, by subdivisions which, like most of those established for fossil plants, are artificial; for they depend upon characters which, observable upon fossil specimens, are supposed to be identical with some of the more striking ones observed upon living plants, like the form of stems, leaves, etc., and which are of no real importance for a classification based on nature (natural classification). Of course the paleontologist has to search carefully for points of affinity between the preserved organs of fossil plants and those of living vegetables, in order to fix a classification as closely related as possible to the order established by nature. But sometimes, no real points of correlation can be found, and this is the case with the Algæ. For example, the botanists for the description of the living marine plants, now have divided the whole series into three essential families or sub-classes as follows:

1. *Melanospermeæ* (*melanos*, black—*sperma*, seed). Plants olive green or olive brown in color; fructifications monœcious or diœcious.
2. *Rhodospermeæ* (*rodeos*, rose color). Plants rosy red, purple, rarely brown or greenish red; fructification diœcious.
3. *Chlorospermeæ* (*chloros*, light green). Plants grass green, rarely of a livid purple; fructifications disposed through all parts of the fronds, every cell being capable of having its contents converted into spores.†

As the spores or seeds of the *Algæ* can be discovered only by microscopical anatomy, and as the color of the plants is never preserved in a fossil state, it is clear that a classification of this kind can not be taken into account for the study of the remains of fossil *Algæ*.

*Some of the descriptions are borrowed or modified from my work, U. S. Coal Flora, report P of the Second Geol. State Survey of Pennsylvania.

† W. H. Harvey, Nereis boreali—Americana.

I shall, therefore, merely remark here upon some groups or species of *Algæ*, classing them according to what is known of their distribution, first, in the Cambrian and Silurian; second, in the Devonian; third, is the Carboniferous.

1. CAMBRIAN AND SILURIAN ALGÆ.

OLDHAMIA, *Forbes*.

Plants composed of thin filaments of equal length, with flexuous or dichotomous divisions, disposed star-like around a central point.

O. radiata, Forb., pl. 1, f. 2 (3 enlarged), Cambrian rocks, Ireland.

These remains, as yet extremely rare, are still problematical in their nature and in their relation. Some paleontologists have considered them as being those of animals, Ascidians or Bryozoans; others see in them merely tracks of some kinds of worms; others, among them Schimper, who has had for examinations the best preserved specimens of this kind, admit them as plants related to the Nullipores or Coralines, a group which is still represented in the vegetation of the seas by species of beautiful and large plants, whose tissue is generally covered with a stony crust.

SPHÆROCOCCITES, *St.**

Plants flat, many times dichotomous, from the base divisions disposed starlike.

S. SHARAYANUS, *Goepp.*

Pl. 1, *f.* 4.

Plants orbicular in outline, composed of branches diverging from around a central point, branches rigid, forking from the base, flat, truncate, or somewhat obtuse at the apex.

Hab. Lower Silurian of Bohemia, with *Chondrites antiquus; Buthotrephis, flexuosa.*

HARLANIA, *Goepp.*

(*Fucoides, Hall.*)

Fronds thick, coriaceous, dichotomous-flabellate, transversely and often longitudinally furrowed, hence sub-quadrangular.

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*This genus has been modified by Schimper, and now contains mesozoic species only.

H. Hallii, *Goepp.*

Plate 2, fig. 3.

Abundantly found in the Medina epoch, the lowest of the Upper Silurian, where entire strata of rocks are filled with this peculiar organism. Its nature, like that of many other species of the Silurian, has been contested and forms of this kind have been considered as being tracks of some animals, worms or crustaceans. But the interlacing of the fronds which are not passed through or flattened by superposition of others, evidently contradicts the supposition. They were apparently tubulose, like other species described here below, but already of a somewhat more complex structure than the species of the lower silurian. The genus has one species only.

SPHENOTHALLUS, *Hall.*

(*Sphen*, wedge—*thallos*, shoot, frond.)

Plants consisting of a stem with diverging wedge-form leaves, or of detached leaves, having this form, leaves apparently succulent or thickened, and sometimes coriaceous.

The author describes two species. *S. angustifolius* (with narrow leaves,) *S. latifolius* (with broad leaves,) remarking that this genus is probably limited for its habitat to the silurian or lower silurian strata. The specimens were found in the Hudson River group, or the upper strata of the lower Silurian, corresponding with the Cincinnati group, where the oldest remains of land plants have as yet been found.

The figures given of this species by Hall, Pal. of New York, p. 261, pl. 68, f. 1, are so much like that of a small branch of *Cordaites*, that if the leaves were straight, the plant would be referred to this genus. The leaves of *Cordaites* though flat, are sometimes succulent and of thick texture.

PALÆOPHYCUS, *Hall.*

(*Paleos*, ancient—*phucos*, marine plant.)

Frond simple or ramose, cylindrical, or sub-cylindrical, articulate here and there. Plate 1, f. 5, 5*a*.

The three species described by Hall, are *P. tubularis P. rugosus* and *P. simplex.* The figure quoted above gives an idea of the characters of these plants, though it represents a species with much smaller fronds much more closely and distinctly articulate. These specimens have been found in the Trenton limestone of the lower Silurian of New York. This genus has, however, representatives in the Devonian and even the Carboniferous.

BUTHOTREPHIS, *Hall.*

(Greek for *produced in the depth of the sea.*)

Frond cylindrical or compressed, ramose; branches numerous.

Six species of this genus are described and figured by Hall in the Pal. of New York, *B. antiquata*, *B. gracilis*, *B. succulenta*, *B. nodosa*, *B. flexuosa* and *B. foliosa*. *B. gracilis*, Hall, pl. 1, figs. 1, 6 and 7, is extremely variable, at least if we have to consider as referable to the same species all the specimens which have been figured as varieties and which differ as much in the size of the plants as in their mode of ramification. From fig. 5 to fig. 6, copied from the same plate, 5, vol. 2, of the Pal. of New York, there are indeed intermediate forms which present a great diversity of size and ramification. They are described as var. *gracilis*, *intermedia* and *crassa*. But as the specimens are from two different epochs, the Trenton lower, the Clinton upper Silurian, some of the so called varieties may represent true species.

Though the types of the Algæ are long lived, and of wide distribution, it is probable that if perfect specimens could be obtained of the fossil species they would show a much greater diversity of characters than it is possible to see from the often indistinct fragments which have been obtained.

DICTYONEMA, *Hall.*

(*Dictyon*, fish net.)

Frond divided from a common central point into numerous branches expanding fan-like, with thick branchlets or subdivisions repeatedly dichotomous nearly in right angles connecting the primary branches, and forming a kind of reticulation like the meshes of a fish net.

D. Retiformis, and D. Gracilis, *Hall.*

Pal. of New York, ii, p. 174 *and* 175, *pl.* 40 *F. and* 40 *G.*

These two species have been considered by Hall as corals, but he remarks that the branches consist of a black film enveloping a semi-calcareous or carneous interior, being apparently like *Graptolites* in texture. Schimper remarks that the fossil is changed into anthracite in the Silurian strata of Norway, and that Goeppert has discovered a sporange placed upon a branchlet connecting two primary divisions; that therefore the vegetable nature of this production can not well be doubted. In the Devonian there is a predominant group of plants which have great affinity of structure with Dictyonema.

2. DEVONIAN ALGÆ.

Though remains of marine plants are found in prodigious abundance in some strata of the Devonian period, few have been collected and described. This is probably due to the great difficulty of separating distinctly preserved forms from the heaps of materials, or rather impressions, which appear to have been made by these remains. The strata where the plants are mostly found, beds of hardened clay or sandstones, have their horizontal layers carved in a multitude of more or less irregular impressions, representing mere fragments of plants, of which no definite outline can be recognized. The appearance of some surfaces seems produced by heaps of vegetables, thrown, half decomposed, upon a soft bottom of mud or sand, and compressed there until the whole vegetable matter has been embedded to be later partly destroyed by decomposition. Formations of this kind have been observed in Pennsylvania in the vicinity of oil bearing strata. They are also frequently seen in the Waverly clay beds of Ohio, and from these beds beautiful specimens have been obtained, which, however, have not yet been examined for description.

Allusion has been made above to a group of Algæ of the Devonian, related to those of the Silurian by their composition of long filaments radiating from a common center and transversely crossed by branches which seem to unite them. They look like narrow pieces of ribbons placed vertically and horizontally, at a short distance, imitating in miniature the pattern of the Scotch plaid. Of this group three genera have been described, as follows:

UPHANTÆNIA, *Vanux.*

(*Uphantos*—woven.)

Frond large, funnel shaped, regularly latticed by broad, ribbon like ribs, one series radiating from a common center, the other disposed concentrically.

U. Chemungensis, Vanux; the only species known has been found in the Chemung, Upper Devonian.

DICTYOPHYLLUM, *Hall.*

Frond flabellate or funnel shaped, latticed by radiate and concentrical divisions, stem obconical or sub-cylindrical, hollow, striate outside like the divisions, equal or with inflated round or nodose articulations.

Schimper remarks that the impressions of this plant are fan like, but that when living the plant was funnel shaped. He says also that the stem is inflated here and there by large knots placed the one above the other with some likeness to the stems of *Halonia*. This remark is not exactly correct. From a number of specimens which I have had opportunity to observe, the inflation of the stems is merely the base of branches placed in horizontal rows. The branches short, enlarged at their point of attachment, narrowed or contracted in the middle where (in one specimen) they are scarcely one cm. broad are abruptly enlarged, knot-like, at the top.

Hab. Chemung group.

SPIROPHYTON, *Hall.*

Fronds membranaceous, cup-shaped, or attached to a short stem around which the lamina is spirally turning upward, representing in its sections and by compression the tail of a cock (*cauda galli*).

Half a dozen species of this genus have been described by Hall, the most common being *S. cauda galli*. The general appearance of these vegetable organs is represented pl. 2, f. 1, but *S. cauda galli* has much broader, more circular fronds or segments, which when flattened upon the rocks, as they generally are, have a diameter of twelve to twenty cm., often forming whole circles by their curved branches. Some rocks are locally blackened to great thickness by the impressions of this plant.

3. CARBONIFEROUS ALGÆ.

For a long time it was supposed that no kind of Algæ could be found in the coal measures. These plants, as it has been seen above, have not entered into the composition of the coal, and therefore their remains have not been mixed with the species of land plants abundantly preserved in the roof shale of coal beds, though these sometimes have brackish shells mixed with ferns, etc. The coal formations covered very extensive inland flats, which the sea did not penetrate, or which came into it by narrow shallow inlets, inhabited by shells, but not deep enough to support the vegetable marine life. The Algæ of the coal have been found in connection with beds of limestone, or of clay iron ore, more rarely in sandstone.

As yet few species are known. Some of them are referable to the two types already present, one in the Silurian *Paleophycus*, the other in the Devonian, *Taonurus* or *Fucoides cauda galli*, others to a far different group, which seems peculiar to the formation and has indeed remarkable characters. Most of the species have been found in Indiana, and though partly described and figured in one of the annual reports, they should be here briefly recorded in order to have a general view of the palæozoic Marine Algæ.

Of the genus *Palæophycus*, Hall, described above, we have seen from Indiana:

PALÆOPHYCUS MILLERI, *Lesq.*

Geol. Rep. of Ind., 1875, *p.* 136, *pl.* 1, *f.* 1, 3.

Frond large, erect or spreading around a central axis, branches forking in an acute angle of divergence or anastomosing between them, cylindrical or slightly flattened, generally thick toward the obtuse apex, sometimes umbonate, transversely cut or strangled by deep fissures at right angles to the axis; surface smooth or punctulate.

Hab. Concretions of carbonate of iron, over coal L. Vigo County, Indiana. E. T. Cox, J. F. Miller.

P. GRACILIS, *Lesq., plate 1, fig. 5, 5a.*

Geol. Rep. of Ind., 1875, *p.* 137, *pl.* 1, *figs.* 5, 6.

Frond small, enlarging upward or outside by repeated dichotomy; branches cylindrical, forking in a more or less open angle of divergence, slender, slightly decreasing in thickness from the base up to an obtuse point, easily split transversely, generally smooth, sometimes punctate.

Hab. With the preceding, of which it may be a variety.

P. DIVARICATUS, *Lesq.*

Geol. Rep. of Ind., 1875, *p.* 138.

Frond flattened into creeping branches, diverging around from a central axis; branches cylindrical or more or less flattened by compression, irregularly forking and anastomosing by cross divisions nearly equal in size their whole length, obtuse; surface smooth.

Hab. With the preceding. J. F. Miller.

ASTEROPHYCUS, *Lesq.*

Stems cylindrical, expanded and divided starlike from the central axis; segments flattened or inflated.

A. SIMPLEX, *Lesq.*

Plate B, fig. 78.

U. S. Coal Flora, p. 13, *plate* 1, *figs.* 7 *and* 8.

Frond composed of cylindrical spindle shaped branches placed starlike around a small central axis and free to the base.

Hab. Ferruginous clay, above the millstone grit near Beaver, Pennsylvania.

A. Coxii, *Lesq.*

Plate 2, fig. 4.

Geol. Rep. of Ind., 1875, *p.* 139, *pl.* 2.

Divisions of the frond flattened, large, oblong, obtuse or obcordate; surface deeply and irregularly wrinkled lengthwise.

Hab. Hard sandstone or quartzite, in connection with coal beds. Cut off of the Wabash, near New Harmony, E. T. Cox. Also, near Rock Castle, Ky.

This species has great affinity with those of the following group, being, like them, supported by a stem or axis around which the divisions of the fronds were successively placed upon another. Its relation to Algæ of our epoch is unknown.

CONOSTYCHUS, *Lesq.*

Stipe cylindrical, continuous; frond enlarging from the base upward in the shape of a cup, or growing up and enlarging by successive superposed concentrical layers; top, cup shaped, concave.

The plants of this group are distantly related to a tribe of Marine Algæ of the present time, the *Acetabulariæ*, which bear upon a continuous stipe successive umbrella-shaped fronds, the lower rendered solid by incrustation of calcareous matter.

C. Broadheadi, *Lesq.*

Stipe short, cylindrical, transversely ribbed; frond semi-globular, cup shaped, concave inside, distinctly three-costate and deeply wrinkled lengthwise on the outside; substance thick.

A most beautiful organism resembling a cup, more than eight cm. across at its top, five cm. upward from the apex of the stipe to the borders, with an average thickness of one cm. The outside has three equal strong ribs with enlarged wrinkles, disposed lengthwise between them, and regular undulate rugose branchlets which seem as sculptured by hand for the outside ornamentation of the cup. This remarkable organism has been figured in the U. S. coal flora (pl. B, f. 1) with the two following species.

Hab. Shale near the base of the coal measures, Vernon county, Missouri.

C. prolifer, *Lesq.*

Fronds thick, disciform, concave, disposed in a successive series, upon a continuous narrow cylindrical stipe.

The discs are like small plates, concave above, abruptly curving on the outside of the axis, with a nearly flat base. They are grown superposed upon each other, attached to a central axis or stipe, whose remnant is seen in the center of the discs. This peculiar species is not very rare.

Hab. Same as the preceding, also found in Kentucky, with *Asterophycus Coxii.*

C. ORNATUS, *Lesq.*

Plate 2, *f.* 5.

Frond obconical, composed of superposed layers or plates generally increasing in width from the base upward, and regularly lobate on the borders by deep lines diverging star-like from the axis and passing up to the top.

The mode of development of this plant agrees with that of the two preceding species and proceeds from a cylindrical basilar axis, by the superposition of successive layers formed around it.

Hab. Sandstone of the Coal Measures above the millstone grit of Illinois.

TAONURUS, *Fish.—Ost.*

Spirophyton, Hall. Fucoides, Vanux. Chondrites, Lesq.

We have seen above *Fucoides*, or *Spirophyton Cauda galli*, as a plant extremely common in the Devonian. It passes up to the lower Carboniferous, but has not yet been found above the Millstone grit. The following species procured from the upper coal of Illinois, appear really different.

TAONURUS COLLETTI, *Lesq.*

Plate 2, *f.* 1.

Frond large narrowed to a basilar support, obovate in outline, lamina cut into narrow linear segments, joined in their length, or separated, curved up in half circles, converging to the borders. This species appears, like the following, derived from a cylindrical axis to which it is attached by its narrowed base.

TAONURUS MARGINATUS, *Lesq.*

Plate 2, *f.* 1, 2.

Caulerpites marginatus, Lesq. Trans. Am. Phil., vol. 13, *p.* 314, *pl.* 7. *Physophycus, Schp.*

Frond derived from a fucoidal cylindrical axis, branching in its lower part, enlarged upward to a small utricale, which gradually expands into a lyrate lamina folded transversely in irregular striæ curving scythe shaped and converging on both sides to the flattened smooth borders.

This species merely differs from the preceding and from *Fucoides Cauda galli*, by the persistence of its fucoidal smooth border around the striate, or plicate lamina. This character has not been observed in *F. Cauda galli*. But the first mode of growth of this last plant has not been sufficiently observed, and probably we have here a demonstration of its peculiar development by the gradual enlarging of the hollow cylinder into a vesicular appendage, as in f. 2, considerably enlarged, for the composition of large fronds, like those figured in the Mem. of the Phil. Soc., where the border is persistent, while it is mostly destroyed in *T. Colletti*, and entirely so in *F. Cauda galli*.

Hab. Ferruginous very hard, compact shale at the horizon of the millstone grit, on Slippery Rock Creek, Pennsylvania.

II SERIES—VASCULAR ACOTYLEDONOUS PLANTS OR ACROGENS.

FIRST CLASS. EQUISETACEÆ OR HORSETAIL FAMILY.

Plants herbaceous or tree-like, coming out of subterranean articulate rooting rhizomas often tuberculate at the articulations (pl. 4, f. 3); stems generally striate or furrowed lengthwise, fistulose and articulate, traversed at the articulations by a diaphragm (partition of thin cellular tissue); branches coming out at the base of the leaves, verticillate like the leaves, which are generally united at the base, forming sheaths; flowers of both series born upon a fugacious prothallium (a primitive tissue composed of thin intersected filaments, covering the ground at the base of the plants); fructification composed of verticillate receptacles, attached in rows around a central axis by short pedicels, (pl. 4, f. 5), and superposed in the form of a cone, (pl. 4, f. 4 and top of f. 1).

This class is separated into two sub-classes, the first comprising the true *Equisetaceæ*, to which is applicable the above definition, and to which belong the genus *Equisetum* (Horsetail); the second the *Calamarieæ*.

The *Equisetaceæ* are at the present epoch herbaceous plants of comparatively small size, the stems in the northern hemisphere being scarcely one cm. in diameter and half to one cm. in altitude. In the tropical regions, some plants of this family are four to five cm. high and two cm. thick. The *Equisetaceæ* have had their largest point of development in the Trias and the Jurassic, but have been sparingly represented in the Carboniferous, there only by a few separate sheaths of *Equisetites*.

For the present I have to consider merely the second group or subclass; that of the *Calamarieæ* or *Calamiteæ*, which essentially differs from the

Equisetaceæ by the leaves free to the base, generally lineal-lanceolate or obconical; by the branches coming out from the axils of the stem-leaves, verticillate in the upper part of the stems, and especially by the great size of the plants.

The origin of the plants of this section goes up to the middle, even the lower Silurian, where fragments represented (pl. 3, f. 3-6) and referred to two genera of the *Calamarieæ* have been found. In the Devonian, remains of *Calamites*, the more important genus of the *Calamarieæ*, are already abundant. But the group takes its essential development in the Carboniferous, where trunks and branches of many of its species are found in connection with nearly every coal bed or appears to have composed layers of coal by their remains only. From the upper Carboniferous to the middle Permian the *Calamarieæ* rapidly decline and altogether disappear.

CALAMARIEÆ.

CALAMITES, *Suckow.*

Pl. 5, *f.* 1–6.

Plants arborescent; stems cylindrical, narrowed at base to the point of attachment to a subterranean rhizoma, (pl. 5, f. 1, reduced size), hollow, more or less distantly articulate, constricted and traversed at the articulations by an horizontal membrane (diaphragm, f. 5), regularly striate or costate lengthwise by equal parallel more or less broad furrows (f. 2–5), gradually narrowed or rounded at top, divided at the articulations in opposite or verticillate branches. The leaves upon the primary stems fall off very soon, at least they are never found attached to the stems, but only the scars of the point of attachment are marked by small round or oval tubercles, just above or below the articulations. These scars are distinctly seen upon f. 4 and 5; but they are often obsolete or totally destroyed, as in f. 2 and 3. The branch-leaves, however, are generally preserved fossil. They are all equal, linear,narrowed up to a short point, free to the base, very entire and costate to the middle, placed in whorls at the articulations. The fructifications of *Calamites* are described with the genus *Asterophyllites*, or what Schimper calls *Calamocladus*, branches of *Calamites*, as they are considered to be by some authors.

For a long time the derivation of the stems of *Calamites* from a rhizoma and their mode of attachment to it, have been unknown, and the ancient authors, Brongniart, Lindley & Hutton and Sternberg, have sometimes considered the conical part of the stems as their top and have figured them accordingly, or upside down. Recently some authors, especially Grand 'Eury, a celebrated paleontologist of France, have discovered the rhizomas and have seen the mode of attachment of the stems, as seen in pl. 5, f. 1, a figure copied from the Coal Flora of this last author. It appears, however, that the stems of the *Calamites* have been very soon separated at their base from the rhizomas, or that rootlets and rhizomas being of a soft cellular tissue, have been rapidly destroyed by maceration, and for this reason are rarely found in connection with stems. There is near Carbondale, Pennsylvania, a forest of *Calamites*, whose stems are still standing, embedded into a bank of sandstone, twenty to thirty feet high, through which an inclined tunnel has been cut. An immense amount of fragments of these stems have been thrown out of the mine and neither in connection with the fragments, nor at the base of the stems seen erect along the walls of the tunnel, could any remains of rootlets or of rhizomas be discovered. The stems are there in their natural state and position, as they were when living, erect, covered with a thin hard polished and ribbed epidermis, the whole internal cylinder transformed into sandstone, but the original hollowness of the trees is seen in transversal bends, depressions, irregular folds, caused evidently by compression, or by semi-prostration; for when they were imbedded in the sand by some cataclysm, they were already dry and in an incipient state of decay. The stems of these *Calamites* at Carbondale vary from eight to sixteen cm. in diameter, and as far as can be seen from the thickness of the sandstone bank through which they pass, as some of them are seen piercing the upper surface of the bank, their length was six to eight meters. Some larger trunks of *Calamites* have been observed in Carboniferous strata, but they are generally found flattened after decomposition, and it is then difficult to measure exactly their diameter.

The *Calamites*, as said already, have contributed a large part of the materials which enter into the composition of the coal beds. Their range of distribution is from the middle Devonian to the Permian. They lived in local groups, under circumstances favorable to their growth; for if some beds of coal appear nearly entirely formed of their remains, no trace can be seen of them, neither in the coal nor upon the roof shale of some others. They were probably annual or of short existence, and thus, though their stems were hollow, they could contribute to the matter of the coal an immense amount of woody materials by the repeated prostration and heaping of their stems and branches.

The possibility of such a fact has been disputed by some authors as being against the laws of nature, which, at the present epoch, they say, can not, even in humid tropical regions, produce such an amount of vegetable matter by the growth of any tree in one year. Without considering the great difference in the atmospheric conditions at the coal period, as compared with those existing now, it may be remarked that we have in the present flora of North America a kind of vegetable which, in its nature and mode of life, may elucidate in some way the mode of vegetation of the *Calamites*. The Cane (*Arundinaria*) is a kind of grass, which, in the swamps of the South or on the borders of some rivers, grow at one shoot twenty feet in length—even more, branch the second year and a few times afterward, until it flowers, and then dies and decays. The undergrowth of forests of Magnolias and other large trees in the Dismal Swamp of Virginia, is essentially composed of Canes, growing so close that they form a kind of impassable wall which can be penetrated only with the ax. In some years this whole compact mass of vegetation is locally prostrated, giving by its decomposition a thick layer of woody matter or peat.

The bark of the *Calamites*, sometimes thick, is easily destroyed by maceration, and therefore most of the specimens of stems, obtained in sandstone and other kind of strata, are merely impressions of the mold or of the inner surface under the bark. This bark is sometimes a hard, polished crust of no more than one mm. thick, while some species (pl. 5, f. 6), have a thick compact woody bark, often as persistent against decomposition as the inner wall of the cylinder. A specimen of the same species as the one figured as quoted above has the inner cylinder six and one-half cm. broad, flattened, and the bark one and one-half cm. thick. From this peculiar character and from that of some *Asterophyllites*, Brongniart and other authors have supposed that these vegetables are not all mere acrogen plants, but that some of them are referable to dicotyledonous gymnosperms of a peculiar genus allied to the conifers, and named *Bornia* or *Calamodendron*.

The specific characters of the *Calamites* can be derived only from the outside appearance of their bark or from the surface of the stems, the ribs, their width and relative position in crossing the articulations where their ends are either continuous in the same plan of direction, or alternate; from the distance of the articulations, the size and position of the tubercles or scars of leaves, etc., and as all these so-called characters are variable sometimes upon the same stem, it is very difficult to satisfactorily define the species. Some authors have, for this reason, multiplied them in great number; others, like d'Ettingshausen, have come to the conclusion that there is only one. There are, however, between their stems, some differences which appear to be constant and sufficiently distinct to be considered as specific. And what shall be seen here below of the fructifications of *Asterophyllites*, evidently shows that if the *Calamites* are their trunks, they ought to represent a certain number of species. Those which are more generally admitted are the following:

CALAMITES SUCKOWII, *Brgt.*

Pl. 5, f. 5.

Stems of medium size, always larger than the space between the articulations; ribs half round, separated by narrow furrows; tubercles oval, more or less distinct; bark thin. The most common species of the genus.

C. MAJOR, *Weiss.*

Stem large, twenty cm. or more; articulations close; ribs large, three mm.; bark thicker than in the preceding.

C. RAMOSUS, *Artis.*

Stem branching at the distant articulations (merely in the upper part); ribs flat, furrows narrow; tubercles oval or undefined at both ends of the ribs; scars of branches large, round.

C. CANNÆFORMIS, *Schloth.*

Pl. 5, *f.* 2.

Stems large, articulations at variable distances; furrows broad, obtuse, sometimes marked in the middle by a sharp line; ribs convex, wedge form, alternately jointed at the articulations; scar leaves distinct or obsolete.

C. APPROXIMATUS, *Schloth.*

Pl. 5, *f.* 6.

Stems very variable in size; bark thick; articulations somewhat contracted, close, especially toward the base where they are sometimes only one-half cm. distant; ribs indistinct upon the bark; surface clearly marked upon the impressions of the under side, convex, with deep furrows, two or three, sometimes, converging at the base to one point of the articulations.

C. CISTII, *Brgt.*

Pl. 5, *f.* 4.

Articulations distant, ribs narrow, half round; furrows obtuse, striate, tubercles small, round, oval or absent.

C. DUBIUS, *Artis.*

Merely differs from the last by the furrows more distinctly striate, the ribs narrower, the articulations very distant, the tubercles mostly obsolete.

BORNIA, *Roem.*

Differs from *Calamites* by the articulations scarcely constricted, the ribs being cut square or obtuse at the articulations and continuous (not alternating); cortical cylinder thick; leaves verticillate.

Genus as yet unsatisfactorily defined like *Calamitea* and *Calamodendron*, and of which one species only is described, *Bornia radiata*, Schp., (*Calamites*, Brgt.), represented by a stem bearing a row of canaliculate leaves at the articulations. The leaves of the only specimen I have seen as referable to it are less than one mill. broad and six and a half cm. long, apparently joined by two at the base.

ASTEROPHYLLITES, *Brgt.*

Pl. 6.

Calamocladus, Schp. Bechera, Bruckmannia, Volkmannia, etc. St.

Stems articulate; branches opposite, simple, open or oblique; central axis, hollow or solid; leaves verticillate, free to the base, linear and acuminate, simple-nerved; fructifications either in elongated ears or cones, bearing double sporanges attached to the axis by a short pedicel (pl. 4, f. 9, 10), or in tubercles (macrospores), attached to the axils of the leaves.

There is still a great deal of uncertainty concerning the true nature of the plants which have been named *Asterophyllites* by Brongniart and most of the authors after him, and which considered as branches of *Calamites* by Schimper, and described under the name of *Calamocladus* or *Calamophyllites*, appear to have a more marked degree of analogy to the *Lycopodiaceæ* than it has been supposed until now. Pl. 4, f. 6, 9, 10 show, by the cross section of a cone, exactly the same kind of fructification as is observed on a cone of living *Equisetum*, f. 1, 4, 5. Now I have figured pl. 6, f. 4–6, branches of *Asterophyllites gracilis*, bearing (f. 5) small tubercles, or rather, macrospores, in the axils of the leaves, and fig. 6 a conical ear of the same nature, by its outside characters, as that of pl. 4, f. 6, and still in f. 3 of pl. 6, an ear also of the same kind as those which are generally considered as fructifications of the *Asterophyllites*. F. 5 and 6 belong to the same species; the character of the leaves is too distinct from those of any other species to permit any doubt about the identity of the specimens, which, moreover, are all from the same locality and mostly upon the same pieces of shale. As far as I have been able to see it by breaking some of the sporanges of f. 3, they contain only microspores, so small, indeed, that with a high power of the microscope they appear like glomerules of pulverulent matter; while branches of *Asterophyllites* have the tubercles of the axils of the leaves very close, as f. 2, and some of them, distinctly exposed by falling off of the leaves, show the tetrahedral structure of macrospores. This, indeed, indicates a fructification very much like that of the *Lycopodiaceæ* of the coal, as seen in pl. 16, f. 5, 6. This peculiar mode of fructification is still elucidated by the characters of other specimens. But until this question may be decided by the anatomy of silicified cones, cut in thin lamellæ for microscopical examination, I shall follow the general classification of the European authors and describe the cones like those of pl. 4, f. 5, under the name of *Calamostachys* (*stachys*, an ear), and those like f. 3, 6, as *Volkmannia*.

The range of distribution of the genus *Asterophyllites* is from the Middle Devonian to the Permian, like that of *Calamites*. Its more commonly found and more distinctly characterized species are the following:

A. equisetiformis, *Schloth.*

Pl. 6, *f.* 1-2.

Primary branches long, striate; costa thick; branches more or less oblique; leaves linear acuminate, open, straight or curved inwards, thickly costate; fruiting plants with thick branches, close articulations and small round tubercles in the axils of the leaves. Pl. vi, f. 3 may represent the *Volkmannia* of this species, which is common in all the thickness of the coal measures.

A. anthracinus, *Heer.*

Is much like the preceding, differing merely by the leaves, longer than the internodes, curved upward, the medial nerve obsolete. Not as common as the preceding. Middle coal measures.

A. longifolius, *Brgt.*

Branches generally small; articulations distant; leaves numerous, very long, six cm. or more, and narrow, scarcely one mill. in diameter, flat, flexuous, apparently soft, subulate pointed. Lower coal measures, rare.

I have seen a specimen which seems to be the *Volkmannia* of the species. It is the upper part of a branch one cm. broad, irregularly striate, with lateral branchlets or ears two and one half and three and one half cm. long, covered with appressed linear, narrow scales eight mill. long, connate to near the apex, twice as long as the articulations. The leaves of the stems are two to four cm. long, narrow, broadly flat-nerved, lineate lengthwise by the erosion of the surface exposing the fibrous texture.

A. regidus, *Brgt.*

Differs from the preceding by thick branches, the short articulations, the leaves rigid, shorter, concave or carinate, incurved, half cylindrical, the thick nerve. It is more generally found than the last.

A. SUBLÆVIS, *Lesq.*

Branches thick; articulations close, equidistant; internodes smooth, not ribbed, merely slightly undulate under the inflated articulations; leaves short, linear-lanceolate, gradually acuminate; branchlets at right angles, short, narrow, with two or three whorls of short leaves. Very rare except in the anthracite of Rhode Island.

A. FOLIOSUS, *Ll. and Hutt.*

Branches slender, narrowly striate; leaves shorter than the articulations, generally open and flat, in whorls of eight to ten; distinct at base, linear lanceolate, obscurely nerved.

Species described under many specific and generic names from the different appearances presented by its fragments; the trunk and branches are sometimes covered with rootlets divided in multiple very thin filaments which have been described as *Pinnularia* or *Myriophyllum*, etc., while the tops of the branches, forming buds with close appressed leaves, have been taken for *Annularia*. It is not rare, but often in unrecognizable fragments.

A. GRANDIS, *St.*

Stems distinctly striate, contracted at the articulations; leaves open, narrowly linear-lanceolate, short, thin, with the nerve indistinctly marked. This has been described as *Bechera* by Ll. and Hutt. Rarely found.

A. FASCICULATUS, *Lesq.*

Plate 6, *f.* 7.

Stem comparatively thick; branches dichotomous; fasciculate or opposite and distichous; distinctly striate under the articulations; internodes short; leaves short, three to four mm., lanceolate; fructifications in axillary tubercles of narrow linear spikes. A fine species especially found in the coal of Clinton, Missouri.

A. GRACILIS, *Lesq.*

Plate 6, *f.* 4–6: *pl.* 5, *f.* 3.

Ultimate branches very slender, obscurely striate; leaves two mm. long, longer than the internodes, narrowly lanceolate, pointed, curved inward in whorls of eight to ten; fructifications of two kinds; in lanceolate cones (*Volkmannia*), sessile on the articulations, narrowed at the point of attachment, three cm. long, one-half cm. broad toward the base, covered with appressed imbricate, short lanceolate scales, connate to the middle, pointed (f. 6), and in small tubercles attached in rows in the axils of the leaves (*Calamostachys*, f. 5 and 5a). The fragment of *Calamites* (pl. 5, f. 3), represents the stems of this species. Found as yet in the sub-conglomerate coal measures.

ANNULARIA, *Brgt.*

Plate 3, *f.* 3—3*b*; *pl.* 7, *f.* 1-5.

Stems articulate, traversed at the articulations by a strong diaphragm; branches opposite, diverging nearly at right angles from the articulations; leaves verticillate, joined at base by a narrow ring (*Annulus*), hence their name, lanceolate, spathulate or lingulate, abruptly or gradually acuminate, sometimes obtuse, fleshy, even emarginate at the apex; fructifications in long cylindrical spikes with close articulations and narrowly lanceolate bracts, bearing round sporanges in the axils of the leaves, or oval ones pedicellate, attached in the middle of the internodes.

The fructifications as described and figured by the authors are much like those of *Asterophyllites.* But their characters are not yet sufficiently known; for these fructifications are very rare, at least as found attached to their support.

A. LONGIFOLIA, *Brgt.*

Plate 7, *f.* 1, 2.

Stem narrowly striate; leaves in whorls of eighteen to twenty-four, lanceolate spathulate, more or less abruptly acuminate, medial nerve broad, deep. A very common species, and very variable in the size of its leaves.

A. INFLATA, *Lesq.*

Leaves inflated, semi-cylindrical, club-shaped and obtuse, apparently fleshy; medial nerve none, or indistinctly seen upon leaves flattened by compression.

May be a variety of the preceding species deformed by immersion; the number of the leaves is generally greater, twenty-six to thirty-two in the large whorls. Rarely found except in the nodules of Mazon Creek.

A. CALAMITOIDES, *Schp.*

Stems thick, branches closely articulate; stem leaves long, erect, numerous; branch leaves shorter, linear-lanceolate gradually acuminate. The leaves are flat, shorter, not as thick as in *A. longifolia.* A rare species.

A. SPHENOPHYLLOIDES, *Brgt.*

Plate 7, *f.* 3, 4, 5.

Stems slender; branches and branchlets at right angles; verticils flat, of twelve to twenty leaves which are often longer on the outside, spathulate, slightly emarginate or obtuse at the apex, (f. 3, 4,) or abruptly apiculate, (f. 5,) more or less re-curved on the border. The species is common and very variable; mostly found in the middle coal measures.

A. EMERSONI, *Lesq.*

Plants of small size; stems comparatively strong, distinctly striate, with divisions as in the last species; verticils of leaves smaller; leaflets thick, oblanceolate, taper pointed; costa none or immersed and obsolete.

A fine, small species, found at the horizon of the Pittsburg coal.

A. RŒMINGERI, *Lesq.*

Plate 3, *f.* 3–3*b*.

Stems long and slender, articulate, smooth; articulations at short, regular distances, inflated, bearing oblique branches and small lingulate apparently flat leaves, either truncate or rounded at the top; nerve obsolete.

The remains of this plant, which is not very clearly defined on account of too fragmentary specimens, merit to be considered, as they evidently represent a species of this genus and therefore prove the existence of the *Calamarieæ* already in the lower Helderberg Sandstone or upper Silurian. These specimens were found by Dr. Rœminger in Michigan.

SPHENOPHYLLUM, *Brgt.*

(*Sphen*, wedge.)

Plate 3, *f.* 4–6; *plate* 7, *f.* 6–11.

Plants herbaceous, stems articulate, somewhat inflated at the articulations, pinnately, bipinnately divided; leaves verticillate, sessile, in whorls of wedge-form leaflets, entire at the lateral borders, round or truncate at the laciniate dentate or lobate upper margin; medial nerve none; veins diverging from the base, straight, dichotomous; fructifications in cylindrical spikes of globular sporanges placed in the axils of bracts or scales curved upward in a sharp flexure from near their base (f. 7).

The plants of this genus, like those of *Annularia*, were water plants whose upper or emerged branches were spreading upon the surface of stagnant water. Some species have the leaflets more or less divided, often more expanded on the upper side of the whorls, according, it seems, to their growth upon the surface of the water.

S. SCHLOTHEIMII, *Brgt.*

Plate 7, *f.* 6, 7, 7*a*.

Verticils of five to nine broadly cuneate leaflets, rounded and crenulate at the upper border; veins free at the base, dichotomous, distinct.

A most common and beautiful species, easily known by the rounded upper borders of the leaves. It ranges through the whole thickness of the coal measures from the conglomerate upward.

S. EMARGINATUM, *Brgt.*

Differs from the preceding by the leaflets truncate, not rounded, obtusely dentate at the top, in verticils of six to nine; the veins are less numerous. Found especially in the upper coal measures, but not common.

S. LONGIFOLIUM, *Germ.*

Plate 7, *f.* 10, 11.

Stems robust; leaflets large, one and one-half to three cm. long or more, either bifid at the apex with lobes merely crenate or deeply dentate or split in long acuminate divisions (f. 11); veinlets numerous, not confluent at base; verticils of six to nine leaflets. A very fine species apparently rare. I have seen specimens from the low coal of Clinton, Mo., and from the Pittsburg coal, an upper vein.

S. CORNUTUM, *Lesq.*

Stem thick, obscurely striate; branches nearly at right angles; verticils of six leaflets, connate to above the base, broadly cuneiform, divided from the middle into seven to nine linear obtuse nearly equal lobes; veins distinct, flat, four to five at the base of each leaflet, forking once only, each division ascending to the top of one of the lobes. A very remarkable species, the leaflets being divided like the fingers of a hand. Found only as yet at Colchester, Ill.

S. FILICULME, *Lesq.*

Plate 7, *f.* 8.

Branches slender, very long, filiform; verticils of six narrow leaflets, the lateral twice as long as the two inferior ones, all narrowly cuneiform, truncate and dentate at the upper borders; primary nerves two to three, distinct at base, forking twice. Not uncommon, and found in the whole extent of the coal measures, even at the base of the Permian of Virginia.

On account of the difference in the length of the leaflets, a difference which may be caused by habitat in the water or uopn its surface, this form has been considered as a variety of the following species. It is, however, found locally always with the same characters.

S. OBLONGIFOLIUM, *Germ.*

Plate 7, *f.* 9.

Leaves obovate-oblong, bifid to the middle, one to three acutely dentate, in verticils of six. A rare species, found only at Cannelton.

It is well to observe that the species of this genus are all subject to great variety by the size and subdivisions of the top of the leaflets. That is shown by the multiple synonymy of the species published by European authors.

S. PRIMÆVUM, *Lesq.*

Plate 3, *f.* 4-6.

The species is made from specimens too fragmentary to afford a satisfactory specific diagnosis. It is, however, evident that the fragments represent, either by stems or by separate leaflets, a species of this genus very closely allied to *S. Schlotheimii.*—All these fragments have been found in the Cincinnati group of the Hudson River epoch, lower Silurian.

MACROSTACHYA, *Schimper.*

Plate 5, *f.* 7.

Plants arborescent, articulate; articulations close, smooth or the internodes thinly striate; outer surface distinctly striate or plano-costate, with very narrow furrows alternating at the articulations; leaves appressed, linear, carinate and simply nerved in the middle, acuminate and finally truncate; leaf-scars marked upon the articulations by transversely oval rings; scars of branches verticillate, large, round, umbonate with a stigmarioid central mammilla; spikes very large, cylindrical; bracts lanceolate, costate in the middle, imbricate, scarcely longer than the internodes.

The above definition is taken from Schimper's "Vegetable Paleontology," for I know, of the plants of this genus, only fragments of stems like the one figured and the large spikes which I have figured (pl. 4, f. 7 and 8), and which the author refers to *Macrostachya.* Some of them are very large, oblong, larger in the middle, narrowed upward or downward or cylindrical and sometimes curved, varying in length from four to eighteen cm. and from one to four cm. in diameter. Sometimes their base is marked upon the shale by circular impressions nearly as large as the broad scars at the base of pl. 5, f. 7, but often also they are narrowed into a pedicel, as in pl. 4, f. 7, and therefore do not seem to have any reference to the large stems, being apparently attached to small branches like the spikes of *Calamites;* hence the relations of these peculiar organs is still uncertain. The large spikes, though not very common, are found in the whole thickness of the coal measures. The stems are per contra very rare. The two fragments which I have seen come from the coal of Cannelton, where the large spikes are abundant enough.

SECOND CLASS.

FILICACEÆ, (*Ferns.*)

Everybody knows the ferns. They grow everywhere, in every kind of climate, in the cold regions of the North, where they are rare, becoming more and more abundantly distributed toward the equatorial countries, especially in the islands, wherever atmospheric humidity predominates.

The Ferns belong to the Acrogens, plants with a distinct axis, gradually unfolding from the apex only, composed of woody fibers and vessels. They have that in common with the *Equisetaceæ*, but they differ from them by the apical uncinate development of their stems and branches and by their leaves, flat and thin laminæ, either entire or divided in multiple sections, according to the characters of their nervation.

Fossil remains of this class of plants have been found in the lower Silurian of France, in a specimen representing a branch with leaves of large size, already denoting an advanced stage of development. This fragment discovered at the base of the middle Silurian, near Angers, and described by Saporta as *Eopteris Morieri*, is figured (pl. 3, f. 9). No remains of ferns have been found as yet in this country lower than the Devonian. But in this formation, the ferns are already so numerous and represented by species of so large development, that their first appearance or their origin on the North American continent may be rationally supposed to be much older, at least as old as it is in France or in the upper part of the lower Silurian.

Ferns show the greatest degree of predominance in the carboniferous age, where the number of their species, extremely diversified, is considerably larger, at least locally compared, than it has been at the preceding geological periods and even than it is at the present time; for the number of species already described from the carboniferous is nearly one thousand. At the present epoch more than three thousand species of ferns are known. But we must consider that the coal flora, though widely distributed, was governed by permanent and uniform atmospheric and geological circumstances, while now the ferns are distributed over all the part of the world inhabited by man, and therefore, their life is modified by the greatest differences in the temperature and habitat, according to the localities where they are found. Taking for comparison some countries where the circumstances of climate are not much varied, the superiority of the vegetation of the ferns at the coal epoch appears very great in favor of the carboniferous. For example, the Philipine Islands have only three hundred species of ferns; Java and Southeastern Africa, four hundred; the islands of the Gulf and the eastern intertropical shores of America, six to seven hundred.

Atmospheric moisture and a high uniform degree of temperature essentially favor the vegetation of the ferns. These elements were, it seems, at the highest degree during the Carboniferous period, hence the luxuriance of the vegetation of ferns which at that epoch, covering all the low grounds, either as thick bushy species of the undergrowth, or as trees, have contributed by their remains at least one-half of the materials which compose the coal. The fern-trees now inhabit intertropical regions, especially the islands of the Pacific Ocean, or the slopes of high mountains near the equator. There, in foggy regions, they sometimes reach an altitude of one hundred feet. Their shape is most graceful (pl. 8, f. 1); their trunks, simple or without branches and cylindrical, are generally covered by the scars of the base of decayed leaves (f. 5, 6, 7), very varied in forms, and their fronds (whole leaves) are cut into multiple, always graceful, subdivisions. At the present time the trunks of tree-ferns rarely measure thirty cm. in diameter; in the coal measures silicified trunks of ferns are found twice as large.

The bushy ferns of the coal were also generally of very large size. Though most of them are known only by small fragments of stems and leaves, parts of fronds are seen on the roof-shale of the coal beds, measuring three or four meters in length and proportionately large, with flattened stalks fifteen to twenty cm. broad.

The ferns are perennial, herbaceous, climbing or arborescent plants. Their branches and branchlets are, before expansion, convolute in spiral, like a watch spring (circinate vernation), and gradually unfold in their march of development. The stems grow up from inflated or more or less elongated creeping organs, rhizomas (root-stalks). The rhizomas are generally, for the bushy herbaceous ferns at least, of soft cellular tissue, and therefore easily decomposed and destroyed by maceration. Their remains are very rarely found preserved in the coal measures.

The fronds, that is leaves of ferns including the stalks, are simple, without division of the axis (petiole or rachis), or more generally branching; the branches (pinnæ) are primary when attached to the main axis (rachis), secondary as divisions of primary pinnæ, tertiary, quaternary, and so on for the subdivisions.

The branches of the fronds are either pinnate by opposite or alternate branches on both sides of the rachis, or dichotomous by the forking of the stems and branches as seen pl. 8. f. 2. Very often the primary and secondary divisions are dichotomous while the branches are pinnate.

As it is very rare to find fronds of ferns preserved entire in a fossil state, and as the paleontologist has generally mere fragments for its description, the preserved part of a fern is often described as leaf or pinna and the divisions accordingly as primary, secondary pinnæ, etc. The foliate divisions are pinnules or leaflets, which are entire or lobed, or cut in various forms and described with the same terms as for the dicotyledonous plants.

The more important characters to be considered in the determination of the ferns are their nerves or veins, and the fructifications. The fruiting organs, being generally absent or destroyed by maceration, the nervation has therefore to be studied with the greatest care. The first nerve traversing the pinnules, sometimes lengthwise, is simple and then it is generally strong, often looking like a division of the rachis. It is more essentially divided and subdivided in the same way as are the fronds, in primary, secondary, tertiary nerves or veins, the ultimate divisions reaching the borders of the leaflets, being the nervules or veinlets; the veins are then pinnate, bipinnate, etc. Often, also, no medial nerve being formed, the veins may be all of about equal thickness, either parallel at base along the rachis, pl. 11, f. 1, 2, or diverging fan-like from the base or from a point of the leaflets (pl. 10, f. 1, 2, 6), and filling them, either straight or curving back, alternately forking in ascending. This kind of venation is flabellate and dichotomous.

Sometimes the veins in passing up towards the borders from their base are curved in numerous flexures, which become joined in the middle, as in pl. 11, f. 3–4, forming a reticulate nervation.

The fruitifications (fruit dots) of ferns are generally placed upon the lower surface of the leaflets in small receptacles supporting or containing the capsules (sporanges) which bear the *sori* (glomerules of seeds). Not only, as said above, the fruitifications of the ferns of the coal measures are rarely found, but when present, the sporanges are generally obscure and the disposition of the *sori* is rarely distinct enough to allow the determination of their characters. Hence it has not been possible to fix, as is done for the living ferns, a classification based upon fructifications. It is therefore upon the characters which may be clearly seen, those taken from the arrangement and ramification of fronds or leaves, the forms and subdivisions of the pinnules and especially the nervation, that the distribution of the ferns in groups, genera and species has been established.

Brongniart's Classification, which is still generally followed, is based upon these different characters. It is abridged by Schimper in his "*Paleontologie Vegetale*", as follows:

1. Frond simple or with compound pinnules, free or adhering, without medial nerve or with a mere basilar nerve vanishing upward; veins dichotomous or flabellate (*Neuropterideæ*), pl. 10.

2. Frond bi, tri or many times pinnate, with pinnæ or pinnules narrowed to the base, flabelliform, entire or scarcely lobed; veins diverging from the base without a distinct midrib. (*Adiantideæ.*) Pl. 9, f. 3, 4.

3. Fronds divided as in the last group, diversely lobed; veins pinnate or bipinnate from the base. (*Sphenopterideæ.*) Pl. 15.

4. Fronds simple, pinnate, bipinnate or tripinnate, with pinnules generally adhering by their base to the rachis, often confluent by the borders, forming more or less deep lobes, entire or serrulate, not lobed, secondary veins pinnate or dichotomous. (*Pecopterideæ.*) Pl. 14.

A number of other classifications, among them that of a Ettingshausen, have been more recently proposed, but they are more complex and can not be well understood without a long series of figures. I have, therefore, followed here that of Brongniart, merely changing the order of the groups in accordance with the relation of the plants to be described.

1. NEUROPTERIDEÆ.

(*Neuron*, nerve; *pteron*, wing.)

This order of fossil ferns contains the genera *Neuropteris*, *Lesleya*, *Dictyopteris* and *Odontopteris*, which constitute a distinctly characterized and most interesting group of ferns, all bushy, generally of large size, with long dichotomous pinnæ and pinnules of beautiful forms. These ferns have no analogy to any species living at the present time. They appear already in the Silurian, as far at least as can be seen by the form of the leaflets and the nervation of *Eopteris Morieri*, Sap., mentioned above as the oldest known species of fern. In the Devonian, they are represented by fragments of pinnæ bearing large nearly round or cuneiform leaflets; in the sub-carboniferous they are already found in a large number of species, but still more abundantly in the middle coal measures, preserving always the same typical characters, up to the Lower Permian, where they disappear entirely.

NEUROPTERIS, *Brgt.*

(*Neuron*, a nerve.)

Fronds dichotomous in the lower part, tripinnate in the upper, pinnules varying from round to ovate, obtuse or rarely acuminate, mostly entire, round, cordate or auricled at the base, attached to the rachis by the middle, sessile, rarely short pedicellate; veins either coming out all from the base of the pinnules (pl. 10, f. 2, 6, 7), or from a medial nerve (*costa*), (pl. 10, f. 3, 5), diverging fan-like, arched backward in passing toward the borders, many times dichotomous, the costa generally dissolved at or below the middle.

Two genera of Brongniart, *Cyclopteris* (*kuclos*, circle) and *Nephropteris*, are now forcibly united to this one. To *Cyclopteris*, were referred round, separate leaflets, like pl. 10, f. 7, which were supposed to belong to peculiar species, but which are now known to be merely lower leaflets attached to large stems, mostly in the forks or the base of pinnæ of *Neuropteris*. The lower leaflet (pl. 10, f. 4) shows already a deviation of the common form, which is still more marked in f. 7 of the same plate. To the genus *Nephropteris* were referred separate oval or ovate leaflets, with all the veins diverging from the base, as in pl. 10, f. 1, where the small basilar leaflets have this character, and therefore should be placed in the genus *Nephropteris*, while the large leaflets of the same species, as seen in the figure, have a distinct medial nerve from which the veins are derived. Until recently these small leaflets have been found always separated, and their true characters in the composition of the pinnæ had not been recognized.

The fruitification of *Neuropteris*, and indeed that of all the *Neuropterideæ*, is not positively known. Small oval tubercles are sometimes seen in the forks of the veins near their base, on the surface of some species of *Neuropteris*, but they are much like those small parasitic excrescences (*fungi*), seen upon the leaves of ferns and other living plants. What seems to confirm the opinion that those small tubercles represent the fruitifications of *Neuropteris* is the discovery in France of true sporanges having about the same forms as those of *Neuropteris* and attached upon the point of the veins at the borders of the leaflets of *Odontopteris*. I have already figured this kind of organism upon leaflets of *Neuropteris gibbosa* in the first Geological Report of Pennsylvania, 1858, (pl. 5, f. 3).

The more common and more remarkable species of *Neuropteris* are those with trifoliate leaves, one of the leaflets being very large, ovate, obtuse, terminal, the other two small, round or oval, basilar. Of these are *N. hirsuta*, *N. decipiens*, *N. cordata* and *N. angustifolia*, (the last pl. 10, f. 1), all very similar in all their characters, differing merely by the surface smooth or covered with hairs, the veins more or less close, the size of the leaflets, which in *N. decipiens* attain a length of twelve to fifteen cm. long and four to six broad. Though the nervation appears exactly the same in these species, the difference in the closeness of the veins is readily seen in counting their number as marked on one cm. of space at the borders of the leaves. Then those of *N. fimbriata* (pl. 10, f. 2) with leaflets variable in size, sometimes as small as f. 4 and oval, sometimes twice as large as in f. 2 and round, always beautifully and distinctly fringed on the borders. *N. Elrodi* (pl. 10, f. 3) represents a species not rare in the sub-carboniferous sandstone or on the shale of the whetstone beds of Indiana, where it was found by Dr. Elrod. It is represented in the coal fields of Alabama, also, with *N. Smithii*, which has the same kind of nervation, but the leaflets broadly oval or nearly round. One of the most common species and the more widely distributed, found as it is from the sub-conglomerate measures to the Permian, is *N. Loschii* (pl. 10, f. 4). I have represented only an ultimate pinna, the primary pinnæ being very large, alternately and pinnately branching and the leaflets generally of the same size as figured; the lower pinnules become round or cyclopterids towards the base of the fronds; f. 7 is one of these. It has been described as *Cyclopteris elegans*, before its relation to *Neuropteris Loschii* was recognized. F. 5 and 6 are two leaflets of a peculiar form, *N. callosa*, which shows the great diversity of the pinnules of the same species; the leaflets (f. 5) are attached pinnately like those of f. 4, while those like f. 6 are basilar. Their identity is perfectly ascertained by the characters of the nervation. This shows how difficult it is sometimes to specify fragments of ferns, and how many species could be made from a single plant, if one would consider only as characters the peculiar forms of the leaflets. The number of American species of *Neuropteris* described until now amounts to more than forty.

ODONTOPTERIS, *Brgt.*

Plate 11, *f.* 1, 2.

(*Odous*, a tooth.)

Fronds large, bipinnate; pinnæ opposite or subalternate; pinnules of various forms, generally oblong-obtuse, joined to the rachis by their whole base (not by the middle only), sometimes decurrent, either disjointed and separated to the base, or connate to the middle, becoming confluent toward the top of the pinnæ and gradually effaced in passing to a terminal leaflet; lower pinnules sometimes attached to the main rachis and difform; veins derived from the rachis, more rarely from a midrib, thin, dichotomous, diverging straight or in slight curves in passing out to the borders.

This genus is so intimately allied to *Neuropteris* that some of its species, like *Odontopteris Alpina*, *O. Worthenii*, are indifferently ascribed to one or the other of the two genera.

The species of *Odontopteris* were bushy ferns with immense fronds. Some have been seen five to six meters long with petioles more than thirty cm. broad. Their distribution in the geological measures is about the same as that of the species of *Neuropteris*. No species, however, are known in America from the Devonian; they appear somewhat later, that is, at the base of the millstone grit, being more predominant in the first coal above these measures, at Mazon Creek, etc., where the largest number of species have been observed. Some of peculiar types are found in the upper coal beds of Pittsburg, and above it in the permo-carboniferous measures. In Europe many species have been described from the Permian.

The more notable species are:

ODONTOPTERIS ALPINA, Gein.

Fronds dichotomous or irregular in their divisions, pinnules, either large, obtuse, attached to the rachis by the middle of their base, like the leaflets of *Neuropteris*, or smaller, half round, attached by their whole enlarged base, and therefore with the true characters of the genus. The veins are rarely straight, but generally curved back as in *Neuropteris*.

O. CORNUTA, *Lesq.*

Known merely by a few leaflets lanceolate in outline, entire towards the base, divided from the middle upward in linear lanceolate acuminate lobes irregularly placed, the terminal one being generally longer, linear lanceolate.

O. HETEROPHYLLA, *Lesq.*

Has some likeness to the preceding by the great variety of forms and sizes of the pinnules or of the lobes, which are short, half round, reniform, or long, linear lanceolate.

O. SUBCUNEATA, *Bunb.*

Pinnæ linear, with distant oblique ovate or cuneate pinnules, obtusely acuminate or obtuse, auricled at base, enlarging or decurring to a broad point of attachment. A new species, *O. affinis*, (pl. 11, f. 1) closely allied to this, has the leaflets oblong, very obtuse, attached by the whole decurring base, which is never auricled.

O. SCHLOTHEIMII, *Brgt.*

Pl. 11, *f.* 2.

Fronds bipinnate, with primary divisions oblong-lanceolate, enlarged in the middle, the secondary pinnæ at right angles or somewhat oblique, pinnately divided in oval obtuse pinnules, the lower nearly free, the others generally smaller, more and more confluent toward the apex where they pass into small deltoid or lanceolate obtuse terminal pinnules; veins parallel from the base, distinct and distant, forked above the middle.

Of the eighteen species described in this genus from the United States coal measures, four only are European.

LESLEYA, *Lesq.*

Pinna or leaf simple, very entire or deeply lacerate on the borders, broadly lanceolate, gradually narrowing towards the base, obtuse, traversed by a thick costa effaced under the apex, veins oblique, curved, equal, repeatedly dichotomous.

This genus is known by one species only, *L. grandis*, represented by some beautiful leaves or simple pinnæ found under the Chester limestone of Illinois, by Prof. A. H. Worthen. It is intermediate for its characters between *Neuropteris* and *Glossopteris* of Brongniart, this last genus containing only jurassic species and distinct by the veins reticulate at base, nearly as in *Dictyopteris*. The leaves of *Lesleya*, one of which is preserved entire, are twenty-two cm. long, eight cm. broad in the middle.

DICTYOPTERIS, *Gutb.*

Plate 11, *f.* 3, 4.

Fronds bipinnate, pinnules cordate, truncate or rounded at base, sessile by the middle or short pedicellate, oblong, obtuse or lanceolate, entire; veins flexuous, connected by flexures or intersections, forming a more or less distinct and close reticulation of polygonal meshes.

Though the genus is widely distributed from the sub-carboniferous to the upper coal strata, its species are few and generally found in small fragments. Two of them, which have been described from American specimens, are proper to this continent: *Dictyopteris rubella*, pl. 11, f. 4, with a bi or tripinnate frond and leaflets either smaller oblong obtuse or broadly lanceolate, or larger nearly round (cyclopterid) cordate auriculate at base narrowed to an obtuse apex all entire: *D. obliqua*, pl. 11, f. 3, whose leaflets, at right angles to the rachis and very close, are all of the same size and form, oblong, somewhat narrowed to an obtuse apex and falcate or slightly curved inward, the meshes of the areolation being close and round polygonal.

GENERA OF INDEFINITE RELATION.

In "United States Coal Flora" the following genera have been considered separately as being without distinct relation to any of the groups established by the authors: *Megalopteris*, Daws; *Tæniopteris*, Brgt.; *Neriopteris*, Newby.; *Orthogoniopteris*, Andrews; *Protoblechnum* and *Idiophyllum*, Lesq. Of these, the two first only have been described from good specimens with reliable characters.

MEGALOPTERIS, *Daws.*

(*Megas*, grand.)

Plate 9, *f.* 2.

Fronds very large, simply pinnate; pinnæ or leaflets oblique, lanceolate, entire, decurring by the prolonged lower side upon the main rachis which is thus alate, the prolonged part of the pinnules joining at base the upper basilar border of the ones underneath; medial nerve thick; veins all emerging from the thick rachis, obliquely diverging toward the borders, dichotomous and curved upward in reaching them.

The name of this genus implies for the fronds of its species a very large size. Indeed some fragments of leaves have been found measuring eleven and one-half cm. in width, indicating a length of sixty cm. Eleven species of *Megalopteris* have been described. But as the nervation is scarcely different in any of them, and the form of the leaflets is much the same, this number will probably be reduced when good specimens have been obtained. All the species are sub-carboniferous or upper devonian.

TÆNIOPTERIS, *Brgt.*

Plate 11, *f.* 5.

(*Tænion*, ribbon or band.)

Fronds or pinnæ simple, large, linear; medial nerve or rachis broad, canaliculate; veins at right angles to the costa, either simple or forking a little above the base, very thin and close.

The species of this genus are considered as Permian or Permo-Carboniferous by the European authors. *T. Smithii*, Lesq., figured as above, has been obtained in the sub-conglomerate coal measures of Alabama.

Of the other genera, *Neriopteris* and *Orthogoniopteris* are more or less uncertainly defined, as they have been established each for a simple species and from fragmentary specimens. *Danæites*, a genus of Gœppert, has its essential characters taken from the position and the form of the sporanges. The two species which I have referred to it have the nervation of *Alethopteris*, and should perhaps be placed in this genus. The last, *Idiophyllum*, is established for a very peculiar, nearly round coriaceous leaf, with a thick medial nerve, gradually effaced upward, thick lateral veins, sub-opposite, oblique and curving in passing toward the borders, crossed nearly at right angles by continuous equidistant venules, which appear as folded up in contrary directions, forming by intersections regular quadrate meshes. The characters of this leaf, figured in "United States coal flora" (pl. 23, f. 11), totally at variance with those of any species of ferns of the carboniferous, are somewhat like those of a dicotyledonous leaf; the nervation, however, recalls the type of some Jurassic species of ferns. This leaf has been found in the concretions of Mazon Creek. A few species of this genus have been lately described by Prof. Schenk, from the Carboniferous of China; none as yet from that of Europe.

PSEUDO-PECOPTERIDEÆ.

To this group pertain the genera *Lescuropteris*, *Callipterdium*, *Alethoptheris*, *Protoblechnum*, *Pseudopecopteris*, *Pteris* and *Oligocarpia*. The three first of these genera are intermediate between *Neuropteris* and *Pecopteris*.

LESCUROPTERIS, *Schp.*

Pl. 11 *f.* 6.

(Personal name.)

Fronds large, tripinnate; rachis broad, foliate; pinnæ close, pinnatifid, oblique; lobes ovate, obtuse or acute, inclined outside, connate to the middle, decurrent; primary nerves thin, dichotomous; lower pairs of lateral veins emerging from the rachis, the other alternately from the midrib, forking twice, the upper once only.

The two species described, *L. Moorii*, Lesq., and *L. adiantites*, Lesq., pl. 11, f. 6, are from the upper coal of Pennsylvania.

CALLIPTERIDIUM, *Weiss.*

Plate 12, *f.* 1.

(*Kallos*, fine.)

Fronds large, polypinnate; pinnules attached to the rachis by the whole base, often decurrent, the lower descending to the main rachis, all connate or disjointed at base, primary nerves distinct, often strong, dissolved below the apex; lateral veins oblique, curved backward in passing to the borders, dichotomous, the lower generally attached to the main rachis.

By the dichotomous divisions of the arched veins, this genus is related to *Neuropteris;* by the mode of attachment of the pinnules and by their form to *Alethopteris* or even to *Odontopteris*. Its more important species are:

C. SULLIVANTII, *Lesq.*

Plate 12, *f.* 1.

Pinnæ long, linear-lanceolate; leaflets large, decurring, lingulate, rounded at the enlarged apex, narrowed, connate and decurring toward the base; costa very thick, flat; veins thin, close, dichotomous, the lateral nervation being that of *Neuropteris*.

This beautiful species is not rare in the coal above the conglomerate, especially in the nodules of Mazon Creek.

Callipteridium Mansfieldi, *Lesq.*, *C. neuropteroides*, *Lesq.*, are two species of the same type and closely allied to the preceding, while *C. Owenii*, *C. inæquale*, *C. Prardeei*, are more distinctly related to *Alethopteris*. The other species, *C. Aldrichi*, *C. membranaceum* and *C. Massilloneum* are like true *Alethopteris*, and should have been referred to this genus except for the curving back of the veins. *C. rugosum*, Lesq., pl. 13, f. 1, is more distinctly related to *Pseudopecopteris*.

The distribution of the genus appears limited to the upper strata of the sub-conglomerate coal measures, and to the lowest of the middle, especially.

ALETHOPTERIS, *St.*

Plate 12, *f.* 2.

Fronds polypinnate, pinnules coriaceous, mostly entire, enlarged at base, connate or free, with borders generally reflexed; medial nerve thick, immersed into the epidermis, marked by a groove on the upper face of the leaflets, prominent on the lower; lateral veins open, often at right angles to the rachis, simple or forking once, continuous, derived from the main rachis between the primary nerves.

The separation of this genus from *Pecopteris* is not marked by a very definite line. The only characters which I consider as distinctive of the two genera are the presence of the rachial veins in *Alethopteris*, the larger size of the pinnules and the direction of the veins more at right angles from the medial nerve. The fructifications of this genus, also, appear to be marginal, the sori being placed under the reflexed margin as in the living *Pteris* or *Pellea*, while those of *Pecopteris* are round, separate and generally placed in two rows upon the lower surface of the pinnules.

The distribution of the genus is the same as that of *Callipterdium*. Most of its species have been found either in the upper part of the sub-conglomerate coal strata or immediately above the millstone grit. Of the eleven species described in the coal flora the most common and distinctly characterized are:

A. SERLII, *Brgt.*

Plate 12, *f.* 2.

Generally found in large pinnæ whose pinnules are all linear-lanceolate, sub-obtuse, like those of the upper part of f. 2, with the secondary veins at right angles, very close, either simple or forking once from near the middle.

A. LONCHITICA, *Schloth.*

Much like the last; but the pinnules are generally smaller, disjointed to the base and extremely variable, sometimes broad and obtuse, sometimes narrow linear and acute; the terminal pinnules are long, linear-lanceolate; the lateral veins also nearly at right angles, are more distant, simple and more rarely forking from near the base.

A. AQUILINA, *Schloth.*

Resembles the preceding; it has the pinnules shorter and comparatively broader, the veins slightly oblique, forking twice, while *A. ambigua*, Lesq., smaller in all its parts, has the veins mostly obsolete, covered as they are by a thick epidermis, distant, simple or forking once. The medial nerve is comparatively very thick, abruptly dissolved under the apex of the leaflets.

PROTOBLECHNUM, *Lesq.*

Fronds large, simply pinnate; rachis very thick, scaly towards the base; pinnæ long, narrow, linear-lanceolate, acuminate, entire, enlarged at base on the lower side into a decurring auricle, generally free; medial nerve strong, reaching the apex; veins at a broad angle of divergence, curving in passing to the borders, forking twice.

The only species *P. Holdeni*, Andr., is represented by two opposite extremities of a frond which was apparently fifty to sixty cm. long. The simple pinnæ are much shorter toward the base of the frond, only two cm. long, while those of the middle are six to seven cm. long; the rachis is one cm. broad at base, where it is covered with a thick coating of long scales; the nervation is oblique and arched, nearly as in species of *Callipterdium*, a genus from which it differs essentially by its simply pinnate frond. The specimens were found in the Waverly formation of Ohio at the base of the lower coal measures.

PSEUDOPECOPTERIS, *Lesq.*

(*Pseudos*, false.)

Plate 12, *f.* 3; *pl.* 13, *f.* 2.

Primary rachis forking near the base in diverging branches of equal size or divaricate and dichotomous; branches polypinnate; ultimate divisions sometimes forked; pinnules connate or separated to the base, of various shape, oblong, obtuse or ovate, lanceolate, oblique, or at right angles, simple or diversely lobate, generally decurring to the rachis and bordering it by a narrow wing; lateral veins oblique, generally forking once, the lowest pair twice; sometimes dichotomous.

This genus includes a large number of species whose essential and common character is the dichotomous division of the fronds, especially in the lower part of the stems. The character of the leaflets, their relative position, their shape and nervation are variable, sometimes like those of *Pecopteris*, sometimes also like those of *Sphenopteris*, and for that reason, the plants which are now embodied in a single genus, were indifferently referred by the authors either to *Pecopteris* or to *Sphenopteris*. Though differing in their specific characters, they all have, besides the dichotomous division of the stems, a peculiar and common facies, the leaflets often being more or less regularly lobate as in pl. 12, f. 3, or the primary nerves by decurring to the rachis and joined by all the secondary ones, leaving a distinct smooth border along the base of the pinnæ, as in pl. 13, f. 2.

The fructifications of *Pseudopecopteris* are not positively known. In the first section of the genus containing species whose relation is marked to *Pecopteris* by the form of the leaflets and their relative position, fruiting pinnæ of one species, *P. Mazoniana*, have been observed with large round sori, placed in simple rows along the border of the pinnules, near the end of the upper branches of the veins containing three to four oblong sporanges placed star-like around a central point, therefore, very much like the fructifications of *Pecopteris*, as seen (pl. 13, f. 3a and 3b). This first section should then seem more appropriately placed with *Pecopteris*, though the ramification of the branches is evidently dichotomous. But fructifications of an analogous character are also seen in *Gleichenia*, a genus of ferns which, still represented in the flora of this epoch by a number of species, was already present in the jurassic flora and became predominant in that of the Cretaceous. Therefore the species composing the first section of *Pseudopecopteris* have their proper place in this new genus as related to the *Gleicheniecæ*. From recent observations made in Europe, the fructifications of species of the 2d section are analogous to those of *Dicksonia*.

Of the three species composing the first section, *P. Mazoniana*, Lesq., is the more remarkable. Its size is larger than that of any species of *Pecopteris*, the primary pinnæ are pinnately divided in the lower part and forked near the top; the pinnules are large, oblong, half round at the apex; the veins are pinnate distinct and forking once in the middle from a thick medial nerve. Fine figures are given of this species in the U. S. Coal Flora, pl. 32.

The distribution of the twenty-five species which compose the second section, is in accordance with the relation of their characters. Ten species are sub-conglomerate, one of them found even at the base of the carboniferous in its point of union to the Devonian. They are all composed of lobate, or more generally of trilobate leaflets, like *P. muricata*, Brgt., pl. 12, f. 3, a species most common in the Whetstone beds of Indiana, to which *P. glandulosa*, Lesq., *P. latifolia*, Brgt., *P. acuta*, Brgt., *P. speciosa*, Lesq., *P. virginiana*, Meek, *P. trifoliata*, Brgt., *P. polyphylla* and *P. macilenta*, Ll. and Hutt., are closely related. Ten species of the same section are found at the horizon of the first coal above the Millstone grit. The more remarkable are *P. Newberryii*, pl. 13, f. 1, allied to *P. nervosa*, Brgt., *P. Plukeneti*, Brgt., *P. dimorpha*, Lesq., *P. anceps*, Lesq.—*P. irregularis*, St., though found above the conglomerate is analagous to *P. trifoliata*, Brgt., which is sub-conglomerate, but has also been found in small fragments above the Millstone grit.

In order to give a better insight into the characters of these ferns, I describe the more important species of the second section.

PSEUDOPECOPTERIS NERVOSA, *Brgt.*

Fronds tripinnate or compound, dichotomous and multifid; primary pinnæ large, broadly lanceolate; secondary divisions open, linear-lanceolate toward the apex; pinnules oblique, connate from the base or above, ovate, obtuse or lanceolate obtusely acuminate, the inferior ones on the lower side generally bilobate; medial nerve effaced above by divisions; lateral veins all derived from the midrib, at an acute angle of divergence, forking once. A large beautiful fern, not rare in the sub-conglomerate measures and in the first coal above the conglomerate.

P. PLUCKNETI, *Schloth.*

Somewhat like the preceding, but smaller in all its parts, the pinnules entire, undulate and crenulate on the borders, the lower not lobate, the lower veins forking twice, the upper only once, all distinct but not inflated. Species common above the Millstone grit, not observed under it.

P. NEWBERRYII, *Lesq.*

Plate 13, *f.* 2.

Pinnæ divided at the top in two diverging branches; secondary pinnæ short, distant, nearly at right angles to the rachis; pinnules about as in the preceding species, the veins being all forking once only, the up per simple. The frond appears small and simply forking at the top of the stipe, but never pinnate. I have seen small plants not higher than four cm. and in an apparently incipient state of development, with exactly the same characters as those of the one figured.

P. MURICATA, *Brgt.*

Plate 12, *f.* 3.

Fronds very large, decompound and dichotomous or polypinnate; secondary pinnæ long, linear-lanceolate; tertiary divisions open, sometimes at right angles, distant; pinnules distant, variable in shape, lanceolate-acuminate, sometimes distinctly lobate, the lower lobes half round, the terminal pinnules acute, or the upper lanceolate, entire or undulate; primary nerve thick, dissolved under the apex; lateral veins thick, more or less inflated toward the borders, the upper forked once, the lower twice. Mostly sub-conglomerate. The figured specimen is from the Whetstone beds of Indiana.

P. ANCEPS, *Lesq.*

Frond divided as in the preceding species; pinnæ of the third order oblique, distant, rigid; ultimate pinnæ short, inclined upward, lanceolate or oblong; pinnules short, round, ovate or subquadrate, the lowest generally free, the upper ones gradually more and more connate, the ultimate becoming simple and undulate by the cohesion of the pinnules; veins forking twice, either derived from a thin middle nerve, or dichotomous and flabellate from the base. Species locally very common above the conglomerate.

P. LATIFOLIA, *Brgt.*

Frond tripinnate, bipinnate above; secondary pinnæ long, with a thin alate rachis; pinnules distant, inclined outside, ovate-lanceolate in outline, deeply lobed; lobes half round, entire, the lower sometimes irregularly dentate; middle nerve flexuous; lateral veins dichotomous, curved, forking once or twice; substance of the pinnules very thick, coriaceous—rarely found. The only good specimens I have seen are from the sub-conglomerate of Alabama.

P. acuta, Brgt., has the same characters as the last, but the terminal pinnules are acute.

P. speciosa, Lesq., and *P. Virginiana*, Meek, are two splendid species whose divisions of stems and leaves have great analogy to those of *P. muricata*, but are all much larger, with pinnæ and pinnules flat, the rachis winged. The nervation is of the same character. Both these species are sub-conglomerate and sub-carboniferous, *P. Virginiana* being found at th very base of the carboniferous measures.

PECOPTERIDEÆ.

PECOPTERIS, *Brgt.*

Plate 13, *f.* 3; *pl.* 14, *f.* 1, 3 *b.*

Fronds bi, tri or poly-pinnate; ultimate pinnæ long, pinnatifid; pinnules adhering to the rachis by their whole base, free or more or less deeply connate at base, open or inclined but not decurring, borders generally contiguous or nearly so; secondary veins derived from the medial nerve of the pinnules, simple, or bi-trifurcate; fructifications often preserved as round sori, in simple or double rows along the borders, and composed of sporanges generally placed star-like around a central point. (Pl. 13, f. 3, 3 b.)

The species of this genus are very numerous and variable, especially in the form and relative position of the pinnules. Schimper, in "*Paleontologie Vegetale*," has grouped them in separate sections according to their apparent relations to genera of ferns of the present epoch. This mode of division being difficult to understand for those who are not well acquainted with the living ferns, I have admitted the following sections, established from characters which, observable upon fossil species of the coal, are generally persistent and more easily recognized:

1. *Pecopteris goniopterids* (*gounos*, fructified). Lateral veins simple or forking, incurved.

2. *Pecopteris proper* or *Cyatheoides* (*kuathos*, cup), answering to the characters described for the genus. The leaflets are generally coriaceous, of coarse substance, convex on the upper face. The species of the group are sub-divided according to their nervation either in simple or in once or twice forked veins. (Pl. 14, f. 1, 2.)

3. *Pecopteris villous*, whose leaflets have the surface hairy or villous.

4. *Pecopteris crestate*, whose pinnules are short, lobate or cut at the apex in two or three small teeth.

Of the group of the *Goniopterids*, the more important and common species is *P. unita*, Brgt., (pl. 13, f. 3). I have figured merely an ultimate pinna with the pinnules contiguous in their whole length, the veins simple, incurved; the fructifications seen upon separate leaflets. But the fern was very large, its secondary pinnæ broad and short with the tertiary ones like that figured, close, all of the same length and character. Another species, *P. emarginata*, has the tertiary pinnæ much longer and broader, some of them fourteen cm. long, two and one-half cm. broad, but all the characters, nervation, fructifications, form of the pinnæ, are so exactly like those of *P. unita*, that these large leaflets, always found separate from the stems, have been considered by some authors as representing a large form of the same species. *P. longifolia*, Brgt., *P. lanceolata*, Lesq., are, however, positively distinct species, the pinnæ being entire, not lobate nor undulate on the borders. *P. arguta*, Goep., has the veins thick, oblique, parallel, straight to the borders, not incurved. These last named species and two others composing the group are rarely found in the American Carboniferous; the two first are common enough. All pertain to the supra-conglomerate measures.

PECOPTERIS (*Cyatheoides*.)

The species of this group were mostly tree-ferns, hence their remains are locally very abundant. I have seen a whole cabinet of carboniferous fossil plants composed merely of fragments of fronds and pinnæ of the same species. Of course these fragments are mostly different, representing pinnæ of first, second, third degree of divisions, all of peculiar and sometimes so varied characters that it is at first difficult to recall them to one species only. None of the species of this group have been as yet found below the Millstone grit, at least in the North American

Carboniferous. Among the more noticeable are *P. arborescens*, Brgt., which takes its name from the elegant shape of its pinnæ, comparable to that of a miniature tree. Its pinnules are small, the lateral veins simple. In the lower part of the branches, the ultimate pinnæ become much longer, the pinnules narrow, close, of unequal length and the veins forking once. With *P. platyrachis* and *P. nodosa*, which have the nervation of the same character, the species is distributed in the upper part of the carboniferous from the Pittsburg coal to the Permian. Per contra, *P. quadratifolia*, which has also large and multifid fronds, but which is easily recognized by its very small, nearly round leaflets, truncate or angular at the top, is, for its distribution, limited to the lower strata above the conglomerate.

P. Strongii, *Lesq.*

Plate 14, *f.* 2.

Remarkable for the great length of its pinnæ and the peculiar position of its leaflets which, deflexed near the base and all more or less distant, give to the pinna the appearance of a simple frond. The species has, however, been found in fragments of pinnæ like that of f. 1, which, represents another species of fern. Its habitat is in the coal just above the conglomerate.

P. oreopteridis, *Schloth.*

Pinnules broader and shorter; veins forking once at or near the base and curving, so that their ends reach the borders at right angles.

P. Candolleana, *Brgt.*, and P. elliptica, *Bunb.*

Eespecially distinct by the pinnules distant from each other and not contiguous on the borders. The first has long linear narrow pinnules; the second has them short smaller ovate. The nervation is about the same in both, the lateral veins forking once or twice.

The largest species of the group, *P. Miltoni*, is extremely diversified in the form of its pinnæ and the size of the pinnules, which, though generally large, become very small in some of the lateral divisions of the fronds. In this species, the veins are generally twice forked, first near the base and then in the upper part of each veinlet. This and the two preceding are found generally distributed through the middle carboniferous measures.

The villous *Pecopterids* are not very numerous in species. As their surface is covered with a more or less thick coating of short hairs the nervation is indistinct or seen only with difficulty. It happens, however, that by maceration the upper surface of the leaflets is sometimes destroyed and the veins are exposed in relievo; at other times the coating of hairs has been rubbed off and the veins become distinct. This is the case in *P. vestita*, pl. 14, fig. 1, which has the same kind of division of its fronds as the species of the preceding section, but which, besides its generally villous surface, is distinct by the very oblique veins forking once at base, the upper branch forking again. As seen in fig. 1 a., the sori are placed between the veins near their point of division.

P. villosa is the more common species of this group, even perhaps of the genus, sometimes covering by its remains the roofs of long tunnels of some veins of coal. It is by the characters of its divisions and also of its nervation much like *P. Miltoni*, differing by its smaller leaflets, contiguous on the borders, and the villous surface.

The crestate *Pecopterids* are especially represented by *P. erosa*, Gutb., whose ultimate pinnæ are linear, narrow at right angles to the rachis, thick-nerved in the middle and cut on the borders by simple or double very small teeth, giving to them the appearance of small saws. The veins are simple to above the middle and there branch in two or three divisions reaching the point of the teeth. The fructifications are on comparatively large round sori placed on the borders of the pinnæ, covering the teeth in the dentate species, or placed as in the following:

P. SOLIDA, *Lesq.*

Plate 14, fig. 3, 3 b.

Pinnæ simple, with a very thick rachis and divisions at right angles attached by the enlarged base of the thick medial nerve; pinnules linear or slightly narrowed to an obtuse apex, rounded and enlarged at the base, very entire, coriaceous, without trace of veins; fructifications in round distant sori placed in rows along the borders, with sporanges placed starlike around a central point.

Some species of *Pecopteris* are of uncertain relation to the groups established. In the U. S. coal flora, forty-five species of this genus are described.

OLIGOCARPIA, *Goepp.*

Fronds bi or tripinnate; primary pinnæ oblong-lanceolate; secondary open, linear; pinnules divided in oblong or half round leaflets, connate at base, crenulate on the borders; primary and secondary veins nearly of the same size, thin, distinct, the lateral curved to the borders, simple or forked.

This genus is intermediate between the *Pecopterideæ* and the *Sphenopterideæ*, the divisions and shape of the pinnæ being like those of *Pecopteris*, while the nervation and the crenulate borders indicate affinity to *Sphenopteris*.

Three species have been described; one *O. Gutbieri*, common to Europe and America, has been found as yet only in the lower coal beds above the conglomerate; another, smaller in all its parts and more delicate, *O. Alabamensis*, pertaining to the sub-carboniferous, is known from a mere fragment. *O. flagellaris*, Lesq., is upper carboniferous.

SPHENOPTERIDEÆ.

Fronds bi, tri, poly-pinnate; divisions open or at right angles; pinnules narrowed at base, often decurring, cuneiform, entire or pinnately lobed; lobes rarely entire, crenulate, dentate or laciniate; primary nerve (medial nerve of the pinnules) slender, alternately dichotomous, the simple branches entering the base of each lobe to pass by branchlets into the sub-divisions of the lamina. In the genus *Eremopteris*, the lateral veins enter the lobes at an acute angle of divergence from the midrib and passing up to the borders are flabellate, dichotomous, parallel and close, as in species of *Neuropteris*. In the genus *Archæopteris*, the veins are flabellate and dichotomous, as in *Odontopteris*, but diverging and flabellate from the wedge-form base. (U. S. Coal Fl.)

Until now little has been published by European authors on the fructification of the *Sphenopterideæ*, which are variable for each group. A number of fructified species have been found in the North American Carboniferous, and it may soon be possible to fix a classification of the species upon the characters of their sori. Until this can be done and in order to facilitate their determination I have separated them in the following sections:

1. *Sphenopteris* (*Pecopterid*). Fronds with ultimate pinnæ deeply lobed; lobes connate to the middle or higher; veins pinnate as in *Pecopteris*. Some species of this group have been described as *Pecopteris* by Brongniart.

2. *Sphenopteris* (*proper*). Pinnæ more deeply divided in lobes or pinnules, narrowed and decurring at base, generally dentate or crenate at the apex.

3. *Sphenopteris* (*Hymenophyllites*). Fronds poly-pinnate, rachis of the the ultimate and penultimate divisions composed of narrow linear fascicles of veins, mostly united into a simple, rarely double nerve, bordered by a narrow lamina and repeatedly dichotomous in the pinnules, whose lobes or segments of lobes are entire, linear, obtuse or narrowly lanceolate, acuminate, rarely cuneiform.

Eremopteris, separated from *Sphenopteris*, by Schimper, is a transitional division passing to the genus *Triphyllopteris*, of the same author or to the following group.

4. *Adiantites.* The characters of this group are mentioned above for its more important genus, *Archæopteris.* On account of the peculiar nervation, its species have been sometimes united to *Cyclopteris*, though, as it will be seen, the characters are far different.

SPHENOPTERIS, (*Pecopterid.*)

Of the species of this group, *S. chærophylloides*, Brgt., is one of the finest, and more generally found in good specimens in the coal measures. The leaf is bipinnate, the pinnæ long, linear or lanceolate in the upper part, composed of oblique close deeply pinnately lobed pinnules, the lobes obscurely dentate and distinct to below the middle; lateral veins forked. The fructifications are in small round sori, placed upon the lower branches of the veins abruptly ending in the middle of the lamina. This species has been described by Brongniart from European specimens.

Two other European species, *S. Murrayana*, Brgt., and *S. alata*, Brgt., are represented in the "U. S. coal flora," by plants whose characters are somewhat at a variance with those described by the author. As of these two species the first is in Europe, of jurassic age, the other from the carboniferous of New Holland, the two analogous North American forms, though previously supposed identical, have been described as *S. pseudo-Murrayana* and *S. subalata.* Both are fine and distinct. The divisions of the pinnæ and pinnules are of the same type as in *S. chærophylloides.* Six species have been described of this group, all from the first coal above the conglomerate.

SPHENOPTERIS, (*proper*).

In the plants of this group the rachis is generally flat, the ultimate pinnæ long, curved and flexuous, the pinnules oblique, pinnately lobed or dentate, the veins pinnately derived from the medial nerve, the lower forking, the upper simple.

Of the seven species of this division, six have the same range of habitat as those of the last; one is sub-conglomerate.

S. MIXTA, *Lesq.*

Plate 15, *f.* 1, 2.

Most variable and diversely represented in fragments of its pinnæ, the pinnules being either pinnately lobed, as in fig. 1, with lobes half round entire or diversely cut, or merely pinnate, as fig. 2, with lobes inclined oblong obtuse entire.

S. Brittsii.

Plate 15, *f.* 3.

Pinnæ regularly pinnately divided in alternate oblique oblong more or less deeply crenate lobes. It was first known from small fragments found in Missouri but has been recently obtained in very large and beautiful specimens from the coal measures of Southern Ohio, the locality and horizon, however, being still unknown. The fructifications are marked in one or two deeply set round sori, placed inside of the undulations or teeth of the lobes. The surface of the leaves is verrucose.

SPHENOPTERIS, (*Hymenophyllites*).

Plate 15, *f.* 4.

These plants, by the divisions of the pinnules and the nervation, have a relation to species of *Hymenophyllum* of the present epoch. The divisions are more or less numerous, obtuse or acute, always entered, each by one veinlet which ascends to the borders.

The ten species described from this group have been mostly found below the conglomerate, even in the sub-carboniferous measures below the Chester limestone; two only ascend to the base of the middle coal. Indeed, most all of the species of *Sphenopteris* have been found in the lowest coal strata, either below the conglomerate or immediately above it. A peculiar group of the genus, however, is represented in the Permo-Carboniferous measures of Virginia.

S. spinosa, *Goepp.*

A peculiar and very rare species. The frond is divaricate, poly-pinnate; primary pinnæ reflexed, large; secondary divisions ovate or broadly lanceolate in outline, pinnately lobed; lobes palmately cut in linear or wedge form obtuse generally bifid laciniæ, the terminal prolonged into a long sub-cylindrical acuminate or obtuse point.

The whole plant is thick; the branches thick, round; the pinnules squamose on the surface; the veins, very thin, buried into the epidermis, are in fascicles, dividing at the base of the lobes and entering them.

The species is very rare in the American coal measures; some fragments have been found at the Colchester coal, of Illinois, above the conglomerate. A very fine specimen is in the National Museum at Washington, coming from Paxton, Sullivan County, Indiana. Fragments of the species have also been obtained at Clinton, Missouri.

S. TRIDACTYLITES, *Brgt.*

Plate 15, *f.* 4.

This species represents a type of ferns most common in the sub-carboniferous measures. The fronds are tripinnately divided; the secondary pinnæ open, lanceolate; the pinnules ovate-lanceolate in outline, gradually shorter toward the apex, sessile, slightly inclined or at right angles to the round rachis, pinnately lobed; lobes wedge form, the lower trifid, the middle narrower, bifid, the upper simple, the segments short, linear-obtuse. The fruitifications are in groups of small round sori placed on the under face of the lobes and covering them nearly entirely. They have been figured in the "U. S. Coal Flora," pl. 55, f. 9, 9 *b*.

As closely allied to this species, the following may be quoted: *S. furcata*, with longer pinnules, palmately deeply lobed, subdivided in three linear long segments, oblique or diverging. *S. Hildrethi* differing from the last by the rachis narrower, not geniculate, the pinnules pinnately lobed, the segments shorter. *S. flexicaulis*, which has the division of the rachis very flexuous and winged, the pinnules small, palmately lobed into short entire obtuse segments. To these may be added *S. trichomanoides*, *S. elegans* and *S. Hœninghausii*, differing by the position and form of the lobes all small and palmately divided.

Three species of *Sphenopteris* are still separately described as of uncertain relation, *S. Ballantini*, Andr.; *S. linearis*, Brgt., both sub-conglomerate, and *S. flaccida*, Crepin, found in the Vespertine sub-carboniferous of Pennsylvania.

EREMOPTERIS, *Schimper.*

Plate 15, *fig.* 5 (*eremos* solitary).

Upper part of the fronds dichotomous; pinnæ open or oblique, irregularly pinnatifid; segments long, narrowly obovate or wedge form, obtuse, entire or crenulate, the lower deeply lobate.

Of the eight species described of this genus, six are sub-carboniferous, mostly found in the low coal of Alabama; the two others ascend to the first coal above the conglomerate. Two of them are European.

E. ARTEMISIÆFOLIA, *Brgt.*

Plate 15, *fig.* 5.

Answers to the above description of the genus. The other species differ especially by the position of the pinnæ at right angles, the rachis flexuous, and the length and mode of division of the pinnules.

E. MARGINATA, *Andr.*

Plate 9, *fig.* 5.

Is of uncertain affinity, related by its nervation to *Adiantites*. The species of this genus are generally rare.

ADIANTITES, *Brgt.*

Fronds large, bipinnate or tripinnatifid; pinnules oblique, simple or bi, trilobate, gradually or abruptly narrowed to the point of attachment; veins dichotomous from the base, dividing fan-like, straight, thin, distinctly marked.

To the *Adiantites*, I refer *Triphyllopteris*, Schp., and *Archæopteris*, Daws.

TRIPHYLLOPTERIS, *Schp.*

Lower pinnules sub-opposite, tripartite or trifoliate, sometimes pinnatifid, the upper gradually more simple, all narrowed or contracted to a flat slightly decurring short pedicel; veins equal, simple or dichotomous.

Of this genus, two American species only have been described, one from the sub-conglomerate measures, the other from the sub-carboniferous.

T. CHEATHAMI, *Sp. nov.*

Pl. 15, *f.* 6.

Pinnæ apparently large, secondary divisions at right angles to a flexuous narrowly keeled rachis; pinnules or ultimate pinnæ oblique, broadly lanceolate in outline, pinnately three to five lobed; lobes trifid, cuneiform, the upper simple or bifid, the terminal cuneiform, crenate or split at the apex; veins dichotomous, flabellate.

T. LESCURIANA, *Meek.*

Pinnules broadly wedge form, narrowed to a short oblique flat pedicel, decurring to the rachis, deeply three, rarely four lobate; lobes disjointed to the middle or below it, the middle distinct, longer, all oblanceolate blunt at the apex, rarely acute; nervation that of the genus.

A beautiful species discovered by Prof. B. F. Meek at the base of the sub-carboniferous measures of Virginia.

ARCHÆOPTERIS, *Daws.*

(*Archaios*, ancient.)

Plate 9, *f.* 3, 4.

This fine genus has the characters described above for *Adiantites*. All its species belong to the upper Devonian or the lowest strata of the sub-carboniferous; none have been found in the productive carboniferous measures. The fronds were very large, some of them at least, with long straight or flexuous branches and wedge form leaflets, rounded at the upper borders or truncate, entire or crenulate, variable in length from less than 1 to 5 cm. and ½ to 4 cm. broad. The fructifications, or decomposed fertile pinnules, are placed along the rachis of the pinnæ in rows of fascicles of club-shaped spore-cases attached to an excurring medial nerve, pl. 9, f. 3.

Seven species have been described, two of which are figured. One, *Archæopteris minor*, Lesq., pl. 9, f. 3, represents the species with fructifications, the other, *A. obtusa*, Lesq., pl. 9, f. 4, is a fragment of a very large pinna. Both are Devonian or of the lowest sub-carboniferous measures of Pennsylvania, the Pocono. Fragments of one species only, *A. Bockschiana*, Goepp., represent the plant as tri-pinnately divided, the ultimate pinnæ bearing reniform or broadly obovate pinnules, either alternately placed along the rachis or trifoliate, indicating the relation of the group to the *Sphenopteris*. These fragments were obtained in the (Pocono) sub-carboniferous measures of Pennsylvania.

FERNS OF UNCERTAIN RELATION.

RHACOPHYLLUM, *Schimper.*

Plate 15, *f.* 7–9.

Fronds either flabelliform nearly entire, or irregular many times divided; rachis flat, generally much enlarged, leaf-like or scarcely thicker than the foliaceous lamina which is always very variable in the size and mode of its divisions; veins generally indistinct, following the rachis in parallel bundles passing by dichotomy in the foliaceous divisions.

Though the morphology of the plants described in this genus may be quite as clear as that of the other ferns of the Carboniferous, their nature and their role in the vegetation is as yet uncertain. If some species appear related to *Sphenopteris* (*Hymenophyllites*) by the divisions of their pinnæ and the distribution of the veins, first in flat bundles in the primary rachis, then diversely forking in passing to the pinnæ, the lobes, etc., others are without any affinity whatever to any known characters of the ferns. They appear to have been either a protophyllous vegetation, appearing before the stems of ferns and preceding their development, as are now the tissues of filaments preceding the vegetion of mosses or mushrooms, even of some ferns of the present epoch, where parts of the organs of the inflorescence are developed before the production of the fruiting plants. Others were evidently parasites, as they are often found attached to the stems of different species of ferns. Extremely variable in their characters, especially in the forms of their divisions even upon the same species or the same branches, as can be seen (pl. 15, f. 7), they are still more so in the size of the plants. Some are still smaller than that figured, pl. 15, f. 8; others have pinnæ twenty to thirty cm. long, either dividing all around from a central point, or erect and pinnately branching, the main axis being two to four cm. broad. Their texture sometimes thick and coriaceous, was apparently generally soft and easily decomposed, as they have been rarely found in the stratified shale of the coal, but often in the concretions or nodules of Illinois and Indiana, where the soft cellular remains of plants have been more generally preserved.

More than twenty species referable to this genus, or rather group, have been described. What is said above, of the great disposition of the plants to vary, renders the circumscription of the so-called species as difficult as it is uncertain. Some of the more marked are the following:

R. FLABELLATUM, *St.*

Leaves large, fifteen to twenty cm. long, coriaceous, rounded, wedge form, entire at base, enlarged, flabellate and laciniate at the apex; fascicles of nerves distinct, parallel.

A very rare, beautiful species, found in the sub-carboniferous of Indiana, Illinois, rarely in the coal above the conglomerate.

R. MEMBRANACEUM, *Lesq.*

Frond large, pinnately divided, rachis or medial axis flat, broad; divisions alternate, broad, turned upward, cut at the apex in acute short segments; veins distant, distinct and dichotomous.

The frond was at least twenty cm. long; the main rachis forty cm. broad, the primary divisions two cm. The specimen which only shows a fragment of the frond is from the Clinton coal, Missouri.

R. LACTUCA, *St.*

Medial axis either long and pinnately divided or sessile, enlarged from the base all around, diversely lacinate; primary divisions large, curving outward, the ultimate short, linear, lanceolate, or long, linear, flexuous, obtuse or acute. The specific name is derived from the subdivisions of the fronds of this fern, spreading around like the leaves of a bunch of lettuce. The species is commonly found in the middle coal measures.

R. CORRALLINUM, *Lesq.*

Plate 15, *f.* 7.

Plants of small size; basilar pinnæ diverging in a circle from a central axis; broadly lanceolate, pinnately dichotomous; divisions oblique, the ultimate either short, truncate, obtuse, or narrow, slender, filiform, forked once or twice, surface dotted with hairs.

This species obtained in the nodules of Mazon Creek exposes the variability of the ramification and the diversity of characters of fragments of the same plant.

R. ADNASCENS, *Ll. and Hutt.*

Plate 15, *f.* 8.

Still smaller than the preceding and not less variable; fronds many times dichotomous; divisions radiate or divaricate from the base, narrow, linear, obtuse or truncate; veins parallel or simple in each division. Common and often found attached to the rachis of other ferns.

R. INFLATUM, *Lesq.*

Plate 15, *f.* 9.

Ramification subpinnate; lower lobes divided in obtuse half round pinnules, most of the others being linear and entire.

Some species of this genus, composing a peculiar group, have analogy to Fucoids or marine plants, or to some kinds of fungi.

TRUNKS OF FERN-TREES.

As seen pl. 8, where a tree-fern has been reproduced in its general appearances, the trunks of these trees are distinctly marked from their base upward by the scars of the points of attachment of their leaves or of the base of the petioles upon the bark. In living tree-ferns the traces of the vessels which pass from the trunk to the rachis are more or less distinctly preserved, pl. 8, fs. 5, 6, 7. On the fossil specimens, the traces or points of vascular bundles are generally effaced and the outlines only of the inner structure of the base of the petioles remain as in pl. 8, fs. 8–10. These scars are not rare in the American coal measures, but rarely found, still attached to stems, and mostly isolated upon detached fragments of the bark.

These scars are so distinct and so widely different in their characters that they serve for the determination of species of tree-ferns, of which, of course, the fronds and leaves are unknown; for until now no trunk of a fossil tree-fern has been found with the fronds attached to it, and therefore the specific relation of the scars to fern-leaves is unknown.

Tree-ferns are often found silicified in the coal measures. In petrifications of that kind, as it has been remarked already, the internal structure is generally distinctly preserved and can be studied anatomically by thin slides prepared by the lapidary for microscopical examination. But for these trunks, also, a peculiar or separate study has to be made, independent from that of the remains of fern-leaves preserved in the shale; for the silicified trunks have not even the bark preserved, and therefore not, or very rarely, the scars of the petiole. Hence the inner structure can no more give an idea of the foliaceous vegetation of the tree, than do the scars of the petioles.

According to the characters of the scars and of the inner structure, which are peculiar, very varied, and apparently reliable for the constitution of specific or generic groups, the fragments of fern-trees have been more generally considered under the following four divisions: *Stemmatopteris*, *Caulopteris*, *Megaphytum* and *Psaronius*.

STEMMATOPTERIS, *Corda.*

Plate 8, *f.* 9–10.

Trunks erect, cylindrical; scars large, disciform, oval, round or ovate, disposed in quincunxial or spiral order, and composed of an outer flat border or ring, and of an internal disk, formed by impressions of fascicles of vascular tissue generally horse-shoe shaped, the horns curved inward in the upper part of the scars, either short and hooked, or descending to below the middle of the scars and there united.

Fourteen species of *Stemmatopteris* are known now from the American specimens obtained from the middle coal measures, the range of these trees being especially from above the conglomerate to the Pittsburg coal, and still higher to the Permo-Carboniferous. Some of these disks are remarkable for their large size, which, in *S. insignis*, is twelve cm. in length, eight and a half cm. broad; others by the scales bordering the scars; others still by their peculiar shape, as *S. mimica*, pl. 8, f.10, which represents the outlines of the face of a man. *S. polita*, f. 8, is a simple inside scar, with inner surface quite smooth. *S. angustata*, f. 9, is remarkable for its narrow shape compared to its length. These are figured to show the great difference between the characters of the scars.

CAULOPTERIS, *Ll. & H.*

This name, like the preceding, merely signifies trunk of fern. The species of the genus differs from those of the last in being marked by linear bands or striæ, remains of vessels passing from the trunk to the rachis, or by impressions of rootlets obliterating their original shape. Generally the scars appear ovate or elliptical, without mark of the horseshoe shaped vascular lines. The unreliability of the so-called generic divisions of this kind is seen in the fact, that sometimes, when the linear bands are casually effaced by erosion or maceration, and the horseshoe shaped lines are seen underneath. Generally, however, the species of this group have the scars continuous, elongated at base in such a way that the upper scar is joined to the lower by that linear often flexuous prolongation. The species of this genus, of which eight are known, follow the same distribution as those of the preceding.

MEGAPHYTUM, *Artis.*

Plate 8, *f.* 11.

(*Megas*, large; *phuton*, plant.)

Scars large, round-quadrate in outline, contiguous or very close, placed in opposite bi-serial rows; internal disks convex, with central or vascular impressions, horseshoe shaped, or a medial band, dividing vertically the disks into two lobes, joined in the middle or at the base.

The disposition of fronds of ferns in two opposite rows and close to each other is peculiar, and has not been remarked upon any fern-trees of the present epoch. The appearance of these trees was probably, upon a very large scale, however, about like that of the leaves of certain species of palms, divided in the middle by the prolongation of the petiole with the rays or leaves on both sides of it.

Of the four species described, *M. protuberans*, Lesq., is represented by a small fragment and in reduced size (pl. 8, f. 11). *M. McLayi*, Lesq., has scars of about the same form, broader, however, measuring nine cm. at the cordate base and twelve cm. long. The distribution of the species is like that of *Stemmatopteris.*

PSARONIUS, *Cotta.*

(*Psaros*, speckled.)

As a generic division, this name is admitted by authors for the description of trunks of ferns found silicified, generally covered in the lower part by a coating of adventive roots, and whose woody cylinder is subdivided into branches composed of fascicles of vessels of various shapes immersed into the cellular medular tissues. When the transverse section of these trunks is polished the fascicles of vessels represent multiple varied and beautiful designs, like those of marble, variegated in color and often figured like stars. Trunks of *Psaronius* are common enough in divers parts of our coal measures, especially in Southern Ohio, Virginia and Northeast Kentucky.

Some silicified rachises of ferns, whose internal structure has been examined by transverse sections, have been described by authors under the name of *Rachiopteris*.

LYCOPODIACEÆ, or *club moss family*.

Plate 16.

The *Lycopods*, living at the present epoch, are herbaceous, rarely shrubby plants, with a dichotomous ramification (pl. xvi, f. 1, 2), or branches, alternately or pinnately divided. The leaves are small, disposed in spiral or in verticils, uniform of biform, ovate-lanceolate or linear, simply nerved in the middle. The disposition of the leaves is very variable, even upon the same stem or branches. In the genus *Selaginella*, the leaves are four ranked and biform, one series being placed in the upper part of the stems, composed of smaller leaves appressed to the stems, the other on the lower face, of much longer leaves, horizontally spreading. The organs of reproduction are in sporanges, placed in the inside part of the leaves, generally axillary (pl. 16, f. 4, 4*a*), containing spores, either large, macrospores (f. 5), or, in some genera, spores of two kinds in separate sporanges; macrospores, organs of germination and fructification; microspores (small spores), apparently contributing like the pollen of the dicotyledons to the fertilization of the macrospores. The *Lycopodiaceæ* have, therefore, a higher degree of organization than the ferns.

The *Lycopodiaceæ* of the Paleozoic formations had nearly the same organization as described above for species of the family living at the present epoch. As seen, pl. 16, f. 6, 7, which represents a strobile, the sporanges (f. 6) are placed in the axils of leaves (blades), curved at base into a support (sporangiophore) joining the axis in right angle (f. 6*a*), and these sporanges merely contained macrospores (f. 5, 6). Sometimes sporanges, placed in the upper part of the cones, contain only microspores, while those underneath have macrospores, a fact which, however, has been rarely observed. The cones of the *Lycopodiaceæ* of the coal are sometimes very large, four to five times as large as those figured; pl. 16, f. 6, 7. They are rarely found in a complete state of preservation; some fragmentary, like f. 6, expose, by disintegration, the axis and the sporanges attached to it; some others, cut transversely, as f. 8, and flattened, show the disposition of the sporanges around the axis, and the form and mode of attachments of the blades. Generally the sporanges or the sporangiophores with the blades, are found detached and separately mixed with other fragments of plants upon the shales of the coal, as f. 9, 10, 11. They show great variety in the characters of the fructification and, of course, of the plants wherefrom they are derived.

The *Lycopods* of the coal, generally of small size and herbaceous, are rare and compose a group of little importance, the *Lycopodites*. A second group, that of the *Lepidodendreæ*, is mostly composed of large trees of elegant forms, bearing long branches, early deprived of their leaves and fruiting strobiles pending from their extremities. One of the trees representing the genus *Lepidodendron* is reproduced, pl. 17, f. 1. The leaves were linear, or linear-lanceolate, very variable in length, from one to twenty cm., according to the different species, generally flat or concave or canaliculate, marked in the middle by a strong nerve. Their points of attachment are distinctly seen even upon the small branches deprived of their leaves, by cicatrices, which were generally, at first broadly rhomboidal or square, and very small, one to two mm., and they generally increased, especially in length, with the growth of the trunks and of the branches. The scars, therefore, vary in size according to their age or their place upon the trees, either upon the branches or the trunks. These scars, generally distinctly preserved, (pl. 17, f. 3–7), and now found upon fragments of trunk or of bark, serve by their characters to the determination of the species. Of course they are somewhat subject to variations, either by casual modifications in the growth of the trees, or by some unknown local deformations, and, therefore, it has been supposed by some paleontologists that the determination of species, from the scars of the bark, is fallacious and that, without reason, a too high valuation has been made of the number of species of *Lepidodendron* described from the carboniferous. In contradiction to this opinion it may be said that impressions of trees of *Lepidodendron* have been found in Europe, upon sandstone strata, measuring a hundred feet in length and ten feet in diameter, whose surface was distinctly marked with their scars. Of this size I have not seen any. But I have visited in Pennsylvania, at the falls of Little Beaver River, a sandstone formation containing the remains of a forest of *Lepidodendron*, *Stigmaria*, *Sigillaria*, etc., where impressions of trunks are distinctly exposed, sixty feet long (sixteen to eighteen metres), fifty cm. in diameter, with the scars of the bark distinctly preserved in their minutest details, and all exposing the same characters in the whole length of the stems. What is known also of the great diversity of forms and sizes of the leaves, of Lepidodendron, of their cones, and of their blades, seems on the contrary to show that the number of species described as yet from the characters of the scars of the bark is rather put too low than too high.

The genus *Lepidodendron* is as remarkable for its peculiar distribution as it is for the great number and the great size of its representatives. In the Paleozoic times, immense forests of these trees composed part of the vegetation, covering as wide surfaces as are occupied by the great forest of conifers at the present epoch. Their remains have entered for a great part into the components of the coal.

The presence of the *Lycopodiaceæ* has been recognized in the old geological formations as far down as the lower Silurian. Two species of *Psilophyton*, Daws (*psilos*, naked; *phyton*, stem;), a genus related to *Lepidodendron*, have been found, the first, *P. gracillimum*, Lesq., (pl. 3, f. 1), in the Cincinnati group, lower Silurian, the second, *P. cornutum*, Lesq., (f. 2), in the lower Helderberg sandstone of Michigan. Fragments of the species of the same genus have been discovered also in the upper Silurian of Canada. The fragments of branches (pl. 3, f. 7, 8,) representing, by the scars of their surface, plants related to *Lepidendron* or *Sigillaria* have been found also in the lower Silurian of Ohio. Hence the family appears, by the same kind of evidence, as old as the ferns and the *Equisetaceæ*.

Fossil remains of the *Lycopodiaceæ* found in the American coal measures, represent with some species of *Lycopodites*, or true Lycopods, the following genera of the *Lepidodendreæ: Lepidodendron* with their organs of fructification *Lepidostrobus* and *Lepidophyllum; Ulodendron, Knorria, Halonia, Lepidophloios, Cyclostigma* and fruiting fragments, *Lepidocystis* and *Sporocystis*, not sufficiently known in their relation to the plants which they represent.

LYCOPODITES, *Brgt.*

Plants herbaceous or subarborescent; leaves all of the same form in spiral order, or biform four ranked; fructifications in small axillary tubercles (macrospores), either spread along the stem or agglomerated in spikes at the top of the branches.

Of the eight species of the *Lycopodites* known from the North American coal measures, one, *L. Ortoni*, distinctly represents the group of the *Selaginellæ* of the present epoch. Another, not yet published, *L. simplex*, has a long, simple stem, linear, somewhat flexuous, five mill. broad, covered with short lanceolate sharply pointed leaves, bearing in the axils small round tubercles. It is closely related to *L. leptostachys*, a species described from European specimens by Golderberg. Another, *L. arborescens*, has a primary stem three cm. in diameter, which divides nearly at right angles into a round branch only seven mm. broad with numerous dichotomous pending branchlets, and short, ovate, concave, lanceolate, sub-imbricate leaves. Branches of this kind are not very rare in the coal, but when found separate from the primary stem, as they generally are, they have been considered as fragments of branches of *Lepidodendron*. They greatly differ by the concave leaves, whose nerve is obsolete and the stems without leaf scars.

Lycopodites appear to follow in the distribution of their species the same march as *Lepidodendron*. The best known are from the sub-conglomerate measures of Pennsylvania and from the lowest coal above the conglomerate of Illinois. One species only, *L. strictus*, Lesq., is from an upper coal bed near New Harmony, Ind.

LEPIDODENDREÆ.

LEPODODENDRON, *St.*

Plate 17. (*Lepidos*, *gen.* of *lepis*, scales; *dendron*, tree.)

The genus has the characters of the *Lepidodendreæ*, above described. The species are recognized merely by the leaf-scars marked upon the bark or surface of the branches and trunks. These scars, which are the remains of the base of the leaves, are rhomboidal-oblong or rhomboidal-square upon the small branches, and very variable in size. Generally called bolsters, when taken in their whole, they bear in the inside, cicatrices or leaf-scars, which, rhomboidal, enlarged on the sides, are dotted in the middle by three points (vascular scars), and generally have under the lower border two small oval tubercles, cicatrices of bundles of vessels, named appendages, and placed on each side of a medial line (*cauda*, tail), which, like the appendages, is more or less distinct, sometimes deep and wrinkled across, sometimes obsolete. Pl. 17, f. 6, represents distinctly these different organs.

Little is known of the internal structure of *Lepidodendron*. One silicified species, *L. Harcourti*, has been described by Brongniart from microscopical analysis of its internal tissue. Its characters have been found analogous to those of some *Lycopods* of the present epoch, *Psilotum* and *Tmesipteris*. Another species, *L. vasculare*, has shown the structure of *Sigillaria*.

The roots of these trees are not positively known. Some authors consider *Stigmaria* as roots of *Lepidodendron* and *Sigillaria*.

A subdivision of *Lepidodendron* into different genera has been proposed by some European authors, based upon the relative position of the bolsters and the mode of attachment of the leaves, either toward the top, or the middle of the cicatrices. As these characters are unreliable, this classification especially followed by Sternberg and Goldenberg has been abandoned.

Of more than forty species of Lepidodendron known from American specimens, I merely describe a few of the more remarkable ones, in order to show on what kind of characters are based the specific determinations. The essential groups are represented upon plate 17.

1. Bolsters ovate or obovate, angular on the sides or not.

L. DISTANS, *Lesq.*

Plate 17, *fig.* 7.

Bolsters or cicatrices distant, ovate, narrowed upward and downward about in the same degree, rounded on the sides; leaf-scars rhomboidal, with equal sides; vascular points, appendages and cauda very distinct; space between the scars narrowly wrinkled lengthwise.

To this group belong a number of species. *L. obovatum*, which has the same characters, but the lobes contiguous, as are those of fig. 6. *L. modulatum*, whose cicatrices are bordered by a deep undulate groove which appears upon the impressions like a half round regularly deeply wrinkled margin. In these species the leaf scars are placed low, nearer to the middle. *L. dichotomum*, St. pl. 17, f. 1*b*., represented by a large number of varieties, among them *L. obovatum*, *L. gracile*, etc. It is the most common of the genus.

2. Bolsters narrow, acute or acuminate at both ends, angular on the sides. leaf-scars enlarged sideward, but not reaching to the borders; vascular points, appendages and cauda distinct.

L. ACULEATUM, *St.*

Plate 17, *f.* 6.

Characters as above.

The difference in the place of the leaf-scars, either in the middle of the cicatrices or in the upper part and in their forms also, serve as characters for the determination of the species of this group.

3. Bolsters still longer and narrower, either contiguous or separated by a narrow space; leaf-scars in the middle generally prominent, appendages and cauda none.

L. RIMOSUM, *St.*

Plate 17, *f.* 3.

Leaf scars unequally rhomboidal, more rounded on the lower side, comparatively very small. The group has few species or perhaps only the one figured.

4. Bolsters broadly ovate; leaf-scars in the upper part, as broad as the space between the borders, transversely oval; vascular scars very distinct; appendages none; cauda marked by transverse wrinkles filling the base of the bolsters.

To this group belong *L. Brittsii*, Lesq., pl. 17, f. 4 a, 4 b, *L. Worthenii* and the European *L. Volkmannianum*, which is considered there as one of the species limited in its distribution to the Culm or sub-carboniferous.

Of the two species named above, the first has been found at Clinton, Mo., in the lower coal above the conglomerate, the second is sub-carboniferous, or of the horizon of the Chester limestone. This species should be present in the Whetstone of Indiana.

5. *Bolsters ovate, rhomboidal; leaf-scars broad, rounded above, subtruncate at base; vascular scars and cauda distinct; appendages none; cicatrices of the decorticated surface rhomboidal quadrangular.*

L. DIPLOTEGIOIDES, *Lesq.*

Plate 17, *f.* 5.

A peculiar species of the sub-conglomerate of Arkansas.

With *L. dichotomum*, the most common species of the genus is *L. Veltheimianum*, St., which, more generally present in the sub-conglomerate, has however, been found in the upper strata of the coal measures, even according to Goeppert in the lower Permian. The species is difficult to determine and very variable. Its more marked character is the position of the broad leaf scars in the middle of the bolsters, whose borders are continued in the form of an S, with more or less deep undulations. The appendages, vascular points and cauda are more or less distinct; the bolsters are short or long, either contiguous or separated by a narrow space or flat border; the leaf-scars are transversely spindle-shaped, the upper part convex, the lower obconical.

A form which has been considered by some authors as a variety of this last species is *L. clypeatum*, Lesq. Its cicatrices are irregularly rhomboidal, nearly as broad as long with the sides obtuse, unequilateral, and the leaf-scars transversely rhomboidal, large. This species, though extremely variable, is distinct, not only by the unequilateral twisted shape of the bolsters, but also by its distribution, which is mostly with the first coal above the conglomerate, though some specimens have been found in the sub-conglomerate coal measures.

LEPIDOSTROBUS, *Brgt.*

Plate 16, *f.* 6, 7, 8; *plate* 17, *f.* 2.

The strobiles or fruit-bearing cones of *Lepidodendron* have been considered above in their mode of organization. Their form is generally cylindrical, conical, acute or rounded at the top. They greatly differ in their length and size, from two to three cm. long and less than one cm. broad, to forty to fifty cm. long and four to five cm. broad. The characters serving to determine them specifically are far more diversified, reliable and persistent than those of *Lepidodendron*. They are taken not merely from the size and shape of the strobiles, but especially from the form of the blades or bracts of the sporangiophores, the form and mode of attachment of the sporanges, their direction, either oblique or in right angles, etc. However, there is often some difficulty in ascertaining the characters of the blades and the sporanges when the cones preserved in their integrity are flattened by compression. And when they are broken in parts, either showing the sporanges and the blades in circular rows as in pl. 16, f. 8, or disseminated and separated from their supports as in pl. 16, f. 9–11, the shape and size of the cones often remain uncertain. It has, therefore, been advisable to separate the organs according to their degree of preservation. The genus *Lepidostrobus* represents the entirely preserved cones of *Lepidodendron*, or such part of the strobiles well preserved enough to show their shape and size, while in the genus *Lepidophyllum* (*phyllon*, leaf) are described merely the leaves of *Lepidodendron*, and especially the blades of their cones, pl. 16, f. 9, 10, 11.

The more interesting or more common species of *Lepidostrobus* found in the coal measures of North America are:

L. Goldenbergii, *Schp.*

Strobiles very large, cylindrical, thirty-three cm. long, four and one-half cm. broad; blades or bracts broadly lanceolate, acuminate, two and one-half cm. long, four to five mill. broad, half open, curved inward.

L. prælongus, *Lesq.*

Spikes narrow, cylindrical, very long, seventy cm. or more; sporanges inclined upward, blades narrow, linear or lanceolate-acuminate.

L. hastatus, *Lesq.*

Plate 17, *f.* 2.

Strobile conical, short; blades lanceolate-acuminate, enlarged, hastate at base, as in pl. 16, f, 9, which is *Lepidophyllum hastatum*, or the detached blade of this strobile.

L. spectabilis, *Lesq.*

Cone linear-oblong, rounded at base, obtuse at the top, sporanges long, at right angles to the axis; blades short, narrowly lanceolate-acuminate, appressed and closely imbricate. A beautiful cone forty cm. long, five broad in the middle. The European *L. variabilis* is of the same type, but much smaller.

L. OBLONGIFOLIUS, *Lesq.*

Plate 16, *f.* 8.

Strobiles with a broad axis; sporanges short, cuneiform, acuminate at base; blades large, oblong-lanceolate to the acute or obtuse apex.

L. ORNATUS, *Park.*

Plate 16, *f.* 6, 7.

Strobiles small; blades short, broadly lanceolate-acuminate, closely imbricate, appressed, coriaceous, convex and carinate on the back by the thick medial nerve. The point of attachment to the sporanges is large rhomboidal and equilateral. The cones of this character discovered in the N. American coal measures, are larger than those figured from European specimens.

A group of cones of *Lepidostrobus* type which I have separated under the name of *Macrocystis*, have long strobiles, large sporanges joined to the axis by their base without either sporangiophores or bracts; pedicels none, or very short; sporanges filled with macrospores attached around a central axis.

These strobiles were extremely long, their sporanges oblong, obtuse at the outside or bladder-like, of various size and shape. A number of species are described with figures in the U. S. coal flora. When detached, these sporanges have been sometimes taken for and described as fruits (*Carpolithes*).

LEPIDOPHYLLUM, *Brgt.*

As representing blades or bracts of strobiles of *Lepidodendron*, the descriptions of species of *Lepidophyllum* relate to their form and size. But of course the species are hypothetical, for the blades found separate from the cones may belong to strobiles already described as *Lepidostrobus*. Specimens of *Lepidophyllum* are much oftener found than those of entire well preserved cones, and generally they are found spread together in numbers upon the shales. From this, the persistence of their characters may be surmised, as generally the shales or specimens obtained at the same place bear only blades and sporanges of one distinct form identical in shape and size. Some of the species of *Lepidophyllum* have been described or mentioned above in considering the genus *Lepidostrobus*. They are figured pl. 16, f. 9, 10, 11. But there is another group of species of this kind, all of much larger size, with blades seven to ten cm. long, twelve to sixteen mill. broad, which pertain to cones of *Lepidophloios*, and will be examined with the genus.

ULODENDRON, *Ll. and Hutt.*

(*Ulos*, wood—forest.)

Plate 18, *f.* 2, 3.

Stem arborescent, rarely branching, bearing in alternate or opposite rows, large round or oval cicatrices, impressions of the base of sessile cones, marked with concentrical impressions of scales around a central axis and short, lanceolate leaves, which, early falling off, have left, as scars of their points of attachment, rhomboidal oblong or oval small bolsters, disposed in spiral like those of *Lepidodendron*; fructifications in long, cylindrical strobiles.

The affinity of *Ulodendron* with *Lepidodendron* is so well marked that some authors have not separated the genera, though legitimate the separation may appear. The trunks of *Ulodendron* seem to have been simple or rarely ramified, like those of *Sigillaria*; the leaf-scars are scarcely variable in size or not much larger upon trunks of great size, for the bark is not expansible as in *Lepidodendron*, but splits lengthwise by the enlarging of the trunks, and the intervals between the borders of the scars are filled by woody excrescences which, sometimes, widen laterally and cover part of the bark and its scars. To these differences may be added the fact that the leaves of *Ulodendron* are very rarely seen. I have not yet been able to find any one attached to the stem.

The large disks placed in vertical series and supposed to be scars of cones, are variable in size, increasing in width with the growth of the trees. No kind of organism has been found attached to trunks of *Ulodendron* which might explain the origin of these scars. Some paleontologists consider them as supports or cicatrices of a strobiliform inflorescence, or of cones of fructification produced upon young stems and easily detached. Others, among them Brongniart, regard them as cicatrices of conical tubercles covered with leaf-scars as are those of *Halonia*. The first opinion appears more probable, and is more generally admitted, but some American specimens have been found which give the same degree of authority to both assertions, showing that if, in some cases, those large impressions are the scars of small fruiting organs like strobiles, they represent in some others the abortive buds of branches. The question is discussed in the "United States Coal Flora," pp. 399 and 400.

Six species of *Ulodendron* have been described from American specimens. Their range of distribution is the same as that of species of *Lepidodendron*. The more distinctly characterized are the following:

U. MAJUS, *Ll. & Hutt.*

Stem large, bolsters rhomboidal, peltate or angular at the apex, the lower half round; inside scars transversely oval, marked in the middle by three vascular points; disks of strobiles large, round, generally umbonate in the middle, about one cm. distant, transversely, six to seven mill. vertically. The scars of the base of the strobiles are slightly excentrical.

U. MINUS, *Ll. & Hutt.*

Plate 18, *f.* 3.

Stems of small size; disks circular, close; leaf-scars small, convex, rhomboidal, marked at the basilar angle by a short vertical line. This species is generally found in the subconglomerate measures.

U. ELONGATUM, *Lesq.*

Plate 18, *f.* 2.

Leaf scars distinctly rhomboidal, twice as long as broad, acute at both ends, bordered with a flat, smooth margin; inside scars exactly central, small, rhomboidal, elongated and narrowed sideward; disks oval, large, distant, pitted or rugose inside; axis central and umbonate. This species with *U. ellipticum*, Lesq., a closely allied one, is not rare in the first coal above the conglomerate.

U. PUNCTATUM, *Ll. & Hutt.*

Leaf scars punctiform in corticated specimens and disposed in quincunxial order; disks very large and distant, oval, marked with deep lines or striæ, radiating toward the borders from an excentrical protuberance.

The disks of this species are very large, sometimes as long as fourteen cm., and ten cm. broad; the excentrical axis is a protuberance having rather the appearance of the base of a broken branch than that of the cicatrice of the base of a strobile. But all the scars have the same kind of excentrical protuberances and it is not well possible to explain how all these cicatrices, if they were those of broken branches, could have exactly the same form and size. The species is mostly found in the conglomerate sandstone.

New discoveries concerning these large disks of *Ulodendron* rather tend to increase the uncertainty concerning their true natures than to clear it. A large trunk, examined upon the roof of a tunnel in a mine of Pennsylvania, shows two rows of alternate disks, one of them composed of disks twice as large as those of the other, but of the same form, the large ones fifteen cm. long, ten broad; the small only five cm. long and two broad. Of course such differences can not be caused by maceration and compression.

KNORRIA, *St.*

Plate 19, *f.* 7, 8.

Trunks covered with elongated, semi-conical or truncate tubercles placed in spiral order, more or less closely imbricated, leaving, after falling off, round, convex marks, with a single vascular scar or point in the middle; leaves long, linear, more or less inflated at the base, medial nerve flat.

Until now the only specimens I have seen referable to this genus are decorticated or obscure fragments covered with the persistent base of the leaves, as in f. 8, or with short, either broad, obtuse, or narrow, circular leaves or impressions. Some authors do not consider as reliable or persistent the characters which separate *Knorria* from *Lepidodendron* and have identified some so-called species of *Knorria* as a decorticated state of *Lepidodendron Veltheimianum*. Impressions of that kind are also sometimes remarked upon the decorticated surface of trunks of *Sigillaria monostigma*. But these deformations are casual, while the characters of *Knorria* are traceable through the successive layers of the bark. Of this kind one species only is described here from American specimens:

KNORRIA IMBRICATA, *St.*

Plate 19, *f.* 7, 8.

Tubercles of the trunks semi-cylindrical, conical, truncate or obtuse, those of the branches small, papilliform, closely imbricate.

A number of European species are all, more or less, distinctly referable to this. Among others, *K. acicularis*, Goepp., whose scars are cylindrical, about one cm. long, only two mm. thick. Upon the same flattened specimen I have seen, on the upper part, the scars exactly of the above description, while on the lower face of the branch, they were more enlarged, convex like those of *K. Schrammiana*, a species also of Goeppert, and on one side they were effaced into round scars like those of a small kind of *Stigmaria* described by the same author under the generic name of *Ancistrophyllum*. Specimens of *Knorria* have been found mostly in the subconglomerate coal measures and immediately above the conglomerate.

HALONIA, *Ll. & Hutt.*

Plate 18, *f.* 1, 4.

Stems of medium size, dichotomous; surface of the bark tuberculate; space intermediate to the tubercles marked with rhomboidal bolsters; decorticated surface covered with punctiform round or oval papillæ, obtuse or perforated in the center, placed in spiral order.

There is, upon the nature of the different kinds of cicatrices marked upon these trunks, the same uncertainty as for those of *Ulodendron*. The large tubercles, pl. 18, f. 4, placed in quincunxial order, either flattened or hollow at the top, or entirely covered with scars of scales or of leaves and obtuse at top without traces of perforation, have been considered by some authors as the inflated base of leaves, and the intermediate surface scars as marking the point of attachment of scales. But it is not possible to admit that leaves were placed at the top of tubercles sometimes very large, while intermediate rhomboidal scars, like those of *Ulodendron*, are seen, f. 4, covering the large tubercles even to the top. Discussing the matter and the opinions of authors in "United States Coal Flora," pp. 409–418, and having, for examination of this genus, American specimens better preserved than any found in Europe, I have considered the large tubercles of *Halonia* as mere adventive or undeveloped buds of branches, and the intermediate surface cicatrices as leaf-scars.

All the American specimens referable to this genus have been procured in the low coal measures, either below, or within, or just above the conglomerate.

H. TUBERCULATA, *Brgt.*

Plate 18, *f.* 4.

Tubercles large in quincunxial order, button like, conical-obtuse, open, irregularly deeply hollowed at the top, or more acute, entire or closed; leaf scars transversely rhomboidal, marked in the center by a punctiform vascular scar; decorticated surface punctate.

H. TORTUOSA, *Schp.*

Stems small; tubercles in quincunxial order or alternate in vertical rows, variable in distance, small, half globular, marked in the middle by a large vascular point; intermediate scars transversely rhomboidal; decorticated surface marked by small round papillæ.

The specimen is flattened; the tubercles of the upper face are close, in two rows nearly in the middle, while on the lower more flattened face, there are also two rows of the same kind of tubercles, but distant, placed along and close to the borders, as if the stems had been creeping and the scars forced outside. This specimen seems to represent a creeping rhizoma.

H. FLEXUOSA, *Gold.*

Plate 18, *f.* 1.

Tubercles distant, inflated, lateral and alternate; leaf-scars of the corticated surface vertically rhomboidal (as figured by the author); those under the cortex are ovate, acute, small papillæ, marked with a distinct vascular point.

As seen on the figures, the large tubercles placed on the sides give to the branches a flexuous form. They are covered with leaf scars to the apex. Found in the middle coal measures.

H. PULCHELLA, *Lesq.*

Branches small, cylindrical; scars small, hemispherical, close, in spiral order.

A very small branch, a little more than one cm. in diameter; found in the sub-conglomerate coal of Arkansas.

H. SECRETA, *Lesqx.*

Stem of medium size; tubercles in regular spiral order, equidistant, transversely oval, covered with a thin hard convex smooth cortex; sub-cortical scars rhomboidal-oval, inflated at the borders, marked in the central narrow depressions by three round vascular points placed in horizontal series as in *Lepidodendron*; surface of the stem smooth.

A very peculiar species, described from a remarkably well preserved specimen four and one half cm. broad, which, originally cylindrical, has been flattened by compression. All the scars marked upon the surface are somewhat convex and transversely oval, the convex part being a thin but very hard, smooth crust, covering deep cavities at the bottom of which are seen the true leaf scars distinctly marked by the three vascular points described above. This specimen shows better than any other of this genus that these tubercles represent undeveloped or adventive organs, either leaves or branches. In this case the distribution of the vascular scars indicates them as leaves.

LEPIDOPHLOIOS, *St.*

Plate 18, *f.* 5–8.

Stems arborescent, erect, with four-ranked branches disposed in spiral order; leaves coriaceous, linear, long and narrow, with a thick medial nerve attached at base to thick sub-erect or recurved bolsters inflated in the upper part, dotted under the leaf-scars by a small mammilla. Areoles transversely rhomboidal, marked horizontally by three vascular scars minutely papillose under the cortex.

The figures made from American specimens do not give a just representation of the surface characters of the plants. The leaves were apparently produced upon long inflated bladder-like supports, which, by compression, have been curved back and flattened. At least this is surmised from the large beautiful specimens which have been found in Europe and have been described and figured by Golderberg. In these specimens, the branches are horizontal, the scales or base of the leaves on the branches on both sides are flattened, so that the leaf-scars are turned toward the stem, and those upon the stem toward the base, and therefore, to be right to nature, the fragment of bark represented (pl. 18, f. 5), should be overturned. The leaves were like those of *Lepidodendron*. I have seen only short fragments upon a broken stem of one species. They are rarely found still attached to the branches; even the stems with these scars are very rare. The fructifications are like those of *Lepidodendron*, in sporanges fixed to large strobiles by the base, with sporangiophores enlarged outside into large oblong lanceolate blades, as in *Lepidophyllum acuminatum*, Lesq., (pl. 18, f. 6). These large species of *Lepidophyllum*, of which there are many, have not yet been seen in connection with strobiles. But fragments of very large cones, twenty cm. in diameter or more, have been found at Cannelton, covered with scaly-form leaves like those of pl. 18, f. 7, under which are large appressed glomerules of macrospores, at least twice as long and as thick, like those of f. 8. These agglomerations do not seem to be enclosed in sporanges; they appear merely covered by the bracts. There is still a great deal of uncertainty about the true nature of these plants, which, however, are evidently referable to the *Lycopodiaceæ* by the characters of the fructifications and the cicatrices of their bark.

The more interesting species described of this genus from American specimens, and mostly known by the scars of the surface, are the following.

L. CRASSICAULIS, *Corda.*

Bolsters elongated, persistent, imbricated (a character common to most of the species); leaves linear-acute, carinate on both sides, and by transverse section, rhomboidal or inflated in the middle and alate on the borders; leaf-scars rhomboidal, narrowed and elongated to the base. The pith or medullar cylinder of this species, and perhaps of other species of *Lepidophloios* is woody and transversely ribbed like that of species of *Cordaites*. It is generally known under the name of *Artisia*. Its habitat is in the first coal above the conglomerate.

L. AURICULATUS, *Lesq.*

Bolsters very large, thick, broadly rhomboidal, rounded both in the upper and lower part, imbricated on the borders, polished; leaf scars transversely narrowly rhomboidal and acuminate on the sides, obtuse at the top, angular at the base. The bolsters are as large as three cm. laterally and two and a half cm. vertically. I found this beautiful species at St. John, Illinois, with numerous specimens of *Lepidophyllum acuminatum*, Lesq., pl. 18, f. 6.

L. MACROLEPIDOTUS, *Gold.*

Plate 18, *f.* 5.

Bolsters imbricating at base, somewhat tumescent, obtusely curved on the sides, mammillate in the middle; leaf-scars transversely rhomboidal, rounded on the upper side, nearly truncate on the lower; vascular scars three, the middle larger and placed a little lower. This species, which has been found at Grape Creek, on the limits of Indiana and Illinois, greatly resembles *L. laricinus*, which has bolsters and leaf scars much smaller, and which has been found at divers localities at the horizon of the conglomerate or below, as far down as the Chester limestone.

CYCLOSTIGMA, *Haught.*

Stems arborescent; surface of the bark covered with small sub-globose or conical acute tubercles placed at a short distance, about one cm., topped by a vascular prominent point or flattened at the apex into small round areoles with a medial vascular point; decorticated surface smooth or obscurely striate lengthwise by the series of tubercles, which, under the bark, are oval, elevated at the upper part and gradually effaced in decurring downward, like the base of leaves of *Knorria*, and preserving the impressions of the vascular scars.

The only specimens of this kind found in the American coal measures are referable to *C. Kiltorkense*, Haught., which answers by its characters to the description of the genus. These specimens were found at the base of the middle coal measures near Peoria, Illinois. Plants of this kind are common in the old red sandstone of England, and also in the coal measures of Bear Island, where, associated with *Bornia radiata*, *Lepidodendron Veltheimianum*, species of *Knorria* and of *Archæopteris*, they indicate the age of the formation as sub-carboniferous.

SIGILLARIEÆ.

Trees of large size; trunks simple or forking near the apex, either smooth or longitudinally ribbed or furrowed, marked by leaf-scars (areoles) of various forms, disposed in spiral or quincunxial order; leaves linear, grass-like, triplicate, simple nerved; radicular divisions (*Stigmaria*) thick, dichotomous, horizontally expanded, bearing long linear simple cylindrical fistulose leaves or rootlets, flattened by compression, more or less regularly disposed in spiral order, leaving as scars of their points of attachment, exactly circular areoles with a central vascular round point.

The internal structure of the plants of this family is as yet little known. The phytopaleontologists who have in France and in England studied the texture of the wood by slides prepared of silcified specimens, do not agree in their definition of the essential characters, the first considering the structure as analogous to that of the *Dicotyledonous gymnosperms*, the second to that of the *Lycopodiaceæ*. It is not advisable to discuss the question now, especially for the reason that we have not as yet discovered in the American coal measures any silicified remains of these plants, and are unable to study their structure. Considering what is known from outside characters, leaves, the scars of their points of attachment, it is evident that the relation of the *Sigillarieæ* is with the *Lepidodendron*. Their external conformation is the same, and by their large size and the great number of their species, they fill in the formation of the coal, the same part as the other kinds of Lycopodiaceous trees.

Species of *Sigillaria* are distributed through the whole thickness of the Carboniferous. Rarely found in the lower strata they become more abundant in the middle and upper part of the coal measures. Of this family we have only the two genera, *Sigillaria*, and the appendages considered as their roots, *Stigmaria*.

SIGILLARIA, *Brgt.*

Plate 20.

The essential characters of the genus are the same as those of the family described above. The areoles are extremely variable in size and form, round, oval, truncate, emarginate, hexagonal, transversely rhomboidal, either in vertical series upon trunks costate lengthwise, or upon smooth or variously rugose surfaces not costate, where they are spirally placed in juxtaposition or at more or less distance. They are always marked, either in the center, or more generally in the upper part, with three small vascular cicatrices, one simple medial punctiform, the two others lateral and vertical, semilunar or linear. The species of this genus are very numerous, more than fifty are described from the American coal measures.

In order to facilitate their determination, they have been distributed in groups from their affinity in the disposition, shape and place of the leaf-scars or areoles as follows:

1. Trunks not costate; areoles more or less distant, not contiguous. Pl. 20, f. 6.

2. Trunks not costate; areoles close; contiguous. Pl. 20, f. 7.

3. Trunks costate; ribs not large, simple; areoles close, nearly contiguous at base, or more distant, discoid or ovate. Pl. 20, f. 3–5.

4. Ribs large, generally divided in three zones. Pl. 20, f. 1, 2.

In the first section the more common species is *S. obliqua*, Brgt., with surface smooth, areoles one to two cm. distant, oblique rhomboidal, prolonged and obtuse downward, emarginate at top, angular on the sides. To this species, *S. fissa*, Lesq., and *S. monostigma*, Lesq., are closely allied. This last is remarkable on account of its simple vascular scars, without lateral ones, placed near the top of the areoles. Its bark is composed of different layers, which, taken separately, have each scars of different shape and size. It is well to remark now, that, as is seen pl. 20, f. 1, 6, the surface scars are always very different from those of the decorticated layers, and that the decorticated specimens are rarely, if ever, appropriate for specific determination.

S. DILATATA, *Lesq.*

Areoles flat or slightly umbonate, enlarged and acuminate on the sides, emarginate at the upper border, arched at the lower, cortex distinctly undulate-striate lengthwise; subcorticated scars two, small, oval, horizontally close to each other; intermediate surface undulately striate lengthwise.

S. RETICULATA, *Lesq.*

Plate 20, *f.* 6.

Much resembles the last species by the form of the areoles, which are, however, much larger. The intermediate surface is deeply irregularly transversely striate, and the scars surrounded by a smooth flat border.

S. STELLATA, *Lesq.*

Is a beautiful species with large distant hexagonal areoles, whose upper borders are emarginate, the lower rounded, the lateral slightly curving outside in the middle, surrounded by deep flexuous lines, diverging all around star-like. Very rare.

Of section 2, *Sigillaria Brardii*, Brgt., pl. 20, f. 7–7 c, is the more common and the more remarkable species. The areoles are transversely rhomboidal-oval, enlarged and acuminate on the sides, with the lower borders obtuse, the upper emarginate. The decorticated surface is extremely variable. Sometimes, as in f. 7 a, the inside areoles are obsolete, the vascular scars two, large, oval, only marked in the middle; or as in f. 7 b, the lower outside lines are erased, the upper only preserved, covering the inside areoles, whose vascular scars are erased. In f. 7 c, nothing is left but the vascular scars. Fig. 8 represents a fragment of the root or *Stigmaria* of the species. The species is more abundant in the subcarboniferous.

In section 3, with costate surface and areoles vertically close, contiguous at base or distant, *S. tesellata*, Brgt., with transversely ovate, small, very close areoles, and *S. mammillaris*, Brgt., with large oblong-ovate obtuse ones, a little more distant, are the most common. Few species of this group are known, but those of the following, with areoles vertically more distant, are numerous.

S. Pittstoniana, *Lesq.*

Plate 20, *f.* 3.

Ribs flat, convex on the borders only, surface irregularly rugose; areoles comparatively small, oval, obtusely truncate at top; vascular scars in the middle of the areoles; upper bark thick, transformed into coal, marked with a single small oval scar.

S. Sillimanni, *Brgt.*

Plate 20, *f.* 5.

Ribs narrow, plano convex, slightly undulate, punctate or rugose above the scars, areoles ovate, truncate at the top, enlarged toward the rounded base; vascular scars placed a little above the middle, decorticated surface distinctly lineate; vascular scars double, small, oval, close.

S. ovalis. *Lesq.*

Plate 20, *f.* 4.

Resembles the preceding. Areoles are strictly ovate, obtuse at both ends; furrows between the ribs marked by mere lines and flat; decorticated surface more coarsely striate; scars simple, small; narrowly oval.

The species of the fourth section are remarkable not merely for their large ribs divided in three zones, but for the peculiar property of the subcortical scars of increasing to a great degree by the growth of the trees, and of becoming so much deformed, that their original shape is totally obliterated. The supra-cortical areoles do not increase in the same degree; they are, on the contrary, generally small, and thus one may see, upon good, partly decorticated specimens, the small areoles of the upper layers, while on the sub-costical surface the scars are sometimes more than twice as large. This can be explained only in supposing that the upper cortical layers may become separated from the lower cortex, which, remaining attached to the trees, continue to grow and enlarge while the surface layers remain unchanged.

Two of the more important species are the following:

Sigillaria marginata, *Lesq.*

Plate 20, *f.* 1.

Ribs very large, bordered on both sides by a broad narrowly striate zone; medial furrows flat; areoles large, distant, ovate in outline, truncate at the top, rounded at the base; space between the areoles punctate; decorticated surface thinly striate, its scars double, oval, long, contiguous in the middle. Found near Pittston, Pennsylvania, in the middle coal measures.

SIGILLARIA LACOEI, *Lesq.*

Plate 20, *f.* 2.

Ribs very large; lateral zone convex, the medial canaliculate; areoles very distant and comparatively very small, oval or ovate-oblong, deeply emarginate at the top, rounded at base or, when deformed by lateral compression, enlarged in the middle and narrowed, obtuse at both ends; subcortical scars single, large, lanceolate or more enlarged and inflated at base. Found in the middle coal measures near Pittston.

A group of species of *Sigillaria* has been considered by Brongniart as a separate genus under the name of *Syringodendron* [*suriggos*, reed-like]. It includes deeply costate species whose vascular scars are united in one very small and diversely shaped, either round with a central punctiform vascular scar, or cuneiform emarginate at top, or oval, more enlarged on one side, and mucronate. The species, according to Schimper, represent merely decorticated forms of *Sigillaria*, of which the relation of the scars to the areoles of the surface is unknown, and which, therefore, can not be satisfactorily determined.

STIGMARIA, *Brgt.*

Plate 19, *f.* 1–4.

In the definition of the genus *Sigillaria*, *Stigmaria* is described as representing its radicular sub-divisions. Indeed trunks or stems of *Sigillaria* have been found in Europe, in Canada and in this country, with roots still attached to their base, these roots bearing the characters of *Stigmaria*. For reasons mentioned below, I consider the *Stigmaria* as a vegetable of a peculiar nature, capable, like some water plants of the present epoch, of maintaining its life a long time independently of aerial stems, but able in peculiar circumstances to produce by vertical growth, trunks of *Sigillaria* as its fruiting stems. According to this the genus *Stigmaria* is defined as follows:

Floating stems or roots, generally growing horizontally, distantly forking; branches long, scarcely variable in size in their whole length, subcylindrical or more or less flattened on the lower side; medullar cylinder (pith) woody, often eccentrical, composed of fascicles of vessels disposed star-like; leaves long, tubulose, linear when flattened, leaving, after disruption, on the surface of the stems, round scars composed of two concentrical rings with a central umbonate mammilla pitted in the middle by a punctiform vascular scar.

In their original floating state, the plants of *Stigmaria*, like those of some conferves, mosses, even phænogamous species have continued for long periods their vegetation at the surface or on the bottom of shallow water basins, and have gradually filled them with their debris. Most of the under clay beds of the coal contain remains of *Stigmaria* only, without even a fragment of trunk of *Sigillaria*. Beds of this under clay from twenty to forty feet thick, seen along rivers of the coal fields of this country, in Kentucky especially, are filled with fragments of *Stigmaria*, without any other kind of vegetable remains. This proves that, as for the under clay beds of the peat deposits of the present epoch, which have the same characters as those of the coal and are formed of detritus of floating water plants, the *Stigmaria* plants have lived for long periods of time by themselves or in their floating nature, and that, as it is the case also for the formation of the peat beds, it is only when the mass had become compact by the heaping of the debris, and strong enough for supporting trees, that *Sigillaria* have grown upon *Stigmaria*, as trees producing flowers and fructifications. Some plants of the present epoch have the same property. They live as floating stems, dividing in numerous filaments, some of them bearing bladdery or vesicular appendages by which they are sustained in water, never producing flowering stems until they have a compact solid ground, when budding knots are formed by the connection of some branches, from which aerial fruiting plants are derived.

Stigmaria stems and leaves are also found in the coal, where they are always flattened and recognized only by the scars of their leaves. In the clay, the stems generally preserve their cylindrical or sub-cylindrical shape, for often, the pith is not central, but placed at the under surface, which is then somewhat flat and without leaves.

The scars of the leaves of *Stigmaria* being always of the same form or round, variable only, either in their relative disposition, sometimes in regular spiral or quincunxial order, sometimes irregularly placed, or in the size of the scars, it is very difficult to find distinct characters for the determination of the species. For this reason some authors have described one form only as species, with a great number of varieties.

S. FICOIDES, *Brgt.*

Plate 19, *f.* 1, 2. (*Fig.* 1 *is in a very reduced state.*)

A most common form. Its characters are the same as given for the genus. The stems are extremely long. On the flat surface of a bed of metamorphic clay, as hard as limestone, in Pennsylvania, I have followed these stems prolonged to sixty meters or more without diminution in their thickness, except at their point of dichotomy, which is very rarely seen. The leaves also are very long, thirty, sometimes sixty cm. or more. Some authors represent them as forking near their extremities. I have never seen any one divided in that way, but always simple and of the same thickness, only enlarged above the point of attachment, which is more or less contracted. They sometimes, but rarely bear at their ends a kind of large oval tubercle, which has been considered by some authors as the fructifications, but which is merely a bladder-like appendage to support them in water. The leaves and also their scars are of different thickness according to species or varieties.

Of the varieties described by authors the more marked are:—*Var. undulata* (pl. 19, f. 3). Cortex marked by longitudinal, narrow ribs, undulating by contraction between the scars.—*Var. stellata.* Cortex marked by short, broad lines diverging star-like from the scars as in pl. 19, f. 4.—*Var. inæqualis.* Areoles unequal in size, indistinct, surface obscurely striate.—*Var. reticulata.* Surface distinctly reticulate—striate around the scars.

Under the generic name of *Stigmarioides*, I have described fragments of roots bearing rootlets and marked with much smaller tubercles than those of *Stigmaria*, without central vascular points, as pl. 19, f. 5, and under that of *Sigillarioides*, fragments apparently of the same nature or roots, bearing appendages like leaves of *Sigillaria*, flat with a medial nerve and leaving, for their impression of the point of attachment, transversely rhomboidal areoles, similar to those on the stems of *Sigillaria* (pl. 19, f. 6). These generic divisions are not yet definite. The organs representing roots, of soft cellular texture, are very rarely preserved in the coal shale; the few of them known as yet have been found in concretions of Mazon Creek.

As seen from the description of the genera of the Lycopodiaceous plants, where so many facts and appearances are still unexplained, or merely hypothetical, it is not surprising that vegetable paleontology is not yet able to ascertain the nature and characters of fragments of their roots.

But, admiring the multiplicity, the regularity, the harmony of the forms observed in the stems, the scars of leaves or of branches, the cones and their sporanges, their blades, the appendages considered as roots or floating divisions, etc., we are forcibly led to the conclusion that the family of the *Lycopodiaceæ* was, at the coal epoch, represented by an immense number of plants of divers characters, many still unknown to us, and of which the genera and the species established and described as yet, only represent a mere fraction.

NOEGGERATHIEÆ.

The relation of this order of vegetables is not positively determined. The plant from which it was established, *Noeggerathia foliosa, St.*, was considered by Goeppert as related to *Cyclopteris* or to the ferns, while Brongniart comparing it to species of *Zamia* placed it between the *Cycadeæ* and the Conifers or in the dicotyledonous gymnosperms. A number of species referable to *Noeggerathia* have been described by authors, all of uncertain affinity, and I have myself, in the Report of the First Geological Survey of Pennsylvania, 1858, placed in the genus *Noeggerathia* four species later recognized as ferns of the genus *Archeopteris;* for the pinnules or leaflets of *Noeggerathia foliosa* have about the same shape and the same nervation. As far as known until now the only leaves obtained in the American coal measures, and related to this genus or with characters appearing intermediate between the ferns and gymnosperms, have been abundantly found on the roof of a coal mine of Ohio. From these leaves the following genus has been established.

WHITTLESEYA, *Newby.*

Plate 9, *f.* 1.

Frond simple or pinnate; nerves fasciculate, confluent at the base, simple, not dichotomous, ascending parallel to the upper border, which is dentate or undulate; fructifications unknown. Of the three species described, the following only has been found in a large number of specimens.

W. ELEGANS, *Newby.*

Plate 9, *f.* 1.

Leaves, or pinnæ simple, thick, narrowly fan-like, rounded in narrowing to the petiole, truncate and acutely dentate at the upper border; veins in bundles of slender parallel filaments, converging at the base toward the top of the petiole and at the apex in entering the teeth, becoming connivent at their sharp points.

Though the leaves have been found in profusion in the locality indicated above, none has been seen attached to stems; the pedicels, generally cut short, are not longer than one cm.

The relation of this species is apparently with *Cyclopteris digitata*, Brgt., now referable to *Baiera*, a genus of the *Cycadeæ*. The relation seems the more probable since a species of *Baiera* and other vegetable fragments related to the Ginkgo, a Conifer, have been discovered in the Permo-Carboniferous measures of Virginia, as published by Profs. White and Fontain in Report P. P. Geological Survey of Pennsylvania.

III SERIES. GYMNOSPERMOUS PLANTS.

CORDAITEÆ.

From recent researches especially pursued by Grand'Eury and B. Renault, two celebrated French authors, who have made anatomical analyses of the woody tissue and of divers organs of the *Cordaiteæ*, the plants of this order are now recognized as pertaining to the *Phenogamous gymnosperms*, and to compose a separate group intermediate to the Conifers and the *Cycadeæ*. A number of genera have been described as referable to the *Cordaiteæ*. Of these, the best known and more commonly distributed, are the following ones.

CORDAITES, *Ung.*

Plate 21, *f.* 1, 3.

(Dedicated to Corda.)

Plants sometimes of great size, irregularly divided; trunks composed of a large medullar cylinder or pith, marked on the outer surface by transverse narrow parallel ribs, rarely joined by divisions, covered by double or triple layers of wood and bark; leaves placed in spiral order, more or less distant, of various length and width, linear, more generally enlarged upward, obtuse, entire or obliquely truncate, undulate and vertically cleft at the apex, semi-embracing at base or gradually narrowed to the somewhat inflated point of attachment, marked lengthwise by primary and secondary close simple parallel nerves generally more distant in the middle of the leaves and slighily thicker toward the base; flowers in simple racemes from the axils of the leaves; fruits generally ovate, sessile of various size.

These plants, known until now merely by fragments of leaves, are not rare in the coal measures and are generally distributed from the upper Devonian to the upper coal strata, passing above to the Permian. The flowers were known formerly as *Antholithes*, the fruits as *Carpolithes*, but their reference to species of coal plants, represented by leaves or fronds, was unknown. Now Grand'Eury has found in France a prostrated and silicified forest of *Cordaites*, and has been able to give by restoration, the figure of their trunks (thirty m. high, more than thirty cm. in diameter) with branches, leaves and flowers. These flowers are now separately described as *Cordaianthus*, the fruits as *Cordaicarpus*.

As said above, the leaves or *Cordaites* being generally large were known merely by fragments. Their reference to the genus was easily made, on account of the peculiar nervation which has no analogy to that of the ferns; but the American specimens could rarely be specified until a few years ago when a number of well preserved large ones, bearing not only leaves preserved in their integrity, but branches with leaves attached to them and flowers, pl. 21, f. 1., were obtained at Cannelton, Pennsylvania. From these specimens it has been possible to describe a number of well defined species of which the following are the more important.

C. GRANDIFOLIUS, *Lesq.*

Leaves large, of a strong texture, widening upward and fan-like from a narrow truncate base, round truncate or rounded undulately lobed and cleft at the apex; nervation double; primary nerves obtuse, distantly dichotomous or splitting, inflated and more distinct toward the base, with one often indistinct secondary nerve. The stems of this species are unknown. The leaves are very large and much enlarged upward. One of these, thirty-one cm. long, with a base of one cm., is sixteen cm. wide at the upper border, where it is cleft in short laciniæ; another six mill. broad at base, thirty-two cm. long, is fifteen cm. broad at the apex. The species is found at Pittston, in the sub-conglomerate measures.

C. BORASSIFOLIUS, *Ung.*

Leaves five to eight cm. broad in the middle, where they are widest, gradually narrower both ways, upward to the obtuse or truncate apex more or less deeply cleft downward to the slightly contracted semi-lunar point of attachment; primary nerves indistinct to the naked eyes, close, five to seven in one mm., with generally one intermediate secondary vein; surface thinly rugulose crosswise. The leaves of this species are sometimes very long and rounded at the apex, and there nearly as broad as in the middle; and sometimes forty-five cm. long. They are commonly found over the whole thickness of the middle coal measures.

C. LACOEI, *Lesq.*

Plate 21, *fig.* 2.

Leaves elliptical, obtuse or rounded and narrowed to a point, small and comparatively broad at base; nerves distinct, the primary about one mill. distant, with four to six intermediate ones. A rare species found at Pittston.

C. MANSFIELDI, *Lesq.*

Stems with a thin polished bark indistinctly marked by the scars of the convex base of the leaves; leaves long, open, narrow, nearly exactly linear, gradually narrowed at the apex to an obtuse point, averaging fifteen mm. broad and fifteen cm. long, but much shorter and narrow upon the young branches; nerves distinct, the primary separated by two to four intermediate veinlets; flowers in simple racemes, composed of four sepaloid involucres attached by short peduncles to the common flexuous pedicel; fruits oval, sessile. The species is abundant at Cannelton. The fruits are larger than those of the following species.

C. COSTATUS, *Lesq.*

Plate 21, *f.* 1–1 *b*, 4.

Stem irregularly costate by the decurring prolongation of the tumescent leaf scars; leaves erect, narrow, nearly linear or slightly enlarged upward; primary nerves unequal in distance, three to five in a space of two mm.; intermediate veins three to four; surface transversely rugose; male flowers sessile, on simple sub-cylindrical axillary racemes; fruits large, oval, slightly contracted to the tumescent point of attachment upon a narrow branch. The species is as common at Cannelton as the last and sometimes in very large specimens, one of which has been found with a branch bearing a fruit like f. 4.

C. SERPENS, *Lesq.*

Stems slender, narrow, flexuous or serpentine, abruptly truncate at the top by the flattening of the medullar cylinder and continued by a broad terminal long flat leaf-like prolongation; lateral leaves in right angle to the stems, sub-linear, narrowed to the point of attachment; nervation distinct; primary nerves separated by three to four intermediate ones.

A very remarkable species, which seem to have lived in water and floating. The terminal leaves at the end of the stems are large, two to two and one-half cm. broad; those along the stems are at right angles, one-half to one cm. broad; the stems narrow, one and one-half to two cm. broad. The conformation of the stem is very peculiar. Always flexuous, serpentine, unequal in thickness or inflated here and there, its woody cylinder transversely ribbed, pl. 21, f. 3, is abruptly flattened or truncate at the end of the branches, where its place is taken by large leaves, following the direction of the stem, while the lateral are much narrower, sometimes flexuous, divided in narrow laciniæ and placed at right angles as floating. These characters have been observed upon a large number of specimens. Found with the last.

CORDAIANTHUS, *Grd.'E.*

(*Anthos*, flower.)

This genus includes, as implied by its name, flowers of *Cordaites.* The characters of the species are rarely distinct, as the flowers are generally flattened, obscured or half destroyed by maceration and compressed. *C. gemmifer* represents the group of species of male flowers, buds or gemmules, composed of imbricated scales, often attached to the axil of a linear bract. *C. baccifer* is appropriated for fertile flowers in racemes, bearing at the axils of foliaceous bracts small rudimental or immature ovules, either obtuse or pointed.

CORDAICARPUS, *Grd.'E.*

(*Carpos*, fruit.)

This genus is established for the description of the fruits of *Cordaites*, of which the number is considerable, but whose relation to the plants to which they belong is generally unknown, as they are mostly found loose or remaining attached to the racemes only when very young and still immature.

C. Gutbieri, *Gein.*

Plate 21, *f.* 4, 5.

Fruit oval or ovate, sub-cordiform, rounded or truncate at one end, obtusely pointed at the other; surface smooth; pericarp (outer envelope) transformed into a thin coating of coaly matter.

These fruits, extremely common at Cannelton, with remains of *Cordaites*, are all about of the same shape, but very variable in size. Those of f. 6, 6a, described as *C. apiculatus*, are analogous in their form, but represent a distinct species.

A few other genera, described by Grand'Eury and myself in this section, are not as yet clearly enough related to the *Cordaites*. Among them are the following:

DICRANOPHYLLUM, *Grd.'E.*

Stems slender; leaves narrow, grass-like, linear, sub-coriaceous, of various lengths, forking or dividing at the top in filaments, nerved like *Cordaites*. A few American fragments are apparently referable to the genus, but they are not sufficient for specific determination.

DESMIOPHYLLUM, *Lesq.*

Stems slender; leaves narrow, sub-linear, gradually enlarged from the base, either simple or sparse or fasciculate at base, joined three or four together, surface of the stems and leaves irregularly striate lengthwise by prominent large bundles of nerves buried under the epidermis, which is thick, irregularly granulose.

There is of this genus a single species, *D. gracilis*, Lesq., represented by one specimen only.

TÆNIOPHYLLUM, *Lesq.*

Plate 21, *f.* 8, 8a.

Stems large; leaves crowded, fistulose, flat by compression, thick, exactly linear, decurring at base; surface smooth, opaque or shining.

The characters of this genus, of which three species are described, are not in concordance with those of *Cordaites*. The leaves, exactly linear, were apparently tubulose when living; their surface is not marked by parallel nerves, but by very short lines directed lengthwise, crossed in right angles by thinner ones, forming a kind of areolation like the meshes of a very fine tissue. I have also found some of these long leaves containing within their channels or under the coaly layer of their surface groups of macrospores, which could be seen for the whole length, either marked indistinctly through the compressed surface, or distinctly wherever the epidermis was destroyed. If this appearance, observed upon many specimens, is not deceptive the relation of these plants is with the *Lycopodiaceæ.*

FRUITS OR SEEDS.

A number of fruits or seeds of very different characters are found already in the upper Devonian and become more and more abundantly distributed in the carboniferous measures. Plate 22 represents by a few specimens of those fruits, some of their more remarkable forms and their great variety of size and shape. I have already described under the name of *Cordaicarpus* a few of the species positively referable to *Cordaites.* The relation of the others in regard to the plants from which they are derived is mostly unknown. Considering merely the outside characters of the seeds of the coal measures, those which can be recognized without anatomical analysis, most of the paleontologists have classed them in four generic divisions, *Cardiocarpus*, *Rhabdocarpus*, *Trigonocarpus* and *Carpolithes.* Some French authors, Brongniart especially, have been able to examine the inner structure of a number of silicified fruits of the carboniferous and have applied to them a different nomenclature. A record of these determinations would now be useless in this country, where no fruits have been found silicified or preserved in such a way that their inner structure can be microscopically studied. I have, therefore, preserved the old and general classification.

CARDIOCARPUS, *Brgt.*

(*Cardia*, heart.)

Seeds of various shapes, composed of a compressed, generally cordiform or oval nucleus, surrounded by a flattened fibrous border, or a membranous wing, representing the pericarp or testa.

As it is difficult to understand the characters of the seeds from mere description, I mention only the figured species of this or of the other genera of fossil fruits.

C. HARVEYI, *Sp. nov.*

Plate 22, *f.* 1.

Nucleus large, oval in outline, with concentrical borders nearly one cm. broad, deeply emarginate at top, forming two erect sharply pointed horns separated by an obtuse sinus. The tube by which the pollenic substance enters the ovary (tubular micropyle) is distinct.

Found in the sub-conglomerate coal of Arkansas.

C. INGENS, *Lesq.*

Plate 22, *f.* 2.

Nucleus cordiform, narrowed at the apex into a micropyle passing up to the sinus of the margin; wing broad, following the outline of the ovule, becoming a little larger toward the apex, where it is deeply cut into a narrow sinus. Same geological station as the last, but found at a different locality.

C. OVALIS *Lesq.*

Plate 22, *f.* 3, 4.

Seeds of medium size; nucleus cordiform ovate; border narrow, concentrical, slightly larger above, emarginate at the apex. I consider f. 4 as representing the nucleus loosened from its testa.

The species is common in the sub-conglomerate beds of Arkansas.

C. SIMPLEX, *Lesq.*

Plate 22, *f.* 13.

Seeds small, nucleus broadly cordate, obtuse, broadly winged, emarginate at apex. Seeds of this character, very variable in shape and size, have sometimes been described as *Samaropsis.*

C. BICORNUTUS, *Lesq.*

Plate 22, *fig.* 14.

Seeds small, broadly winged; nucleus oblong-ovate, acute, bordered by a broad margin prolonged downward and narrowed into a pedicel, enlarged, deeply emarginate to the apex of the nucleus, and diverging in two acuminate horn-shaped points.

This seed is very remarkable. The nucleus is hard, compact, less flattened by compression than the testa from which it is easily separated. It evidently belongs to a different group and was first described under the name of *Ptilocarpus*, Lesq. Found in the upper coal of Ohio.

C. MAMILLATUS, *Lesq.*

Plate 22, *figs.* 5, 5*a.*

Seed small; nucleus oval, mamillate at the base, regularly and deeply striate, surrounded by a narrow border or flattened testa. The testa is destroyed in the specimen figured. I have only seen it fragmentary upon a specimen somewhat different, a little larger and round, which may represent another species. It may therefore be referable to the following group:

RHABDOCARPUS, *Goepp and Berger.*

(*Rabdos* striated.)

Fruits often of large size, costate or striate lengthwise, acute or acuminate, surrounded by a testa sometimes destroyed or deficient.

R. INSIGNIS, *Lesq.*

Plate 22, *fig.* 6.

Seed (nucleus?) large, broadly oval, apiculate, marked at base by a large cicatrice at its point of attachment, indistinctly striate by equidistant larger leaves, and irregularly closely lineate or wrinkled lengthwise.

A beautiful fruit found at Pittston, Pennsylvania.

R. MANSFIELDI, *Lesq.*

Plate 22, *fig.* 7.

Fruit very large, obovate, truncate at the point of connection to the the stem; testa thin, wrinkled by fragments of a layer of rugose coaly matter; nucleus distantly obscurely striate lengthwise. Fruits of this kind, but scarcely as large as the one figured, are not rare at Cannelton. One has been found apparently attached to a branch of *Cordaites Mansfieldi*, and is therefore a *Cordaicarpus*. As the attachment to the stem is considered by some a mere casual superposition of the fruit to a fragment of stem, I describe the fruit here in the genus to which it is referable by its outside characters.

R. MULTISTRIATUS, *Presl.*

Plate 22, *figs.* 8, 9.

Seeds oval, rounded at base; outer testa prolonged beyond the nucleus and narrowed upward into an obtuse or truncate apex, obscurely ribbed and striate lengthwise; nucleus shorter, ovate, apiculate, distinctly equally ribbed, marked at base by a large cicatrice or point of attachment. Found over the middle coal measures, especially in the shale of the first coal above the conglomerate.

R. HOWARDI, *Lesq.*

Plate 22, *fig.* 10.

Fruit large, oblong, curved to one side, rounded at base, abruptly narrowed at the apex to a short acumen, marked lengthwise, with distant narrow elevated ribs indistinctly minutely lineate in the intervals. Appears to be a nucleus, perhaps referable to *Trigonocarpus*. Found in a bed of sandstone in the coal measures of Ohio.

TRIGONOCARPUS, *Brgt.*

Plate 22, *f.* 11, 12.

Fruits ovoid, compressed triangular at the point of insertion, three or six costate; ribs more distinct and prominent toward the base, sometimes disappearing above; apex pitted by a small round or triquetrous mamillate cavity.

T. DAWESII, *Ll. and Hutt.*

Plate 22, *f.* 11.

Fruit broadly ovate or oblong, abruptly pointed, marked with three strong prominent ribs.

These seeds as described by European authors are very variable in size and also of different shape, appearing to represent different species. Found in many specimens at the base of the coal measures of Indiana in conglomerate sandstone.

T. SUBCYLINDRICUS, *Lesq.*

Plate 22, *f.* 12.

Fruit small, tri-costate and slightly triangular, subcylindrical in outline, generally narrowed upward and pointed, smooth; basilar cicatrice large, triangular.

CARPOLITHES, *Schloth.*

Plate 22, *f.* 15--18.

Seeds of various forms and of uncertain relation, not referable by their characters to any of the preceding genera, often representing ovules deprived of their testa.

C. BICUSPIDATUS, *St.*

Plate 22, *f.* 15.

Nucleus small, enlarged in the middle or transversely oval, rounded at base, rapidly narrowed to a sharp point, entirely smooth. Fruits of this kind are not rare in the lower coal measures, sometimes found with a narrow pedicel.

C. ORBICULARIS, *Newby.*

Plate 22, *f.* 16.

Nucleus exactly orbicular, inflated, smooth. Rare. Found at Cannelton.*

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* Cannelton and Pittston, referred to in this paper, are in Pennsylvania.

C. REGULARIS (?), *St.*

Plate 22, *f.* 17, 17*a*.

Nucleus very small, oval, surrounded by a concentrical larger testa, pitted at the apex by a small round alveole. Species perhaps referable to *Cardiocarpus*. Shale of the middle coal strata; rare and unsatisfactorily known like all the *Carpolithes*.

C. ARCUATUS, *Lesq.*

Plate 22, *f.* 18.

An oblong linear fruit, five cm. long, without its slender, curved pedicel-one cm. broad in the middle where it is narrower, like strangled, slightly curved, inflated above, abruptly narrowed to a short inclined beak, and also narrowed at base into a pedicel one and one-half cm. long. The upper surface of the pericarp is a striate coating of coal, the lower surface is dotted by transversal short wrinkles. The fruit is very peculiar and does not show relation to any kind of seeds described as yet from the coal measures. Found in a thin layer of coal in Kentucky, at the horizon of the Conglomerate. It is probably referable to the genus *Rhabdocarpus*, and is described as *R. arcuatus* in the "United States Coal Flora."

The Fossils of the Indiana Rocks, No. 3.

BY CHARLES A. WHITE, M. D.

GENERAL REMARKS.

One of the most important formations in the State of Indiana is that which is known by the name of Coal Measures; a name which was applied to the corresponding formation in England in the early history of geology. Whatever of signification the name may have originally had, it is now used as a proper name of a geological formation, just as the names Niagara, Hamilton, Corniferous, etc., are used for other formations. The great Carboniferous system of rocks is known to exist over a large part of the two Americas, and large parts of Europe and Asia also. It probably exists in other divisions of the earth, but in those just named it has been more or less extensively studied.

The strata of the Carboniferous system are usually separated into three divisions, namely, the Lower Carboniferous (or, as it is sometimes called, Subcarboniferous), the Coal Measures and the Permian. The Lower Carboniferous strata are well developed in Indiana; and some of the most interesting fossils that have been found in the State come from that formation. In the States to the westward of Indiana, the Lower Carboniferous series has been divided into five distinct groups, each being characterized by fossils which are peculiar to its own strata. The greater part of these groups are recognized within the State of Indiana, and have received much attention from geologists and paleontologists, on account of their interesting geological features and the richness of their fossil remains.

The Coal Measures are, in like manner, divided into three groups or subdivisions, under the respective names of Lower, Middle, and Upper Coal Measures, the latter being sometimes called Permo-Carboniferous. The lines or planes of demarkation between these three subdivisions of the Coal Measures are not so distinct as they are between the subdivisions of the Lower Carboniferous series; neither are they so distinctly separated from each other by the character of their respectively contained fossils.

In consequence of this similarity of the fossils contained in the Coal Measure series, some geologists are not disposed to recognize the subdivisions that have been named as anything more than a convenience of arrangement for study and description. Many geologists also seriously question the existence of the Permian formation in any of the States which lie to the eastward of the Mississippi River; and, so far as any information is concerned which may be furnished by invertebrate fossils, the question is still an open one. Professor Cope, however, has described some important vertebrate remains from Vermillion county, Illinois, which he regards as clearly indicating the Permian age of the strata from which they were obtained.

In this article, I shall treat only of the fossils of the Coal Measures, and I shall confine myself to the invertebrate forms, omitting, entirely, all vertebrate forms and plants. Before proceeding with the description of these fossils, I will, in compliance with the often expressed wish of Professor Collett, present some popular remarks of a general character which have a bearing upon the subject of this article.

To properly understand the subject of any special investigation in Paleontology, one must carefully inquire into the physical conditions which existed at the time the fossil forms he studies were living ones; and this may be done with more satisfactory results than many may suppose. It is not strange, that those who are not accustomed to geological investigations often think such efforts are necessarily profitless, nor that they should sometimes regard any statements which may be made with reference to the physical conditions that existed upon the earth at a time so remote as the Carboniferous age as amounting to nothing more than vagaries of a vivid imagination, or that they are, at best, mere speculations as to what conditions may possibly have then existed. It is true that we can not now know what the physical conditions were which prevailed during any former period of the earth's history with the same minuteness that we know the conditions now existing, but nothing is more certain than that we may know what some of those conditions were with approximate accuracy. Taking the present conditions which prevail upon the earth as a key to the past, we are able to reach conclusions which, for extent, variety, and evident accuracy, would have startled us at the outset. Let us consider, briefly, a few examples of the methods by which geologists reach their conclusions with reference to physical conditions which prevailed during past geological ages.

The most northerly point in American seas at which true reef-building corals now exist is in the vicinity of the Bermuda Islands. The waters of the sea to the northward of this are, except perhaps in the deepest waters, too cold to allow the existence of coral-forming polyps.* Further-

* Since this paragraph was written, the labors of the U. S. Fish Commission have demonstrated the existence of a considerable variety of corals in the deep sea in much higher latitudes; but this does not materially affect the application I make of the facts mentioned.

more, coral-forming polyps are found only in marine waters, never in fresh waters. In all the geological periods, however, which are represented by the formations of Indiana, of whatever age, coral-forming polyps existed, and, in the strata which represent those periods, fossil corals are now found. We infer, therefore, that the waters in which all the formations of Indiana were deposited (with the exception of the beds of coal and some of their immediately associated layers) were of marine saltness, and probably as warm as those of the Florida Keys. Furthermore, formations of the same geological age as some of those of Indiana are found within the Arctic circle, containing, in both regions, fossil corals of the same or closely related species. Similar forms of fossil corals are also found in various parts of both the eastern and western hemispheres, and on both sides of the equator. We, therefore, infer that the conditions of climate upon the earth, in those ages, were very different from those which now prevail, and certainly much more uniform. Again: We find imbedded in certain of the strata within the Arctic circle, where no trees can now grow on account of the coldness of the climate, remains, not only of a great variety of forest trees, but, also, many vegetable forms that are closely related to living tropical or subtropical species. We infer from these facts, that there has been a time when the climate within the Arctic circle was milder than the present climate of Indiana.

By the study of the aqueous life now existing upon the earth, naturalists find that certain genera, families, orders, and even classes, of animal forms are restricted to marine waters; that is, to those which have a saltness equal to that of the ocean. Other forms, again, are found only in brackish waters; and still others only in waters that are wholly fresh. When, therefore, we find any fossil remains that come under either of these three categories, we feel confident that we know, approximately at least, whether the waters in which those animal forms lived were salt, brackish or fresh, although long geological periods have elapsed since the last of those forms was living and since those waters gave place to dry land.

Again, certain forms of mollusks are now found living only upon the land, and others mainly or only in marshy places. In case, therefore, of the discovery of fossil shells like those of the first-named kind, we infer that the land upon which they lived was near by, and that the shells were drifted into the waters in which the deposits which now contain them were made. In the case of the other forms, it is legitimate to infer that they were entombed where they lived; and the associated conditions and contents of the strata will tell, with approximate clearness, whether their habitat was a marsh or a lake. In a few instances, discoveries of fossil land shells have been made which were mingled in the same strata with those of true marine mollusks. The inference, in those cases, was plain, and associated circumstances confirmed it, that the strata in which these fossils were found were deposited in the sea and near the shore, that the land shells were washed into the sea by land drainage, drifted out, sunk, and were entombed with the shells of those mollusks which had lived and died in the waters there. The sediment which entombed them was hardened into rock, the sea receded by the gradual elevation of the land, and now, in the heart of a continent, the geologist's hammer lays bare these ancient forms, and he reads a history which had lain, as in a sealed book, for ages.

By the study of marine life, naturalists also find that certain mollusks and other animal forms inhabit deep, and others shallow, waters. Others, again, are known to thrive in waters charged with sediment; while certain forms can exist only in the clearest water, and are instantly killed by the accession of sediment. Similar distinctions are recognized by paleontologists among fossil forms, and the character of the material of which the strata are composed usually agrees with such determinations; that is, the character of the rocks which enclose the forms corresponding to deep sea life indicates a finer condition of the sediment than that of the wave-washed shallow water deposits. It is no uncommon thing to find among the strata of a formation evidences of the local destruction of life by the irruption of sediment into waters which had long previously been clear.

Since all stratified rocks have been deposited under water, the various formations, when first deposited, were, of necessity, approximately level. When, therefore, we find the formations tilted so that the strata stand at any considerable angle with the horizon, we necessarily infer that they have become so tilted by a subsequent movement of the earth's crust at that place. This tilting of the strata may be so slight as not to be discernable to the eye at the limited exposures which the prevalent overlying soil allows. In such cases, it is only discoverable by traversing the region in which the strata in question occur, and, finding them to gradually disappear beneath another formation, or, finding still another formation, to come gradually to the surface from beneath the one upon which our observations began. In other cases, the strata are found tilted at a high angle, or flexed up against a mountain side, and often entering largely into the structure of mountains. In all such cases, it is needless to say that these movements of the earth's crust took place after the strata so disturbed were deposited, but the use geologists make of this obvious fact is important. For example: It is well known that strata of the Carboniferous age enter largely into the structure of the Allegheny Mountains, and, as the greater part of these strata were formed beneath the level of the sea, it is clear that the entire elevation of those mountains took place after the close of the Carboniferous age. Indeed, certain other facts are now understood to point to a very much later date for the origin of the elevation of those mountains than the close of the Carboniferous age. Again, Cretaceous and Tertiary strata are strongly flexed up against the ranges of the Rocky Mountain system, and in some places they enter largely into the structure of those mountains. It is, therefore, plain that the Rocky Mountain system had no existence prior to the close of the Cretaceous period or the beginning of the Tertiary. Mountains are by no means the stable objects they seem to be in comparison with the shortness of human life and human history, and it is probable that many mountains and mountain ranges have risen upon, and disappeared by erosion from, the face of the earth in former geological times, but it is practically certain that all the present mountains of the earth were formed since the animals lived whose remains are described upon the following pages.

These remarks will serve to indicate the methods by which geologists reach the conclusions they put forward. While many of these conclusions are full and satisfactory, it is not to be denied that many important problems still await solution; and that, in many cases, the order of past events is obscure or the geological record of them is abruptly broken. Considering the circumstances, however, the minuteness and accuracy of the geological history which has been read in the rocky strata of the earth are truly surprising. While the student of the physical geography of the present day defines the features of the earth as they now are, the geologist catches here and there, through the ages that have passed, a multitude of glimpses of the features that our old earth has put on and worn for a time, and then laid aside; of broad seas whose boundaries were far from those which are known to modern geography, and whose waters teemed with strange forms of life; of the rise of continents, where once were only islands or a shoreless sea; of mountain ranges that rose in grandeur, and then slowly wasted away to their very bases by the corroding action of the elements; of broad regions covered with verdure and peopled with a wonderful wealth of animal life. With these hints concerning the methods of reasoning adopted by geologists, I may now present some remarks concerning the physical conditions which are thus understood to have prevailed during the Carboniferous age and while the animals were living whose fossil remains are described on following pages.

When the name "Carboniferous" was first chosen for the great system of stratified rocks that succeeds those of the Devonian age, it was supposed that all the mineral coal of the earth was contained within it, and the name was chosen in consequence of that opinion. A coal-like substance, called lignite, was then known to exist in comparatively small quantities in different formations of much later geological age than the Carboniferous; but these deposits were regarded as unimportant and the coal was believed to be inconsiderable in amount. The idea then prevailed that during the Carboniferous age, peculiar conditions existed for the abundant growth of vegetable life such as the earth never knew before and has never known since. As our knowledge of the geology of the earth has increased, however, so much coal has been found in strata other than those of the Carboniferous age, that it has become a question whether more than half of the known coal of the earth is referable to that age. All the coal of the numerous and important mines that have been opened in western North America, west of the 100th meridian, is obtained from strata none of which are older than the Cretaceous period; and its origin is, therefore, of much later date than the close of the Carboniferous age. It is now, also, known that immense quantities of coal of much later origin than the Carboniferous age exist in other parts of the world, notably in China. The following extract from a chapter by the eminent geologist, Dr. Newberry, in Pumpelly's Geological Researches in China, Mongolia, and Japan, presents this fact in a clear light: "We have, of course, no right to assume that no Carboniferous coal exists in China, for it may very well happen that, as in our own country, coal seams of economic value, but of different ages, will be found there at points not greatly removed from each other. But geologists will not fail to be deeply interested in the fact that so large portions of the coal basins of China, including beds of both antharcite and bituminous coal—worked for hundreds of years, probably the oldest coal mines in the world—are wholly excluded from the Carboniferous formation. So large is this coal-bearing area, indeed, that, when joined to the Triassic, Cretaceous, and Tertiary coals of North America, they quite overshadow the Carboniferous coals of Europe and the Mississippi Valley, and suggest the question, whether the name given to the formation which includes the most important European strata has not been somewhat hastily chosen."

Moreover, there are large regions in different parts of the earth where the strata of the true Carboniferous age, known to be such bý the character of the fossils they contain, are found to contain no coal. Still the name "Carboniferous"—coal-bearing—remains as a proper name for this system of rocks, wherever it may be found, although its strata may contain no coal; and even though strata of another geological age in the same region may contain an abundance of coal. These facts make it clearly apparent that the mere presence of coal in any strata, is, of itself, no indication of their geological age, and it will, therefore, be readily understood that the only true indication of the geological age of any formation is furnished by the fossil which it may contain. Hence, the importance of paleontology in the study of the geology of any region.

As regards the coal of Indiana, it all belongs to the true Carboniferous age, and no strata of the geological age of those which contain the coal of western North America exist in this State. In the further discussion of this subject, therefore, I shall have reference to strata of the Carboniferous age alone.

Those who have studied the fossils of the Mesozoic and Tertiary periods

—that is, the geological periods which succeeded those of the Carboniferous age—are familiar with the fact that there is great diversity of the species of those fossils in the various regions of the earth; that is, the number of species belonging to any given one of those periods which are found in more than one of the grand divisions of the earth, is very small, and a large proportion of the species are apparently confined to a small area. In the case, however, of the fossils which characterize the Carboniferous age, we find many of them to have an almost world-wide distribution. For example, several of the species which occur in the Coal Measure rocks of Indiana are not only found in other and widely separated parts of our own country, but they occur, also, in the Carboniferous strata of South America, Europe, and Asia. This fact indicates that a far greater uniformity of conditions then existed all over the earth than existed in the subsequent periods, or than exists at the present time; that is, the conditions were sufficiently alike in different parts of the earth to allow of a great uniformity of animal life. But since coal is found in only a part of the whole series of strata which make up the Carboniferous system, and in certain regions coal does not exist at all among its strata, although the characteristic fossils are there, it is plain that the precise conditions which resulted in coal making were not everywhere uniform. Indeed, it is certain that in large portions of those regions of the earth within which deposits of stratified rocks were produced during the Carboniferous age, no coal whatever was produced. It is, also, true that within those areas where coal-forming material was accumulated, the conditions favorable for its production alternated with unfavorable conditions, so that beds of coal alternate with beds of limestone or sandy and clayey layers.

Coal is unquestionably of vegetable origin; and, although traces of vegetable structure are not always distinguishable in it, fragments of plants like those which contributed to its production are found scattered in the layers which are associated with the coal beds. Alternating with the coal beds are strata composed of sandy and clayey shales, together with limestones and sandstones, which strata make up the great bulk of the Coal Measures. These strata contain the fossil remains which characterize the formation. In some of the layers, as before stated, remains of plants are found; but, in others, fossil shells, corals, etc., prevail, sometimes abundantly. It is plain that the plants must have grown upon the land, and that the animals which formed the shells and corals lived in the waters in which the strata were deposited, and their characters show plainly that those waters were marine. The abundance of vegetable matter that it must have required to produce such extensive beds of coal, the character of the coal beds, and their freedom from extraneous substances, and the character, also, of some of the associated strata, show that the vegetation in question grew upon the very surfaces upon which we now find their remains in the form of coal. The character of the vegetation whose remains we find, that of the material composing the layers which enclose them, and that of some of the animal remains which those layers also enclose, show that the coal-producing vegetation grew in immense marshes, only slightly raised above the level of the sea. It is hardly to be questioned that coal was in the condition of peat in the first stage of its production, and that this peat was produced, as peat always is, by the partial decomposition of vegetable matter under water, or in a state of constant moisture.

Now, these conditions being understood, the following conclusions necessarily follow: In every region that is now a coal field there were, during the period in which the material was produced of which the coal was formed, oscillations of the earth's crust; that is, there were gentle and wide spread risings and sinkings of the crust, in consequence of which the land surface remained for a long time just above the level of the sea; then, sinking, it remained for a long time beneath its level. These risings and sinkings were repeated as often as there are separate beds of coal, however thin or economically unimportant they may be. While the land surface was just above the level of the sea in the Carboniferous age, vegetation grew most luxuriantly, and, from its debris, peat beds of enormous thickness and extent were formed. When the land gradually sank again beneath the sea level, these peat beds were covered with sedimentary material, which afterward, as the ages passed, became changed to the condition of shales, sandstones, and limestones that we now find them to be, and the peat became changed to coal. We find those shales, sandstones, and limestones charged with fossil remains of such a character as to show that both they and the strata which enclose them are of marine origin.

Such is a statement of the leading features of the conditions which prevailed during the coal-forming period of the Carboniferous age. Such conditions prevailed over a large area which is now included in the North American continent, and of which a large portion of Indiana now forms a part. As before stated, the coal-making conditions did not prevail everywhere during the Coal Measure period; but they occurred in circumscribed, yet very extensive, areas. It is believed by geologists, that the great area in which the coal of Indiana was deposited once extended from eastern Pennsylvania to beyond the Missouri River, and from Michigan to the northern portion of the Gulf States. Coal has been found among Carboniferous strata as far west as eastern Nebraska and Kansas, but with insignificant exceptions, it has never been found in any strata of the Carboniferous age to the westward of that region, although the aggregate thickness of the strata of the Carboniferous system is very much greater in that far western region than it is anywhere east of the Missouri River. In that western region, the strata are almost wholly of marine origin; and as they consist almost entirely of sandstones and limestones, without coal or carbonaceous shales, it is plain that conditions favorable to the abundant growth of vegetation did not exist there in any portion of the Carboniferous age. That is, while the coal-plant forests of the eastern portion of the continent were growing luxuriantly, the unbroken sea prevailed over what is now the western portion, or at least over that part of it which is found to be occupied by Carboniferous strata. In those western marine Carboniferous strata very many of the fossil species are identical with those which are found in Indiana, in strata which alternate with beds of coal. We, therefore, infer that while those portions of Indiana which are now occupied by the Coal Measures were beneath the level of the sea, the waters which submerged them were continuous to that far-off western region. Indeed, as I have before shown, it was doubtless then continuous, also, over a large part of the earth.

Now, let us inquire as to the character of the life that existed during the time within which the Coal Measures of Indiana were formed, and within the area which now constitutes the great coal field of eastern North America. If, during that period, there were mountains upon any part of what is now the North American continent, they were far to the northward and northeastward; at least, it is certain that none of the mountains that now make up either of the great mountain systems of North America then existed. During that portion of the long Carboniferous age, when and where the land was above the level of the sea it was clothed with a luxuriance of vegetation, such, perhaps, as the earth has never witnessed at any other period of its history. Trees of strange form sent up their towering trunks above the dense undergrowth, but no birds perched in their branches, nor waded the marshes or swam in the pools among them. A few reptiles and batrachians lived there, but reptilian life seems not yet to have gained much of a foothold upon the earth, especially compared with it as it afterward became. None of the mammalia, the chief forms of the animal life of the present day, had yet come into being so far as we yet know. Insects and Myriapods lived then, and, probably, in great abundance, for their means of subsistence abounded in the bountiful vegetation, and their natural enemies were remarkably few. The earth was then a great solitude, and the reigning stillness was perhaps broken, in the intervals of storms, only by the hum of insects and the bellowing of frog-like batrachians. Where the sea prevailed during all this long period, its waters teemed with life. Fishes were there; some of them large and powerful, but all were unlike the scaly fishes of to-day. Mollusks in great abundance, and corals of delicate beauty existed; and a diversity of crustaceans nestled and sported among the seaweeds or crept along the oozy bottom.

Coal-making conditions did not apparently begin with the beginning of the Carboniferous period. The earliest known coal beds were not formed until near the close of the Lower Carboniferous period, and at a time when fully one-third of the great Carboniferous age had passed; and the coal-making condition was not fully established until the middle, or Coal Measure, period of that age. Marine conditions, apparently, alone prevailed during the Lower Carboniferous period. Its fauna was similar to the marine fauna of the Coal Measure period—a portion of the fossil remains of which are figured on plates accompanying this report.

The foregoing remarks are intended to convey to the general reader an idea of the character and significance of the fossil remains I shall describe on following pages. It would require a series of volumes to illustrate all the forms that are now known to have existed during the Coal Measure period alone. In this article I shall necessarily confine myself to a consideration of the fossil shells, corals, and crustacean remains that have been found in the Coal Measure strata of Indiana and those of the adjacent States. I have aimed to select those only which may be reasonably looked for in Indiana, but far the greater part of them have actually been found in its strata. Many of the figures have been borrowed from works previously published, but they are nevertheless correct representations of forms that exist in the strata of Indiana and representatives of the ancient life of a region of which this State now forms only a small part.

FAUNA OF THE COAL MEASURES.

DESCRIPTION OF SPECIES.

PROTOZOA.

The *Protozoa* are not very numerous in the Coal Measures of the United States, or, at least, they are not conspicuous objects to the general collector. Protozoan life doubtless abounded during the Coal Measure period, but the calcareous shells of the Foraminifera appear to be the only forms that have been preserved. The only conspicuous species (or the only one which is likely to attract the attention of the general collector) is the one which is described in the following paragraphs.

FORAMINIFERA.

Genus FUSULINA, *Fischer.*

FUSULINA CYLINDRICA, *Fischer.*

Plate 23, *figs.* 1, 2 *and* 3.

FUSULINA CYLINDRICA. Various European and American authors.

Shell small, varying in shape from elongate-fusiform to subglobose, and, also, varying greatly in size; the extremities usually somewhat prominent, formed until near the close of the Lower Carboniferous period, and at a time when fully one-third of the great Carboniferous age had passed; and the coal-making condition was not fully established until the middle, or Coal Measure, period of that age. Marine conditions, apparently, alone prevailed during the Lower Carboniferous period. Its fauna was similar to the marine fauna of the Coal Measure period—a portion of the fossil remains of which are figured on plates accompanying this report.

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Shell small, varying in shape from elongate-fusiform to subglobose, and, also, varying greatly in size; the extremities usually somewhat prominent, even in the subglobose forms, and have the appearance of being somewhat twisted; surface marked by five longitudinal furrows, which mark the position of the septa, and which are straight, except that they are a little flexed at the ends; aperture very small, and usually obscured by the imbedding rock; volutions six to ten in number, closely coiled, the interspaces narrow; septa from twenty to thirty or more in the outer volution, undulating along their inner edge; the foramina of the septa, or foramen apertures, moderately distinct in specimens that are well preserved.

The common size and shape of specimens of this species is closely like that of a grain of a wheat, but they are often found very much smaller,* and sometimes larger and longer, and both more slender and more globose.

This interesting form is not only common in the Carboniferous rocks of various parts of Europe, but it is found in the Coal Measure strata of the United States, from Ohio to California. It may be sought for at Lodi, Fountain county, Indiana, in the limestone roof of coal K.

CŒLENTERATA.

POLYPI.

As a large proportion of living Polyps form no coral skeletons, it may be inferred that many kinds of Polyps existed in the Coal Measure and in other geological periods, which have left no trace of their existence in the rocks which represent those periods. In strata of some of the periods fossil corals are abundant, but, although a considerable number of widely differentiated forms are found in Coal Measure strata, they are seldom found to constitute a conspicuous feature of the fossil fauna of that formation. I herewith present descriptions of five species of fossil corals, all of which are more nearly related to forms which existed in the previous geological formations than they are to any that are now found living.

Genus ZAPHRENTIS, *Rafinesque.*

ZAPHRENTIS GIBSONI (sp. nov.)

Plate 23, figs. 4 and 5.

Corallum curved, conical in form; its outer surface marked by concentric lines and numerous strong wrinkles of growth, and also by numerous distinct longitudinal raised lines; calyx subcircular, deep, and its edges thin; septal fosset well developed, and situated at the concave side of the corallum; septa thirty-six to forty in number, prominent, and thin within the calyx.

Length, along the longest side, 32 mm.; diameter of the calyx, 25 mm.

This is plainly a typical species of *Zaphrentis*, and, so far as I am aware, it is the only species of that genus which has been found in the true Coal

*In Indiana, it is rarely larger than half the size of a grain of wheat. C.

Measures of the United States, although the genus is well represented in the Lower Carboniferous. It resembles in shape *Z. spinulifera*, Hall, from the Lower Carboniferous limestone, but it is without spines, its proportions are somewhat different, and the calyx is deeper.

Locality. The specimen herein described and figured was obtained from the Coal Measure strata of Vermillion county, Indiana, by Mr. William Gibson, in whose honor the specific name is given.

Genus Lophophyllum, *Edwards and Haime.*

Lophophyllum proliferum, *McChesney.*

Plate 23, *figs.* 6 *and* 7.

Corallum subconical-elongate, more or less curved; more or less irregular in form; base slender, usually pointed; epitheca thin; concentric lines and wrinkles of growth distinct, especially the latter; longitudinal striæ distinct; a few spinules sometimes observable near the slender base; calyx subcircular, moderately deep; columella strong, prominent, compressed so that its longer axis is in the plane of the curve of the corallum; septa varying in number with the size of the corallum, from about thirty to nearly or quite fifty, each alternate one much less prominent than the others, the latter extend to the columella, near which they are usually a little flexed.

Different specimens are variable in proportions; a common size is 18 or 20 mm. long and 10 mm. across the calyx.*

This species is a very common one in the Coal Measures of Indiana, Illinois, and Iowa. A more slender form than the one here described occurs in Illinois and Indiana, to which Professor Worthen has given the name *Cyathaxonia distorta.* To a larger and more robust form I have given the name *Lophophyllum sauridens.*

Locality. Common throughout the Coal Measures.

Genus Axophyllum, *Edwards and Haime.*

Axophyllum rudis, *White and St. John.*

Plate 23, *figs.* 8 *and* 9.

Axophyllum rudis, *White and St. John*, 1867. Trans. Chicago Acad. Sci., I, p. 115.

Corallum irregularly turbinate, more or less contorted; attached at the apex or along the greater part of its length, usually expanding rapidly from the apex to the calyx; surface marked by irregular concentric undulations of growth, by faint longitudinal lines which indicate the position of the septa, and often by more or less numerous irregular rootlets; outer portion of the calyx shallow, central portion moderately deep; columella small, somewhat prominent, flattened.

*Indiana species are three or four times as long as wide. C.

The size of the specimens is somewhat variable. An example of ordinary size measures 20 mm. in length and 12 mm. across the rim of the calyx.

This species is not uncommonly met with in the Upper Coal Measures of Indiana, Illinois, and Iowa. It is sometimes found as a single simple corallum, but it not unfrequently occurs in clusters, which have originated from a parent corallum by lateral gemmation; and the new corallums are often more or less bound together by their rootlets.

Locality. The specimens figured are from Newport, Indiana. These are rather smaller than the average size.

Genus CAMPOPHYLLUM, *Edwards and Haime.*

CAMPOPHYLLUM TORQUIUM, *Owen.*

Plate 23, *figs.* 10, 11, 12 *and* 13.

CYATHOPHYLLUM TORQUIUM, *Owen*, 1852. Geol. Sur. Wis., Iowa and Minn., plate IV, fig. 2.
CAMPOPHYLLUM TORQUIUM, *Meek*, 1872. U. S. Geol. Sur. Nebraska, p. 145, pl. I, fig. 1.

Corallum simple, moderately large, having one or more abrupt flexures in the first five or six centimeters of its length; but, beyond that, it is subcylindrical and approximately straight when full-grown; epitheca thin; surface marked by concentric lines and numerous wrinkles; calyx subcircular, shallow at the outer portion, but deepening abruptly at the middle; margins of the calyx thin; a moderately distinct septal fosset is observable at the side of the calyx, near the convex curve of the corallum; primary septa from thirty to fifty in number, extending a little more than half the distance from the margin of the calyx to its center, moderately strong; secondary septa short, thin, and inconspicuous; tabulæ very wide, occupying about two-thirds the full diameter of the corallum, somewhat irregular, but all arching a little upward; dissepiments forming a multitude of small oblique vesicles between the radiating septæ.

Large examples reach 150 mm. or more in length, and have a diameter of 35 or 40 mm.; but the ordinary size is less.

This coral has hitherto been found only in the Upper Coal Measures or Permo-Carboniferous strata. It is common in Iowa, Missouri and Nebraska, is known in Illinois, and is likely to be found in Indiana in Sullivan and Vigo counties, on and west of the Wabash.

Genus MICHELINIA, *de Koninck.*

MICHELINIA EUGENEÆ (sp. nov.)

Plate 23, *figs.* 14, 15 *and* 16.

Corallum usually in the form of a small globular or irregularly ovoid mass, higher than broad, with the corallites usually opening upon all sides, except its very small base, which is often concave and irregular;

corallites small, but very irregular in size and shape; calyces moderately deep, their walls rather thin and margins narrow or even sharp.

Height of one of the larger masses in the collection 26 mm.; transverse diameter of the same, 17 mm. Diameter of the larger calyces, 3 mm.; of the smaller ones, 1 mm.

Usually the calyces cover the whole outer surface of the corallum except the small base, which was evidently attached to some foreign body; but occasionally a considerable surface above the base is free from calyces and is covered with a wrinkled epitheca. This is the only species of *Michelinia*, so far as I am aware, that has ever been found in the Coal Measure strata of North America, although two or three species are known to exist in the Lower Carboniferous rocks. It is likely that the *Favosites Whitfieldi*, White, from the Kinderhook group at Burlington, Iowa, will prove to be a species of *Michelinia*. If so, it somewhat resembles the form here described in the smallness of the corallites, but not in the shape of the corallum.

Locality. Edwardsport, Knox county, and Eugene, Vermillion county, Indiana, and one or two localities in Illinois.

BRACHIOPODA.

The *Brachiopoda* are among the most abundant and characteristic fossils of the Carboniferous rocks. At the close of this age, a large proportion of the genera, and also some of the families that flourished in this and the preceding age, ceased suddenly to exist. In all the rocks of Mesozoic and Cenozoic age, and also in existing seas, Brachiopods are among the least abundant of shell-bearing animals.

Genus LINGULA, *Bruguiere.*

LINGULA UMBONATA, *Cox.*

Plate 25, *fig.* 14.

LINGULA UMBONATA, *Cox*, 1857. Geol. Sur. Kentucky, vol. III, p. 576, pl. X, fig. 4.

Shell subelliptical in outline, a little narrower behind the mid-length than in front of it; the sides broadly convex; anterior and posterior ends both rounded; the body of the shell gently and somewhat regularly convex, but the umbo narrow and more prominent; beak narrow, minute.

This shell is evidently identical with the *Lingula umbonata* of Cox, although the flattening along the middle is not so distinct as it is represented to be by his figure.

Locality. Cox's specimens were obtained in Kentucky. Those here described and figured are from Vermillion county, Indiana.

Genus Discina, *Lamarck*.

Discina nitida, *Phillips*.

Plate 25, *fig*. 10.

Orbicula nitida, *Phillips*. Geol. of Yorkshire, II, p. 221, pl. XI, figs. 10-13.
Discina nitida (Phillips), *Meek and Worthen*, Illinois Geol. Reports, V, p. 572, pl. 25, fig. 1.

Shell small, subcircular, depressed-conical; the sides sloping nearly straight from the apex to the margins; apex prominent, situated at about one-third the diameter of the shell from the posterior border; lower valve flat, with the usual depression around the foramen; surface of both valves marked by concentric lines and fine lamellations.

Diameter of an average sized example about 8 mm.

Locality. This small *Discina* is common in the Coal Measures of Indiana, Illinois, Iowa and Missouri; abundant at Cannelton and Horse Shoe, of Little Vermillion.

Discina convexa, *Shumard*.

Plate 25, *fig*. 9.

Discina convexa, *Shumard*, 1858. Trans. St. Louis Acad. Sci., I, p. 221.

Upper valve broadly but somewhat prominently convex; sub-circular in marginal outline; the height nearly equal to one-half the diameter; apex somewhat obtuse, but moderately prominent, situated at about one-third the diameter of the shell from its posterior margin; surface marked by the usual distinct concentric lines of growth. A smaller under valve was found at the same locality with the upper valve above described, and probably belongs to this species. It shows a similar surface, which is nearly flat, but it is depressed about the foramen, which is of the usual character; the foramen is situated just beneath the position of the beak of the upper valve.

Diameter of the upper valve, just described, 27 mm.; height, 12 mm.

Locality. Dr. Shumard's specimens were from the Upper Coal Measures of Kansas. Those here described are from Vermillion county, Indiana.

Genus Crania, *Retzius*.

Crania modesta, *White and St. John*.

Plate 35, *fig*. 9, *and plate* 36, *fig*. 5.

Crania modesta, *W. and St. J.*, 1867. Trans. Chicago Acad. Sci., I, p. 118.

The type specimen of this species was free, and both valves were together in place, but the specimens of this collection all appear to have been attached to some foreign object by the lower valve; the upper valve is moderately convex, and the lower flat; both marked by concentric lines of growth. The only examples in this collection are under valves attached to other fossils, and, of course, show only the inner surface. Figure 5, plate 36, shows such valves adhering to a fragment of *Orthoceras Rushensis*, and figure 9, plate 35, shows similar valves adhering to a specimen of *Athyris subtilita*.

Locality. Eugene and Newport, Vermillion county, and at Merom, Sullivan county, Indiana.

Genus Productus, *Sowerby*.

Productus Nebrascensis, *Owen*.

Plate 24, *figs.* 7, 8 *and* 9.

Productus Nebrascensis, *Owen*, 1852. Geol. Report Wis., Iowa and Minn., p. 584, pl. V, fig. 3.

Shell of about average size for a species of this genus; outline in front of the cardinal border rudely semi-elliptical; length usually less than the breadth; cardinal border generally a little less in length than the greatest breadth of the shell, and never exceeding it; antero-lateral margins strongly, and front margins broadly, rounded, in the latter sometimes a little emarginate at the middle; postero-lateral margins somewhat straightened upon, and in front of the ears, meeting the cardinal border at a somewhat obtuse angle; ears small, seldom prominent; ventral valve somewhat regularly convex from front to rear, greatest convexity behind the middle; umbo prominent, projecting behind the hinge line; beak prominent, incurved a little over the cardinal margin; a mesial flattening, amounting sometimes, but rarely, to a distinct sinus, extending from the umbo to the front margin; dorsal valve flattened in the visceral region, the antero-lateral and front portions curving abruptly upward; beak and auricular regions depressed so as to produce a slightly raised, rounded, diverging fold between them respectively, at each side; mesial fold seldom distinct and perceptible only at the front; surface of both valves covered with numerous spines of different sizes, but all very small, those of the ventral valve are borne upon more or less distinctly defined concentric folds, and may be divided into two sets or kinds, one consisting of the stronger and more erect spines, and the other of small, short ones, the latter being closely appressed against the surface; both kinds are more or less connected by means of numerous raised radiating lines, which are more apparent upon the concentric folds than upon the surface of the interspaces.

Length, 33 mm.; breadth, 35 mm.

This species is a common one in the Coal Measure strata in the States of the great Mississippi valley, from Indiana westward; and it is frequently found in the Carboniferous strata of the Rocky Mountain region. As it is usually obtained from a limestone matrix, the spines and outer layer of the shell are removed. Such specimens present an appearance so different from that of those which have been perfectly preserved in a soft matrix that they have been referred to different species, by different authors. See further remarks in connection with the description of the next species.

Locality. Fountain, Vermillion, Parke and Vigo counties, Indiana.

PRODUCTUS SYMMETRICUS, *McChesney.*

Plate 25, figs. 1 and 2.

PRODUCTUS SYMMETRICUS, *McChesney*, 1866. Trans. Chicago Acad. Sci., I, p. 25, pl. I, fig. 9.

Shell suborbicular in marginal outline, the breadth being a little greater than the length; the cardinal border a little less in length than the greatest breadth of the shell; the lateral margins rounding regularly to the front margin, the latter being broadly rounded; ventral valve moderately convex, without a mesial sinus; ears not distinctly defined from the body of the shell, obtusely angular or rounded at their extremities; beak somewhat prominent, incurved but not projecting much over the cardinal border; dorsal valve moderately and somewhat uniformly concave; cardinal process slender, trifid at the end, the middle division being a little more prominent than the other two; surface of both valves marked by small concentric wrinkles or ridges, which are covered by numerous short minute spines, which are directed obliquely forward, and which are somewhat larger upon the ventral than upon the dorsal valve.

Length, 50 mm.; breadth, 52 mm.; convexity, 21 mm. But these dimensions vary somewhat in different specimens.

This form seems to be worthy of a separate specific designation; but it is not to be denied that it is closely related, on one hand, with *P. Nebrascensis*, and on the other with *P. punctatus*, both of which species are also frequently met with in the Coal Measure rocks of the United States. It is also clearly related to *P. scabriculus* of the European Carboniferous. Being associated in the same formation with the two first named species, and possessing so many points of resemblance in common with each other, the genetic relationship of these three forms would seem to be unquestionable; and yet they possess differences which, for both zoological and geological reasons, it is desirable to recognize. The differences between these forms have been discussed at length by Mr. Meek in Hayden's Report on the Geology of Eastern Nebraska, and in Vol. IV of King's Reports on the Geology of the 40th parallel. In the latter work, he has proposed the new specific name *P. Nevadensis*, for a form that is so closely like *P. punctatus* that it has usually been regarded as identical.

Locality. McChesney's type specimens of *P. symmetricus*, and also the one which is figured on plate 25, are from Coal Measure strata in Illinois; but it may be sought for in Vermillion, Vigo, Sullivan, Vanderburg, Dubois, Warrick and Pike counties, Indiana.

PRODUCTUS PUNCTATUS, *Martin.*

Plate 27, figs. 1, 2 and 3.

This species is described and figured in this series of reports for 1881, page 373, plate 42, figs. 1, 2 and 3. For the purpose of grouping the Coal Measure fossils together in this report, that description is repeated here.

This is one of the best known species of characteristic Coal Measure fossils, and one the specific identity of which with the European form of that name has never been seriously questioned. The following description applies to the species as it exists in widely separated localities in the United States.

Shell large, test thin; marginal outline varying from imperfectly four sided, the narrowest side being the posterior one, to subovate, sometimes being wider than long, but sometimes longer than wide; cardinal margin almost invariably shorter than the width of the shell at any part in front of it; anterior border broadly rounded, but usually a little emarginate at the middle; sides flattened, by which means the lateral margins are somewhat straightened; ears small; ventral valve broadly arcuate from front to rear, in which direction there is also a broad mesial flattening of the valve, with usually a shallow but somewhat distinct mesial sinus along its middle; umbo prominent, narrow; beak small, incurved, and projecting slightly over the cardinal border; dorsal valve moderately concave; beak, as such, wanting, its place being concave; mesial fold ill defined, there being only a slight mesial elevation of the valve extending along the visceral and anterior portions; surface of both valves marked by rather numerous and regular concentric folds, which are smaller at the beak and borders than elsewhere, upon adult shells, and smaller and more distinct upon the dorsal than upon the ventral valve; interspaces between the concentric folds plain; folds supporting numerous spines of varying size, but all minute and more or less appressed against the shell.

Length of the example figured, which is of adult size, 67 mm.; breadth of the same at the broadest part, about the same as the length.

Locality. Same counties as foregoing.

PRODUCTUS COSTATUS, *Sowerby.*

Plate 24, figs. 4, 5 and 6; and plate 25, figs. 3, 4 and 5.

The form here described is the one which has usually been referred to the European shell to which Sowerby originally gave the above name. There is, however, much reason to doubt its real specific identity with the European shell, but I am not now prepared to discuss that question satisfactorily.

The shell is of medium size; width greater than the length, measured in a straight line from the hinge to the front border, strongly and deeply arcuate from rear to front; hinge line nearly or quite equal in length to the greatest width of the shell; ears thin, well defined, and bent slightly downward; free margin broadly rounded, the front being slightly emarginate; ventral valve gibbous and strongly curved, having a broad shallow sinus extending from the umbonal region to the front, producing there the before-mentioned emargination of the front border; beak prominent, incurved, but only slightly projecting over the cardinal margin; dorsal valve flattened or only slightly concave in the visceral region, abruptly curved upward at the lateral and front margins; front showing a very slight mesial fold, corresponding with the broad, shallow mesial sinus of the other valve; surface of both valves, except that of the ears, marked by distinct, more or less unequal, rounded, radiating costæ, with interspaces of somewhat less than their own width between them; costæ generally continuous through the greater part of the length of the shell, but sometimes bifurcating, and occasionally two or more of them may be seen to coalesce and form a single costa of more than ordinary size; crossing the costæ, especially on the posterior half of the shell, and forming distinct reticulations with them, are more or less numerous concentric wrinkles; upon the ventral valve, especially toward the margins and upon the ears, there are usually scattered strong, more or less perpendicular, spines. Some of the shells are apparently nearly free from spines, or have only a few upon and near the ears.

Length, 28 mm.; breadth, 34 mm.; convexity, 18 mm.

This is one of the most common and characteristic species of the Coal Measure fossils of Indiana, Illinois, Iowa, and Missouri, and it is also frequently met with in the Carboniferous rocks of the Rocky Mountain region.

It ranges in the Mississippi valley from the Lower Carboniferous to the Upper Coal Measures. It is closely related to *P. semireticulatus*, Martin (the next species described), but it is a smaller shell, and more coarsely and distinctly costate.

Locality. It has been found throughout the Coal Measures of Indiana.

Productus semireticulatus, *Martin.*

Plate 24, figs 1, 2 and 3.

This shell is widely known in the Coal Measures of the United States, and has been generally regarded by authors as identical with the European species to which the name was first applied.

It is a large shell, strongly arcuate; width greater than the length; the length of the hinge line sometimes greater and sometimes less than the greatest width of the shell; cardinal area of both valves very narrow, but distinct; ears thin, more or less prominent, lateral and front borders continuously rounded, the front being slightly emarginate; ventral valve strongly curved; beak depressed and projecting very little, if any, over the cardinal border; a broad, shallow, obscurely defined mesial sinus in most of the examples, extends from near the umbonal region to the front, giving the shell an indistinctly bilobed appearance; dorsal valve flattened in the visceral region, bent abruptly upward at the sides and front; beak flattened or slightly concave; surface of both valves marked by numerous coarse rounded striæ or small costæ, which are crossed in the visceral region by somewhat regular concentric wrinkles of nearly uniform size, giving that part of the shell a semi-reticulated appearance, which is more distinct in some examples than in others; more or less numerous strong, erect spines are scattered upon the ventral valve, generally arising from the costæ upon the body of the shell and from the strong wrinkles upon the ears, upon which latter part they are usually most numerous.

Length of an ordinary sized example, measured in a straight line from the hinge to the front margin, 45 mm.; width, 60 mm.

The differences between this species and *P. costatus* have already been mentioned. Like that species, this one has not only a wide geographical range, but it is also found, in the Upper Mississippi River region, to range from the Lower Carboniferous to the Upper Coal Measures.

Locality. Common throughout the Coal Measures and often in the Lower Carboniferous.

PRODUCTUS CORA, *d'Orbigny.*

Plate 26, figs. 1, 2 and 3.

This species was, by Dr. Owen and Prof. Marcou, referred to the South American form described by d'Orbigny, in "Voyage dans l'Amerique Meridionale," under the name *Productus Cora.* Other American authors have, however, given it various names, and of late years it has generally gone by the name given it by Norwood, *P. Prattenianus.* I have, however, lately, had an opportunity to examine some examples which were brought by Dr. O. A. Derby from the South American localities from which d'Orbigny obtained his type specimens. A careful examination of these has left no doubt in my own mind that Owen and Marcou were right in referring our North American form to *P. Cora,* d'Orbigny. Some of the new specific names proposed by American authors were based upon varietal differences, such as the presence or absence of spines and small tubercles scattered over the surface, or the difference in the size of the radiating striæ; but, while I admit the existence of these variations, I do not regard them as being of specific value. The following description is regarded as fairly representing the species:

Shell sometimes reaching a large size; the breadth generally greater than the length; hinge line sometimes longer and sometimes shorter than the greatest width of the body of the shell; lateral and front margins regularly and continuously rounded; ears prominent, thin, and, therefore, they are generally broken off in the imbedding rock; mesial fold and sinus wanting, but, sometimes, there is an indistinct mesial flattening of the ventral valve; ventral valve somewhat uniformly convex; umbonal region gibbous; beak scarcely projecting over the cardinal border; ears marked by strong wrinkles, which pass inward upon the sides of the valves and become obsolete there, but ending abruptly at the cardinal margin; surface of the valves marked by fine, rounded, radiating striæ, some of which may be traced continuously from the umbonal region to the front, increasing by implantation and occasionally coalescing. A few strong, erect spines are often scattered over the surface of the ventral valve, and the cardinal border always bears a greater or less number of small spines. Although the striæ which mark the surface are always small and slender, their relative size differs very much in different individuals, in some cases being minute and hair-like; in the latter cases, the spines are usually absent from the general surface. One of the examples figured on plate 26, bears the finer striæ, and those of the other two bear the coarser striæ with the spines.*

Locality. This species has a wide geographical and vertical range in the Carboniferous rocks of North America. It may be sought for at the following Indiana localities: Fountain, Vermillion, Parke, Montgomery, Clay, Owen, Pike, Dubois and Warrick counties; also in the Lower Carboniferous.

PRODUCTUS LONGISPINUS, *Sowerby*.

Plate 24, *figs.* 10 *and* 11.

This is another species from the Coal Measure rocks of North America, which has been identified with a European form. It is an exceedingly variable shell, as is evidenced by the large number of synonyms which have been given to it, both in this country and Europe. The form that I here describe and figure is a characteristic one of the Coal Measures of North America, and it is yet a question whether it is correctly identified with the European *P. longispinus.* It is one of the smallest species of *Productus* among the somewhat numerous forms that the Carboniferous rocks afford.

It is much wider than long; the hinge line longer than the full width of the body of the shell; ears prominent, thin, and sometimes a little reflexed, the lateral and front margins forming a rude semi-ellipse, but the front margin is more or less emarginate at the middle; ventral valve gibbous, the more abrupt portion of the antero-posterior convexity being behind the middle; umbo of the ventral valve moderately prominent, the beak projecting slightly over the cardinal margin; mesial sinus broad, and distinct only near the front; surface marked by obscure radiating ribs,

*The Owen Cabinet contained specimens from Indiana, identified by d'Orbigny, and labelled in his own handwriting *P. Cora.* C.

usually obsolete upon the umbo, which are crossed by the usual lines of growth; moderately strong, erect spines are scattered over the surface of the valve (these were originally long, but they are almost always broken off); dorsal valve concave; the median portion slightly raised near the front, corresponding with the shallow sinus of the other valve; surface marked like that of the other valve, except that it is without spines.

Length, 11 mm.; breadth of body portion, 17 mm.; length of hinge line, 21 mm.

Locality. The following Indiana localities have furnished the species here described: Fountain, Parke, Vermillion, Vigo, Sullivan, Knox, Pike, Warrick, Spencer, Posey, Gibson and Vanderburg counties.

Genus CHONETES, *Fischer.*

CHONETES VERNEUILIANA, *Norwood and Pratten.*

Plate 25, *figs.* 7 *and* 8.

CHONETES VERNEUILIANA, *N. and P.*, 1854. Jour. Acad. Nat. Sci., Philad., III, p. 26, pl. II, fig. 6.

Shell small, much wider than long; the cardinal portion extended beyond the sides of the body of the shell, sometimes mucronate; ventral valve convex, bearing a moderately deep rounded mesial sinus which extends from near the beak to the anterior margin, toward which it rapidly deepens and widens; the sinus is usually so distinct as to produce the appearance of two prominent lobes upon this valve; ears somewhat angular and a little reflexed, sometimes obtuse, and in other examples acute and produced; beak moderately prominent; area distinct but narrow, a little wider, however, than that of the dorsal valve; foramen wide; cardinal margin bearing four oblique spines on each side of the beak; dorsal valve concave, and bearing an obtuse mesial fold corresponding with the sinus of the other valve; surface of both valves marked with numerous fine radiating striæ which, with the growth of the shell, increase by bifurcation. These are crossed by a few lines of growth.

Length, 8 mm.; breadth, 12 mm.

Two or three other species of *Chonetes* are more or less common in the Coal Measure rocks, but this one may be readily distinguished by its mesial sinus and the bilobed appearance of the ventral valve.

Locality. Every county in the Coal Measures of Indiana has furnished this species.

Genus ORTHIS, *Dalman*.

ORTHIS PECOSI, *Marcou*.

Plate 32, *figs.* 20, 21 *and* 22.

ORTHIS PECOSI, *Marcou*, 1858. Geol. North America, p. 48, pl. VI, fig 14.
ORTHIS CARBONARIA, *Swallow*, 1858. Trans. St. Louis Acad. Sci., 1, p. 218.

Shell small, sublenticular; outline subcircular or subovate; length and breadth nearly equal, but sometimes the length is a little the greater; front margin regularly rounded or slightly emarginate; hinge line very short, less than half the breadth of the shell; ventral valve having its greatest convexity at the umbo, often flattened a little at the front, but it is always without a definite mesial sinus; beak small, pointed, somewhat prominent, and arched over the small, well-defined area, which is also arched; dorsal valve more convex than the ventral, in old shells, its greatest convexity being behind the middle, generally showing a mesial flattening which extends from the umbo to the front margin; area distinct, but smaller than that of the other valve; beak small, not prominent; surface of both valves marked by fine, close-set, radiating striæ, which increase mainly by implantation, but occasionally by bifurcation; these striæ are crossed by fine concentric lines of growth, and near the front by imbricating lines. The striæ often show small pores upon their backs, apparently marking the position of minute tubular spines which have been removed.

Length and breadth of a large example, each 13 mm.; but the average size is considerably less.

Locality. This little *Orthis* is widely distributed in the Coal Measures from Indiana to Nebraska, and also in the Carboriferous rocks of the Rocky Mountain region. It has been found at the following Indiana localities: Horse Shoe of Little Vermillion and Garrett's Mill, Vermillion counties of Indiana and Illinois.

Genus HEMIPRONITES, *Pander*.

Genus STREPTORHYNCHUS, *King*.

HEMIPRONITES CRASSUS, *Meek and Hayden*.

Plate 26, *figs.* 4, 5, 6, 7, 8, 9, 10 *and* 11.

HEMIPRONITES CRASSUS, *M. and H.* 1864. Paleont. Upper Missouri, p. 26, pl. I, fig 7.
HEMIPRONITES CRASSUS, *Meek*, 1872. U. S. Geol. Sur. Nebraska, p. 174, pl. V, fig. 10, and pl. VIII, fig. 1.

Shell subquadrate or transversely suboblong in marginal outline, compressed; hinge line usually a little shorter than the greatest transverse diameter of the shell, but it is sometimes equal to it; front margin broadly rounded; lateral margins rounded to the front, but straightened posteriorly, forming a more or less distinct angle with the cardinal border;

surface marked by numerous raised radiating striæ, which increase by implantation; the radiating striæ are crossed by numerous concentric lines and several stronger marks of growth; ventral valve nearly flat; cardinal border sloping a little to the lateral margins; beak more or less prominent, usually a little distorted; area flat, moderately broad, and inclined a little backward; pseudo-deltidium thick and moderately prominent; cardinal teeth small; scars of the adductor muscle large and separated by a thin mesial ridge, their outline well defined in old shells; dorsal valve gently convex in the middle and flattened at the postero-lateral portions; both valves marked by crenulations at the inner surface of the borders, but this feature is often obscured.

Length of an average sized example, as they are usually found in the Coal Measures, 25 mm.; breadth, 27 mm.

I have here given the name that this species has come to be generally known by, but it is now generally understood among paleontologists that it does not differ specifically from the *H. crenistria* of Phillips. It is also probable that King's generic name *Streptorhynchus* ought to be used for this group of shells, so that the species here described would then properly bear the name *Streptorhynchus crenistria.*

There is also a much larger form than the one here described, which occurs in the Coal Measure strata of Iowa and Missouri, but which seems to be in all other respects identical with this, although it becomes rough and ventricose with age. Professor Hall has described this form, in his Geology of Iowa, under the name of *Orthis robusta.* A form closely similar, and perhaps identical with the smaller form here described, has been found in the Lower Carboniferous rocks of Iowa.

Locality. This species may be sought for at the following Indiana localities: Lodi, Eugene, Perrysville, Merom, Big Creek, and New Harmony.

Genus MEEKELLA, *White and St. John.*

MEEKELLA STRIATOCOSTATA, *Cox.*

Plate 26, *figs.* 12, 13 *and* 14.

PLICATULA STRIATOCOSTATA, *Cox*, 1857. Geol. Sur. Kentucky, vol. III, p. 568, pl. VIII, fig. 7.
MEEKELLA STRIATOCOSTATA, *W. and St. J.*, 1867. Trans. Chi. Acad. Sci., I; p. 120.

Shell variable in size and shape, indistinctly trihedral in outline, both valves becoming gibbous at full adult age; hinge line usually much shorter than the greatest breadth of the shell; ventral valve usually more capacious than the other, but sometimes the difference in this respect is slight, deepest near the umbo; beak more or less distorted by being flattened, bent backward or to one side or the other, usually toward the dextral side; area triangular, more or less irregular in consequence of the distortion of the beak; height of the area seldom so great as its width at the base, and often much less, its lateral borders well defined, its surface finely striated, both vertically and transversely; fissure varying in proportional width in different individuals, but usually quite narrow, and completely closed by a pseudo-deltidium, which is more or less flattened along each side, prominent along the middle, along which prominence there is a slightly raised mesial line; dorsal valve capacious, more regularly convex than the other; the convexity in some cases is so great behind the middle as to carry a portion of the valve a little behind the cardinal border; flattened along the middle toward the front, but never possessing a true mesial sinus; beak broadly convex, strongly incurved, not projecting over the hinge line; area obsolete, postero-lateral portions compressed so that small, thin ears are formed at the hinge extremities; surface of each valve marked by from ten to fourteen more or less angular radiating plications, having deep, angular interspaces between them; the plications not extending to the beak, increasing in size toward the front, mostly simple, but sometimes bifurcating; plications and interspaces both marked by numerous fine, radiating striæ which, toward the front margin of adult shells, usually converge to the crests of the plications, upon which they meet at acute angles; crossing these converging lines there are also usually zigzag lines of growth to be seen. The convergence of the radiating striæ does not take place until the shell has reached nearly mature size, and occasionally not then.

This shell is quite variable in size and shape, but it is thought that the foregoing description, together with the figures in plate 26, will enable any one to identify the species without difficulty. It is widely distributed in the Coal Measure strata of the States which border upon the Mississippi and Missouri Rivers, and it is also frequently found in the Rocky Mountain region.

Locality. The following Indiana localities have furnished examples of this species: Western part of Vigo county, and adjoining parts of Illinois.

Genus SYNTRIELASMA, *Meek and Worthen.*

SYNTRIELASMA HEMIPLICATA, *Hall.*

Plate 26, *figs.* 15, 16, 17 *and* 18.

SPIRIFER HEMIPLICATUS, *Hall*, 1852. Stansbury's Salt Lake Report, p. 409, pl. IV, fig. 3.
SYNTRIELASMA HEMIPLICATA, *M. and W.*, 1866. Illinois Geol. Sur., II, pp. 323 and 324.

Shell subglobose when fully adult, but only moderately convex when young; hinge line very short, not more than one-third the greatest transverse diameter of the shell; dorsal valve more convex than the ventral, strongly arched, especially in old shells; umbonal region gibbous, projecting backward a little beyond the cardinal border; area narrow, concave; ventral valve convex; beak slightly prominent and slightly incurved; area triangular, small, moderately well defined, higher than wide; surface of both valves marked by fine, regular, crowded, radiating striæ, and a few large subangular radiating plications, which are most distinct at the front margin, but never reach the umbones; a few concentric lines of growth near the front, impart a zigzag appearance as they cross the plications and interspaces.

Genus RHYNCHONELLA, *Fischer*.

RHYNCHONELLA UTA, *Marcou*.

Plate 25, *fig*. 6.

RHYNCHONELLA OSAGENSIS, *Swallow*, 1858. Trans. St. Louis Acad. Sci., I, p. 219.
RHYNCHONELLA UTA, *Marcou*, 1858. Geol. of N. America, p. 51.

Shell rather small, varying considerably in form, usually subtrihedral in marginal outline, and somewhat wider than long; postero-lateral margins converging at an angle which varies in different shells from eighty to one hundred and ten degrees; front broadly rounded, emarginate at the middle; dorsal valve more capacious than the ventral, abruptly convex at the front; beak strongly incurved; mesial fold not prominent, and perceptible only at the front; plications somewhat angular, varying in number from seven to nine and rarely more, distinct at the front, but becoming obsolete at the middle and sides of the valve; from two to four of these plications are borne upon the mesial fold, which becomes obsolete backward with the plications; ventral valve rather shallow, similar to the other valve in the number, distribution, and character of the plications; beak narrow, prominent, and gently incurved; mesial sinus broad and shallow, having from one to three plications which are smaller than those at the sides, and, with the sinus, become obsolete about the middle of the valve; the posterior half of the shell plain, or marked only by occasional lines of growth.

The length of an adult example is about 10 mm.; breadth, 11 mm.

This shell has a very wide geographical range, it having been found from Indiana to Utah and New Mexico. It is closely related to a form that occurs in the Lower Carboniferous of Iowa, to which I gave the name of *R. Ottumwa*, and it is probable that the latter should be regarded only as a variety of the former.

Locality. This species has been found throughout Upper Coal Measures.

Genus SPIRIFER, *Sowerby*.

SPIRIFER CAMERATUS, *Morton*.

Plate 35, *figs*. 3, 4 *and* 5.

SPIRIFER CAMERATUS, *Morton*, 1836. American Journal of Science, XXIX, p. 150.
SPIRIFER CAMERATUS, *White*, 1881. Indiana Geol. Rep. for 1880, p. 149, pl. VIII, fig. 3.

This species was described in a former report (*loc. cit.*), but it is repeated here with better illustrations, and for the purpose of bringing together all the Coal Measure species hitherto described for the Indiana Reports.

Shell usually of medium size, but sometimes quite large, subsemi-circular or subtrihedral in outline, almost always broadest at the hinge line; the hinge extremities often pointed and sometimes mucronate; dorsal valve not quite so capacious as the other; mesial fold distinct, broad at the front, sometimes sharply elevated, but more commonly rounded, clearly defined from front to beak and rapidly increasing in width to the front by the greater or less curving outward of the sides; sides of the valve sloping almost directly from the mesial fold to the lateral borders; antero-posterior convexity of the mesial fold very slight from front to middle, but increasing from the middle to the beak; beak small, projecting slightly over the cardinal border; ventral valve strongly arching from beak to front, the beak being prominent, pointed and curved over the area; area concave, of moderate width, and not narrowing to a sharp angle at the hinge extremities; foramen almost equilaterally triangular, partially closed by a pseudo-deltidium, which is often removed by weathering; mesial sinus well defined from front to beak and in all respects answering to the mesial fold of the other valve; surface marked by numerous distinct, rounded striæ of unequal size, which increase gradually in size toward the front; striæ increasing in number by the division near the beak of the few which are continuous to its point; they are thus generally gathered into more or less distinct fascicles of three or more striæ in each fascicle, the middle striæ of each fascicle being more prominent than the others, and these are the only striæ which reach the point of the beak; the mesial fold and sinus usually have striæ of the same character and arrangement as those upon other parts of the shell, but in some cases they are obsolete upon the sides of the fold and sinus respectively; besides the radiating striæ, the surface is marked by the usual lines and laminations of growth. This is one of the most common species in the Coal Measure strata of North America, of which it is also one of the most characteristic fossils.

Locality. Throughout the Coal Measures of Indiana.

SPIRIFER (MARTINIA) LINEATUS, *Martin.*

Plate 27, *figs.* 4, 5 *and* 6.

This species was described and figured in the Indiana Geological Report for 1881, page 372, and plate 42, figures 4, 5 and 6. These are repeated in this report for the purpose of bringing the Coal Measure fossils together.

The shell which is here figured is one which has usually been referred to *Spirifer lineatus*, Martin, but which McChesney described under the name of *S. perplexa.* Although it very closely resembles *S. lineatus*, one can hardly be satisfied that it is really specifically identical, and it is probable that we shall be justified in adopting McChesney's name. Not having the means for direct comparison with the European form at hand, however, I prefer to leave our shell for the present with *S. lineatus*, where it has been placed by the majority of paleontologists who have noticed it, making the following brief description:

Shell moderately gibbous, transversely subelliptical in marginal outline, the front and sides regularly rounded; hinge much shorter than the width of the shell; cardinal extremities rounded; cardinal area distinct, arched and moderately high; ventral valve convex; umbonal portion prominent; beak prominent, incurved; area small; without median sinus, but there is a slight flattening of the valve at the front, which gives the front margin a very slight sinuosity; dorsal valve regularly convex, both transversely and longitudinally; umbonal portion prominent, but not so much so as that of the other valve; beak moderately prominent and projecting a little beyond the hinge line; surface marked by numerous very faint radiating lines and somewhat stronger concentric lines, the latter being impressed and finely crenulate, the minute crenulations apparently marking the bases of hair-like spines when the surface of the shell was perfect.

Length from ventral beak to front, 17 mm.; breadth, 18 mm.; greatest thickness, both valves together, 13 mm.

Locality. Fountain, Parke, Vermillion, Vigo, Sullivan, Gibson, Pike, Knox, Posey, Vanderburg and Warrick counties, Indiana.

SPIRIFER (MARTINIA) PLANOCONVEXA, *Shumard.*

Plate 32, figs. 23 and 24.

SPIRIFER PLANOCONVEXA, *Shumard*, 1855. Swallow's Geol. Report Missouri, p. 202.

Shell very small; breadth varying from a little more to a little less than the length; hinge line moderately long, but always shorter than the full breadth of the shell in front of it; lateral and front margins regularly and continuously rounded; the dorsal valve nearly flat, and it would be almost circular in marginal outline but for its truncation by the straight hinge line; beak minute, not prominent; cardinal area very narrow; ventral valve capacious, especially its posterior portion, which extends much behind the hinge line and ends in a prominent, strongly incurving, pointed beak; area very narrow, high, concave; mesial sinus absent, but in its place there is usually a slight flattening at the front, and sometimes an indistinct impressed line is seen to extend from the beak to the front margin; surface apparently smooth, but under a lens it is seen to be finely granular, the apparent granules being the bases of minute setæ; a few concentric lines of growth are usually observable upon both valves.

Length, 13 mm.; breadth, 13 mm.; convexity, 8 mm.

This common American shell agrees so closely in many respects with *S. Urii*, Fleming, from the British Carboniferous strata, that the propriety of placing it under any other specific name may well be questioned. In view, however, of the fact that the characteristics of the subgenus *Martinia* admit of the development of very few salient specific features, I am at present disposed to regard these minor differences as affording sufficient reason for continuing the use of Shumard's name.

Locality. This little shell is one of the most widely distributed of the Coal Measure species. It has been found from Virginia to Utah and New Mexico, and in some of the strata of the States bordering upon the Mississippi and Missouri Rivers it occurs in great numbers. It has been found throughout the Coal Measures of Indiana.

Genus SPIRIFERINA, *d'Orbigny.*

SPIRIFERINA KENTUCKENSIS, *Shumard.*

Plate 35, *figs.* 13 *and* 14.

SPIRIFER KENTUCKENSIS, *Shumard*, 1855. Swallow's Geol. Sur. Missouri, p. 203.
SPIRIFERINA KENTUCKENSIS, *Meek*, 1872. U. S. Geol. Sur. Nebraska, p. 185.

Shell small, variable in outline, sometimes subsemicircular and occasionally almost globose, and sometimes the extremities are produced and mucronate; ventral valve more capacious than the dorsal; beak prominent, arching backward; area moderately high, well defined, concave; foramen higher than wide; mesial sinus distinctly defined, rather narrow, often moderately deep, without plications except occasionally a small obscure one at the bottom; dorsal valve somewhat regularly convex; beak scarcely prominent, projecting slightly over the cardinal margin; mesial fold narrow, distinctly defined, a faint linear depression sometimes observable along its middle, which corresponds with the small linear plication which is sometimes seen at the bottom of the sinus of the ventral valve; surface of each valve marked by from ten to eighteen simple prominent plications, rounded or almost angular at top and separated by interspaces of similar width; the plications which bound the sinus are a little larger and more prominent than the others, which thus serve to more clearly define the sinus from the remainder of the shell; the entire surface is also marked by fine, distinct, prominent and closely crowded lines of growth.

The length of a specimen of about average size and proportions is 9 mm.; breadth, between the hinge extremities, 13 mm.

Locality. This is one of the more common of the Coal Measure shells, but it is never found abundantly. It has been discovered at the following Indiana localities: In the Middle and Upper Coal Measures of Vermillion, Vigo, Knox, Gibson, Posey, Vanderburg, Dubois, and Spencer counties.

Genus ATHYRIS, *McCoy*.

ATHYRIS SUBTILITA, *Hall*.

Plate 35, *figs*. 6, 7, 8 *and* 9.

Among the fossil shells of North America, perhaps no species has come to be so well and widely known as this. It is also one of the most common and characteristic of the Coal Measure species.

It is variable in size, and somewhat also in outline, but it is seldom large; subovate in marginal outline, not often as wide as it is long, moderately gibbous, and old shells are sometimes inflated; ventral valve generally a little more capacious than the dorsal; beak prominent, strongly incurved; mesial sinus not very deep, even at the front, and becoming obsolete about the middle of the shell; a more or less distinctly impressed line usually exists along the bottom of the sinus, and extends from the beak to the front margin; dorsal valve somewhat uniformly convex, but more convex near the umbo than elsewhere; beak small, slightly prominent; mesial fold not distinctly defined; surface marked by concentric striæ and by occasional imbricating lines of growth; faint traces of radiating lines, such as are common on shells of this genus, are also occasionally seen.

Length of a specimen of ordinary size, 24 mm.; breadth, 20 mm.; height, 9 mm.

In all the variations which this shell is subject to, it is easily recognizable after an acquaintance with the species has once been formed. One of the most noticeable of its constant characteristics is the impressed mesial line at the bottom of the sinus of the ventral valve. This feature is sometimes obscure, but it is usually sufficiently distinct to be readily recognized. This species ranges through the whole Coal Measure series, and, according to Mr. Meek, into the Permian, also. In geographical distribution it is known from Virginia to the Rocky Mountain region.

Locality. It has been found common throughout the middle and Upper Coal Measures, rarer in Lower.

Genus RETZIA, *King*.

RETZIA MORMONII, *Marcou*.

Plate 35, *figs*. 10, 11 *and* 12.

TEREBRATULA MORMONII, *Marcou*, 1858. Geology of N. America, p. 51.
RETZIA PUNCTILIFERA, *Shumard*, 1858. Trans. St. Louis Acad. Sci., I, p. 220.

Shell small, ovate in outline; both valves more or less gibbous; hinge line short; ears minute and observable only in well preserved examples; ventral valve a little more capacious than the dorsal, posterior portion narrowed to the umbo, which is prominent and considerably arched; beak small, truncated by a foramen of moderate size; area small but well defined; dorsal valve almost as prominently convex as the ventral; umbo prominent; beak incurved and extending a trifle over the cardinal border; surface of each valve marked by from fourteen to seventeen simple, narrow, radiating costæ, having interspaces of similar width; costæ sharply elevated, their backs, as well as the bottom of the interspaces, narrowly flattened; mesial fold and sinus wanting or obsolete.

Length of the largest examples, 12 mm.; breadth, 9 mm.; thickness, 8 mm.; but the average size is less.

This is another widely distributed Coal Measure species, and one that may be readily identified.

Genus TEREBRATULA, *Llhwyd.*

TEREBRATULA BOVIDENS, *Morton.*

Plate 32, *figs.* 17, 18 *and* 19.

TEREBRATULA BOVIDENS, *Morton*, 1836. Am. Jour. Sci., XXIX, p. 150.

Shell ovate or elongate-ovate in marginal outline; sides, behind the middle, laterally compressed, where also the shell is narrower and its vertical diameter greater than it is forward of the middle; ventral valve strongly arcuate from beak to front, the curvature being greatest behind the middle, rather more capacious than the other valve; beak prominent, incurved, but not coming quite in contact with that of the dorsal valve; foramen moderately large, not squarely truncating the beak, but opening obliquely backward; mesial sinus broad, more or less distinct at the anterior part of the valve, but becoming obsolete at or a little behind the middle; dental plates extending but little, if any, in front of the teeth, placed so near the sides of the beak that the space between them and the sides of the shell is very narrow; dorsal valve generally almost straight along the median line from the front margin to a little behind the middle, from which part it gently curves to the beak; gently and somewhat uniformly convex from side to side, without a mesial fold, except that sometimes the front margin is slightly raised to conform to the shallow sinus of the other valve; character of the loop not fully known, but it reaches farther forward than the middle of the shell; surface nearly smooth; shell structure finely punctate.

This shell varies considerably in size and shape. One example in the collection of the U. S. National Museum measures 30 mm. in length. An average size is about 17 mm. long and 12 or 13 mm. broad. This species is more or less common in Coal Measure strata, and it is known to range from Ohio to Nevada.

Locality. It has been found at the following localities in Indiana: Perrysville, Eugene, Newport, Lodi, Terre Haute (west of), Posey, Warrick, Perry and Crawford counties.

POLYZOA.

Genus SYNOCLADIA, *King*.

SYNOCLADIA BISERIALIS, *Swallow*.

Plate 25, *figs.* 11, 12 *and* 13.

SYNOCLADIA BISERIALIS, *Swallow*, 1858. Trans. St. Louis Acad. Sci., I, p. 179.

Polyzoary probably infundibuliform, but the specimens usually found consist only of spreading frond-like fragments; primary branches a little larger than the others, the latter increasing by divergence at various angles from the primary branches, also occasionally from each other, and rarely by starting upward from the middle of a dissepiment; dissepiments celluliferous, a little narrower than the branches, arching upward a little as they extend from branch to branch; fenestrules irregularly four-sided; upper side usually convex and the lower side sometimes concave; about nine of them may be measured in the length of a centimeter; measured upward, they are generally wider than the branches, but occasionally narrower, especially near the base of the polyzoary. Upon the poriferous side of the polyzoary the branches and dissepiments, especially the former, are each provided with an irregular mesial carina, consisting of small, elongate, confluent nodes, which are sometimes sharp and prominent. Cell-apertures moderately large, rounded, borders prominent; cells arranged in single, quite distinct lines, one on each side of the mesial carina of the branches, and generally each dissepiment bears a double row of similar cells. Upon some of the dissepiments the cells form only a single row at the middle, while upon others they are not only double, but another cell is added near the junction with the branch, giving three cells abreast at those points.

This form is one of the most common of the Fenestelloid Polyzoa that occur in Coal Measure strata.

Locality. It may be sought for in Indiana above the roof of coal K., and thence throughout Upper Coal Measures.

CONCHIFERA.

Genus LIMA, *Bruguiere*.

LIMA RETIFERA, *Shumard*.

Plate 28, *fig.* 4.

LIMA RETIFERA, *Shumard*, 1858. Trans. St. Louis Acad. Sci., I, p. 214.

Shell obliquely subovate; posterior side short; anterior side obliquely extended; the valves gently convex; cardinal border comparatively short; the basal border forming a nearly regular semi-circular curve; posterior margin regularly rounded; anterior margin somewhat narrowly rounded below and sloping obliquely upward and backward to the cardinal border; ears small, distinct, nearly equal in size, the anterior one forming an obtuse angle and the posterior one a nearly right angle; beaks moderately prominent and projecting slightly beyond the cardinal margin, and situated near the mid-length of that margin; surface of each valve marked by about twenty-five angular radiating costæ, with interspaces of similar width with the costæ, all of which are crossed by numerous concentric, fine lamellations of growth.

Height, 15 mm.; length, 18 mm.

This is a somewhat rare shell, but it has a rather wide geographical range.

Locality. It may be sought for in the following Indiana localities: Knox, Gibson and Posey counties.

Genus MONOPTERIA, *Meek and Worthen.*

MONOPTERIA GIBBOSA, *Meek and Worthen.*

Plate 30, *figs.* 11 *and* 12.

MONOPTERIA GIBBOSA, *M. and W.*, 1866. Illinois Geol. Reports, II, p. 340, pl. 27, fig. 11.

Shell, exclusive of the wing and posterior prominence, irregularly suborbicular in marginal outline; the valves moderately convex or a little gibbous; the anterior and basal margins forming an almost regular semicircular curve; posterior portion of the shell produced, narrow and narrowly rounded, or subangular, at the extremity; wing slender, compressed and extending backward as far as the narrow posterior extremity, between which the posterior margin forms a deep, broad notch, that is narrowly rounded at the bottom; umbonal ridge moderately distinct; beaks equal, not placed so far forward as the front margin of the shell; anterior lunule deep; cardinal border not as long as the full diameter of the shell; surface marked only by the ordinary lines of growth.

Length, from posterior extremity to front, 27 mm.; height, from base to beaks, 23 mm.

Locality. This shell was originally described from Gallatin county, Illinois. It may be sought for in the following Indiana localities: Vermillion, Sullivan and Posey counties.

Genus MYALINA, *de Koninck.*

MYALINA SUBQUADRATA, *Shumard.*

Plate 29, figs. 1 *and* 2; *and plate* 30, *figs.* 1 *and* 2.

MYALINA SUBQUADRATA, *Shumard*, 1855. Swallow's Geol. Sur. Missouri, p. 207, pl. C, fig. 17.

Shell large, oblong in marginal outline, the height being much greater than the antero-posterior diameter; right valve nearly flat or only slightly convex; the left valve more convex than the right; hinge line nearly straight, usually equal to the greatest width of the valves, at right angles with the vertical axis of the shell; basal margin regularly, and sometimes, but not usually, somewhat narrowly rounded; posterior margin nearly vertical or moderately convex, rounding to the base below and usually meeting the hinge line at nearly right angles, but sometimes at an obtuse angle; anterior margin rounded to the basal margin, vertical along the middle, then reaching the projecting beaks by a moderately broad, concave curve; cardinal area moderately broad, the narrow cardinal furrows well defined; beaks terminal and projecting prominently forward; surface marked only by concentric lines and a few laminations of growth, which are more distinct upon the left valve than upon the right.

Height, from base to cardinal margin of a full grown example, 94 mm.; transverse width of the same, 58 mm.

Locality. This large *Myalina* has quite a large distribution in the Coal Measures. It has been found at the following Indiana localities: Upper Coal Measures of Knox, Gibson and Posey counties.

MYALINA RECURVIROSTRIS, *Meek and Worthen.*

Plate 29, *figs.* 3 *and* 4.

MYALINA RECURVIROSTRIS, *M. & W.*, 1866. Illinois Geol. Reports, II, p. 344, pl. XXVI, fig. 9.

Shell moderately large, except as compared with *M. subquadrata*; obliquely subtrigonal in marginal outline; posterior side compressed; transversely flattened a little beneath the beaks; both valves moderately convex, the left valve being more so than the other; umbo of each valve gibbous and narrowly rounded along the axis; cardinal border straight or slightly convex; its length about equal to the height of the shell in young examples, but it is proportionally shorter in adult examples; posterior margin gently convex in outline, its general range being at nearly right angles with the cardinal border, rounding gradually to the narrowly rounded basal margin; anterior margin rounding to the base below, a little concave above, where it ranges at an angle of about 55° with the cardinal border; beaks terminal, pointed; that of the left valve twisted so as to have a partially backward direction, but the other is merely directed forward; surface of both valves marked by numerous concentric lamellæ of growth, which are most distinct upon the left valve, and more prominent upon the anterior part of the shell than elsewhere; ligament area narrow and traversed by a few longitudinal coarse striæ; just beneath the beaks the anterior margin is thickened so as to present a kind of false area, a little broader than the cardinal area; between these two areas, in the left valve, there is an oblique groove and a corresponding prominence in the right valve; posterior muscular impression large and elongate-subovate, the narrower end being uppermost and located near the middle of the posterior side.

Height, on a vertical line, at right angles with the hinge, 45 mm.; greatest breadth, 40 mm.; convexity, 24 mm.

Locality. The original examples of this species were obtained from the Upper Coal Measures, near La Salle, Illinois, but they may be sought for anywhere in the Indiana Upper Coal Measures.

MYALINA (?) SWALLOVI, *McChesney.*

Plate 30, *figs.* 6, 7 *and* 8.

MYALINA SWALLOVI, *McC.*, 1860. New Paleozoic Fossils, p. 57.

Shell small, oblique, equivalve or nearly so; valves gibbous along their upper median portion, the general aspect of the shell being like that of a *Modiola;* anterior margin sinuous, so that an indistinct small lobe is formed in front of the beaks and the somewhat prominent umbonal ridge; hinge line equal to about one-half the entire length of the valves, straight, meeting the posterior margin without a perceptible angle; postero-basal margin narrowly rounded; cardinal area very narrow and marked by two or three indistinct longitudinal striæ; surface marked by the ordinary concentric lines and a few imbrications of growth.

Extreme length of an average sized example, 28 mm.; greatest transverse breadth, 14 mm.; convexity, 10 mm.

This is a shell concerning which the real generic relations have been regarded as obscure by every author who has written of it. It seems to be worthy of at least a separate subgeneric designation, but none has hitherto been proposed for it.

Locality. It has a very wide distribution in the North American Carboniferous rocks, and in the States bordering the Mississippi it is regarded as characteristic of the Upper Coal Measures. It has been found at the following Indiana localities: Parke, Vermillion and Vigo counties, at the horizon of coal M.

Genus ENTOLIUM, *Meek.*

ENTOLIUM AVICULATUM, *Swallow.*

Plate 28, *figs.* 7 *and* 8.

PECTEN AVICULATUS, *Swallow*, 1858. Trans. Acad. Sci. St. Louis, I, p. 215.
ENTOLIUM AVICULATUM, *Meek*, 1872. U. S. Geol. Sur. Nebraska, p. 189, pl. IX, fig. 11.

Shell compressed lenticular, thin, equivalve, suborbicular in marginal outline, exclusive of the ears; height usually a trifle greater than the transverse width of the shell; the lateral margins, from the mid-height of the shell, regularly and continuously rounded with the basal margin; lateral margins above the mid-height, straight and converging toward the beaks; cardinal margin short, its length less than one-third the transverse diameter of the shell; ears small, flat and nearly equal, obtusely angular at the extremities, defined from the body of the valves by a distinct depression, but not by any auricular grooves; beaks small, compressed, equal, not projecting beyond the cardinal margin; each valve has two shallow, undefined impressions diverging from the beak nearly to the anterior and posterior margins respectively, that on the posterior side being the longer; surface apparently plain, but under a magnifier it is seen to be marked by very fine, close-set, concentric striæ, and occasionally traces of fine radiating striæ.

Height, 24 mm.; breadth, 22 mm.

Locality. This species is found in both the Upper and Lower Coal Measures. Its known geographical range is from Indiana to Nebraska. It has been found at the following Indiana localities: Horizons of coals K., L. and M., in Fountain, Vermillion, Vigo, Pike, Dubois, Perry, and Spencer counties.

Genus EUMICROTIS, *Meek.*

EUMICROTIS HAWNI, *Meek and Hayden.*

Plate 30, *fig.* 10.

EUMICROTIS HAWNI, *M. and W.*, 1866. Illinois Geol. Reports, II, p. 338, pl. 27, figs. 12, 13, and 14.

Shell subovoid in marginal outline; obliquity, little or none; upper posterior margin nearly straight, sloping abruptly downward from the cardinal margin; anterior margin more or less regularly rounded below the ear; basal margin somewhat regularly rounded; cardinal not so long as the median transverse diameter of the shell; hinge area moderately broad; cartilage pit distinct, placed immediately below the beak in each valve; left valve moderately ventricose; umbo a little incurved and projecting a little above the cardinal margin; posterior ear narrow, obliquely truncated; anterior ear larger, its outer margin narrowly rounded; the notch below it deep and subangular; surface marked by somewhat irregular undulating costæ of unequal size; these are crossed by more or less distinct lamellæ of growth, which are sometimes vaulted on the costæ; right valve nearly flat; byssal sinus deep and narrow; surface more obscurely marked than that of the left valve.

Height, 34 mm.; breadth, 28 mm.

Locality. The original specimens were obtained in Kansas. It is also known in Illinois, and may be sought for in the Upper Coal Measures of Indiana.

Genus Aviculopecten, *McCoy.*

Aviculopecten occidentalis, *Shumard.*

Plate 28, *fig.* 3.

Pecten occidentalis, *Shumard,* 1855. Swallow's Geol. Report Missouri, p. 207, pl. C, fig. 18.

Shell inequivalve; both ears well defined; cardinal border at nearly right angles with the axis of the shell and almost as long as its full antero-posterior diameter; marginal outline, exclusive of the ears, subovate; left valve more convex than the right; anterior ear about as long as the posterior one, more convex and a little more sharply defined, by the auricular furrow, from the body of the valve than the other ear, its extremity obtuse, and inferior border concave; its surface marked by distinct radiating costæ, which are a little coarser than those upon the body of the valve at the same distance from the beak; posterior ear clearly defined from the body of the valve by a shallow auricular furrow, sharply angular at the outer extremity; outer margin concave, its surface marked by concentric lines, all radiate markings being obsolete; surface of the body of the valve marked by depressed, flattened, or very slightly convex, radiating costæ, which gradually increase in size toward the free margins, and increase in number by implantation at different distances from the beak, only about a dozen of them reaching it; the implanted costæ, beginning as mere striæ between the others, are of unequal size on all parts of the valve; the costæ are crossed by numerous distinct concentric striæ; right valve flat or slightly convex; beak flattened, and not distinct, as such, at the cardinal border; costæ similar in character to those of the other valve, but they are not nearly so distinct; outline corresponding with that of the left valve, except that the anterior ear is narrower, and defined by a deeper and sharply angular sinus.

Height, from base to cardinal border, 42 mm.; breadth, 37 mm.

This is one of the most common Conchifers of the Carboniferous rocks of the United States, from Indiana westward, and it has been found in Utah and Arizona. It ranges, also, from the Lower Coal Measures to the Upper, and, according to Meek, it passes up into the Permian strata in Kansas.

Locality. It has been found in Pike and Gibson counties, Indiana.

AVICULOPECTEN CARBONIFERUS, *Stevens.*

Plate 28, figs. 5 and 6.

PECTEN CARBONIFEROUS, *Stevens*, 1858. Am. Jour. Sci., XXV, p. 261.

Shell rather less than medium size; its axis a little oblique with the cardinal border; moderately convex; the height and breadth nearly equal; cardinal border nearly or quite straight; its length not quite equal to the transverse diameter of the shell, bearing a marginal ridge in each valve; full margin, regularly and continuously rounded from a little below the mid-height of the shell on the posterior side to a little above it on the anterior side; above this rounded portion the sides of the body of the shell, exclusive of the ears, slope directly to the beak; left valve more convex than the other; the posterior ear well defined, somewhat extended and acutely pointed at the extremity, its outer and lower margin broadly concave; anterior ear about two-thirds as long as the other, more obtuse at the extremity but still angular, distinctly defined from the body of the valve by an auricular furrow, and divided below by a subangular sinus; right valve nearly flat or very gently convex, its anterior ear narrow, and beneath it there is a deep abrupt sinus; posterior ear similar in size and shape with that of the left valve; the left valve bears fifteen or sixteen angular radiating ribs which are separated by furrows of similar size with the ribs, each one terminating at the free border in a sharp, recurved spine; the surface is also marked by lines of growth, which are more distinctly observable upon the ears, which are not marked by distinct radiating features; besides the lines of growth, there are, at somewhat regular intervals, distinct concentric imbrications, which, having been once free borders, show digitations similar to those of the margin; the surface markings of the right valve are similar to those of the left, but much less distinct.

Height, from base to cardinal margin, 19 mm.; breadth about the same.

This is probably the same species that was described, but not figured, by Professor Swallow, from the Upper Coal Measures of Missouri, under the name of *Pecten Broadheadi*; and it is no doubt identical with the *Pecten Hawni* of Geinitz, from Nebraska. Specimens of the same have also been found in New Mexico, by parties connected with the United States explorations and surveys west of the 100th meridian.

Locality. This species has been found at the following localities in Indiana: At Lick Branch, near Silverwood, Fountain county, and in Vermillion county.

AVICULOPECTEN (?) INTERLINEATUS, *Meek and Worthen.*

Plate 30, *fig.* 9.

AVICULOPECTEN INTERLINEATUS, *M. and W.* Illinois Geol. Sur. II, p. 329, pl. 26, fig. 7.

Shell rather small, broadly subovate in outline exclusive of the ears; breadth nearly equal to the height, slightly oblique, or the axis almost at right angles with the cardinal border; hinge line about equal in length to the full breadth of the shell; ears prominent, posterior one more prominent than the other; anterior, basal, and posterior margins regularly and continuously rounded; beak depressed; umbonal slopes moderately distinct; left valve slightly convex or nearly flat; posterior ear a little larger, or nearly of the same size as the other, produced to a sharp angle at the cardinal extremity, its outer border sometimes straight and sometimes curved, and forming an obtuse retreating angle with the posterior margin of the shell; anterior ear triangular, flattened, its outer border slightly convex or nearly straight, and its extremity bluntly angular; surface marked by ten or twelve sharply raised, slender, concentric ridges, each one being of nearly uniform width throughout, but each successively a trifle stronger than the preceding one, separated, along the axis of the valve, by interspaces each of which are four or five times as wide as the adjacent concentric ridges; but the interspaces diminish in width toward the umbonal region, upon which the ridges are very near together; the latter then diverge, crossing the ears, and all end abruptly upon the cardinal margin; surface between the ridges marked by numerous fine, uniform, concentric striæ, and also by faint indications of radiating costæ.

Breadth, 17 mm.; height, from base to cardinal margin, 16 mm.

This interesting shell is somewhat rare, but it is known in the widely distant regions of Central Illinois and Northern Arizona.

Locality. It may be reasonably sought for in the Upper Coal Measures of Indiana.

Genus PINNA, *Linnæus.*

PINNA PERACUTA, *Shumard.*

Plate 28, *figs.* 1 *and* 2.

PINNA PERACUTA, *Shumard*, 1858. Trans. St. Louis Acad. Sci., I, p. 214.

Shell long and slender, tapering regularly from the larger to the smaller extremity; the valves so convex that the shell is subcylindrical, except toward the larger end where it is more flattened; hinge margin straight; the dorsal edges of the valves suddenly erected so as to give the hinge margin a carinated appearance; ventral margin straight like the dorsal, with which it forms an angle of about 12°; posterior margin rounded broadly and obliquely upward and backward to the dorsal margin; surface plain, marked only by obscure concentric lines of growth.

This species is remarkable for its long and slender form. The full length of the largest examples could not have been less than 250 mm.

Locality. It is known in both the Upper and Lower Coal Measures, from Indiana to Nebraska. It has been found in the Upper, Middle and Lower Coal Measures of Indiana.

Genus NUCULANA, *Link.*

NUCULANA BELLISTRIATA, *Stevens.*

Plate 31, *figs.* 8 *and* 9.

LEDA BELLISTRIATA, *Stevens*, 1858. Amer. Jour. Sci., XXV, p. 261.

Shell transversely elongate-subovate, gibbous anteriorly and attenuate behind; basal margin broadly convex, straightened in the middle; anterior margin narrowly rounded; posterior margin very narrow; postero-dorsal margin nearly straight, sloping backward and a little downward from behind the beaks; umbonal ridges well defined, situated near to the postero-dorsal margin, their outline, as seen from above, forming an elongate ellipse which has a concave surface on each side of the median ridge, which is formed by the up-flexed margins of the valves there; umbones prominent; beaks incurved, situated about two-fifths of the full length of the shell from its front; surface marked by fine, regular, concentric, raised striæ, which are obsolete upon the umbonal ridges and the space which they enclose.

Length of a large example, 27 mm.; height, 12 mm.; convexity, 9 mm. A large majority of the examples are considerably smaller than this.

Locality. This species has been found at the following localities: Horizon of coal M., in Vermillion, Sullivan, Vanderburg, and Warrick counties.

Genus NUCULA, *Lamarck.*

NUCULA VENTRICOSA, *Hall.*

Plate 27, *figs.* 9 *and* 10.

NUCULA VENTRICOSA, *Hall*, 1858. Geol. of Iowa, Part II, p. 716, pl. 29, fig. 5.
NUCULA VENTRICOSA, *White*, 1882. Ind. Geol. Rep. for 1881, p. 371, pl. 42, figs. 9 and 10.

Shell small, subovate in marginal outline; valves ventricose, the greatest convexity being a little forward of the middle; posterior end short, obliquely truncated from the beaks to the narrowly rounded posterior margin; basal margin broadly rounded; front margin narrowly rounded; dorsal margin sloping downward with a gentle convex curve to the front margin; beaks well defined, incurved; a more or less distinct dorsal concavity behind them; the general surface having a smooth appearance, but concentric striæ are generally observable toward the basal margin.

Locality. Coal Measure strata, Sullivan county, Indiana, and generally at roof of coal M.

Genus SCHIZODUS, *King.*

SCHIZODUS WHEELERI, *Swallow.*

Plate 30, *figs.* 3, 4 *and* 5.

CYPRICARDIA WHEELERI, *Swallow*, 1862. Trans. St. Louis Acad. Sci., II, p. 96.
SCHIZODUS WHEELERI, *Meek*, 1872. U. S. Geol. Sur. Nebraska, p. 209, pl. X, fig. 1.

Shell of moderate size, irregularly subtrihedral or subovate in marginal outline; posterior portion laterally compressed; anterior portion inflated; umbones elevated; beaks incurved, situated at about one-quarter of the full length of the shell from the anterior extremity; margins of the front and the anterior part of the base forming a continuous and regular curve; basal margin sloping upward and meeting the downward and backward slope of the posterior margin at a prominent angle, which is abruptly rounded at the extremity; dorsal margin straight, sloping a little downward from the beaks to the obliquely truncated posterior margin; posterior umbonal slope prominent, sometimes forming a rather distinct ridge, which ends at the prominent angle of the posterior margin and considerably increases its projection; surface marked only by the ordinary lines of growth.

Length of an ordinary sized example, from the front margin to the posterior angle, 31 mm.; height, from base to umbones, 22 mm.

This is a widely distributed Coal Measure species, it being known to range from Indiana to Nebraska and New Mexico. It is usually found in the condition of casts of the interior of the shell, which give no surface features, but in such cases it is recognizable with little difficulty by its shape.

Locality. It may be reasonably sought for in the Upper Coal Measures of Indiana.

Genus CLINOPISTHA, *Meek and Worthen.*

CLINOPISTHA RADIATA, *Hall.*

Plate 31, *figs.* 6 *and* 7.

EDMONDIA RADIATA, *Hall*, 1858. Geology of Iowa, part II, p. 716, pl. XXIX, fig 3.
CLINOPISTHA RADIATA, *M. & W.*, 1873. Illinois Geol. Reports, V, p. 584, pl. XXVII, fig. 7.

Shell irregularly oblong or suboval in marginal outline, the anterior side being somewhat deeper than the posterior; the valves moderately convex when young, but the shell becomes ventricose with age; beaks obtuse, moderately prominent, situated very near the posterior end of the shell; anterior margin regularly rounded; posterior margin short, vertically truncated; basal margin straightened or slightly emarginate; dorsal margin nearly straight and rounded down to the front margin; ligament short, suboval, and situated immediately behind the beaks; surface having a polished aspect, but it shows fine concentric lines of growth and obscure, fine, radiating lines.

Length, 25 mm.; height, 16 mm.; convexity, 10 mm.

Locality. Upper Coal Measures of Indiana.

Genus EDMONDIA, *de Koninck.*

EDMONDIA ASPINWALLENSIS, *Meek.*

Plate 31, *figs.* 4 *and* 5.

EDMONDIA ASPINWALLENSIS, *Meek*, 1872. U. S. Geol. Survey Nebraska, p. 216, pl. IV, fig. 2.

Shell transversely subovate in marginal outline; valves having considerable convexity, the greatest being in front of, and a little above the middle; basal margin broadly convex; posterior margin somewhat narrowly rounded or sometimes faintly subtruncate; dorsal margin sloping a little downward with a slight convexity; anterior dorsal margin short, and declining abruptly to the narrowly rounded front margin; beaks not prominent, incurved, situated near the anterior end of the shell; surface marked by distinct lines and undulations of growth.

Length, 37 mm.; height, 27 mm.; diameter, 18 mm.

Locality. This species is known to range from West Virginia to Nebraska. It may be sought for in the Upper and Middle Coal Measures of Indiana.

Genus ALLORISMA, *King.*

ALLORISMA SUBCUNEATA, *Meek and Hayden.*

Plate 31, *figs.* 1, 2 *and* 3.

ALLORISMA SUBCUNEATA, *M. and H.*, 1864. Paleont. Upper Missouri, p. 37, pl. I, fig. 10.

Shell reaching a large size, transversely elongate, being two or more times as long as high, gibbous anteriorly, compressed posteriorly, where the valves are a little gaping; basal and dorsal margins sub-parallel, the latter very broadly convex; posterior margin narrowly rounded; front margin still more narrowly rounded below, but above it slopes abruptly upward and backward toward the beaks; dorsal margin slightly concave or nearly straight, and rounded to the posterior border; surface marked by concentric lines and distinct undulations of growth.

Length, 103 mm.; height, from base to cardinal margin, 41 mm. Many examples are somewhat smaller than this, but, occasionally, an example is found that is considerably larger.

This large fine shell has a very wide geographical range, it being known from Indiana to Utah and New Mexico. Throughout this wide range it retains all its essential characteristics so completely that it is readily recognizable.

Locality. It has been found throughout the Coal Measures of Indiana.

GASTEROPODA.

The genera Macrocheilus and Soleniscus.

No more confusion probably exists in relation to any group of fossil shells than is to be found among those which have been referred to the genus *Macrocheilus*, from North American Devonian and Carboniferous strata. Not only have shells of doubtful and diverse character been referred to that genus by different authors, but much uncertainty also exists as to the specific identity of the forms to which various specific names have been given. The causes of this uncertainty are various. First, several of the species which have been proposed have never been figured, the type specimens are inaccessible, and the descriptions alone are insufficient to permit a satisfactory discrimination of those species among the closely related forms. Second, the range of variation among all the recognizable species is so great that with numerous specimens in hand it is often difficult to decide upon definite specific limits. Third, dissimilar groups of species have been placed together under *Macrocheilus*.

Among the somewhat numerous North American Devonian and Carboniferous species, especially the latter, that have been referred to the genus *Macrocheilus* of Phillips, are certain forms which plainly do not answer the description of that genus as it was originally given, or as its characteristics have usually been stated by authors. The differences between these species and those which I regard as true *Macrocheilus* pertain mainly to the columella and inner lip; but they also possess a more massive test. Some of the American species which have been referred to *Macrocheilus* have a plain, more or less sinuous, inner lip, which is only slightly covered with callus and destitute of any trace of ridges or folds. These, I assume to be typical forms of that genus, and the following, among others, may be mentioned as examples: *Macrocheilus Hebe* and *M. Hamiltonæ*, Hall, of the Devonian; and *M. anguliferus*, White, of the Carboniferous. My present belief is that all the Devonian forms that have been referred to *Macrocheilus* will fall into this group, but that it will properly include only a very small part of those which have been referred to that genus from Carboniferous strata. With the very few exceptions referred to, I think all the numerous North American Carboniferous forms which various authors have referred to *Macrocheilus* constitute a distinct natural group which ought to be designated by one, and a different, generic name. I, also, think the form for which Meek and Worthen proposed the generic name of *Soleniscus* ought to be included in this group.

The shells of the group in question are characterized by a more or less thickened inner lip, which also bears one more or less distinct revolving fold. This fold, when the outer lip is entire, is usually visible only as an obtuse prominence near the anterior end of the inner lip; but upon breaking away the outer lip the fold is usually found to be distinct, and often sharp and prominent. Sometimes, also, there is, upon the posterior side of the fold, a broad concave depression which ends at, and deepens, the inward flexure of the inner lip, the posterior border of which depression is sometimes so well defined as to appear like a second revolving fold. This depression is excavated out of the callus which covers the columella and inner lip quite thickly, in such cases, between the depression and the posterior angle of the aperture. Forward of the fold there is little, and sometimes no, accumulation of callus, the anterior end of the outer lip, where it joins the inner lip, being usually thin and more or less prominent when entire. There is, therefore, in unbroken shells, a rather broad, short, more or less distinct, anterior canal, too broad and short to really deserve the name of canal, strongly recalling the corresponding part of *Nassa*. The anterior border of this short canal, however, is prominent, and not emarginate as in *Nassa*.

From the fact that the columellar fold upon these Carboniferous shells is distinct only within the aperture, and that the latter is usually filled with the imbedding matrix, this distinguishing feature seems to have generally escaped the notice of authors. It has not always done so, however, both those eminent paleontologists, Professors Hall * and Geinitz,† having referred to it in published descriptions. Meek and Worthen also observed that the inner lip is "usually provided with an obtuse revolving fold," but none of these authors appear to have regarded that feature as separating such shells generically from those which are destitute of it. Mr. Conrad, however, so early as 1842, proposed the generic name of *Plectostylus* to include shells possessing this character; but that name was previously used by Beck for an entirely different group of mollusks. Mr. S. A. Miller, also, in his Catalogue of American Paleozoic Fossils, refers the *Macrocheilus Halli* of Geinitz to *Soleniscus*, Meek and Worthen. In 1881, I described ‡ two species of this group from the Carboniferous rocks of New Mexico, and also referred them to *Soleniscus*.

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* Geology of Iowa, 1858, Part II, pages 719 and 720.

† Carbonformation und Dyas, in Nebraska, 1866, page 6.

‡ Expl. and Sur. West of the 100th Merid. Supp. to vol. III, pp. 28 and 29, pl. IV, figs. 4 and 5.

Notwithstanding the conscientious accuracy which is apparent in all the work of those authors, I suspected that the anterior portion of their type species is not so prominent as it is represented to be by the restored part of their figures. Applying to Mr. Worthen for permission to examine the type specimen, I learned that it was inaccessible, but he sent me, for examination, an authentic duplicate example. A careful examination of this specimen satisfies me that the anterior portion of the shell in this species is really only a little more prominent than it is in several of those forms which have been referred to *Macrocheilus*, and that that portion is not produced into a proper beak. Meek and Worthen's figures show that the anterior portion of their type-specimen was broken off; and if the line of the restored part had been continued with the curve of the outer lip, or the longitudinal convexity of the volution, it would agree with the lines of growth which are observable upon the specimens sent me by Mr. Worthen. Moreover, their figure shows a prominence of the fold upon the inner lip which did not appear on the one just referred to, until I had dug deeply into the stony material which had filled the aperture. Their figure also appears to represent the outer lip as entire; but to exhibit the columellar fold so prominently as it appears in that figure, the outer lip must have been largely removed. So removing the outer lip, and not its anterior part, would leave the latter having somewhat the appearance of a beak.

Understanding the real characters of the type species of *Soleniscus* to be such as I have here indicated, it is, I think, necessary to regard the form to which they applied that name as congeneric with the greater part, if not all, the forms which are figured with it on plate 34, and with most of those Carboniferous shells which have been by different authors referred to *Macrocheilus*. According to my observations, the principal differences which that species presents from the others referred to, are its more than usually elongate form, a little greater than the usual prominence of the anterior part of the aperture, and a smaller accumulation of callus upon the inner lip.

These forms, as before remarked, are regarded as constituting a natural group which, it appears to me, well deserve a generic designation distinct from *Macrocheilus*. If it were not that Conrad's name *Plectostylus* was preoccupied by Beck, that name could be appropriately retained for this group, to which it was really applied. Conrad's name not being available, the next generic name that has been used for any member of the group ought to be used for the whole group. As *Soleniscus* is regarded as a member of this group, that name ought to be used for it, because no other available name has priority over it.

The following species, which have hitherto been referred to *Macrocheilus*, have been found to possess the prominent columellar fold and other characteristics of the group here discussed, and I would, therefore, refer them all to *Soleniscus; Macrocheilus fusiformis*, Hall, *M. Newberryi*, Hall, *M. planus*, White, *M. ventricosus*, Hall, *Soleniscus brevis*, White, *M. Texanus*, Shumard?, *M. paludinæformis*, Hall, and *M. Halli*, Geinitz. All except the last are figured on plate 34.

It is not to be denied that there are certain forms among those Carboniferous species, which have usually been referred to *Macrocheilus*, that possess, at best, only an obtuse fold upon the columella. They are, however, much more closely related, by all their characteristics, to the species just referred to *Soleniscus*, than are those Devonian and other species which I have refered to *Macrocheilus* proper. Among these species are the three following, which are represented, with the others, on plate 34: *Macrocheilus ponderosus*, Swallow?, *M. medialis*, Meek and Worthen, and *M. primigenius*, Conrad. These, I regard as, at most, no more than subgenerically different from those which I have referred to *Soleniscus*.

Genus SOLENISCUS, *Meek and Worthen.*

SOLENISCUS TYPICUS, *Meek and Worthen.*

Plate 34, *figs.* 18 *and* 19.

SOLENISCUS TYPICUS, *M. and W.*, 1860. Ill. Geol. Rep., II, p. 384, pl. 31, figs. 15 a and 15 b.

Shell fusiform; spire produced, conical, acute at the apex; volutions, seven or more, gently convex, the last one constituting at least three-quarters of the full length of the shell, moderately ventricose about the middle and tapering a little toward the front; aperture comparatively narrow, acute posteriorly, narrowed at the front, outer lip thin and sharp; suture slightly impressed; fold of the columella nearer to the front end of the aperture than to the posterior end, inconspicuous when the outer lip is entire, but prominent within the aperture; surface plain, showing only the usual fine lines of growth.

Length, about 18 mm.; diameter of the last volution, 9 mm.; apical angle, the sides being slightly concave, about 40°.

This appears to be a rather rare species, and has hitherto been found only in the Upper Coal Measure rocks, in the vicinity of Springfield, Illinois; but it is likely to be found in the corresponding rocks in Indiana.

This species was made the type of the genus *Soleniscus*, by Meek and Worthen, but, as I have already shown, a large proportion of the shells that have been referred to the genus *Macrocheilus* possess essentially the same generic characters.

SOLENISCUS (MACROCHEILUS) NEWBERRYI, *Stevens.*

Plate 34, figs. 7 and 8.

LOXONEMA NEWBERRYI, *Stevens*, 1858. Am. Jour. Sci. (2) XXV, p. 259.
MACROCHEILUS NEWBERRYI, *Hall*, 1858. Geology of Iowa, Part 2, pl. 719, p. XXIX, fig. 9.

Shell fusiform; spire produced; its sides convex, apex acute; volutions seven or more, the last one moderately ventricose and constituting more than half the full length of the shell; those of the spire moderately convex; suture distinct, but not very deeply impressed; aperture comparatively narrow; outer lip thin, but the remainder of the test comparatively thick; inner lip thickened by callus; collumella appearing flexuous, and with an obtuse fold anteriorly, when the outer lip is entire, but when the latter is much broken away that fold is found to be angular and prominent, with a deep, broad, concave groove behind it; the posterior side of that groove being abruptly rounded has much the appearance of a second revolving fold; in front of the fold, and between it and the front border of the aperture, there is a narrow concave space or a short broad canal; surface marked by the ordinary fine lines of growth, but it has, in well preserved examples, an almost polished aspect.

Length, 26 mm.; breadth of the last volution, 12 mm.

Locality. Danville, Illinois; but it may be looked for at the horizons of coals M. and N., in Indiana.

SOLENISCUS PLANUS, *White.*

Plate 34, figs. 9 and 10.

SOLENISCUS PLANUS, *White*, 1881. Expl. and Sur. west of the 100th Merid., Sup. to Vol. III, p. XXIX, pl. IV, fig. 4.

Shell subfusiform; spire nearly one-half the full length of the shell; its side gently convex; apex acute; volutions eight or more; those of the spire gently convex; the last one large, but not much ventricose; suture distinct but not deep; test moderately thick; fold of the columella well developed and placed a little forward of the mid-length of the aperture; the spiral groove behind it broad, concave, and well defined; the callus of the inner lip thick, especially behind the groove; outer lip thin, its margin sharp; surface marked only by the usual lines of growth.

Length, 27 mm.; greatest diameter, 9 mm.

This form was described by me from the Carboniferous rocks of New Mexico (*loc. cit.*). I am now inclined to regard it as identical with the *Macrocheilus Newberryi* of Hall, but still it presents such variations that, for the present, I retain it under the name I have applied. At the time I described it, I was not aware that the *M. Newberryi* possessed the distinct columellar fold that I have now shown it to possess, as well as *S.*

planus. Considering the evident wide specific variation of these forms, it seems not improbable that, with full collections in hand, it will be difficult to clearly define the specific boundaries between *S. Newberryi*, *S. planus*, and *S. fusiformis;* all three of which are here separately described.

Locality. The form figured on plate 34 was obtained from near Danville, Illinois; but it may be sought for in Indiana at the horizons of the roof of coals M. and N., and in the Upper Coal Measures.

SOLENISCUS (MACROCHEILUS) FUSIFORMIS, *Hall.*

Plate 34, *figs*, 4, 5 *and* 6.

MACROCHEILUS FUSIFORMIS, *Hall*, 1858. Geology of Iowa, part II, p. 718, pl. XXIX, fig. 7.

Shell elongate-subfusiform; spire more than half the full length of the shell; its sides nearly straight or slightly convex; volutions about ten in number, those of the spire gently convex, the last one large and moderately ventricose; suture shallow; test moderately thick, but the outer lip is thin and sharp when entire; inner lip covered with a strong callus; columellar fold distinct within the aperture, its outer portion obtuse; groove behind the fold broad and deeply concave, with its posterior margin obtuse, but distinctly defined; surface marked only by the ordinary lines of growth.

Length, about 40 mm.; diameter of the last volution, 15 mm.

The specimens here described differ somewhat from the description and figure given by Prof. Hall, but the differences are assumed to be of a varietal character only. As already remarked, however, this form is closely similar to the two forms herein just described.

Locality. Prof. Hall's type specimen is from the Coal Measures of Iowa. The forms here described are from Illinois. The species may be sought for in the Upper Coal Measures of Indiana.

SOLENISCUS (MACROCHEILUS) PALUDINÆFORMIS, *Hall.*

Plate 34, *fig.* 17.

MACROCHEILUS PALUDINÆFORMIS, *Hall*, 1858. Geol. Iowa, part II, p. 719, pl. XXIX, fig. 10.

Shell short subfusiform; spire prominent, but it constitutes somewhat less than half the full length of the shell; its sides gently concave; its apex small, acute; volutions eight or more in number, those of the spire gently convex, the last one ventricose; suture slightly impressed; test comparatively thin for a shell of this group, but there is a thick accumulation of callus upon the inner lip; columellar fold distinct; the groove behind it broad, concave and deep, as seen after a portion of the last volution is removed; surface marked by the ordinary lines of growth.

Length, about 26 mm.; diameter, 15 mm.

I have no doubt that the specimen upon which the foregoing description is based is specifically identical with the *Macrocheilus paludinæformis* of Hall. It is possible, also, as Prof. Hall remarks, that it was upon a cast of this species that Conrad proposed the genus *Plectostylus*, but his specimen being only a cast of the interior, its specific identity can not be fully known.

Locality. The specimen here described is from the Coal Measures of Vermillion county, Indiana. The species is also known to exist in the corresponding strata of Illinois and Iowa.

SOLENISCUS (MACROCHEILUS) VENTRICOSUS, *Hall.*

Plate 34, *figs.* 11 *and* 12.

MACROCHEILUS VENTRICOSUS, *Hall*, 1858. Geology of Iowa. part II, p. 718, pl. XXIX, fig. 8.
SOLENISCUS BREVIS, *White*, 1881. Expl. and Sur. West of 100th Merid., Supp. to Vol. III, p. 28, fig. 5.

Shell subglobose; spire very short, apex small and prominent; volutions about eight in number, those of the spire moderately convex, the last one ventricose; test moderately thick; suture distinct, but not deep; fold of the columella prominent, especially within the aperture, situated a little in advance of the mid-length of the aperture; a distinct, rather broad, deep concavity or revolving furrow at the distal side of the fold; callus of the inner lip moderately thick and broad; surface marked only by the usual lines of growth.

Length 17 mm.; diameter of the last volution, 11 mm.

This is a widely distributed species, and a somewhat variable one, especially in the prominence of the spire; but its small size and globose form render its identification an easy matter. I failed in identifying it with the New Mexican form (*loc. cit.*), because I did not then know that the authentic forms possessed the distinct columella fold that they are now known to have.

Locality. Specimens of this species have been found in Illinois, Iowa, and New Mexico. They may be sought for, in Indiana, at the horizon of coal M. and in the Upper Coal Measures.

SOLENISCUS (MACROCHEILUS) TEXANUS, *Shumard* (?)

Plate 34, *figs.* 13 *and* 14.

MACROCHEILUS TEXANUS, *Shumard*, 1859. Trans. St. Louis Acad. Sci., Vol. I, p. 402.

The form figured on plate 34, is doubtfully indentified with the *Macrocheilus Texanus* of Shumard. I am not satisfied that this is not a large variety of *S.* (*M.*) *ventricosus*, but for the present I prefer to regard it as distinct. It is somewhat more globose than *S.* (*M.*) *ventricosus*, and the spire is proportionally less prominent than it usually is in that species.

Shumard's type was found in Texas, and the specimen here figured was obtained from the Coal Measure strata at Danville, Illinois. It is likely to be found in the Upper Coal Measures of Indiana.

SOLENISCUS? (MACROCHEILUS) MEDIALIS, *Meek and Worthen.*

Plate 34, *figs.* 15 *and* 16.

MACROCHEILUS MEDIALIS, *M. and W.*, 1866. Illinois Geol. Reports, II, p. 370, pl. 31, fig. 5 a and 5 b.

Shell subovate; spire depressed-conical, its sides a little convex, but the apex is small and acute when entire; volutions six or more in number, those of the spire convex, increasing rapidly in size, the last one large, moderately ventricose; suture distinct, but not deep; outer lip thin and sharp at the margin, when unbroken; inner lip covered with callus, and having a moderately deep sinus at the middle, forward of which there is a tendency to form an obtuse fold; but it is not yet known to be continuous within the aperture with a sharp fold, such as all the species possess which have just been herein described; surface plain.

Length, 22 mm.; diameter of the last volution, 17 mm.

Locality. Meek and Worthen's examples were obtained from near Springfield, Illinois. The example figured on plate 34, is from Vermillion county, Indiana.

SOLENISCUS? (MACROCHEILUS) PONDEROSUS, *Swallow?*

Plate 34, *figs.* 1 *and* 2.

MACROCHEILUS PONDEROSUS, *Swallow*, 1858. Trans. St. Louis Acad. Sci., I, p. 202.

The example figured on plate 34 is from the Upper Coal Measures of Iowa, and is given here for comparison, in connection with the discussion of the shells just described. It has not yet been found in Indiana, but there is no apparent reason why it may not be found in the rocks of this State.

This shell, like the last described, is not known to possess a sharply raised fold within the aperture, but it has the deeply sinuous inner lip, and a broad obtuse thickening of the columella below it; in short, it has all the general characteristics of the more globose of the forms that have been referred to *Macrocheilus*, except, perhaps, a sharply raised columellar fold.

SOLENISCUS? (MACROCHEILUS) PRIMIGENIUS, *Conrad.*

Plate 34, *fig.* 3.

STYLIFER PRIMIGENIA, *Conrad*, 1835. Trans. Geol. Soc. Penn., I, p. 267, pl. 12, fig. 2.
MACROCHEILUS INHABILIS (Morton) *Norwood and Pratton*, 1855. Jour. Acad. Nat. Sci. Philad. III., p. 76, pl. 9, fig. 9a and b.
MACROCHEILUS PRIMIGENIUS, *Hall*, 1858. Geology of Iowa Part II, p. 720, pl. 29, fig. 11.

This shell is a somewhat common one in the Coal Measure rocks of Ohio, Indiana, Illinois, and Iowa. In form it resembles the *M. ponderosus* of Swallow, as it has just been identified, but it is regarded as specifically distinct. It differs still more widely from the *Soleniscus* type than either of the two forms that have just been noticed under the respective specific names *medialis* and *ponderosus*. There seems to be nothing upon the columella that is suggestive of a fold, although just behind the place at which such a fold should appear there is a distinct concavity which passes around the columella within the aperture. The test is thick, and there is a considerable accumulation of callus upon the inner lip, and the general characteristics of the shell are like those of the species that have already been noticed.

Genus BELLEROPHON, *Montfort.*

BELLEROPHON CRASSUS, *Meek and Worthen.*

Plate 33, *figs.* 1 *and* 2.

BELLEROPHON CRASSUS, *M. and W.*, 1866. Illinois Geol. Survey, II, p. 385, pl. 31, fig. 16.

Shell large, massive, subglobose; volutions gradually expanding laterally, broadly rounded upon the back, more abruptly rounded at the sides and into the umbilici, which are rather small; outline of aperture reniform, the transverse diameter being the greater; postero-lateral portions of the lip thickened and spread outward and backward over the inner volutions, and also partly over the umbilici; antero-lateral portions of the lip thinner than the others, their margins slightly convex on each side of the mesial notch; mesial band narrow; mesial notch distinct, but not deep; surface marked by distinct lines of growth, a part of which assume the character of somewhat irregular transverse wrinkles.

Diameter in the plane of the coil, 58 mm.; transverse diameter of the aperture, 50 mm.

Locality. This species is known to exist in both the Lower and Upper Coal Measures, and to range from Indiana to Nevada. It has been found in Sullivan and Posey counties, Indiana; but, there, only in the Upper Coal Measures.

BELLEROPHON PERCARINATUS, *Conrad.*

Plate 33, *figs.* 9, 10, 11, 12, 13 *and* 14.

BELLEROPHON PERCARINATUS, *Conrad*, 1842. Jour. Acad. Nat. Sci. Phil., VIII, pl. XVI, fig. 5.
BELLEROPHON PERCARINATUS, *Norwood & Pratten*, 1854. Jour. Acad. Nat. Sci. Phil., III, (U. S.), p. 74, pl. IX, fig. 4.

Shell subglobose; laterally expanded at the front; umbilici closed; outer lip thin at the front, thickened by callus at the sides; inner lip thickened by callus, which is sometimes in the form of a broad, prominent lobe, sometimes trilobed, and sometimes presenting only one narrow lobe, and that at the median line; the last volution is always marked by one strong, rugose or nodose median carina, which extends from the inner lip to the front margin; in most cases there is a more or less distinct revolving ridge at each side of the median carina, and of equal extent with it; the whole surface is also marked by strong transverse wrinkles and lines of growth, but sometimes the lateral ridges are wanting.

Length, 24 mm.; breadth, the same.

This is one of the more common of the shells of the Coal Measure rocks.

Locality. It has been discovered from coal M. throughout the Upper Coal Measures.

BELLEROPHON CARBONARIUS, *Cox.*

Plate 33, *figs.* 6, 7 *and* 8.

BELLEROPHON CARBONARIUS, *Cox*, 1857. Geol. Sur. Kentucky, III, p. 562.

Shell subglobose; dorsal side broadly rounded; umbilici very small, shallow; aperture arcuate, much wider transversely than in the plane of the coil; its border not expanding more rapidly than the uniform rate of increase in the size of the volutions; inner lip not developed as such, the accumulation of callus there being often imperceptible; outer lip thin along the median portion but thickened a little and having a rounded edge toward the umbilici; median sinus not deep, rounded at bottom; median band obscure upon the costate portion of the shell, but moderately distinct upon the outer, plain portion, where it is bounded upon either side by a more or less distinct raised line; the outer third, or more, of the last volution is plain, but the remainder is marked by from twenty to twenty-eight simple, distinct, narrow, revolving, raised ridges or costæ; the two or three nearest the umbilici are, near the plain portion, sometimes broken up into small, irregular nodes.

Diameter of the coil and transverse diameter nearly equal, each being about 17 mm. in the type specimen of Cox, which is figured on plate 33.

Formerly, authors generally referred this shell to the *B. Urii* of Fleming, and it is even now doubtful if we are justified in separating it fully from that species. There are, in different parts of the wide range which this species has, several noticeable varieties, the differences being as to size and character of surface markings. One of these varieties, found in the Rocky Mountain region, I have thought of sufficient importance for separate specific designation as *B. subpapillosus*. The typical forms, however, have a range from West Virginia to Nebraska.

Locality. This species may be sought for throughout the Coal Measures of Indiana.

BELLEROPHON NODOCARINATUS, *Hall.*

Plate 33, *figs.* 3, 4 *and* 5.

BELLEROPHON NODOCARINATUS, *Hall*, 1858. Geology of Iowa, part II, p. 723, pl. XXIX, fig. 15, a, b, c.

Shell subglobose; somewhat expanded at the sides; umbilici closed; the smaller part of the last volution somewhat regularly rounded transversely, but upon the outer half of it there is a broad subnodose median carina, with a narrow, shallow furrow along its middle, and upon each side of the carina there is a broad, shallow depression; the inner half of the outer volution is marked by coarse, revolving, raised lines; outer lip thin; little or no callus upon the inner lip, sides of the aperture near the umbilici having thickened and rounded edges.

Diameter in the plane of the coil, 40 mm.; greatest transverse diameter, 37 mm.

This form is referred with doubt to the *B. nodocarinatus* of Hall, but it seems to present some important differences. It is also closely related to the form which I described from New Mexico under the name of *B. inspeciosus*. The latter shell is more expanded at the outer, and narrower at the inner, part of the last volution than the form here described; the carina is also not so well defined, nor is it nodose. It is probable, however, that both *B. inspeciosus* and the form here described will prove to be only varieties of *B. nodocarinatus*.

Locality. The form here described is from New Harmony, Indiana.

Genus PLATYCERAS, *Conrad.*

PLATYCERAS NEBRASCENSE, *Meek.*

Plate 32, *figs.* 15 *and* 16.

PLATYCERAS NEBRASCENSIS, *Meek*, 1872. U. S. Geol. Sur. Nebraska, p. 227, pl. IV, fig. 15, a, b.

Shell small, elongate-conical, more or less curved, or sometimes subspiral; apex free, bluntly pointed, more or less curved towards the body of the shell and turned toward its dextral side; aperture irregularly oval; its margin thin, broadly sinuous behind and to the left of the apex the remainder of the border usually having several other more or less distinct sinuosities; surface marked by more or less distinct lines of growth, which are parallel with the sinuosities of the border.

Length, 20 mm.; breadth of aperture, 12 mm.

This species was originally described from the Upper Coal Measures of Nebraska, but it has been found to range from Indiana to New Mexico.

Locality. It has been found at the following Indiana localities: Eugene, Edwardsport, and New Harmony.

Genus PLEUROTOMARIA, *Defrance.*

PLEUROTOMARIA TURBINIFORMIS, *Meek and Worthen.*

Plate 32, figs. 7 and 8.

PLEUROTOMARIA TURBINIFORMIS, *Meek and Worthen*, 1866. Illinois Geol. Reports, II, p. 359, pl. XXVIII, fig. 8, a, b, c.

Shell subpyramidal; spire moderately elevated; volutions five or more in number, flattened at the outer side, so as to produce nearly straight sides to the spire, the last volution prominently angular at the periphery, and broadly convex below; umbilicus small and bordered by an obscure ridge; spiral band situated at the peripheral angle of the volutions, very narrow, and bordered by slender elevated lines; surface of each volution marked by about twenty obscure, close-set, revolving striæ, which are crossed by stronger and more regular obliquely transverse lines; these lines curve backward near the spiral band.

Length and breadth, each, about 25 mm.

Locality. Upper Coal Measures, at Lasalle and Paris, Illinois, and in Vigo county, Indiana.

PLEUROTOMARIA TABULATA, *Hall.*

Plate 32, figs. 4 and 5.

PLEUROTOMARIA TABULATA, *Hall.* Geology of Iowa, Part II, p. 721, pl. XXIX, figs. 12, a, b.

Shell unusually elongate for a species of this genus; volutions eight or more in number, prominently angular, the angle situated at about the middle of the volution, and bearing a finely nodulated carina; umbilicus closed; columellar lip a little thickened; suture distinct; surface marked by numerous revolving raised lines which are a little coarser upon the anterior side of the last volution than elsewhere; these are crossed by lines of growth, which give the revolving striæ a more or less crenulated appearance; the striæ of growth bend abruptly backward to meet the peripheral angle, showing that the outer lip was notched at that point.

Length, 52 mm.; breadth of the last volution, 44 mm.

This species is known to exist in the Coal Measure strata from Indiana to Iowa. It was described and figured in the Indiana report for 1880, but it is reproduced here to bring all the Coal Measure shells together.

Locality. Upper Coal Measure strata, Rush Creek, Posey county; Wagon-defeat Creek, Sullivan county, and Warrick county, Indiana.

PLEUROTOMARIA SPHÆRULATA, *Conrad.*

Plate 32, *figs.* 1, 2 *and* 3.

PLEUTOMARIA SPHÆRULATA, *Conrad*, 1842. Jour. Acad. Nat. Sci. Philad., VIII, p. 272, pl. XVI, fig. 13.

Shell depressed, subturbinate; spire moderately extended, its sides straight or gently convex; apical portion truncated; volutions five or six in number, their outer surface flat, and bearing a tuberculated ridge at the distal border, adjacent to the suture; the last volution large, narrowly rounded or subangular at the periphery; its anterior side broadly convex; umbilicus closed; spiral band situated at the periphery, narrow and indistinct; surface marked by lines of growth which, on both sides of the spiral band, bend back to meet it, showing that the outer lip had there a broad and deep notch.

Length of a large example, 22 mm.; breadth of the last volution, 29 mm.

This is a somewhat variable shell, and also a widely distributed one. It has been found at various localities in the Carboniferous rocks, from Pennsylvania to Utah.

Locality. Horizon of coal K., and throughout Upper Coal Measures.

Genus EUOMPHALUS, *Sowerby.*

EUOMPHALUS RUGOSUS, *Hall.*

Plate 32, *figs.* 11 *and* 12.

EUOMPHALUS RUGOSUS, *Hall*, 1858. Geology of Iowa, Part II, p. 722, pl. XXIX, fig. 14.

Shell small, discoid; upper side concave; lower side flat or gently concave; volutions four or more in number, in contact but not embracing, the whole breadth of each being exposed both at the upper and under sides of the shell; obliquely flattened at the periphery, and bearing a narrow prominent ridge at the angle formed by the outer and upper sides; and another similar ridge at the junction of the outer and under sides, the latter being directed outward, and the former upward; aperture subcircular, and not conforming in outline to the two angles mentioned; surface marked by strong lines and wrinkles of growth, which give a rough appearance to the shell, and especially to the two ridges as they cross them.

Diameter of the coil from 12 to 20 mm.

This, a very widely distributed and characteristic species of the Coal Measure strata, may be found from the lowest to the highest coals, culminating in the Upper Coal Measures.

Genus NATICOPSIS, *McCoy.*

NATICOPSIS NANA, *Meek and Worthen.*

Plate 36, *figs.* 6 *and* 7.

NATICOPSIS NANA, *M. and W.*, 1866. Illinois Geol. Reports, II, p. 365, pl. XXXI, fig. 4.

Shell small, subglobose, wider than high; spire much depressed; volutions about three in number, the last one large, and somewhat ventricose; suture well defined; aperture broadly subovate, somewhat straightened at the inner side, its length nearly equal to seven-eighths of the full axial length of the shell; outer lip thin; inner lip moderately thickened; surface marked by fine lines of growth, which are a little stronger and more uniform on the distal side of the volutions, near the suture, than elsewhere.

Length, 5 mm.; breadth, 4½ mm.

This little species is known in the Carboniferous strata from Indiana to Nevada.

Locality. In Upper and Middle Coal Measures.

NATICOPSIS WHEELERI, *Swallow.*

Plate 32, *figs.* 13 *and* 14.

LITTORINA WHEELERI, *Swallow*, 1860. Trans. St. Louis Acad. Sci., I, p. 658.
NATICOPSIS WHEELERI, *Meek and Worthen*, 1873. Illinois Geol. Reports, V, p. 595.

Shell rather small, obliquely subrhomboidal in outline when laterally viewed; volutions four or more, the last one moderately gibbous and composing more than two-thirds the entire length of the shell; aperture subovate; test moderately thick; surface covered thickly with small, prominent tubercles, which, on the small volutions of the spire, are minute, but they increase in size with the growth of the shell; outer lip moderately thin; inner lip somewhat thickened with callus.

Length of a large example, 16 mm.; breadth of the last volution, 14 mm.

This species is a well marked one; and it has also a wide geographical distribution. It is known in the Coal Measure strata from Indiana to New Mexico.

Locality. Swallow's type specimens were obtained from the Coal

Measure strata of Missouri, and Meek and Worthen described and figured it from Illinois. It may be found in Upper Coal Measures of the western part of Vigo county.

Genus POLYPHEMOPSIS, *Portlock*.

POLYPHEMOPSIS PERACUTA, *Meek and Worthen*.

Plate 32, *figs.* 9 *and* 10.

POLYPHEMOPSIS PERACUTA, *M. and W.* Illinois Geol. Reports, II, p. 375, pl. XXXI, fig. 7, a, b.

Shell slender; spire long, attenuated, its sides gently concave; apex small and acute; volutions, twelve or more in number, flattened or very slightly convex at the outer side, the last one large and constituting about one-half the entire length of the shell, extended and somewhat contracted anteriorly; suture slightly impressed, but distinct; aperture narrowly subovate in outline; sharply angular behind, and somewhat effuse anteriorly; outer lip thin; inner lip flexed and a little thickened; surface plain, but, under a lens, fine lines of growth are seen.

Length, 45 mm.; breadth of the last volution, 13 mm.

This species is not a very common one. It is regarded as characteristic of the Upper Coal Measures.

Locality. The species was was originally published from the Upper Coal Measures of Illinois. It may be reasonably sought for at the following Indiana localities: Horizons of coals M. and N. of the Upper Coal Measures.

POLYPHEMOPSIS NITIDULA, *Meek and Worthen*.

Plate 27, *figs.* 7 *and* 8.

POLYPHEMOPSIS NITIDULA, *M. and W.*, 1866. Ill. Geol. Repts. II, p. 374, pl. XXXI, figs. 9, a, b.
POLYPHEMOPSIS NITIDULA, *White*, 1882. Eleventh Indiana Geol. Report, p. 370, pl. 42, figs. 7 and 8.

This shell was published in the Eleventh Annual Report, and referred, with some doubt, to the *P. nitidula* of Meek and Worthen. Our example is larger than the type specimen of Meek and Worthen, but it seems to be specifically identical. It is subfusiform; spire extended, its sides nearly straight; volutions eight or more in number, moderately convex, the last one rather large, constituting a little more than half the full length of the shell; suture impressed and distinct; aperture subovate in outline, angular behind; surface plain.

Length, 27 mm.; diameter of the last volution, 11 mm.

Locality. The type specimens of Meek and Worthen came from the Upper Coal Measures of Springfield, Illinois. The specimen here described and figured is from the Coal Measure strata at Eugene, Vermillion county, Indiana.

POLYPHEMOPSIS ? ————?

Plate 32, *fig.* 6.

In the Indiana Geological Report for 1880, I figured and described this form as *Polyphemopsis fusiformis*, identifying it with the *Macrocheilus fusiformis* of Hall, at that time believing that species to be properly referable to *Polyphemopsis*. In the last particular, I was wrong; and I have, on a preceding page, included Professor Hall's species among those shells which have hitherto been referred to *Macrocheilus*, referring them all, provisionally, to *Soleniscus*.

The form here in question, I do not regard as certainly identical with the *Macrocheilus fusiformis* of Hall, nor am I confident that it properly belongs to the genus *Polyphemopsis*. I refer it here, provisionally, to the last named genus, but it is quite likely that it will hereafter be found to be congeneric with those shells which in this article I have referred to *Soleniscus*.

This shell comes from the Coal Measure strata at Newport, Indiana.

CEPHALOPODA.

Genus ORTHOCERAS, *Breynius*.

ORTHOCERAS RUSHENSIS, *McChesney*.

Plate 36, *fig.* 5.

Shell small, slender, cylindrical or terete; septa moderately concave; siphuncle subcentral; test finely and distinctly striate when the epidermis is not removed.

This is probably the species that was described by McChesney in his pamphlet entitled New Paleozoic Fossils. There are probably three or four small species of *Orthoceras* in the Carboniferous strata of the United States which are so near alike that it is difficult, and apparently unprofitable, to attempt to separate them. The species of this genus, at best, present few prominent specific characteristics. The figure on plate 36 will give a better idea of the character of the fossil in question than a description of it could do.

Locality. Eugene, Newport, Lodi, Merom, Graysville, New Harmony, Rush Creek, Newberg, Indiana, from coal A. to top of the Measures.

Genus NAUTILUS, *Breynius*.

NAUTILUS WINSLOWI, *Meek and Worthen*.

Plate 36, figs. 1 and 2.

NAUTILUS (TEMNOCHEILUS) WINSLOWI, *M. & W.*, 1873. Illinois Geol. Reports, V, p. 609, pl. XXXII, fig. 2.

Shell moderately large, subdiscoidal; umbilici broad and moderately deep, showing nearly the full size of each volution; peripheral side broadly flattened, the middle third being more distinctly flat than the remainder, and the sides sloping slightly to the lateral margins; volutions four or more, their transverse diameter about one-third greater than that of the opposite direction, the lateral margins of the volutions bearing each a row of prominent rounded nodes, which project outwards laterally; from the rows of nodes the sides slope inward with gentle convexity; surface marked by distinct lines of growth, which curve gently backward in crossing the sides of the volutions from the inner margin, and also curve strongly backward in crossing the periphery, indicating a broad mesial sinus in the outer lip.

Diameter of the coil, 125 mm.; transverse breadth near the aperture, including the nodes, 88 mm.

Locality. The type specimen of this species was obtained from the Coal Measure strata at Danville, Illinois. It may be sought for at the following Indiana localities: At horizons of coals M. and N.

NAUTILUS FORBESIANUS, *McChesney*.

Plate 36, figs. 3 and 4.

NAUTILUS FORBESIANUS, *McChesney*. Trans. Chi. Acad. Sci., I, p. 50, pl. III, fig. 4.

Shell somewhat massive; volutions in contact but not embracing; broadly convex on the peripheral side; abruptly rounded at each lateral portion, from which the sides slope abruptly into the umbilici; these are large, broad and deep, showing almost the whole width of each volution; transverse section of the volutions subelliptical, about half as wide in the plane of the coil as it is in the opposite direction; septa plain and moderately concave; siphuncle subcentral; a row of prominent rounded nodes occupies each side of the volutions, and where the shell substance is preserved, it shows close-set, coarse, revolving, raised lines which apparently covered the whole surface.

The full diameter of an adult shell is not known, but it probably reached as much as, or more than, 100 mm.

Locality. Prof. McChesney's type specimen was from Mercer county, Illinois. The one figured on plate 36, is from Newport, Indiana.*

* *N. decoratus*, Cox.

NAUTILUS MISSOURIENSIS, *Swallow?*

Plate 35, *figs.* 1 *and* 2.

NAUTILUS MISSOURIENSIS, *Swallow*, 1857. Trans. St. Louis Acad. Sci., p. 198.

Professor Swallow's description is incomplete, having been evidently based upon either a very small example or the inner volutions of one of larger size. Our example, although incomplete, is much larger than Swallow's specimen, but the characters which he mentions in his description induce me to refer it to *N. Missouriensis* rather than to propose a new name for it, or refer it to any other described species. It is certainly very closely related to *N. spectabilis* of Meek and Worthen (Illinois Geol. Survey, II, p. 308, pl. 25) of the Chester Limestone. Its proportions are similar, and its septa have a like gentle sinuosity, but it is apparently without the row of gently raised obtuse nodes at each side, which characterize *N. spectabilis*. This specimen being only a cast, and somewhat eroded, may really have possessed that feature. The principal objection to regarding our example as specifically identical with *N. spectabilis* seems to lie in the fact that it comes from another formation; but in view of the known intimate faunal relationship between the Chester Limestone and the Coal Measures, their specific identity does not seem improbable.

The full diameter of the coil of our example, when perfect, was not less than 80 or 100 mm.

Locality. Silverwood, Fountain county, Indiana.

CRUSTACEA.

The crustacean remains that have been discovered in all the strata of that great coal-field which includes a large part of the State of Indiana, are few, but they are interesting and important. If we were to regard the smallness of the number of species that have been recognized among these fossil remains as an indication of the prevalence of crustacean life during the Coal Measure period, our estimate would be a very low one. But the small number of species referred to embrace forms which differ widely from each other, and include representatives of four or five orders of the class *Crustacea*. Because of the great diversity of form and structure among these fossil remains of the Coal Measure period, we necessarily infer that crustacean life was not only abundant during that ancient period, but that it had then reached almost as wide a range of differentiation as it has at the present day.

The crustacean life of the Carboniferous age possesses peculiar interest for several reasons. In its strata are found the latest known examples of the Trilobites, that remarkable order of Crustaceans which under a multitude of forms prevailed so abundantly in all the previous geological periods. In strata of later date than those of the Carboniferous age, these crustacean forms have never been discovered, and it is believed that the last of that order became extinct with the close of that age.

The earliest known representatives of the order to which the living horse-foot crab belongs are also found in Coal Measure strata; and with them are also found the earliest known representatives of the shrimps and cray-fishes of the present day. A few other forms are, also, occasionally found in these strata which, like the Trilobites, have ceased to exist, but they are few, and the last of their kind.

We thus find in the strata of the Carboniferous age, and especially in those of the Coal Measure period, a commingling of ancient and modern types of crustacean life. Old things were then passing away, and the new were introduced to supply their places. The same is true, also, with regard to certain other classes and orders of animal life, but not with reference to all, for the changes were gradual, and many important ones did not take place until much later periods.

The following descriptions, with their accompanying illustrations (the former considerably condensed), are copied, mainly, from the work of Messrs. Meek and Worthen upon the Coal Measure fauna of the adjoining State of Illinois, but it will not be unreasonable to expect to find any and all of them in the Coal Measure strata of Indiana.

GNATHOSTOMATA.

Genus LEAIA, *Jones.*

LEAIA TRICARINATA, *Meek and Worthen.*

Plate 39, *figs.* 10, 11, 12 *and* 13.

LEAIA TRICARINATA, *M. & W.*, 1868. Illinois Geol. Rep., Vol. III, p. 541.

The carapace valves of this species are transversely oblong, the length being somewhat more than one-quarter greater than the height, but these proportions vary in different specimens; the anterior border rounded; basal margin broadly convex; posterior margin truncated, nearly straight and usually nearly perpendicular, but, sometimes, oblique, and meeting the dorsal margin at a slightly acute angle; dorsal margin straight, and the dorsal border of each valve is bent abruptly in at right angles with the plane of the valves, thus forming a well defined lanceolate corselet, which is margined at each side by a slender carina; the lateral radiating ridges, slender, sharply defined, and diverge from each other at an acute angle; the posterior one is the longer of the two, straight, and extends to the postero-basal margin; the anterior one is a little curved, and passes from the beak to the antero-basal border; the surface is marked by from twelve to sixteen minute, slender, raised striæ, which run parallel to the posterior and anterior margins respectively.

Length of one of the larger examples, about four-tenths of an inch; height, a little less than three-tenths; and the thickness, both valves together, nearly one-fifth of an inch.

Examples of this interesting bivalve crustacean have been found at various localities in the Coal Measure strata. It is usually so compressed in shale or other rock as to flatten the valves almost completely and obscure the portion which is flexed inward at the dorsal border to form the dorsal corselet. Meek and Worthen, however, obtained some specimens which were uncompressed. The test was very thin, and is usually not preserved upon the specimens. Upon casts of the inner surface of the valve an impressed line shows the position of each radiating ridge, and a similar and much more slender one shows the position on the outer side of each of the delicate, concentric, raised lines.

This form resembles the *Leaia leidyi*, Lea, from Pennsylvania, but Meek and Worthen regard them as quite distinct. These differ from *L. leidyi* in being about twice as large, in having the posterior margin more oblique, the basal margin more convex, and the radiating ridges more sharply defined. The shell is also shorter in comparison with its width.

Locality. Patty's Ford of Little Vermillion River, west of Eugene, Brouillet's Creek, Vermillion county, Indiana.

MEROSTOMATA.

Genus Eurypterus, *DeKay.*

Eurypterus (Anthraconectes) Mazonensis, *Meek and Worthen.*

Plate 37, *figs.* 1, 2 *and* 3.

Eurypterus (Anthraconectes) Mazonensis, *M. and W.*, 1868. Am. Jour. Sci., XLVI (2), p. 21; Ib., 1868, Illinois Geological Reports, III, p. 544.

Only one specimen of this interesting fossil has yet been found, and it is the only known representative in this country, found in the Carboniferous strata, of an interesting order of *Crustacea* that seems to have reached its culmination in the Upper Silurian age. Some of those whose remains have been found in the Waterlime Group of New York were monsters—one of them seems to have been not much short of three feet in length, according to the statements of those authors who have described them.

This carboniferous specimen consists of an impression upon the split surface of an iron-stone nodule. It shows the under surface of all the thoracic segments, and a part of one or two of those of the abdominal series; also the operculum or thoracic flap, the post-oral plate, and the maxillary or basal joints of the swimming feet, all in place. All these parts are in a more or less unbroken condition, but they have been flattened by pressure. There are, also, imprints of some of the succeeding joints of one of the swimming feet, and its oar-like expansion; some obscure impressions of three of the smaller legs on one side, and some of the basal joints of their fellows upon the other side. All these organs converge toward the mouth, the position of which is immediately in front of the post-oral plate. The legs are slender, terminate in a long sharply pointed dactylus like that of the legs of *Pterygotus*, and appear to be without any lateral spines. The carapace, dorsal portions of the thorax, the posterior portions of the abdomen and the telson are unknown.

The post-oral plate is about three-quarters of an inch in length, and eleven-twentieths of an inch in breadth, at the widest part, which is a little behind the middle. It is subovate in outline, broadly rounded at the sides, more narrowly rounded at the ends, the anterior end being distinctly emarginate at the middle. The maxillary joints or plates of the swimming feet expose a subtrigonal outline, their length being a little more than three-fifths of an inch, and their breadth, at the posterior margin, seventenths of an inch. Their lateral slopes are slightly sinuous along the middle, while their anterior ends are narrow, pointed, incurved, and hardly project beyond the anterior end of the post-oral plate. The succeeding joints are distinguishable upon the specimen, but they are not sufficiently well preserved to allow of satisfactory description.

The breadth of the thorax, near the middle, is nearly two and a half inches, and a little more than two inches in length. On the ventral side the middle segments are a little more than seven-tenths of an inch in length or antero-posterior diameter; but both the anterior and posterior ones, especially the latter, are shorter; and they are all rounded at their postero-lateral angles. Some impressions upon the surface of the specimen, however, show that the lateral terminations of the dorsal portion of the posterior thoracic segments extended out beyond the rounded ends of those below, into acutely pointed extremities, directed obliquely outward and backward. These projecting points of one of the posterior thoracic segments are seen to extend out obliquely nearly half an inch beyond the rounded extremities of those below, and to terminate in sharp points. A portion of one of the anterior abdominal segments which remains, appears to show that the abdomen is comparatively narrow, and that the posterolateral extremities of its segments terminate in strong angular processes, directed nearly straight behind, but having oblique anterior margins.

The thoracic flap has lateral wings similar to those of the typical forms of *Eurypterus*, and they have the appearance of being composed of two of the body segments anchylosed together, the anterior one being not more than half as broad as the other, which is of the same size as the body segments. Its mesial appendage has the remarkable length of one and six-tenths inches, and can be traced on the specimen as far back as the posterior margin of the fifth thoracic segment, and it is evidently not bipartite at the extremity. On each side of the anterior end of the mesial appendage there is a small spatulate piece which does not correspond to any known parts of the operculum of the *Eurypterus*. These pieces are a little more than four-tenths of an inch in length and three-twentieths of an inch in breadth. Their sides are nearly parallel, anterior extremities pointed, and their posterior ends transversely truncated with their lateral angles rounded. Their anterior pointed ends terminate nearly in contact with the two small pieces called intercalated pieces, by Prof. Hall.

In consequence of the differences which this species presents from the typical forms of *Eurypterus*, Meek and Worthen suggested that it might be found to be generically, or at least subgenerically, distinct. The differences they designated are the great length and non-bipartite extremity of the mesial appendage of the operculum, and the presence of an additional spatulate appendage at each side of the long mesial one.

Locality. This specimen was obtained from the Coal Measure strata at Mazon Creek, Grundy county, Illinois. It may reasonably be sought for at the following localities in Indiana: Patty's Ford of Little Vermillion River, Brouillett's Creek, Vermillion county, and Durkee's Ferry, Vigo county.

Genus EUPROOPS, *Meek and Worthen.*

EUPROOPS DANÆ, *Meek and Worthen.*

Plate 39, *fig.* 1.

BELLINURUS DANÆ, *M. and W.*, 1866. Illinois Geol. Report, II., p. 395.
EUPROOPS DANÆ, *M. and W.*, 1868. Illinois Geol. Report, III., p. 547.

This interesting ancient representative of the living horse-foot crabs was first described under the generic name of *Bellinurus*, and by that name it became somewhat widely known. Upon the discovery, however, of better examples than were at first known, Meek and Worthen found that it possessed certain characteristics which are not shown by *Bellinurus*. They, therefore, proposed the genus *Euproops* to receive it.

The cephalo-thoracic shield is transversely crescentic in outline, more than twice as wide as long, moderately convex, its height nearly equal to half its length at the median axis; the front margin, including the spine-bearing sides, continuously and regularly rounded; the lateral angles directed obliquely outward and backward with a slight curve, the convexity of which is outward; these angles end in slender acute spines, their points being nearly opposite the middle of the abdomen, and at some distance from its sides; the posterior margin of the cephalo-thoracic shield nearly straight along the middle portion, and gently concave at each lateral portion; mesial lobe small, a little less in height than the adjacent ocular ridges, rounded and well defined at its posterior end, where it bears a central tubercle, which is probably sometimes spine-like; at about one-third the length of the shield from the posterior margin, a less distinct tubercle sometimes appears; the sides of the lobe converge gently forward, then they suddenly converge into a linear carina, which extends forward to the anterior transverse division of the ocular ridge; the area which is included by the ocular ridge is subquadrangular in outline or crown-shaped, and constitutes the middle third of the cephalo-thoracic shield; at its anterior end it is a little wider than its full length, which is equal to about five-sixths the length of the shield; its lateral margins concave; anterior side convex, with a central emargination; its surface is divided into four irregular areas by the mesial lobe with its anterior linear prolongation, and the two less distinct linear transverse ridges; ocular ridge narrow, but distinct, its lateral portions arching inward behind the eyes, and terminating posteriorly at the margin of the shield, nearly opposite the middle of each lateral lobe of the abdomen, in a spine-like process which appears to have been triangular, the process being directed backward, outward and a little upward; the anterior transverse division of the ridge arching forward at each side, and curving backward at the middle. Compound eyes small, distant from each other, and located one at each antero-lateral angle of the crown-shaped central area of the shield, about one-third its length from its anterior margin. Simple eyes are not known to have existed. The abdomen is transversely suboval in outline, wider than long; the lateral margins rounded in abruptly at the front, but, posteriorly, they blend into a regular curve with the posterior margin; the surface of the abdomen a little more depressed than that of the cephalo-thorax, especially in front; the flattened lateral borders are rather narrow, and scalloped between the marginal spines; the breadth of the mesial lobe about equal to that of the cephalo-thoracic lobe, a little more elevated than the lateral abdominal lobes, and half as broad; segments distinct, the first and third, each, bearing a small tubercle, the sixth as long as any of the others, narrowed and depressed behind and bearing a large tubercle, which is apparently sometimes spine-like; lateral abdominal lobes, depressed along the inner side, rounding abruptly down to the flattened free borders at the outer sides and behind; segments defined by linear ridges, which are separated by flattened spaces four or five times as wide as the ridges; the latter extend obliquely outward, and a little backward, across the lateral lobes and their flattened borders, and are produced into the slender lateral spines, which have a gentle backward curve.

The telson is apparently nearly two-thirds as long as the abdomen, gradually tapering, subtrigonal, flat below, angular at each side, and obtusely angular above.

The appendages of the under side unknown, except one leg. This is seen, in one specimen, projecting out from under the cephalo-thoracic shield, between its posterior margin and the abdomen. The leg is slender; about one-eighth of an inch in length of the first segment appearing from beneath the shield; the next segment about one-quarter of an inch long and scarcely more than one twenty-fifth of an inch in breadth. The succeeding segments are traceable upon the specimen nearly one-third of an inch, curving toward the extremity, and apparently ending in a point. The position of this leg in the series has not been ascertained.

The entire length of the animal, from the extremity of the caudal segment to the anterior border of the cephalo-thoracic shield, is nearly two inches. Length of the cephalo-thorax, nearly six-tenths of an inch; breadth of the same, to the extremities of the lateral spines, one and seven-tenths inches; length of the area included by the ocular ridge, half an inch; greatest breadth of the same (the distance between the eyes), six-tenths of an inch. Length of the abdomen, nearly five-sixths of an inch; breadth of the same, excluding the flattened free margins, a little more than nine-tenths of an inch; breadth of the mesial lobe, nearly a quarter of an inch; length of caudal segment, six-tenths of an inch.

Locality. The type specimens of this species were found at Mazon Creek, Grundy county, Illinois, but they may be sought for in the following localities in Indiana: Brouillett's Creek and Durkee's Ferry, Vigo county.

EUPROOPS COLLETTI (n. s.)

Plate 39, *fig*. 2.

On the face of a split iron-stone nodule found in Coal Measure strata at Durkee's Ferry, Vigo county, Indiana, there is an imperfect impression of an *Euproops*, which seems to be specifically different from *E. Danæ*. The specimen is too imperfect for detailed description, and it is, therefore, not attempted. It seems to differ from *E. Danæ* in the following particulars:

The cephalo-thoracic shield is proportionately a little larger, and, although its postero-lateral extremities are sharply angular, they appear not to have been produced into slender spines. The median lobe is wider in front, and it narrows more rapidly posteriorly, and with straighter sides. The caudal spine appears to have been smaller. The lateral spines appear to have been less slender, and the two last ones seem to have been very small and very close to the caudal spine.

Assuming this form to be distinct from *E. Danæ*, the proposed new specific name is given it in honor of Mr. Josephus Collett, who discovered it.

TRILOBITA.

Genus PHILLIPSIA, *Portlock.*

PHILLIPSIA (GRIFFITHIDES?) SCITULA, *Meek and Worthen.*

Plate 39, *figs.* 6, 7, 8 *and* 9.

PHILLIPSIA (GRIFFITHIDES?) SCITULA, *M. and* W., 1873. Illinois Geol. Reports, V, p. 615, pl. XXXII, fig. 3.

As has already been stated, the great order of *Trilobites* became extinct with the close of the Carboniferous age. With the close of the Devonian age, the order became reduced to two or three genera, at most; and in the Coal Measure period, only a few examples of one or two genera are found. Only the two small species which are here described are likely to be found in the Coal Measures of Indiana, yet it is possible that others may yet be discovered.

This species is small, and, when distended, its outline is nearly elliptic. The cephalic shield is semi-elliptic, prominently convex, its breadth about one-third greater than its length; its anterior margin rounded; its posterior margin nearly straight; its postero-lateral angles projecting backward, and forming somewhat strong carinated, sharp spines, their points reaching as far back as the fifth thoracic segment. The glabella is broadly rounded, sloping in front, without an anterior projecting marginal rim; contracted toward its posterior end, which is the most elevated part; its prominent convexity defines it from the cheeks at either side, and it is also bordered, laterally, by a shallow furrow, which becomes obsolete around its front margin; postero-lateral lobes, comparatively large, sub-trigonal, very oblique, depressed, and distinctly defined by the lateral furrows in front; second and third lateral lobes small, transverse, indistinctly defined by short, nearly obsolete, linear furrows; anterior lobe larger than all the remaining portions of the glabella between it and the neck furrow. The neck segment is a little more prominent at the middle than the glabella, strongly arched upward but not forward, its antero-posterior breadth more than twice as great as that of one of the thoracic segments; a minute tubercle is usually observable upon its median line; neck furrow deep, broad, and corresponding to the arching of the neck segment. Eyes comparatively large, half as long as any part of the glabella, prominent behind, the position of their posterior margins opposite the neck furrow, and reaching forward less than half their own length beyond the posterior margins of the cheeks; the visual surface prominent, subhemispherical, smooth, and even appearing to be polished, under a pocket lens. When examined by a high magnifying power, however, it shows numerous regularly disposed minute lenses beneath the smooth, transparent outer layer; palpebral lobes semicircular, convex, and having the appearance of eyelids. Cheeks small in comparison with the eyes and glabella, and slope abruptly from the eyes into the deep, broad marginal furrow; the furrow suddenly becoming obsolete at the anterior lateral margin of the glabella, but extends backward to the subspiniform appendages; posterior margins having an elevated rim, strongly defined by the deep continuation of the neck-furrow; lateral margins, when viewed from above, showing a narrow rim, which, by side view, is seen to be deep, vertically flattened, and marked by fine parallel longitudinal striæ; anteriorly, the rim continues around to the front of the glabella, but it is not sufficiently prominent to be visible from above, and its upper margin is continued in the form of a carina, along the middle of the spinous processes, to their points. Facial sutures, cutting the anterior border in front of the eyes and the posterior margins of the cheeks behind the outer margins of the eyes.

Thorax almost as long as the head, but it is a little narrower, and distinctly trilobate; its mesial lobe prominent, convex, and a little wider than the lateral lobes; its nine segments narrow and subangular. The lateral lobes are depressed, convex, and flattened along their inner sides, sloping abruptly at their outer sides, producing, thus, an obtuse longitudinal angle along each lateral lobe; segments of the lateral lobes, six in number, simple, bent abruptly downward at the middle, where each has a minute pustule, but terminating abruptly at the rather wide border. Surface of the glabella and all the segments more or less granular, the granules being coarser on the posterior part of the glabella and neck segments than elsewhere.

Entire length of a medium sized example, nearly seven-tenths of an inch; length of the pygidium, two-tenths of an inch; breadth of the same, three-tenths; length of thorax, a little less than two-tenths; breadth of the same, a little less than three-tenths; length of the cephalic shield, two and a half tenths; breadth of the same, a little over three-tenths.

Locality. This species is widely distributed in those States which embrace portions of the Coal Measures. It may be found in the following places in Indiana, among others: Perrysville, Eugene, Lodi, Silverwood, and Newport.

PHILLIPSIA (GRIFFITHIDES?) SANGAMONENSIS, *Meek and Worthen.*

Plate 39, *figs.* 4 *and* 5.

PHILLIPSIA (GRIFFITHIDES?), SANGAMONENSIS, *M. and W.*, 1873. Illinois Geol. Reports V, p. 615, pl. XXXII, fig. 4.

This species resembles the foregoing in general aspect, but it is larger. It is subovate in entire outline, as indicated by the detached parts that have been discovered. The cephalic shield is convex, its outer border forming more than a semi-circle, about one-third wider than long, regularly rounded in front and straight behind, but its postero-lateral angles are produced into strong carinated subspinous processes, which are equal in length to the distance from the posterior side of the cheeks to the anterior end of the eyes; glabella prominent, sub-inflated, defined from the cheeks, at each side, by a moderately distinct furrow, which is continuous around the front; its greatest convexity behind the middle, from which part it declines to the rounded front; its length is about one-fourth greater than its width, which is slightly greater between the eyes than it is further forward; the sides are nearly parallel, but a little sinuous along the middle; posterior lateral lobes, comparatively large, prominent, and isolated by the distinct lateral furrow which passes obliquely across, with a lateral curve, from opposite the middle of each eye, so as to intersect the neck furrow; second lateral lobes obscure and much smaller than those behind, defined by a faintly impressed curved oblique line; forward of these lobes there are also obscure traces of two other short obsolete lateral furrows which are hardly visible to the naked eye. Occipital segment well defined but shorter than the glabella, strongly arched upward but not forward, and projecting backward a little behind the range of the posterior border of the cheeks; neck furrow distinct and arched upward with the occipital, or neck segment; its prolongation along the posterior sides of the cheeks very deep and nearly straight for about two-thirds of the way across, towards the lateral margins, where it intersects another furrow, which passes around the sides of the cheeks.

Eyes lunate, rather large, or nearly half as long as the glabella, exclusive of the neck segments; they are prominent, being about as much elevated as the glabella, and their position is about half their own length in front of the posterior margins of the cheeks. The visual surface is smooth, and has a polished appearance under a pocket lens, but no traces of lenses have yet been detected in the eyes by a higher magnifying power. The palpebral lobes are convex, and rest upon the eye like a lid. The cheeks are subtrigonal, sloping abruptly away from the eyes; lateral margins turned downward, and forming a sharp edge below, which is continued backward along the postero-lateral spines. Above this there is a vertically flattened, or sometimes slightly concave, zone, which extends from near the front of the gabella, around the outer side of each cheek, and, passing backward, it becomes a shallow furrow upon the spines, traceable nearly to their extremities. Between this zone and the eyes there is another somewhat similar zone, which extends posteriorily around each cheek, from near the front, and unites with the lateral connections of the neck furrow behind; they then continue, as a single furrow, along the upper margin of the spines, and leave a more or less defined mesial ridge between these two furrows along the entire length of the spines, as well as around the cheeks, to near the front of the glabella; posterior margins of the cheeks behind the neck furrow prominent.

Facial sutures extending obliquely forward and outward from the anterior side of the eyes, then curving inward, so as to cut the anterior margin nearly on a line with the anterior inner extremity of the eyes; from the posterior end of the eyes the sutures are directed outward and backward, intersecting the posterior margin about midway between the neck segment and the spine-like postero-lateral projections.

Thorax not fully known, only a few of the posterior segments having been discovered. These show the mesial lobe to be wider and more prominent than the lateral lobes; the latter lobes are flattened near the mesial lobe, and along the median line of each they are abruptly bent downward; segments divided by a furrow, which extends from the knee inward, along the anterior side.

The pygidium is semi-elliptic in outline, somewhat convex, and a little wider than long, narrower and a little longer than the cephalic shield, narrowing posteriorly, and abruptly rounded at the posterior extremity. Mesial lobe prominent, a little flattened at each side, narrower than the lateral lobes, separated from them at each side by a broad, strong furrow; the lobe tapers gradually backward, and terminates abruptly at a distance equal to about one-third its own length from the posterior margin; a broad, nearly flat, or gently sloping smooth border extends continuously along the whole free margin of the pygidium, which is a little broader at the posterior extremity than it is nearer to the abdominal portion; segments of the mesial lobe seventeen or eighteen in number, straight, rounded, and well defined.

Lateral lobes less prominent than the mesial, and one-third or one-fourth wider, abruptly convex at their outer side; segments nine or ten, simple, separated by distinct furrows, all terminating abruptly at the inner edge of the broad, smooth, marginal zone. The whole surface of the test nearly smooth.

Length of cephalic shield along the median line nearly half an inch; breadth of the same, six and a half tenths of an inch. Length of the glabella, three and a half tenths of an inch; breadth of the same, three-tenths of an inch at the widest part.

Locality. This species is not so commonly found as the preceding one, but it may be sought for at the same Indiana localities as the foregoing.

ISOPODA.

Genus ACANTHOTELSON, *Meek and Worthen.*

ACANTHOTELSON STIMPSONI, *Meek and Worthen.*

Plate 37, *figs.* 4 *and* 5.

ACANTHOTELSON STIMPSONI, *M. and W.*, 1866. Illinois Geol. Reports, II., p. 401, pl. XXXII, fig. 6.

ACANTHOTELSON STIMPSONI, *M. and W.*, 1868. Illinois Geol. Reports, III., p. 549.

Our present knowledge of this interesting species has been gained from several successive discoveries of more or less imperfect examples, and the successive publications of it by the authors above cited have varied somewhat as additional knowledge was gained. The following is a summary of its characteristics:

Elongate or sublinear in shape; the upper antennæ fully as long as, if not longer than, the head and first five thoracic segments together; peduncle rather stout, a little longer than the head; first joint a little longer and wider than the two others, the latter being nearly of equal length; flagellum slender and minutely jointed; accessory appendage about as long as the flagellum and, like it, minutely jointed; inferior antennæ as long as the head and seven thoracic segments together; peduncle a little longer and larger, but, in other respects, it is like that of the upper antennæ; flagellum similar to the upper pair, but a little larger. Head apparently subquadrangular, its upper side longer than the lower, the anterior side being oblique. Eyes small, round, situated just below the bases of the upper antennæ. The thoracic and abdominal segments, together, fourteen in number, all distinctly observed, except the last one; a few of those nearest the head are a little shorter than the others, but, except this, they are all of nearly equal length; their antero-basal margins rounded; posterior margins subrectangular.

The thoracic legs of the first pair are about one-fourth longer and a little larger than those of the five succeeding pairs, and seem to end in a sharp dactylus. The five succeeding pairs of legs are of nearly equal size and form, and their upper segments are short and not enlarged. The seventh pair are nearly as long as the first, and more slender than any of the others. Abdominal natatory appendages long and slender, the styliform pair having the first segment short and quadrangular; second and only other joint as long as the telson, which they closely resemble in shape, their upper and lower margins each with a row of short oblique rather distant setæ, between which a good lens reveals numerous close-set minute setæ. Length of the telson equal to the length of the last four abdominal segments; its vertical width at the base equal to one-half the width of the penultimate abdominal segment, but it tapers to a mucronate point; upper and lower margins setigerous like those of the stylets.

Locality. All the specimens yet found are from Grundy county, Illinois, but it may be sought for at the following localities in Indiana: In concretions on Little Vermillion river and Brouillett's Creek of Vermillion county, and Durkee's Ferry in Vigo county.

Acanthotelson, Eveni, *Meek and Worthen.*

Plate 38, *figs.* 4, 5, 6, *and* 7.

Acanthotelson Eveni, *M. and W.*, 1868. Illinois Geol. Reports, III, p. 551.

All the specimens of this species that have yet been discovered are fragmentary, but Meek and Worthen were satisfied that it is a distinct species from *A. Stimpsoni*. The differences which they pointed out are: That it is larger and more robust, while its body is proportionally longer and more slender. The joints of all the legs, and also of the antennæ, are proportionally longer and more slender. At first, these authors supposed that the stylets were not connected with penultimate, but with the antepenult segments. In their latest publication (*loc. cit.*) they express the opinion that the appearance just mentioned was deceptive, and produced by a displacement of the parts in their specimen during the process of its fossilization.

Locality. This form was discovered in Grundy county, Illlinois, associated with the preceding and other crustacean species, and is likely to be found in any of the Indiana Coal Measure strata that contain similar crustacean forms.

Genus DITHYROCARIS, *Scouler*.

DITHYROCARIS CARBONARIUS, *Meek and Worthen*.

Plate 39, *fig*. 3.

DITHYROCARIS CARBONARIUS, *M. and W.*, 1873. Illinois Geol. Reports, V, p. 618, pl. XXXII, fig. 1.

This species is yet known only by the caudal appendage; but this is so characteristic as to render its identification an easy matter by any collector. It is especially interesting as being the only representative of the genus which American strata have afforded.

The telson and stylets are lanceolate in shape and flattened. All three are closely similar in shape and size, but the telson is a trifle shorter than the stylets, and tapers to the extremity a little more rapidly. The telson is flattened upon its under side, and bears a faint mesial longitudinal ridge, with a faint longitudinal sulcus at each side of it; the lateral margins sharp. Its upper side bears a distinct mesial carina, from which the surface at each side slopes with gentle concavity to the sharp edges. The stylets are flattened upon their under side, where six or seven longitudinal ridges are seen. On the upper side, there is a distinct mesial longitudinal carina, with a concave furrow at each side of it. Along each lateral margin, there are two closely approximate carinæ, one above and the other below, with a narrow sulcus between.

Length of the telson, three-quarters of an inch; greatest breadth nearly one-eighth of an inch. The stylets are a trifle longer, and of the same breadth.

Locality. The original specimen of this species were found in Coal Measure strata at Danville, Illinois. It is a rare species, but it may be reasonably sought for in almost any of the Coal Measure localities in Indiana.

MACROURA.

Genus PALÆOCARIS, *Meek and Worthen.*

PALÆOCARIS TYPUS, *Meek and Worthen.*

Plate 38, *figs.* 1, 2, *and* 3.

ACANTHOTELSON INÆQUALIS, *M. and W.* Illinois Geol. Rep., II, p. 403, pl. XXXII, fig. 7.
PALÆOCARIS TYPUS, *M. and W.* Illinois Geol. Rep., II, p. 405, pl. XXXII, fig. 5.
PALÆOCARIS TYPUS, *M. and W.* Illinois Geol. Rep., III, p. 552.

Upon the original discovery of the first example of this form, Meek and Worthen believed it to belong to the genus *Acanthotelson*, and accordingly placed under the *Isopoda;* but upon the subsequent discovery of other and more perfect specimens, they established the new genus *Palæocaris*, and placed it with the *Macrourans.*

The body, in general shape, is linear, the thorax being slightly wider near its middle than the abdomen, the length of the segments nearly equal in both thorax and abdomen, the length of the inner antennæ about equal to that of the head and thorax together, the peduncles stout, the first joint of it being a little longer and wider than either of the other two; the latter joints are of nearly equal length and their inner borders are margined with fine, close-set setæ; the flagellum very slender and minutely jointed; accessory appendage about as long as the flagellum, which it closely resembles in all respects.

The outer antennæ appear to be a little longer than the others, and the peduncles slightly longer than those of the other pair, and they are also minutely setigerous in front; basal scales (?) oblong, squarely truncated, and about equal in length to the first joint of the peduncles.

The thoracic legs are long and slender, the anterior ones apparently not differing in this respect from the others; none appear to be chelate; the first two or three joints short, the fourth (?) joint tapering and extended horizontally, its length being about equal to four body segments; the succeeding joints slender, and bent abruptly downward and backward. Swimming appendages of the abdomen acutely lance-linear, the length of some of them being equal to four abdominal segments; base of the telson nearly as broad as the penultimate segment; the telson tapering at the sides, which are minutely setigerous, its length equal to two and a half abdominal segments; first joint of the stylets minute; the second lance-linear, each division being as long as the telson; extremities pointed; margins parallel and setigerous.

The ridge and proportions of the parts are given by the figures on plate 38.

Locality. This form, like most of the known crustaceans of the American Coal Measures, was obtained from the strata in Grundy county, Illinois. It may be sought for at the following localities in Indiana: Patty's Ford of Little Vermillion River and Brouillett's Creek in Vermillion county, and Durkee's Ferry, Vigo county, in iron stone concretions, above coal L.

Genus ANTHRAPALÆMON, *Salter*.

ANTHRAPALÆMON GRACILIS, *Meek and Worthen*.

Plate 38, *figs.* 8 *and* 9.

ANTHRAPALÆMON GRACILIS, *M. and W.*, 1865. Proc. Acad. Nat. Sci., Phil., p. 50.
ANTHRAPALÆMON GRACILIS, *M. and W.*, 1866. Ill. Geol. Rep., II, p. 407, pl. XXXII, fig. 4.
ANTHRAPALÆMON GRACILIS, *M. and W.*, 1868. Ill. Geol. Rep., III, p. 554.

Successive discoveries caused Meek and Worthen to modify somewhat their first published descriptions of this species. The following is a summary of its structure, as now understood:

Carapace oblong in form, as seen by upper view, but the lateral margins are gently convex, the two extremities truncated, and its breadth about equal to three-fourths its length. Its lateral margins, forward of the middle, each bear six small, sharp serrations, like those on the type of the genus, but they are sharper, and are directed more obliquely forward. At each antero-lateral angle, there is, also, as in the type species, a larger, projecting, short spine, but this is turned more directly forward. The outer pair of antennæ moderately stout; each peduncle with three joints, which diminish gradually in size, the first longer than wide, and the other two of nearly equal length and breadth, and obliquely articulated. The flagellum is narrower at its base than the last joint of the peduncle, composed of very short segments, about one-third as long as wide. The antennæ were long and slender, but their full length is not known. Inner antennæ unknown.

The figures on plate 38 give the shape and proportions of all the other known parts.

Locality. The only known examples are from Grundy county, Illinois, but the species may be sought for in the same localities as the foregoing.

INDEX.

PART II—PALEONTOLOGY.

INDIANA GEOLOGICAL REPORT, 1883.

ERRATA—PART II—PALEONTOLOGY.

On page 28, line 20, from top, for dichotomous, from the base, read dichotomous from the base.

On page 31, line 7, from base, for Dictyophyllum, read Dictyophyton.

On page 33, line 5, from base, for plate I, read plate B.

On page 33, line 6, from base, for plate B, fig. 78, read plate 1, fig. 8.

On page 36, line 6, from base, for five cm. read five m.

On page 36, line 7, from base, for one cm. read one m.

On page 51, line 1, from top, for a Ettinghausen, read d' Ettingshausen.

On page 55, line 3, from base, for rachis, read costa.

On page 57, line 5, from base, for Prardeei, read Pardeei.

On page 58, line 12, from base, for all linear, read oblong or.

On page 75, line 9, from top, strike out, and.

On page 77, line 16, from top, for they, read then.

On page 101, line 15, from base, for gracilis, read gracile.

On page 78, line 12, from top, for Lepidendron, read Lepidodendron.

On page 100, line 1, from base, for ature, read mature.

Plates and their Explanation.

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Figs. 2, 3. Oldhamia radiata, Forbes, p. 28.

Fig. 4. Sphærococcites Sharayanus, Goepp., p. 28.

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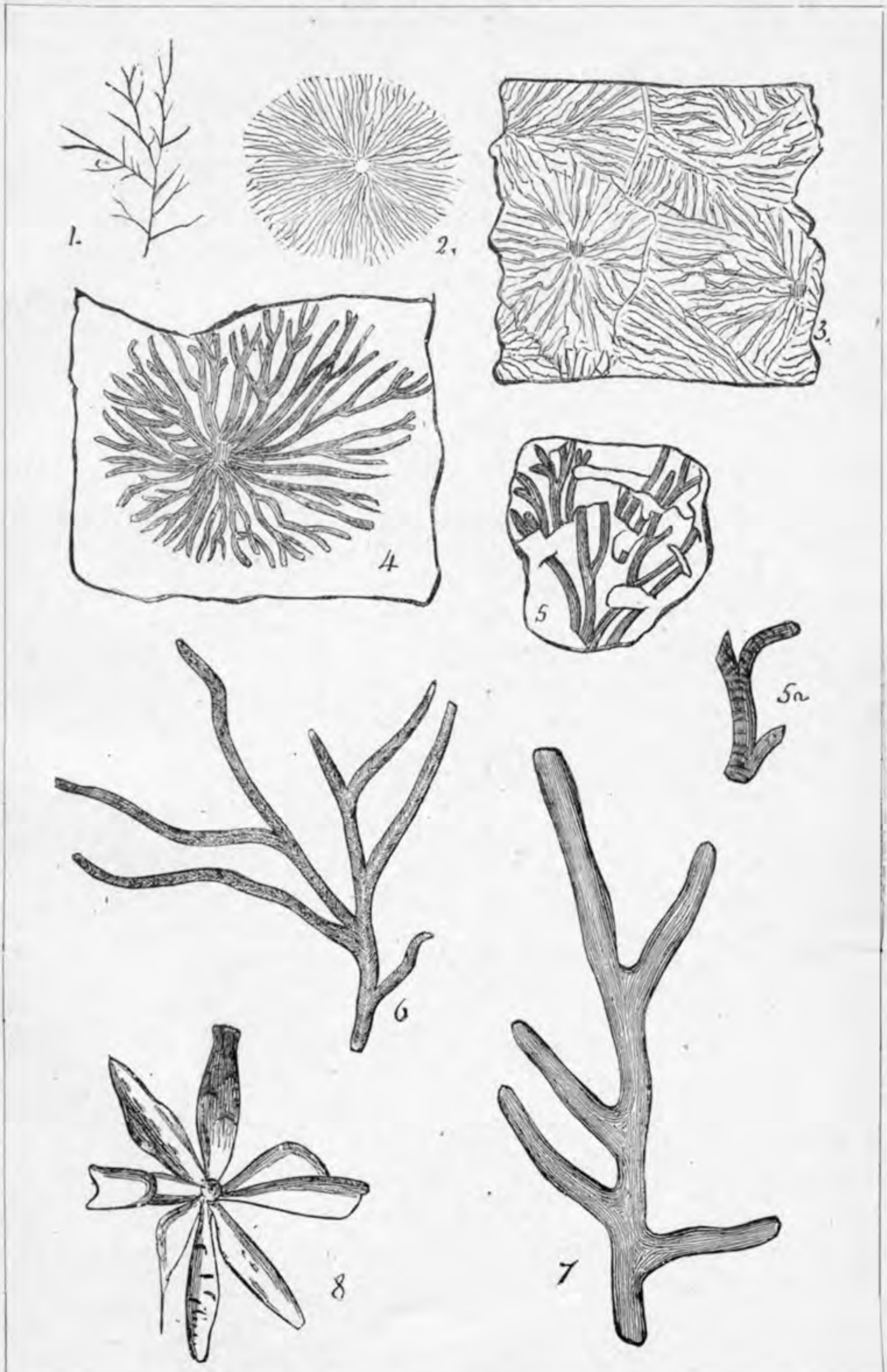
Fig. 8. Asterophycus simplex, Lesq., p. 33.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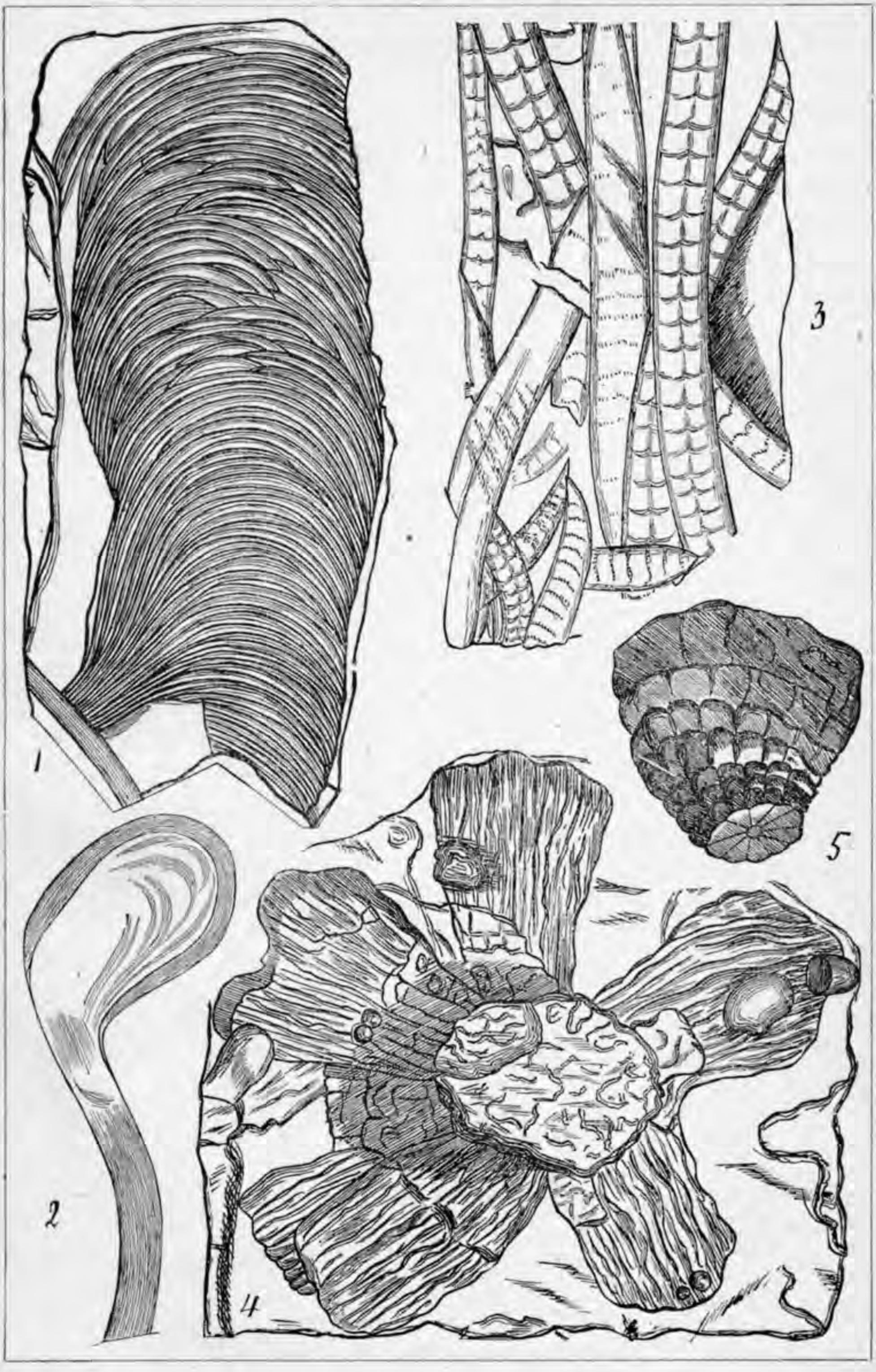
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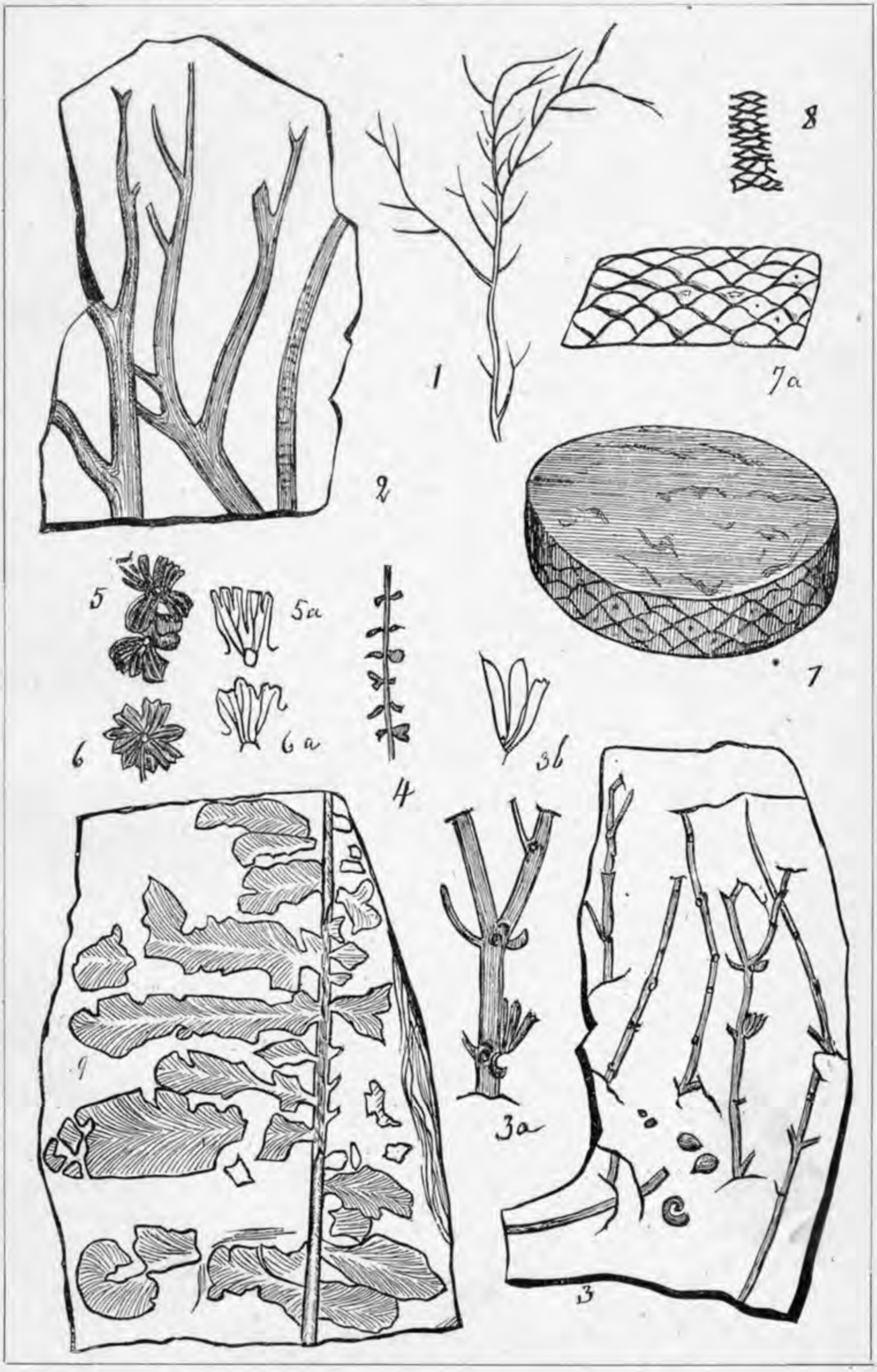
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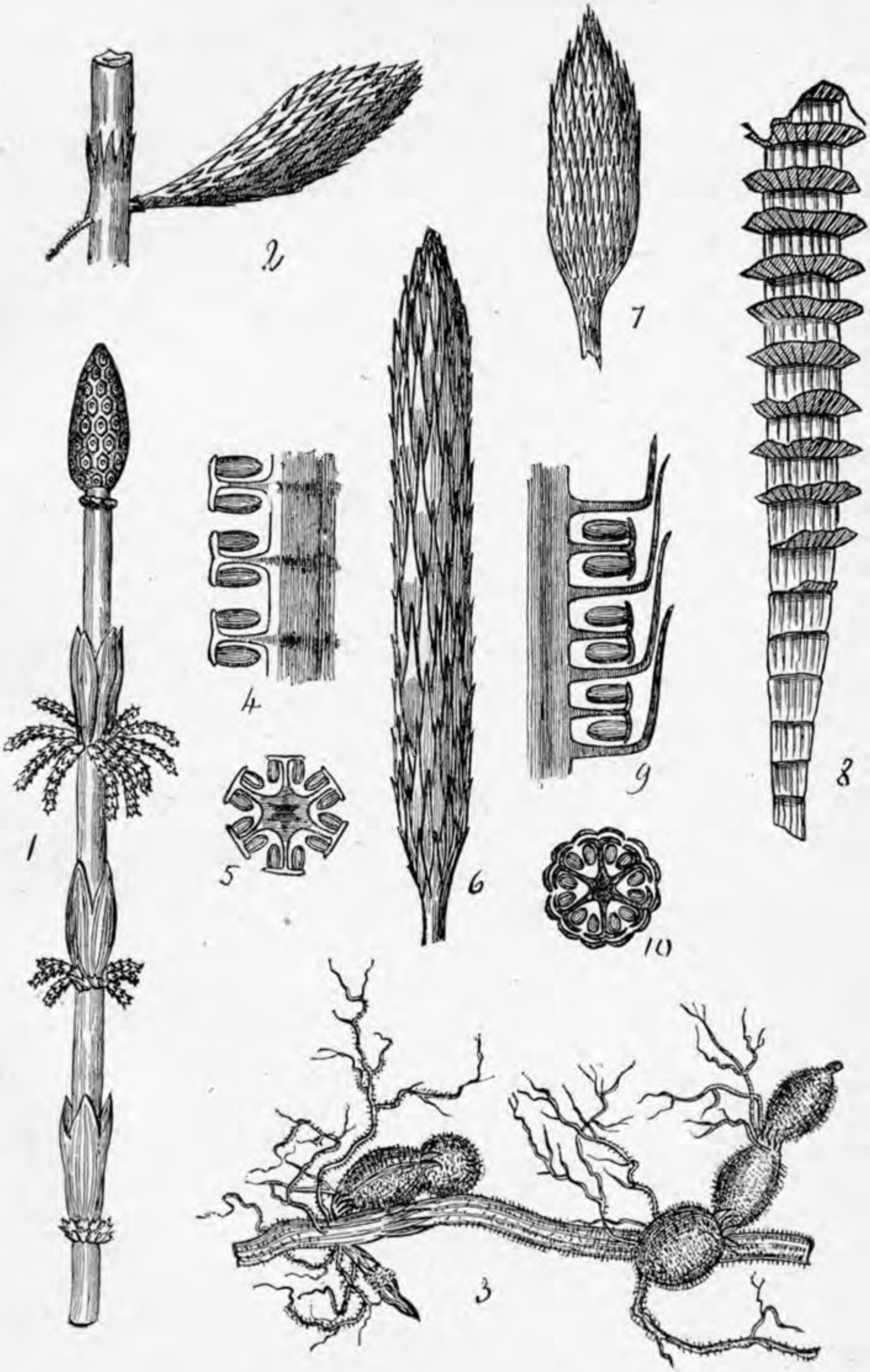
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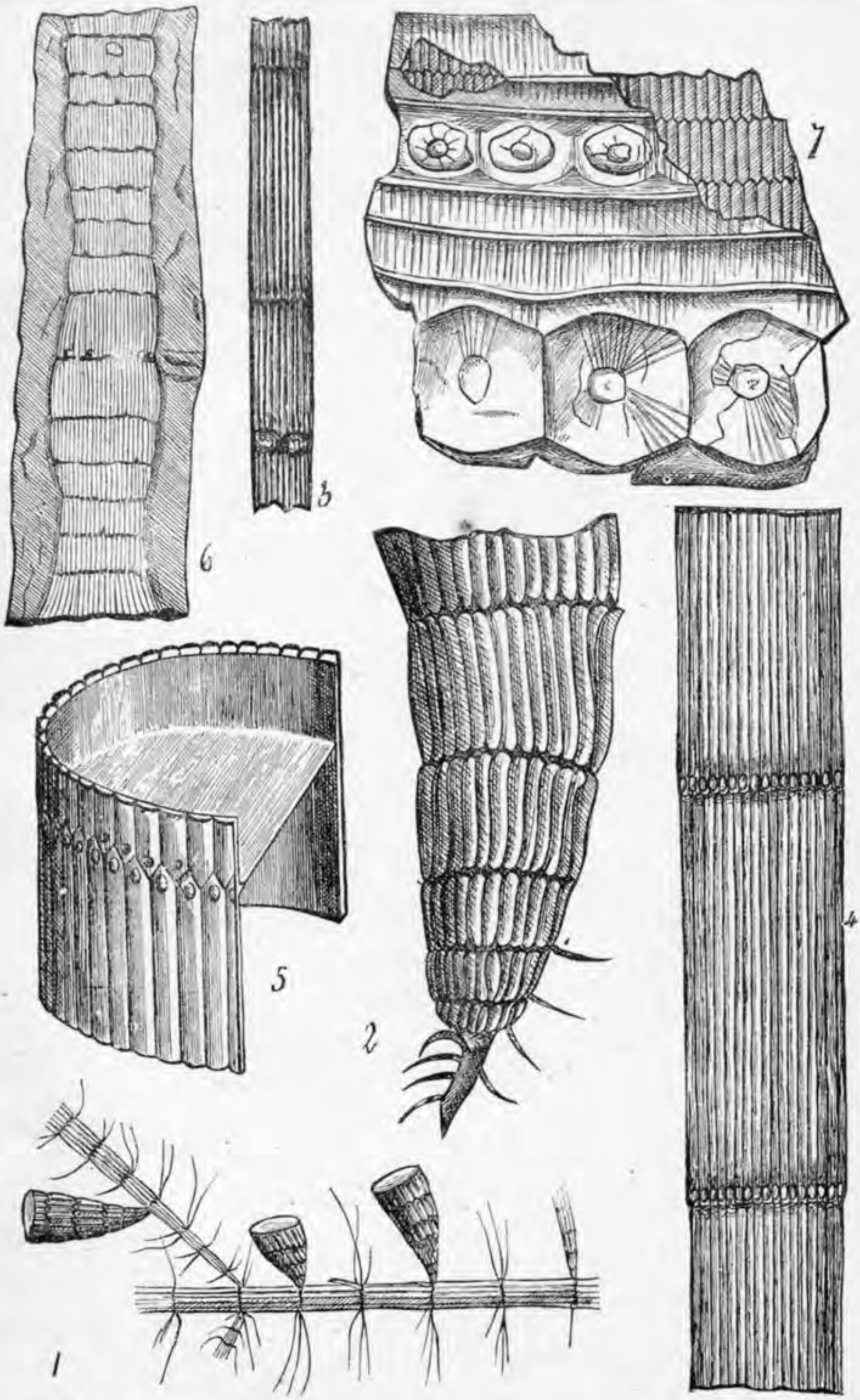
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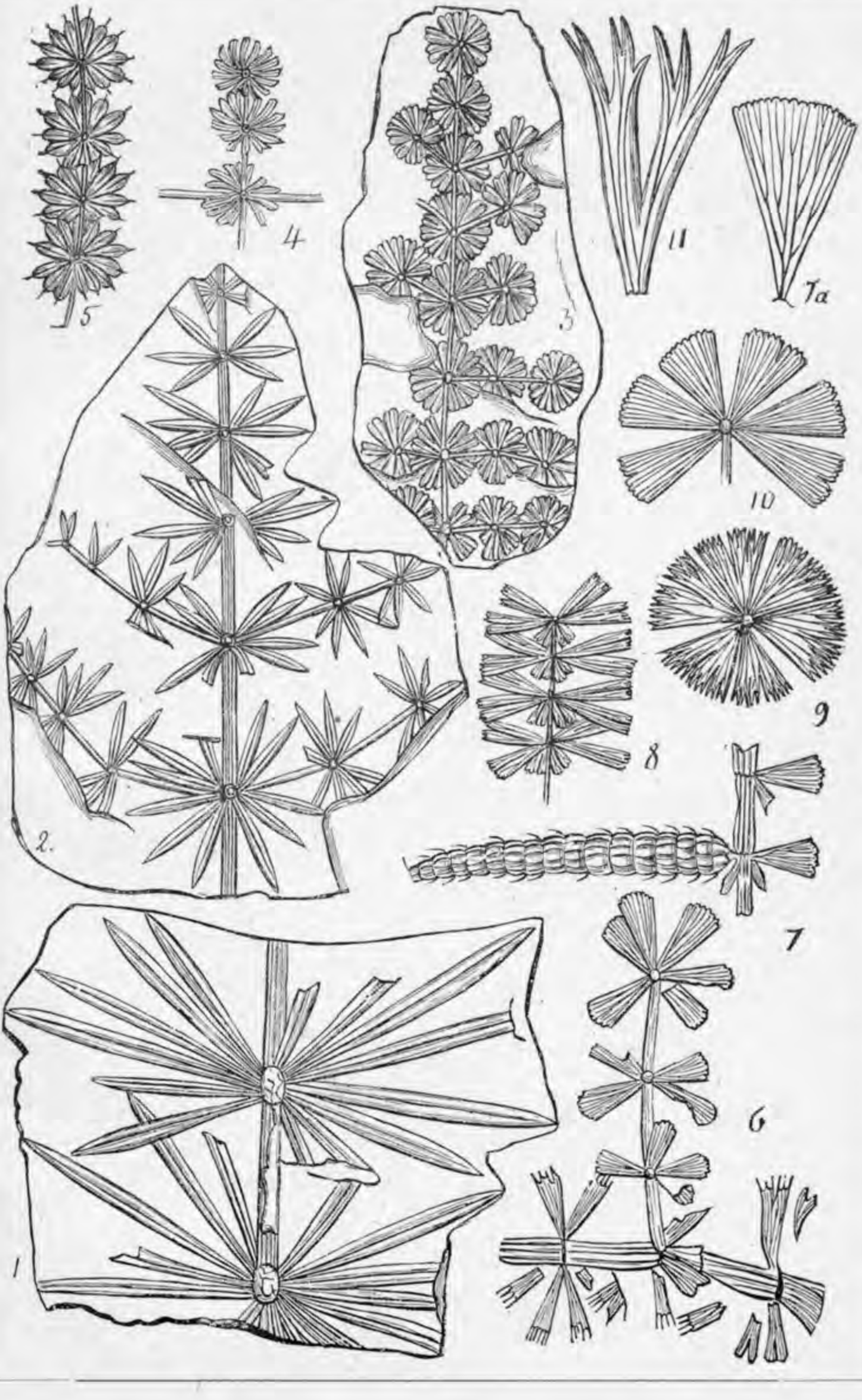
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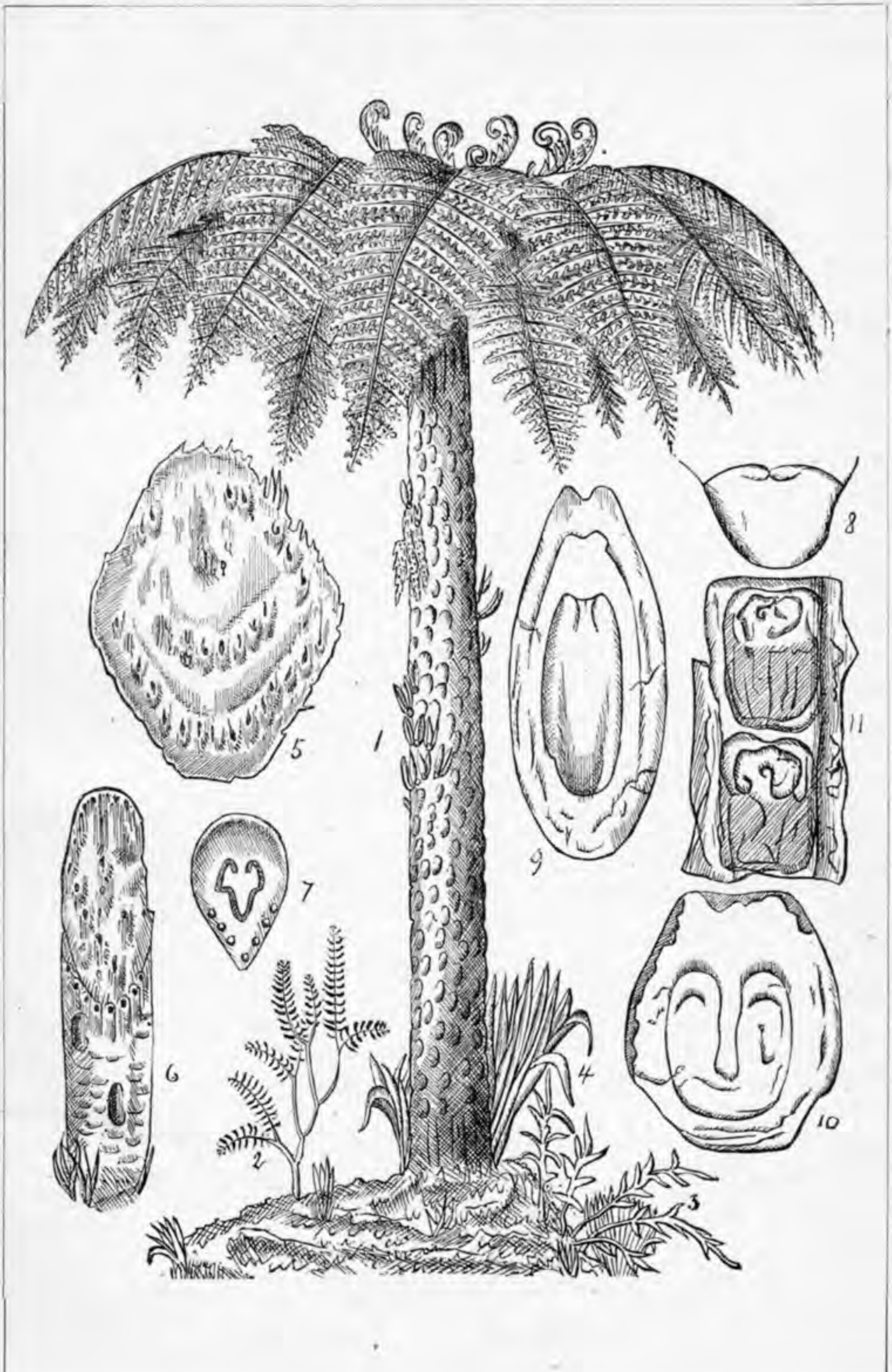
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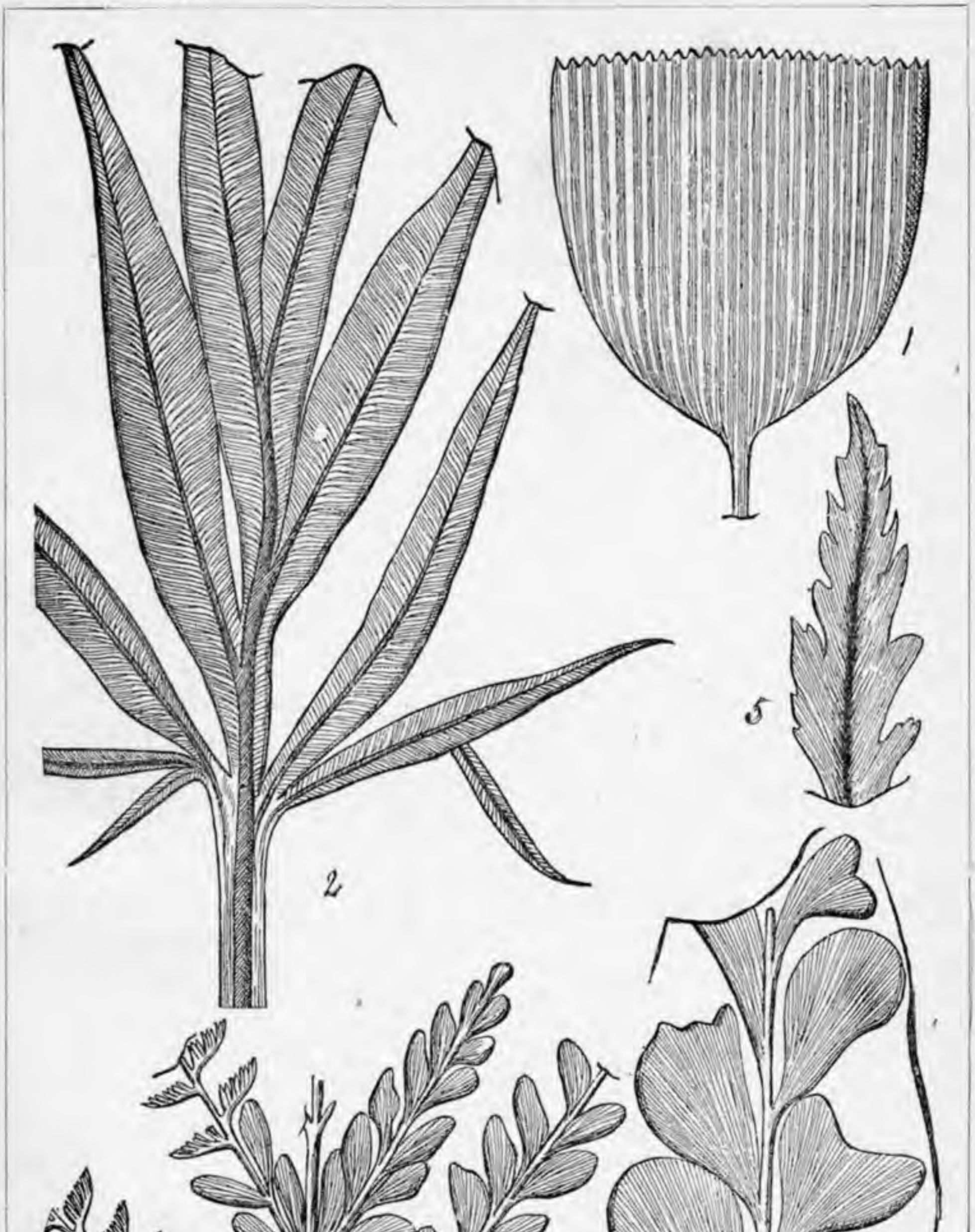
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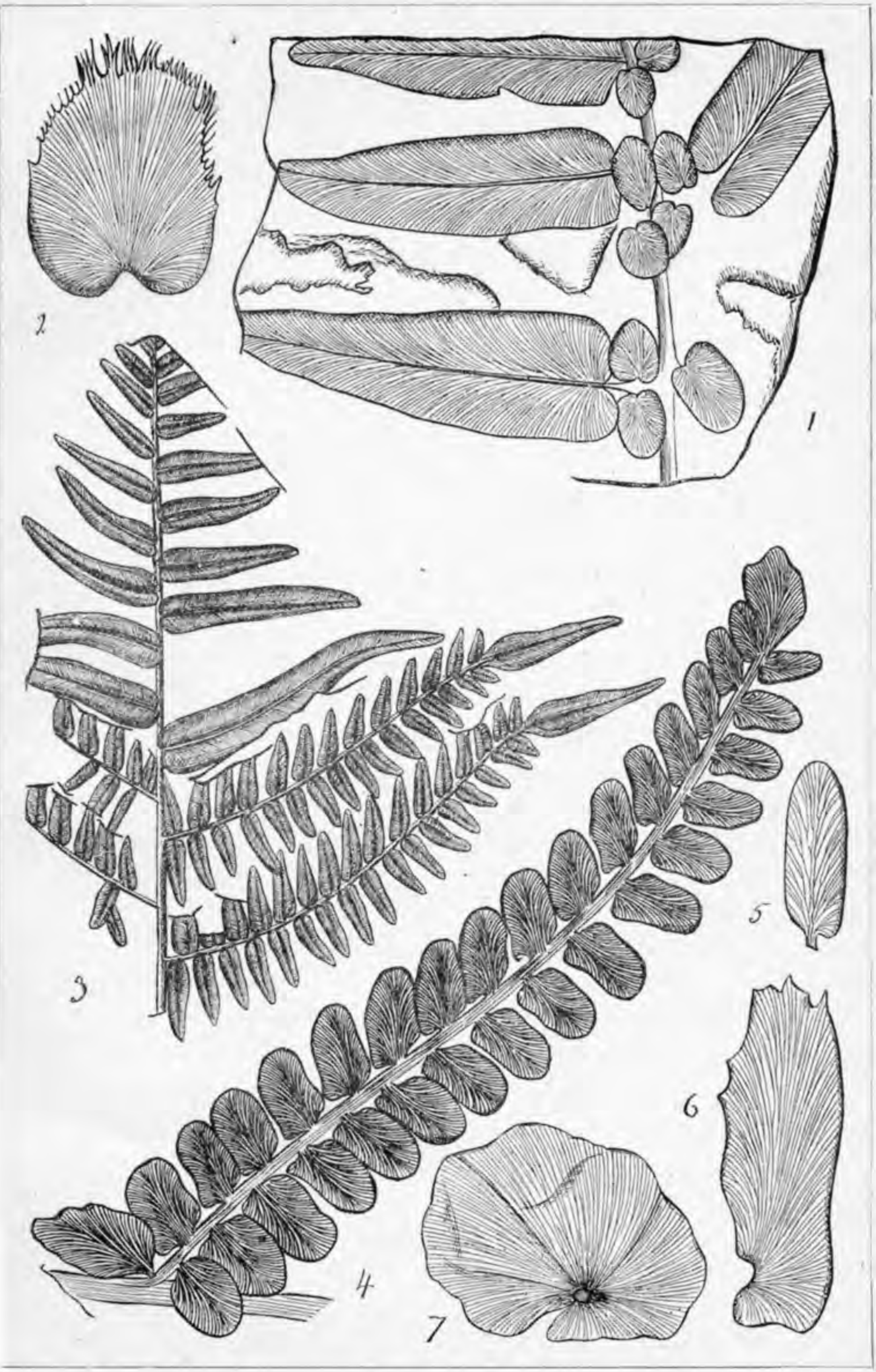
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Fig. 5. Tæniopteris Smithii, Lesq., p. 56.

Fig. 6. Lescuropteris adiantites, Lesq., p. 57.

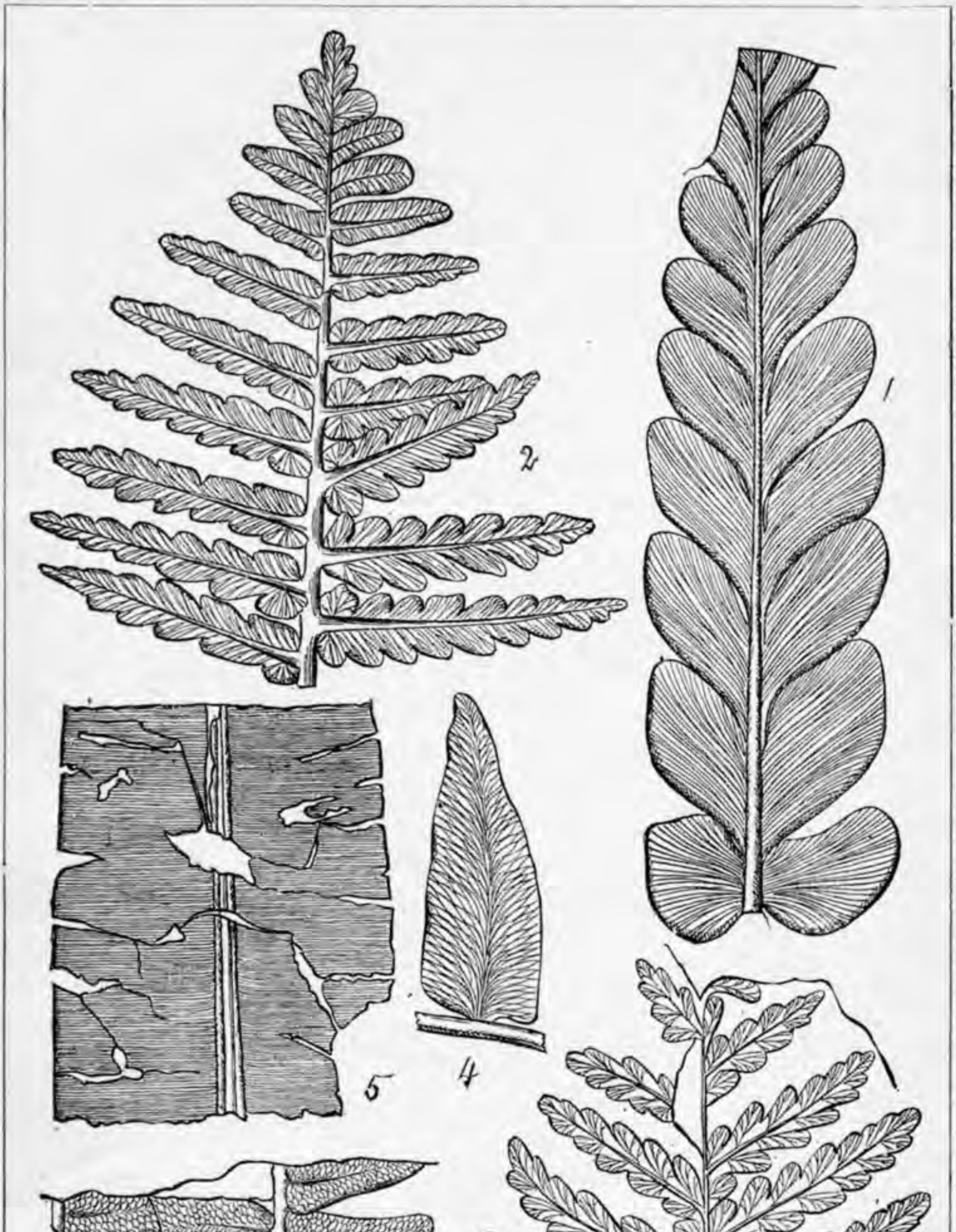
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PLATE 12.

Fig. 1. Callipteridium Sullivantii, Lesq., p. 57.

Figs. 2, 2*a*. Alethopteris Serlii, Brgt., p. 58.

Figs. 3, 3*a*. Pseudopecopteris muricata, Brgt., p. 61.

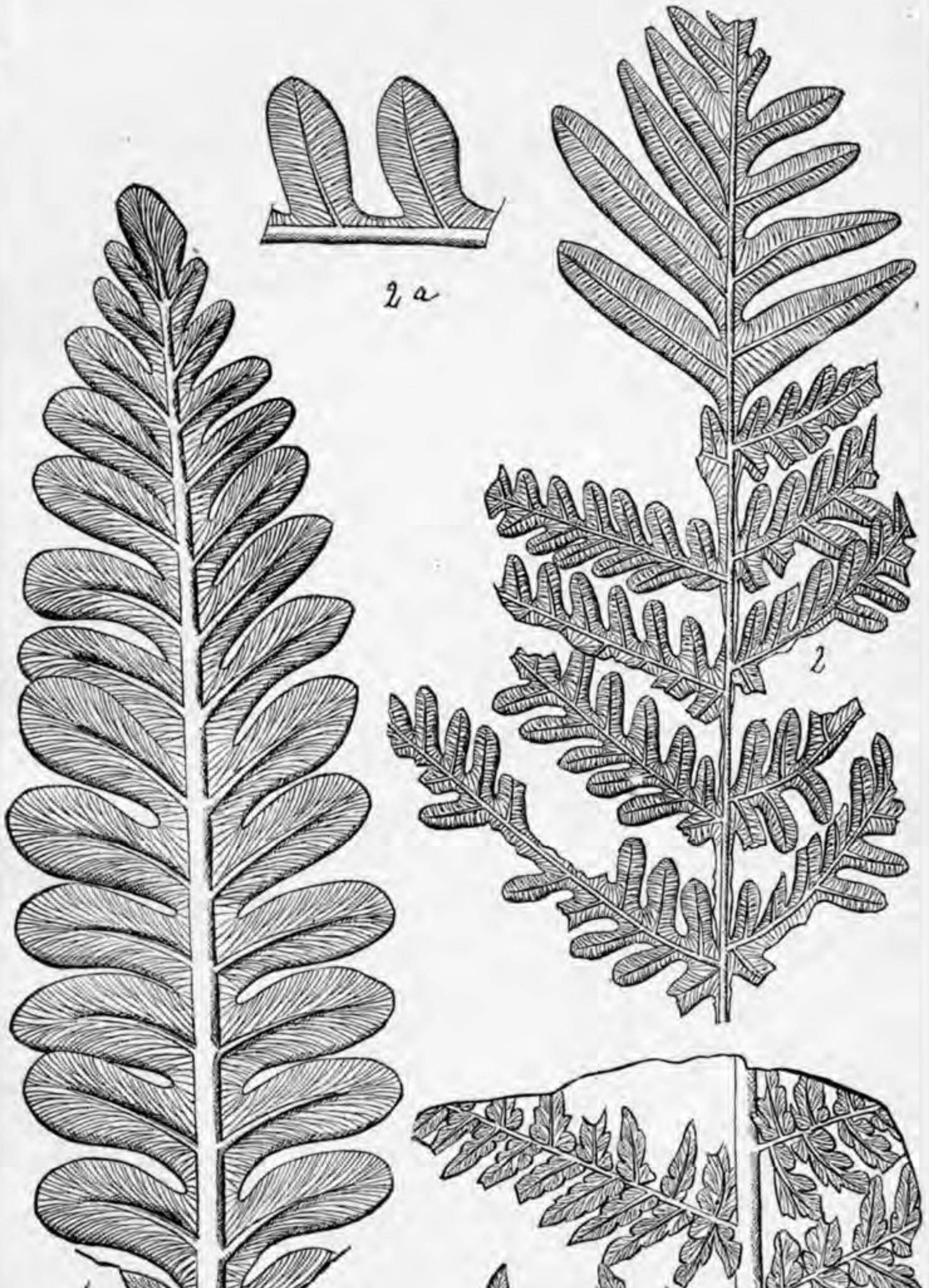
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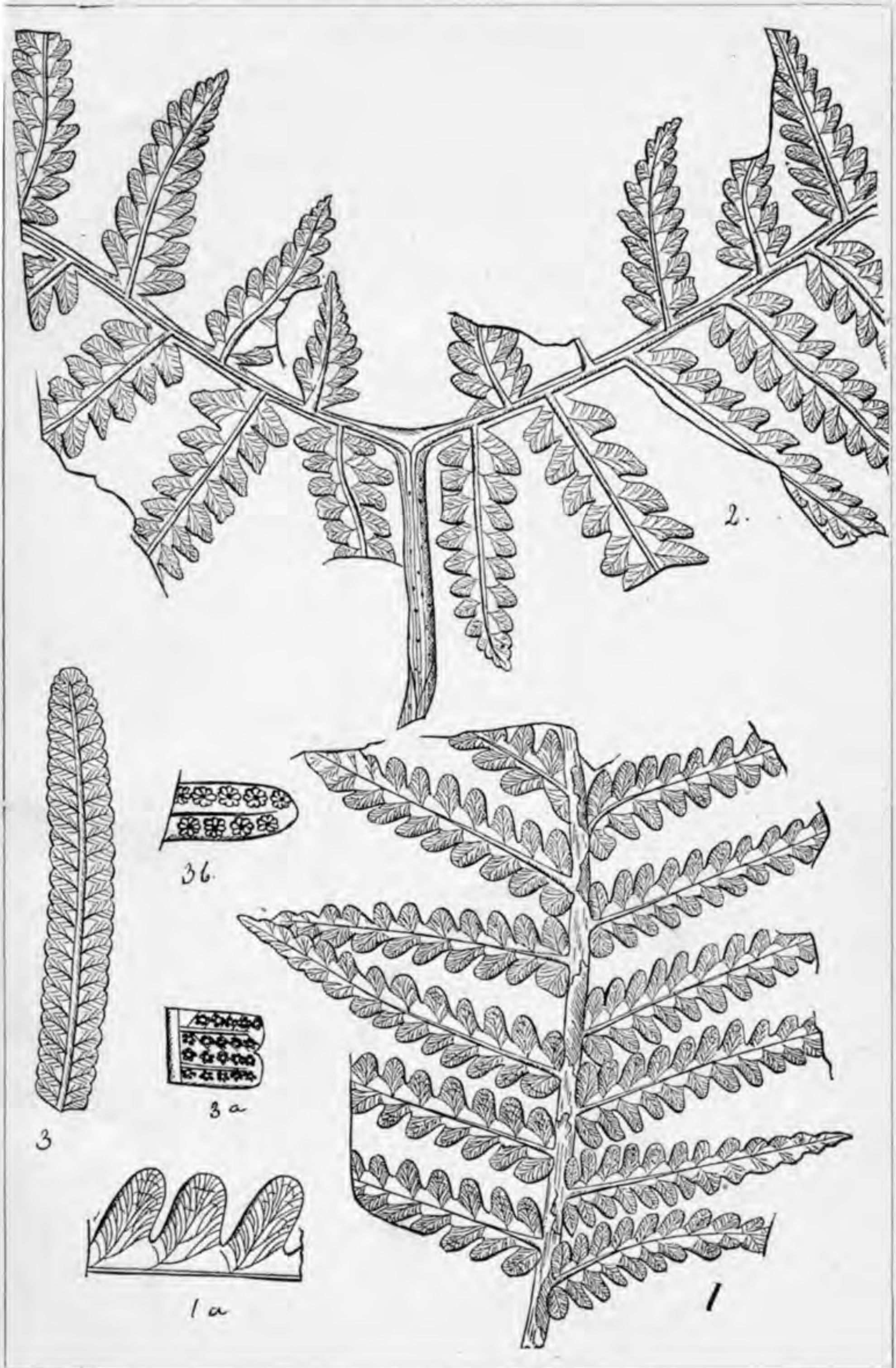
PLATE 13.

Figs. 1, 1*a*. Callipteridium rugosum, Lesq., p. 57.

Fig. 2. Pseudopecopteris Newberryi, Lesq., p. 61.

Figs. 3, 3*b*. Pecopteris unita, Brgt., p. 63.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Figs. 1, 1*a*. Pecopteris vestita, Lesq., p. 65.

Fig. 2. Pecopteris Strongii, Lesq., p. 64.

Fig. 3. Pecopteris solida, Lesq., p. 65.

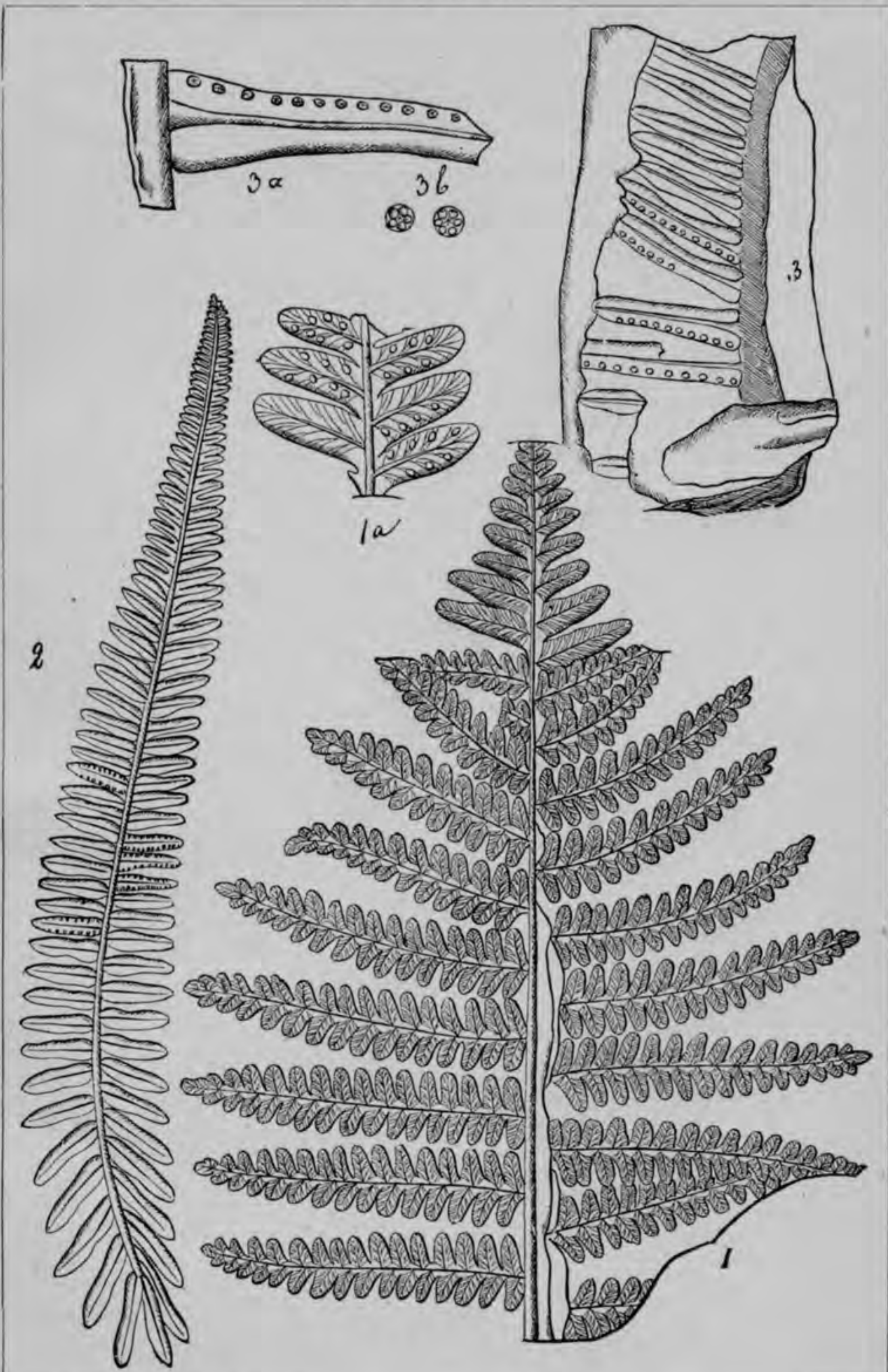
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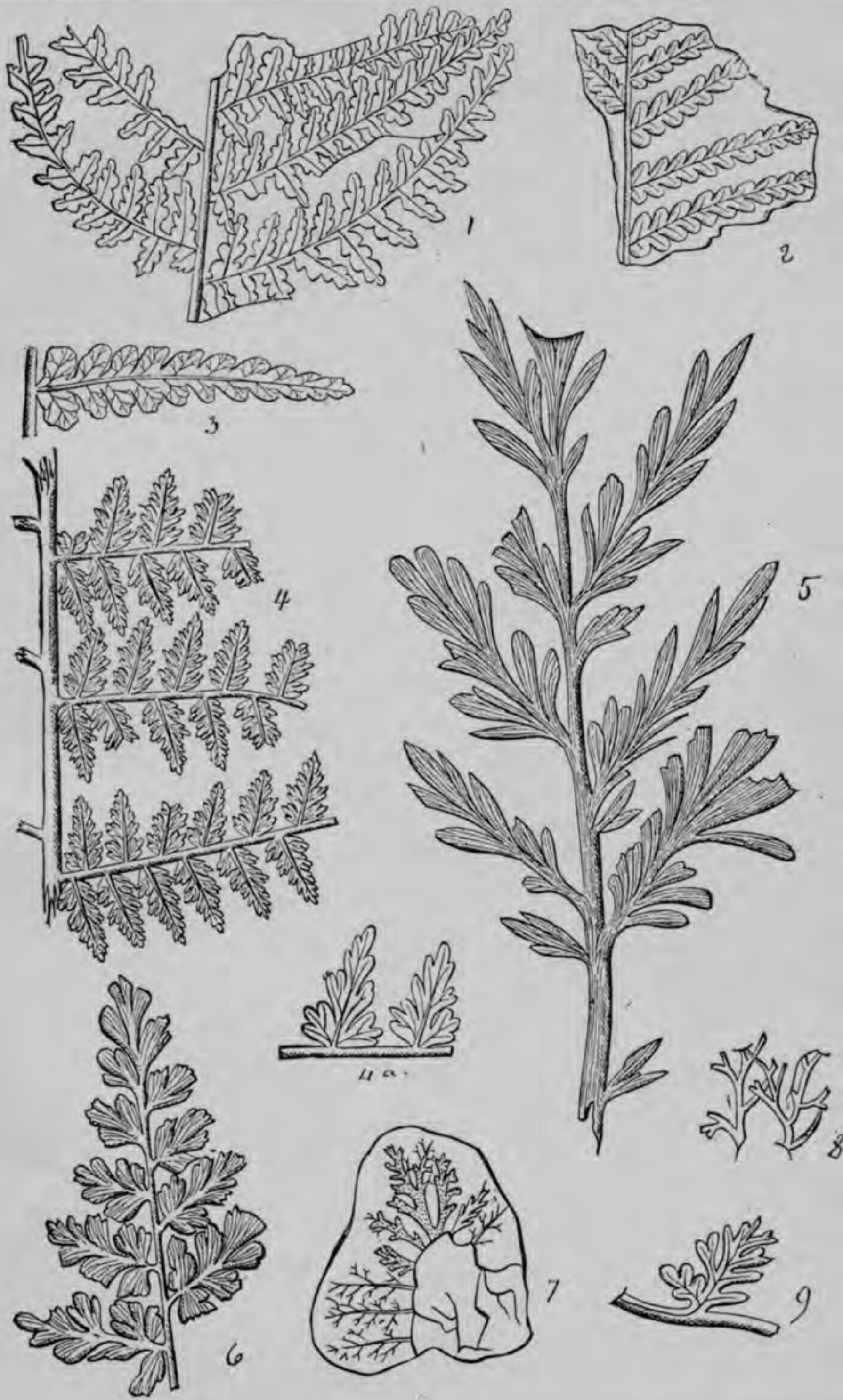
Fig. 8. Rhacophyllum adnascens, Ll. & Hutt., p. 73.

Fig. 9. Rhacophyllum inflatum, Lesq., p. 73.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Figs. 4, *4a*. Axillary sporanges of Lycopods, fig. enlarged, p. 76.

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Figs. 10, 11. Lepidophyllum, species, p. 83.

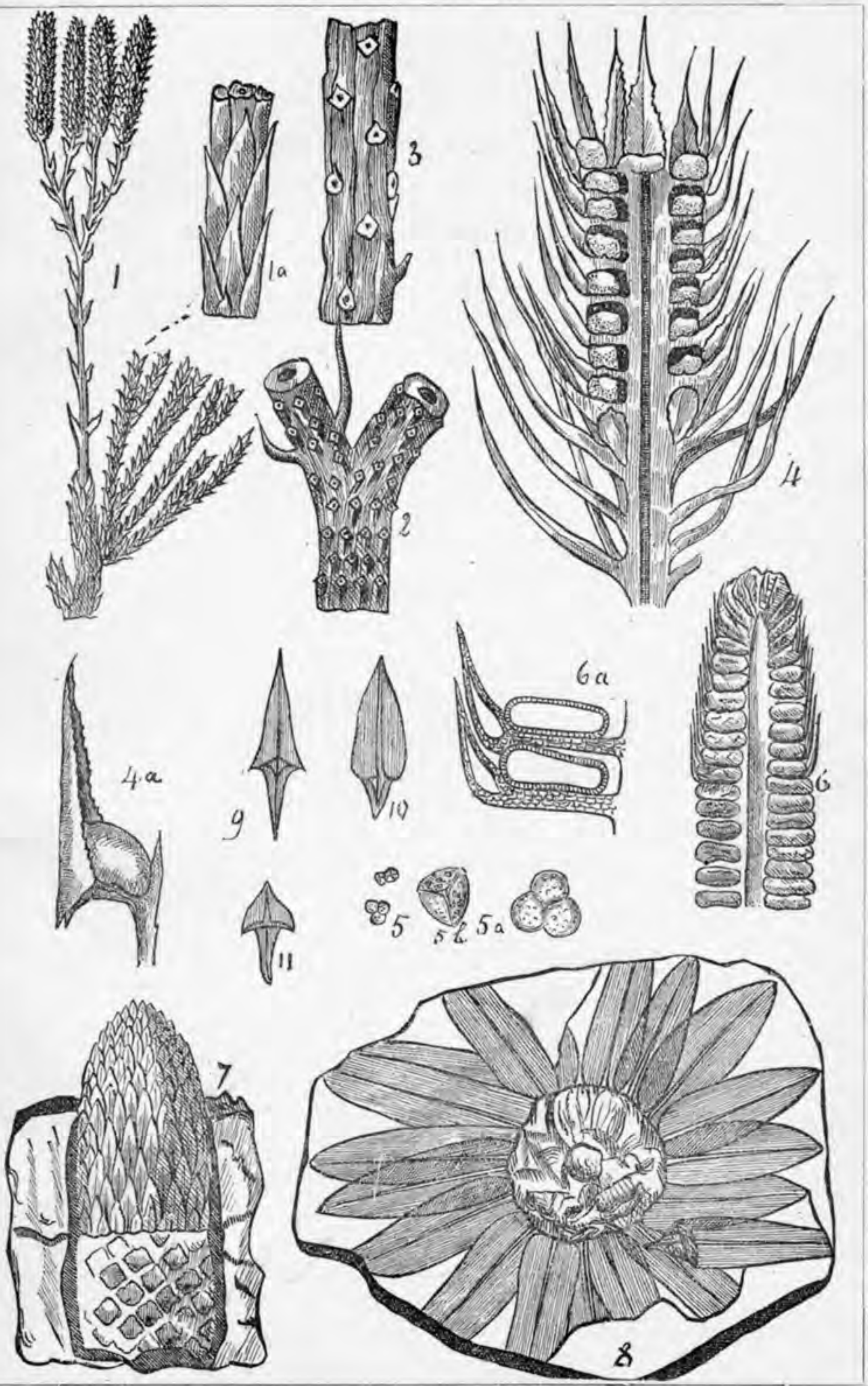
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PLATE 17.

Fig. 1. Restored tree of Lepidodendron, reduced size, p. 77.

Fig. 2. Lepidostrobus hastatus, Lesq., p. 82.

Fig. 3. Lepidodendron rimosum, St., p. 80.

Figs. 4–4*b*. Lepidodendron Brittsii, Lesq., p. 80.

Fig. 5. Lepidodendron diplotegioides, Lesq., p. 81.

Fig. 6. Lepidodendron aculeatum, St., p. 80.

Fig. 7. Lepidodendron distans, Lesq., p. 80.

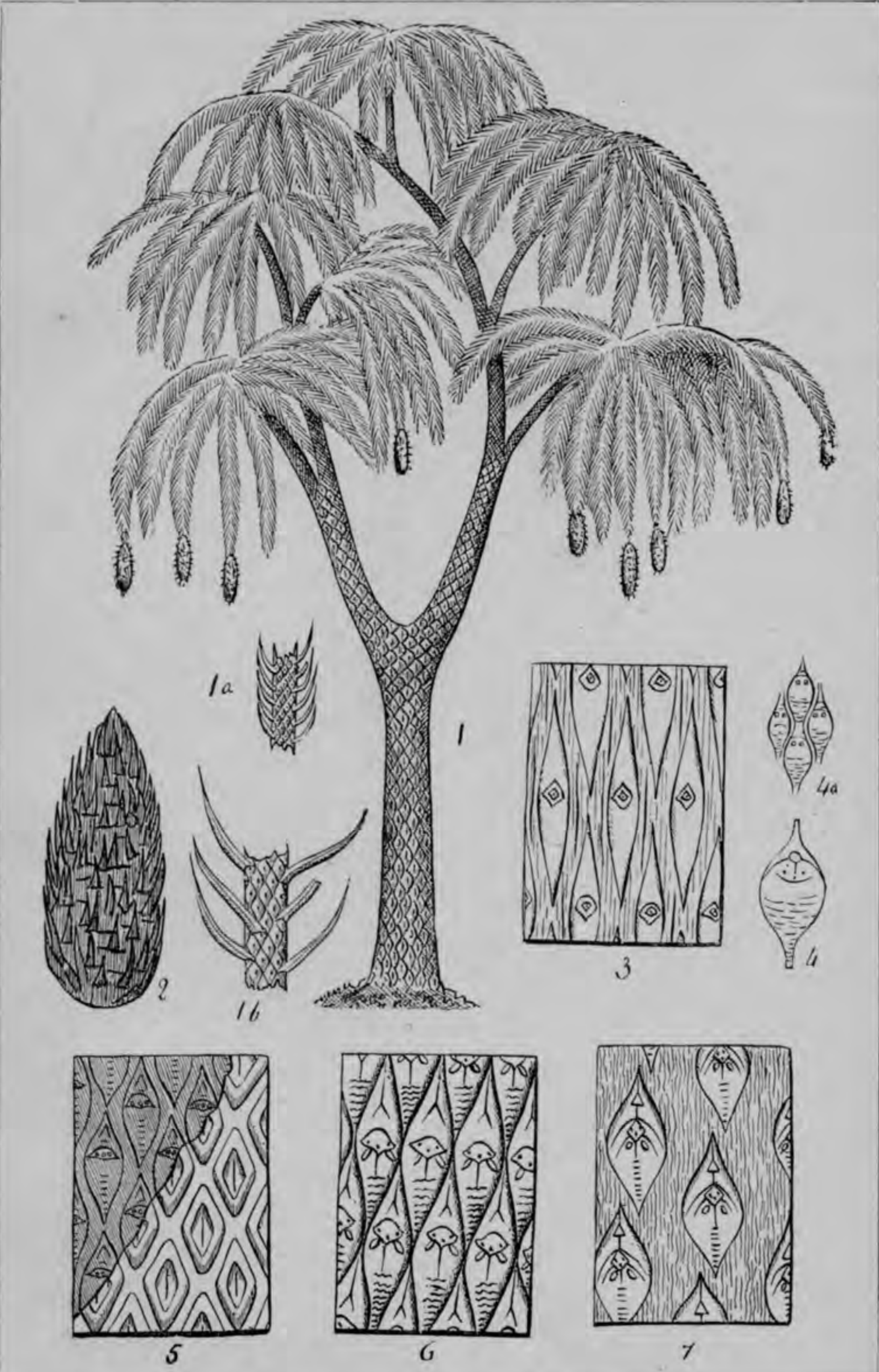
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PLATE 18.

Fig. 1. Halonia flexuosa, Gold., p. 87.

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Fig. 3. Ulodendron minus, Ll. & Hutt., p. 85.

Fig. 4. Halonia tuberculata, Brgt., p. 87.

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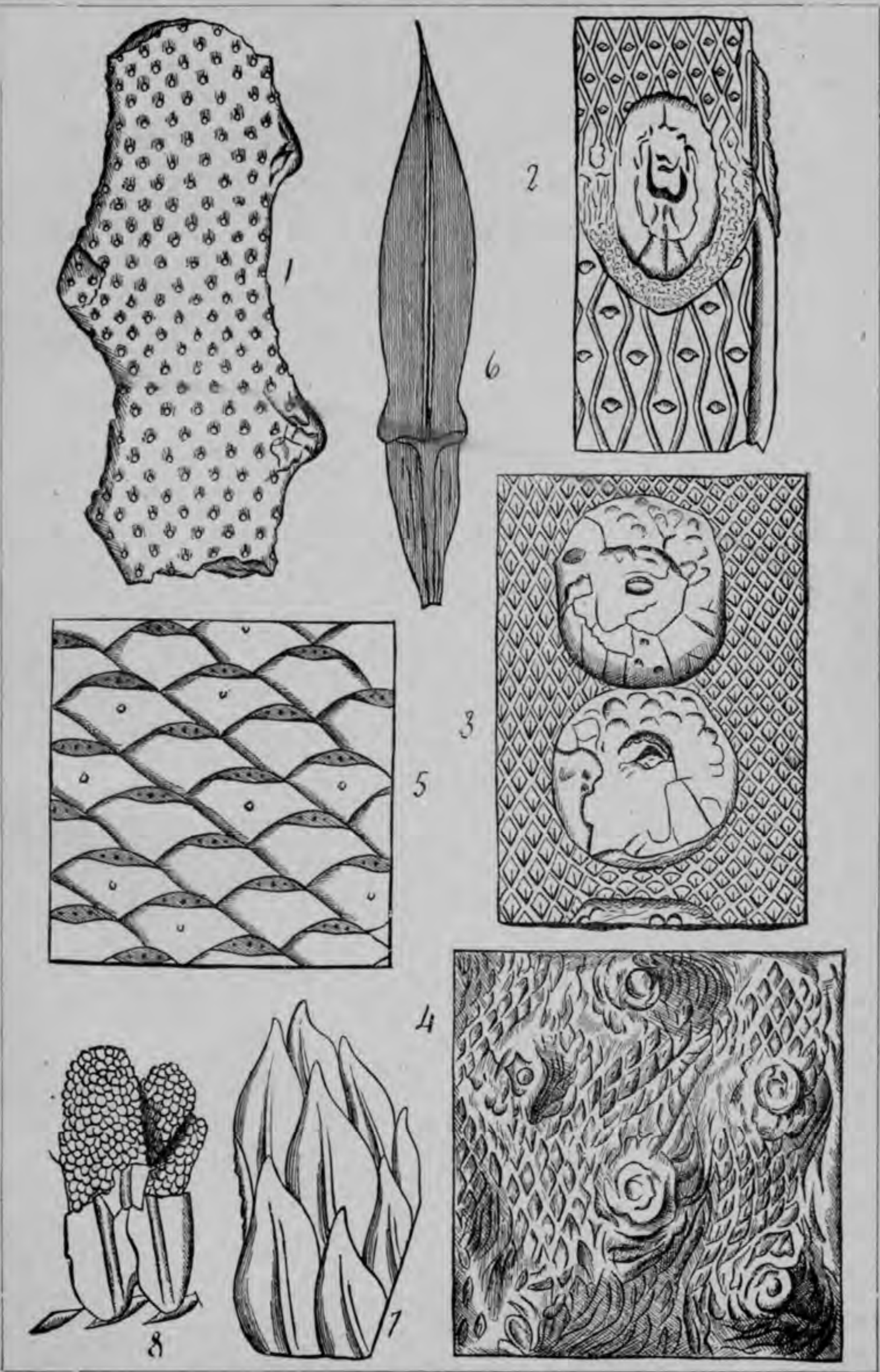
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Figs. 1, 2. Stigmaria ficoides, Brgt., p. 95.

Fig. 3. Stigmaria ficoides var. undulata, Goepp., p. 96.

Fig. 4. Stigmaria ficoides var. stellata, Lesq., p. 96.

Fig. 5. Stigmarioides, Lesq., p. 96.

Fig. 6. Sigillarioides, Lesq., p. 96.

Figs. 7, 8. Knorria imbricata, St., p. 86.

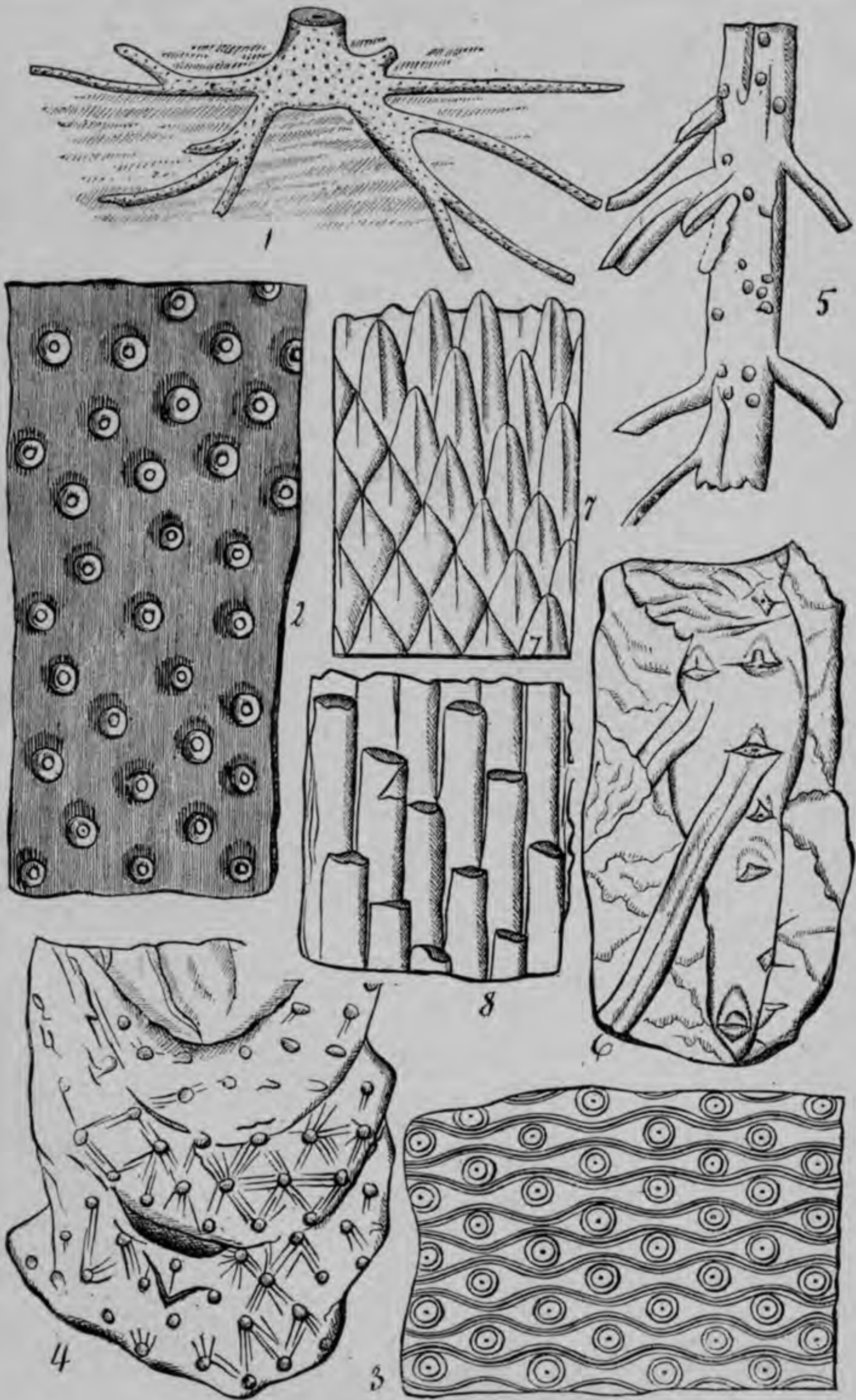
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PLATE 20.

Fig. 1. Sigillaria marginata, Lesq., p. 93.

Fig. 2. Sigillaria Lacoei, Lesq., p. 94.

Fig. 3. Sigillaria Pittstoniana, Lesq., p. 93.

Fig. 4. Sigillaria ovalis, Lesq., p. 93.

Fig. 5. Sigillaria Sillimanni, Brgt., p. 93.

Fig. 6. Sigillaria reticulata, Lesq., p. 92.

Figs. 7–8. Sigillaria Brardii, Brgt., p. 92.

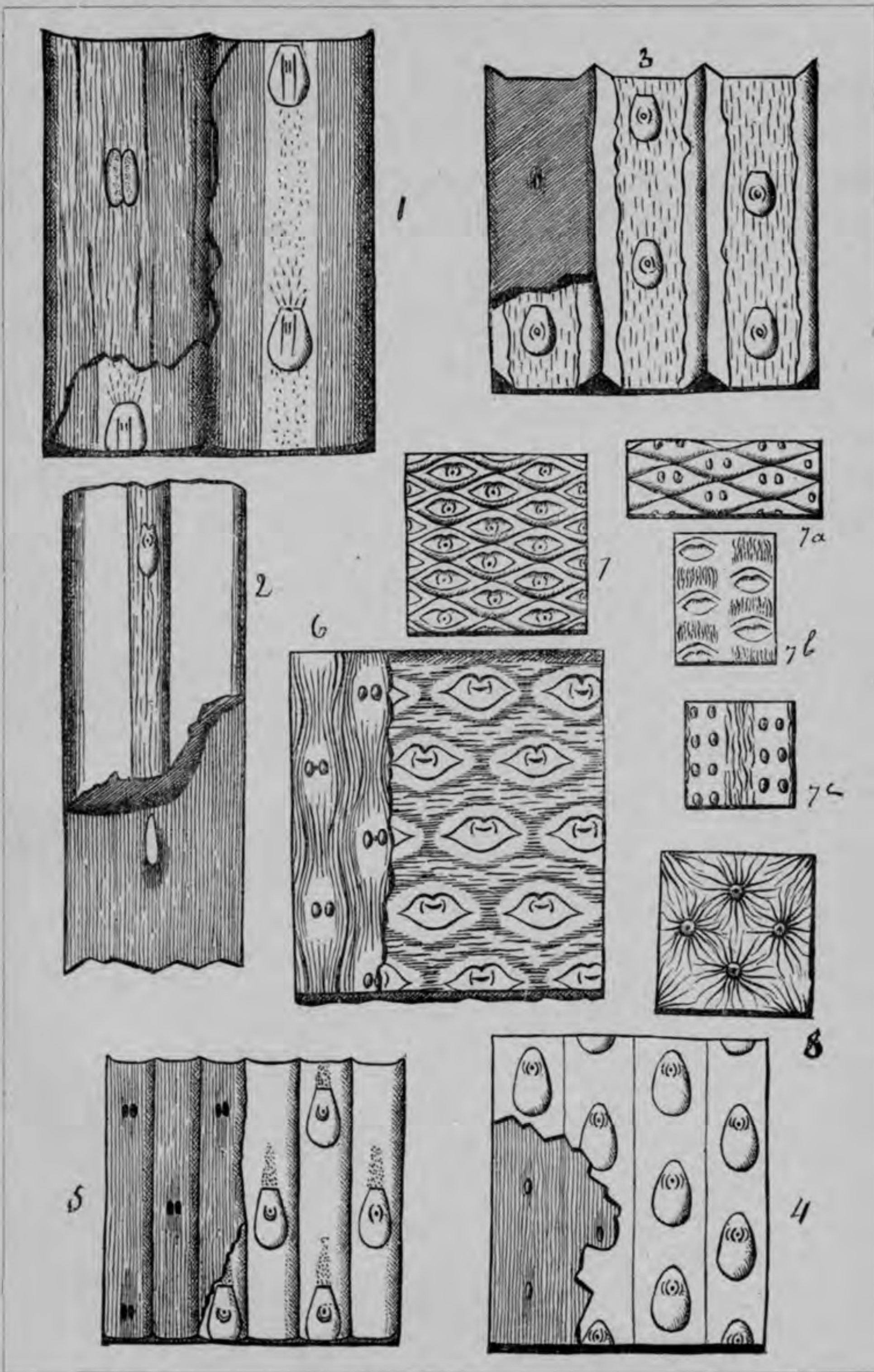
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PLATE 21.

Figs. 1–1*b*, 4. Cordaites costatus, Lesq., p. 99.

Fig. 2. Cordaites Lacoei, Lesq., p. 99.

Fig. 3. Artisia or woody cylinder of C. serpens, Lesq., p. 100.

Fig. 5. Cordaicarpus Gutbieri, Gein., p. 101.

Figs. 6, 7. Cordaicarpus apiculatus, Lesq., p. 101.

Fig. 8, 8*d*. Tæniophyllum, Lesq., p. 101.

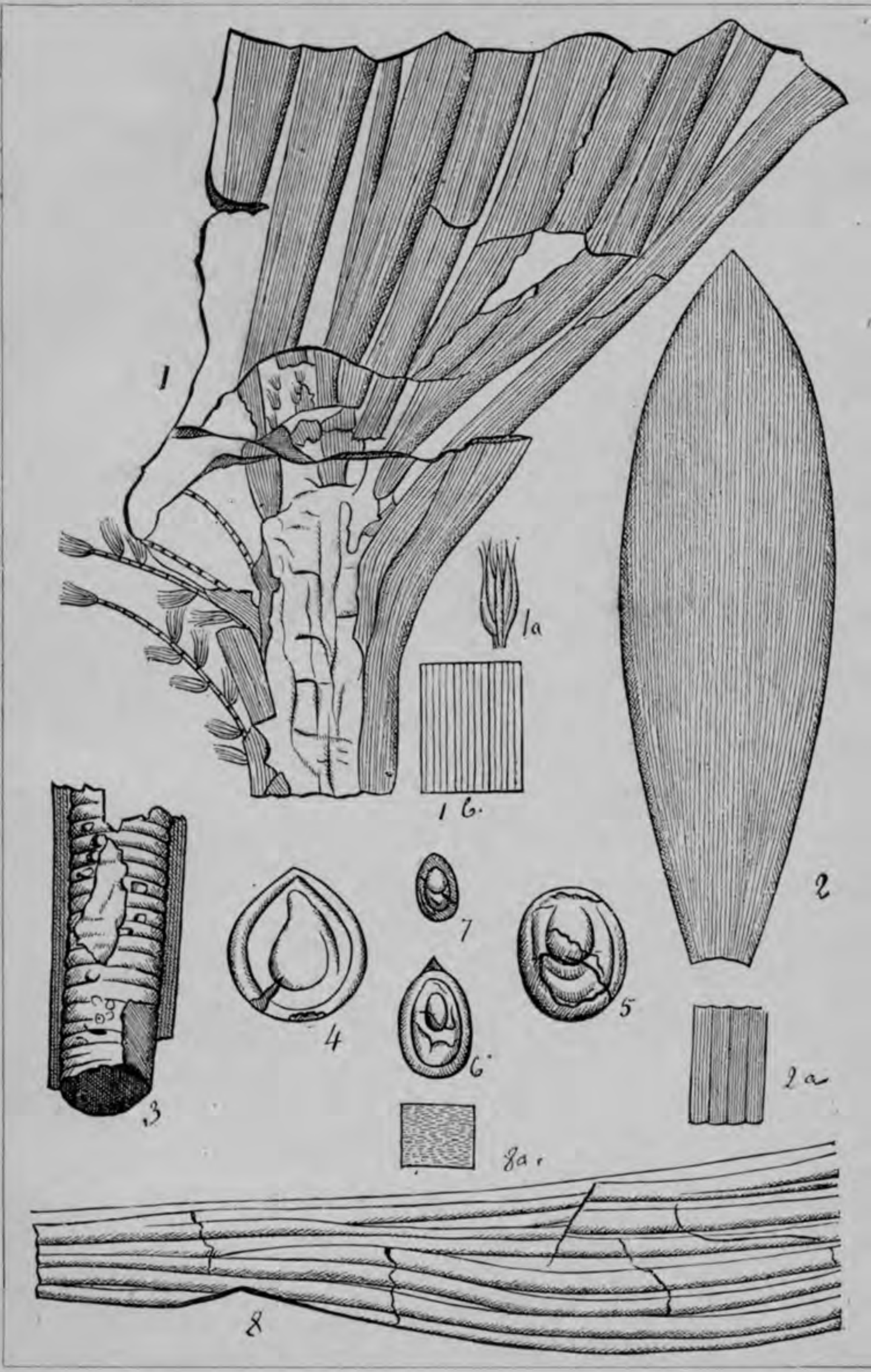
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PLATE 22.

Fig. 1. Cardiocarpus Harveyi, Lesq., p. 102.

Fig. 2. Cardiocarpus ingens, Lesq., p. 103.

Figs. 3, 4. Cardiocarpus ovalis, Lesq., p. 103.

Figs. 5, 5*a*. Cardiocarpus mamillatus, Lesq., p. 103.

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Fig. 7. Rhabdocarpus Mansfieldi, Lesq., p. 104.

Figs. 8, 9. Rhabdocarpus multistriatus, Presl., p. 104.

Fig. 10. Rhabdocarpus Howardi, Lesq., p. 104.

Fig. 11. Trigonocarpus Dawesii, Ll. & H., p. 105.

Fig. 12. Trigonocarpus subcylindricus, Lesq., p. 105.

Fig. 13. Cardiocarpus (Samaropsis) simplex, Lesq., p. 103.

Fig. 14. Cardiocarpus bicornutus, Lesq., p. 103.

Fig. 15. Carpolithes bicuspidatus, St., p. 105.

Fig. 16. Carpolithes orbicularis, Newby, p. 105.

Figs. 17, 17*a*. Carpolithes regularis (?), St., p. 106.

Fig. 18. Carpolithes arcuatus, Lesq., p. 106.

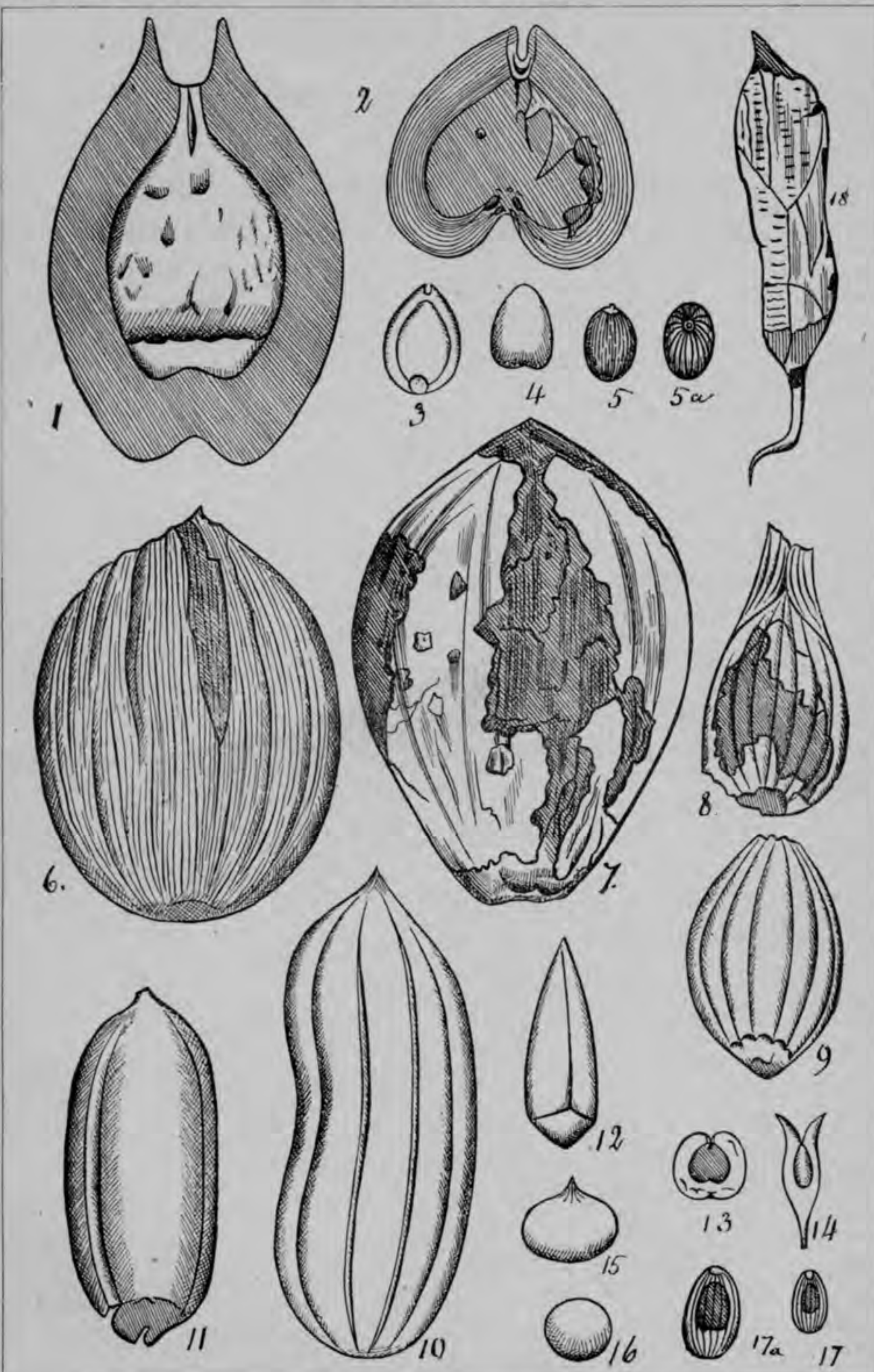
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PLATE 23.

Fusulina cylindrica, *Fischer*.

Page 116.

Fig. 1. A group of specimens; natural size.*
Fig. 2. An elongate example; enlarged.
Fig. 3. A transverse section; still more enlarged.

Zaphrentis Gibsonii, *White*.

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Fig. 4. Lateral view; natural size.
Fig. 5. Another view of the same specimen; showing the calyx.

Lophophyllum proliferum, *McChesney*.

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Fig. 6. Lateral view, natural size; the upper part has been compressed, making it appear much wider than natural.
Fig. 7. Another example, with the calyx broken away, showing the columella.

Axophyllum rudis, *White and St. John*.

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Fig. 8. Lateral view of a small example; natural size.
Fig. 9. View of the calyx of the same example.

Campophyllum torquium, *Owen*.

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Fig. 10. Lateral view; natural size.
Figs. 11 and 12. Two views of another example.
Fig. 13. Transverse section, showing structure.

Michelinia Eugeneæ, *White*.

Page 119.

Figs. 14, 15 and 16. Lateral views of three separate examples; natural size.

*These figures, together with many others upon the following plates, have been copied from the Illinois and Nebraska Geological Reports. This has been done because they represent more perfect specimens in those cases than have yet been obtained by the Indiana Survey.

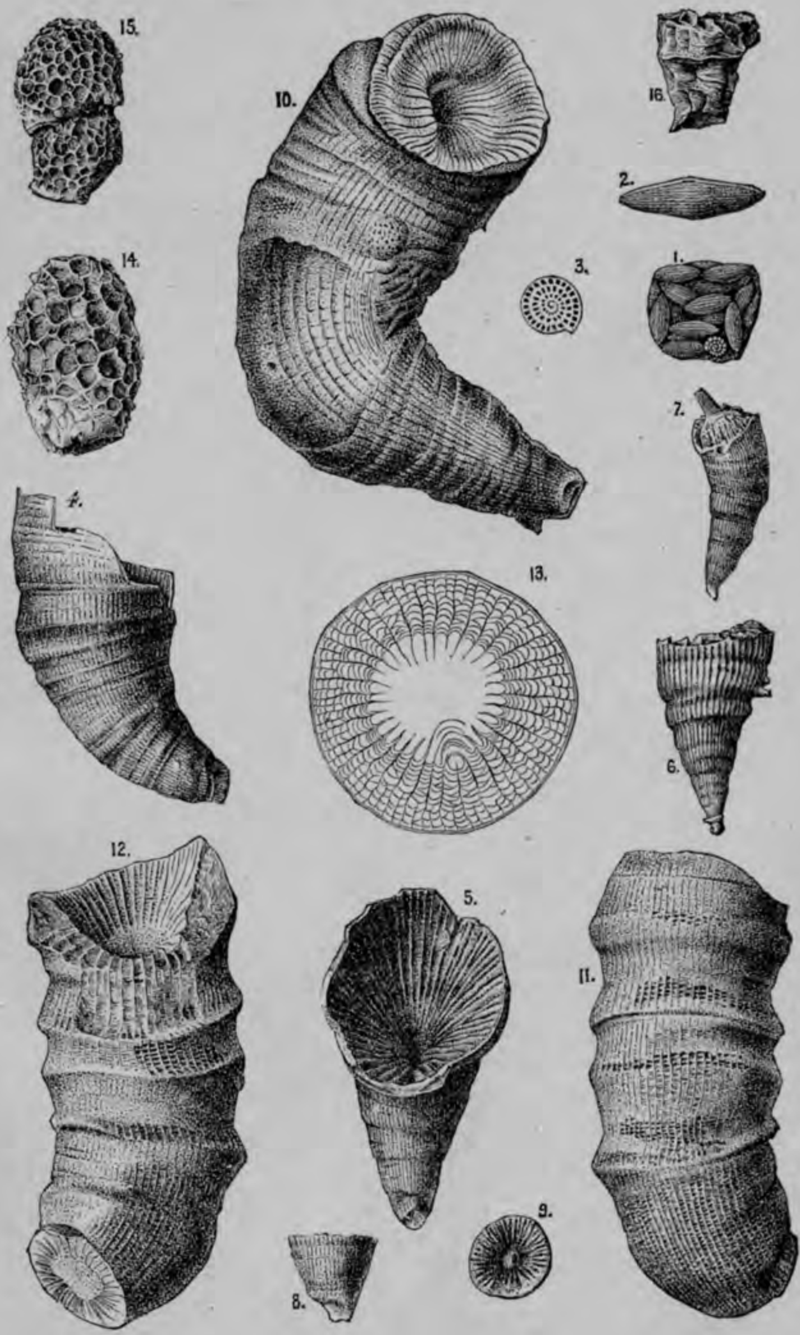
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PLATE 24.

PRODUCTUS SEMIRETICULATUS, *Martin.*

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Figs. 1, 2 and 3. Three different views of a moderately large example; natural size.

PRODUCTUS COSTATUS, *Sowerby.*

Page 124.

Figs. 4, 5 and 6. Three different views of an ordinary-sized example; natural size.

PRODUCTUS NEBRASCENSIS, *Owen.*

Page 122.

Figs. 7, 8 and 9. Three different views o an unusually perfect example; natural size.

PRODUCTUS LONGISPINUS, *Sowerby.*

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Figs. 10 and 11. Dorsal and ventral views of an usual form; natural size.

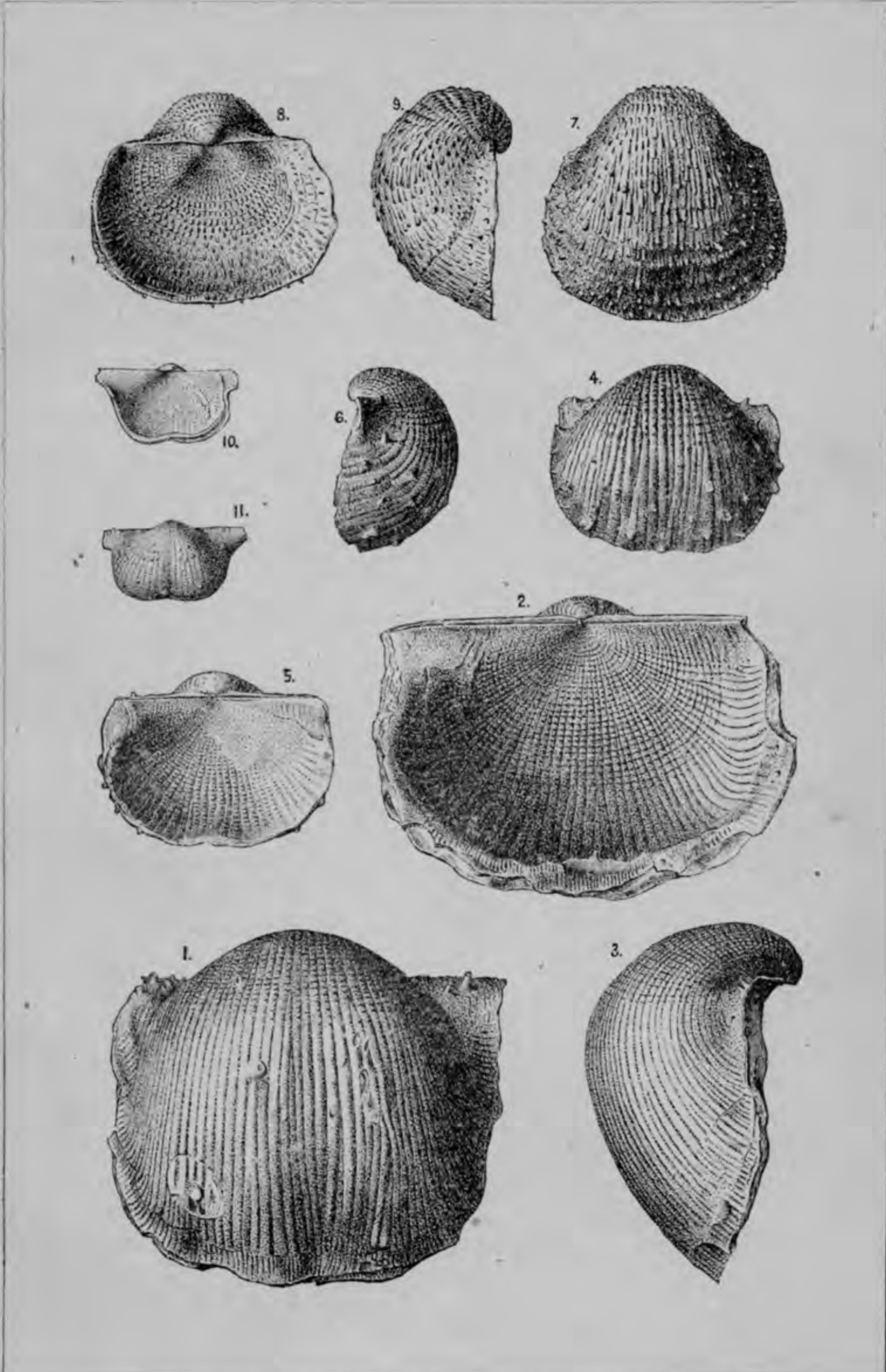
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PLATE 25.

PRODUCTUS SYMMETRICUS, *McChesney.*

Page 123.

Figs. 1 and 2. Two different views of a large example; natural size.

PRODUCTUS COSTATUS, *Sowerby.*

Page 124.

Figs. 3, 4 and 5. Three different views of a large example; natural size.

RHYNCHONELLA UTA, *Marcou.*

Page 132.

Fig. 6. Ventral view; enlarged.

CHONETES VERNEUILIANA, *Norwood and Pratton.*

Page 128.

Fig. 7. Ventral view of a specimen of ordinary shape; natural size.
Fig. 8. A similar view of another example, with mucronate sides.

DISCINA CONVEXA, *Shumard.*

Page 121.

Fig. 9. Upper view of the upper valve; natural size.

DISCINA NITIDA, *Phillips.*

Page 121.

Fig. 10. A piece of rock showing several examples of both upper and under valves; natural size.

SYNOCLADIA BISERIALIS, *Swallow.*

Page 138.

Fig. 11. A fragment of a frond, obverse side; natural size.
Fig. 12. Part of the same specimen enlarged.
Fig. 13. A small portion, more enlarged, showing the poriferous side.

LINGULA UMBONATA, *Cox.*

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Fig. 14. A single valve; natural size.

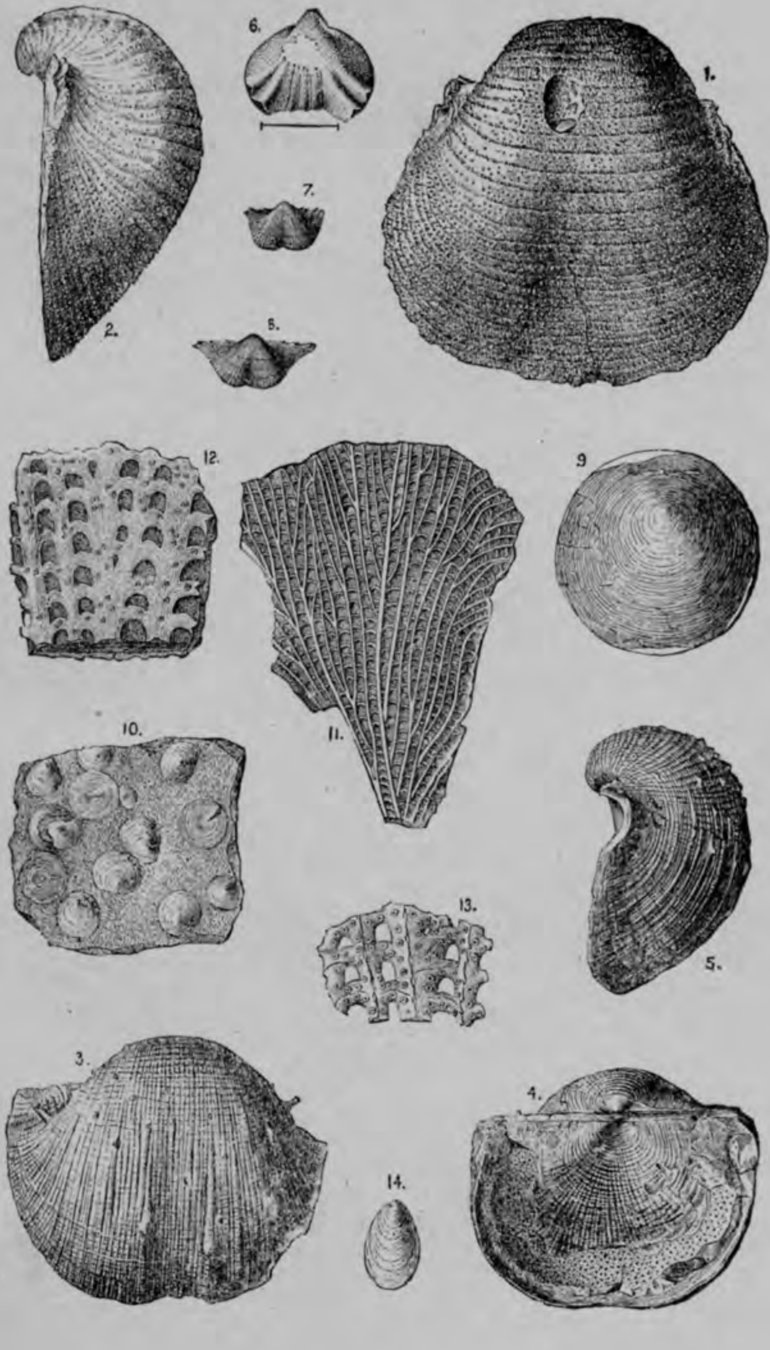
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PLATE 26.

PRODUCTUS CORA, *d' Orbigny.*

Page 126.

Figs. 1 and 2. Opposite views of an ordinary example; natural size.

Fig. 3. Ventral view of another example, showing finer radiating striæ, and the absence of spines on the general surface.

HEMIPRONITES CRASSUS, *Meek & Hayden.*

Page 129.

Figs. 4 and 5. Ventral and dorsal views; natural size.

Figs. 6 and 7. Exterior and interior views of a ventral valve.

Figs. 8 and 9. Exterior and interior views of a dorsal valve.

Fig. 10. Interior view of a larger ventral valve.

Fig. 11. Interior view of a larger dorsal valve.

MEEKELLA STRIATOCOSTATA, *Cox.*

Page 130.

Fig. 12, 13 and 14. Three different views of an adult, but not a very ventricose example; natuural size

SYNTRIELASMA HEMIPLICATA, *Hall.*

Page 131.

Figs. 15, 16, 17 and 18. Four different views of an adult example; natural size.

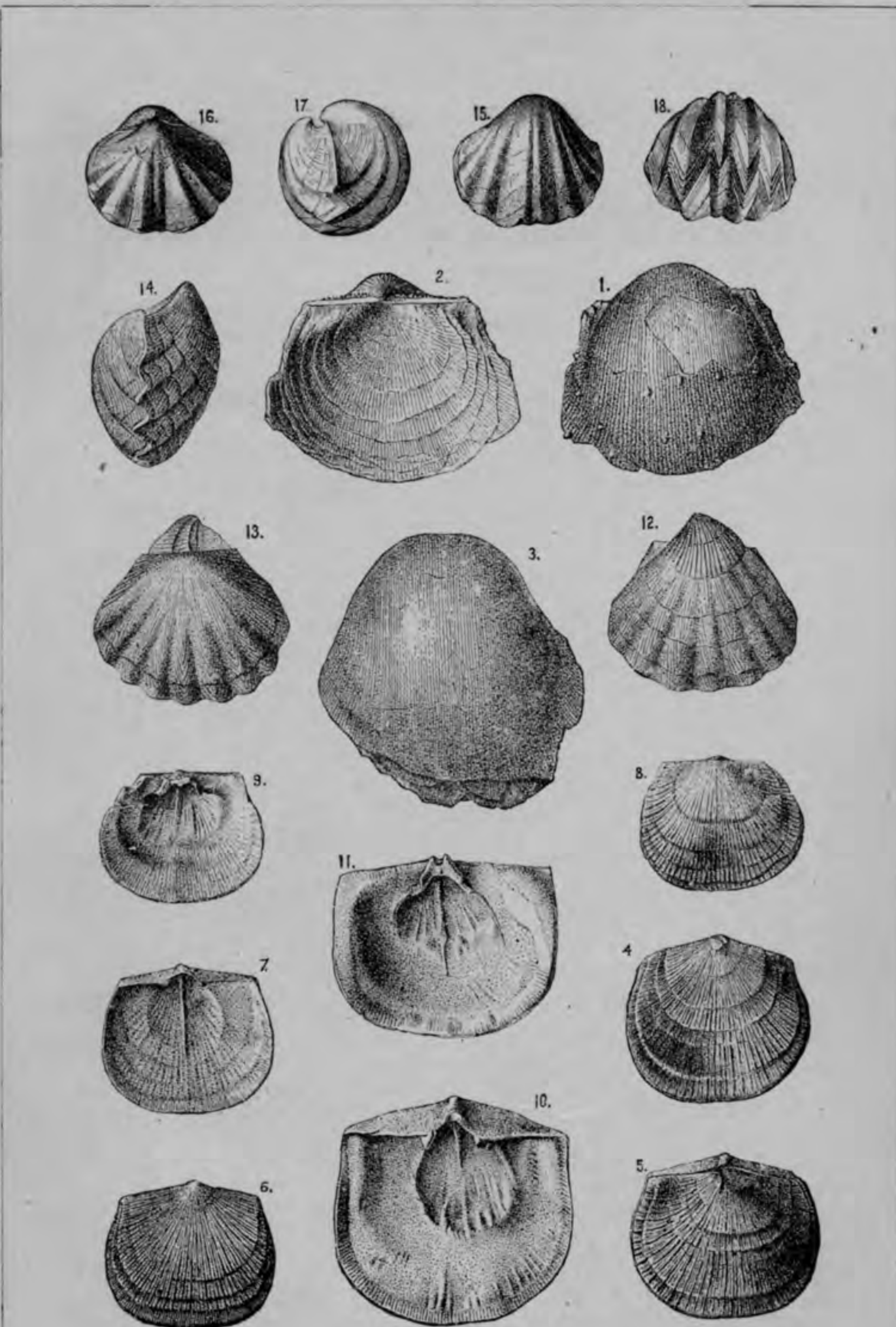
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PLATE 27.

Productus punctatus, *Martin.*

Page 124.

Figs. 1, 2 and 3. Three different views of a large example; natural size.

Spirifer lineatus, *Martin.*

Page 133.

Figs. 4, 5 and 6. Three different views of a medium sized example; natural size.

Polyphemopsis nitidula, *Meek & Worthen.*

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Figs. 7 and 8. Opposite lateral views; natural size.

Nucula ventricosa, *Hall.*

Page 146.

Figs. 9 and 10. Right side and dorsal views; natural size.

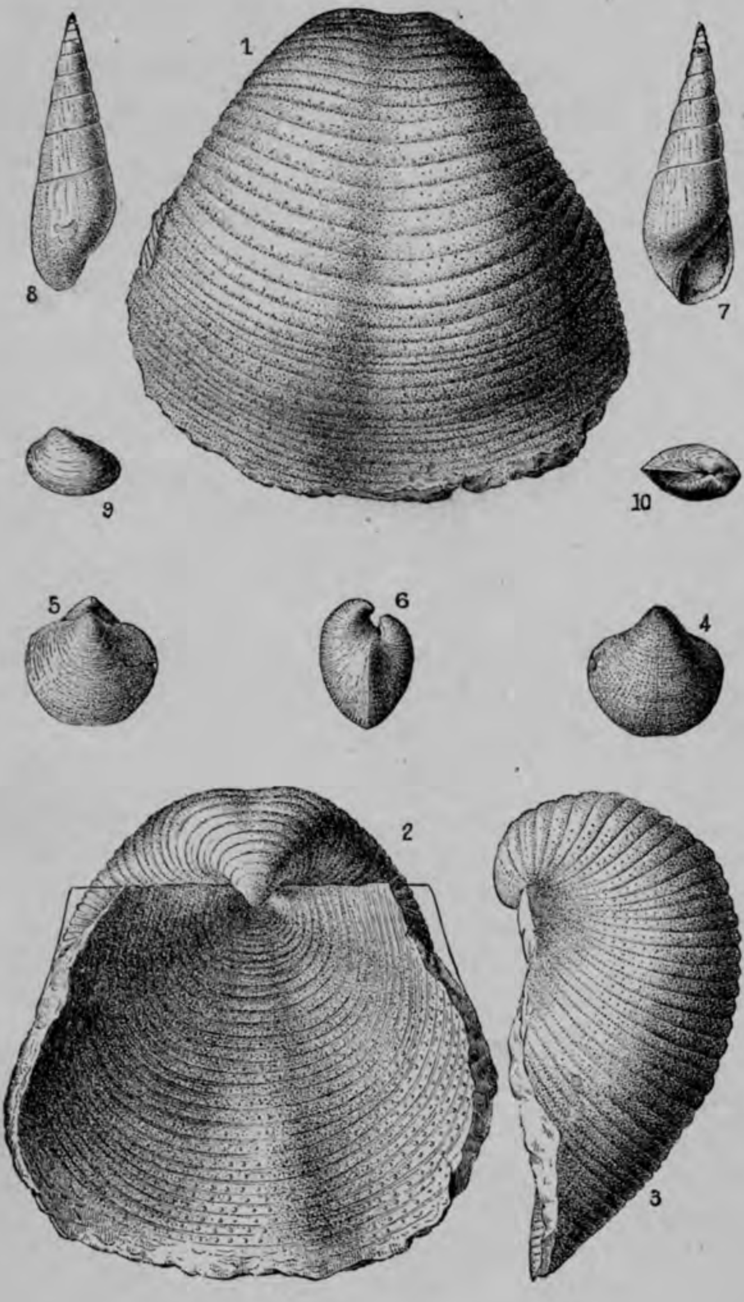
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PLATE 28.

PINNA PERACUTA, *Shumard.*

Page 145.

Fig. 1. Right side view of an internal cast; natural size.

Fig. 2. Dorsal view of the same. The specimen has been distorted by pressure.

AVICULOPECTEN OCCIDENTALIS, *Shumard.*

Page 143.

Fig. 3. Exterior view of a left valve; natural size.

LIMA RETIFERA, *Shumard.*

Page 138.

Fig. 4. A natural cast of both valves; natural size.

AVICULOPECTEN CARBONIFERUS, *Stevens.*

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Fig. 5. Left valve; natural size.

Fig. 6. Right valve of another example.

ENTOLIUM AVICULATUM, *Swallow.*

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Fig. 7. Left valve; natural size.

Fig. 8. Interior view of a left valve, showing the structure of the parts about the hinge.

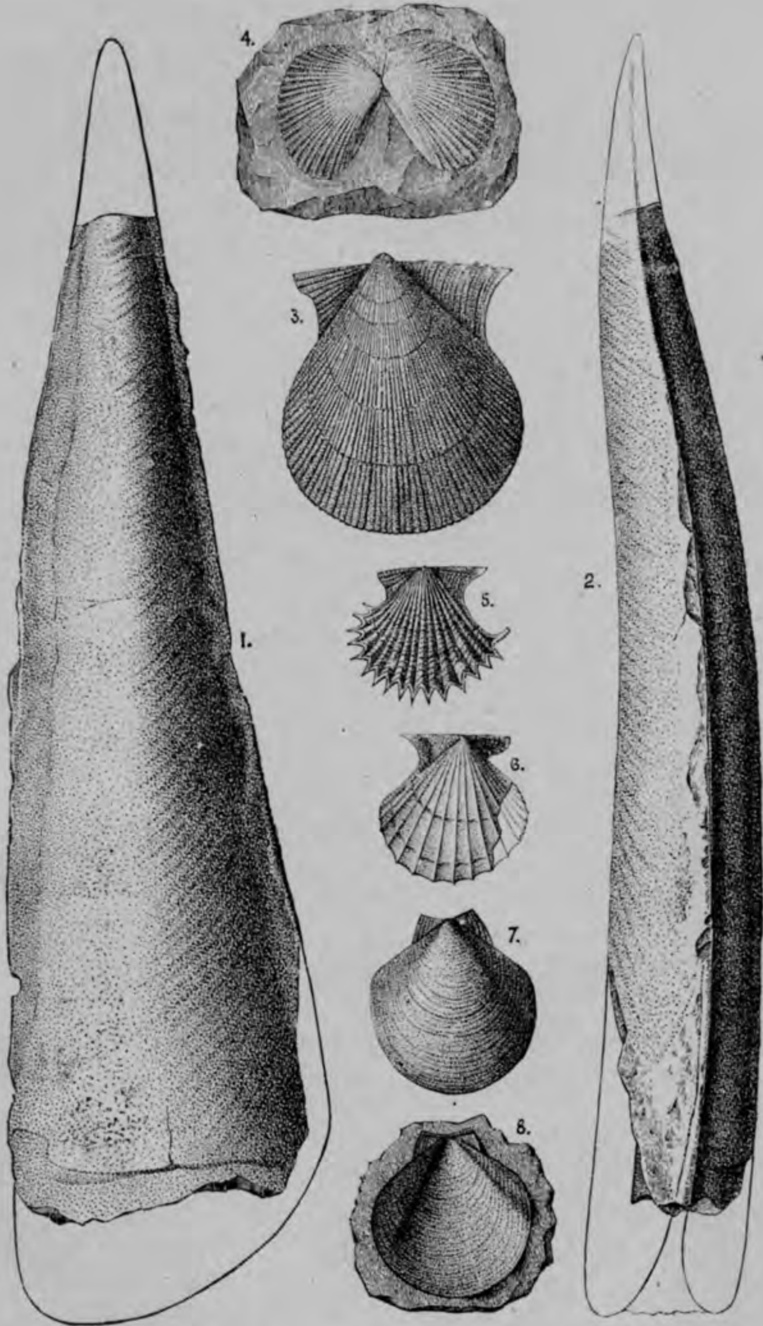
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PLATE 29.

MYALINA SUBQUADRATA, *Shumard.*

Page 140.

Fig. 1. Exterior view of a right valve; natural size.

Fig. 2. Interior view of the same example.

MYALINA RECURVIROSTRIS, *Meek and Worthen.*

Page 140.

Fig. 3. Exterior view of a left valve; natural size.

Fig. 4. Interior view of the same example

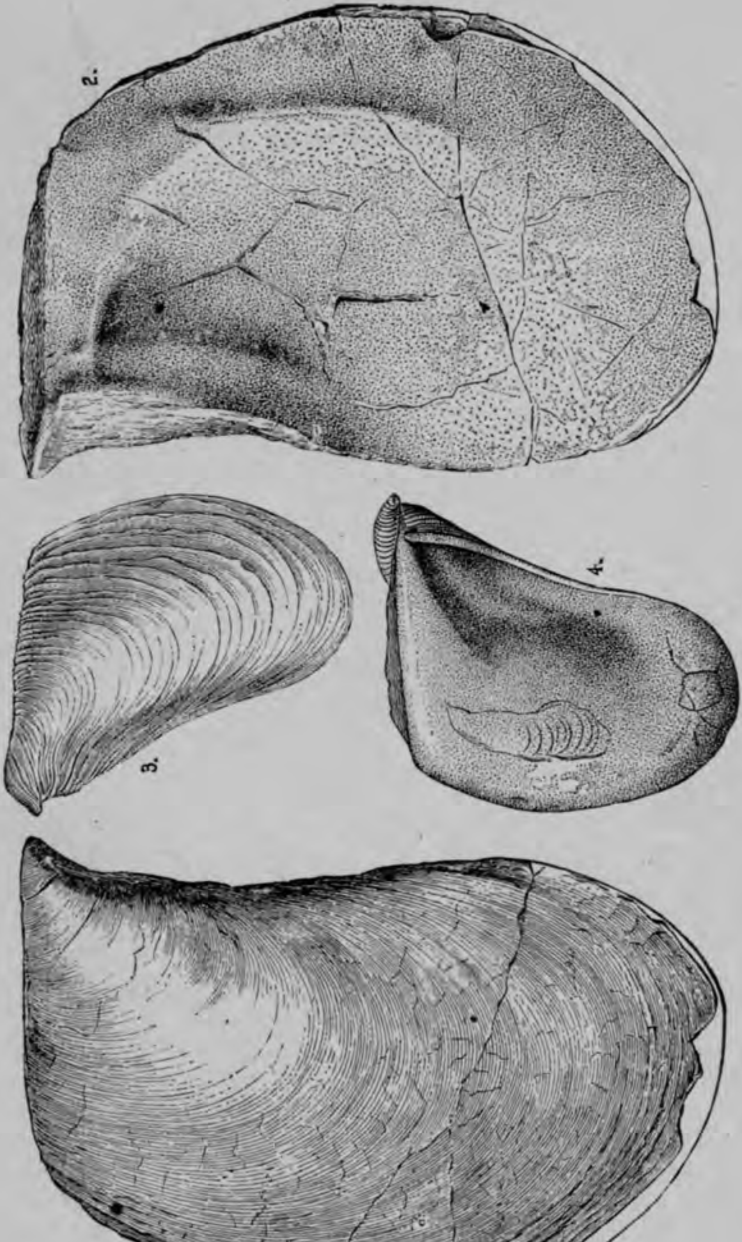
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PLATE 30.

MYALINA SUBQUADRATA, *Shumard.*

Page 140.

Fig. 1. Exterior view of a right valve, with an unusually narrow base; natural size.

Fig. 2. Interior view of the same example.

SCHIZODUS WHEELERI, *Swallow.*

Page 147.

Fig. 3. Exterior view of a left valve; natural size.

Figs. 4 and 5. Lateral and dorsal views of a large internal cast; natural size.

MYALINA (?) SWALLOVI, *McChesney.*

Page 141.

Fig. 6. Exterior view of a left valve; natural size.

Fig. 7. A similar view of a right valve.

Fig. 8. Dorsal view of another example.

AVICULOPECTEN INTERLINEATUS, *Meek and Worthen.*

Page 145.

Fig. 9. Exterior view of a left valve; natural size.

EUMICROTIS HAWNI, *Meek and Hayden.*

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Fig. 10. Exterior view of a left valve; natural size.

MONOPTERIA GIBBOSA, *Meek and Worthen.*

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Fig. 11. Exterior view of a right valve; natural size.

Fig. 12. Anterior view of another right valve; showing the lunule.

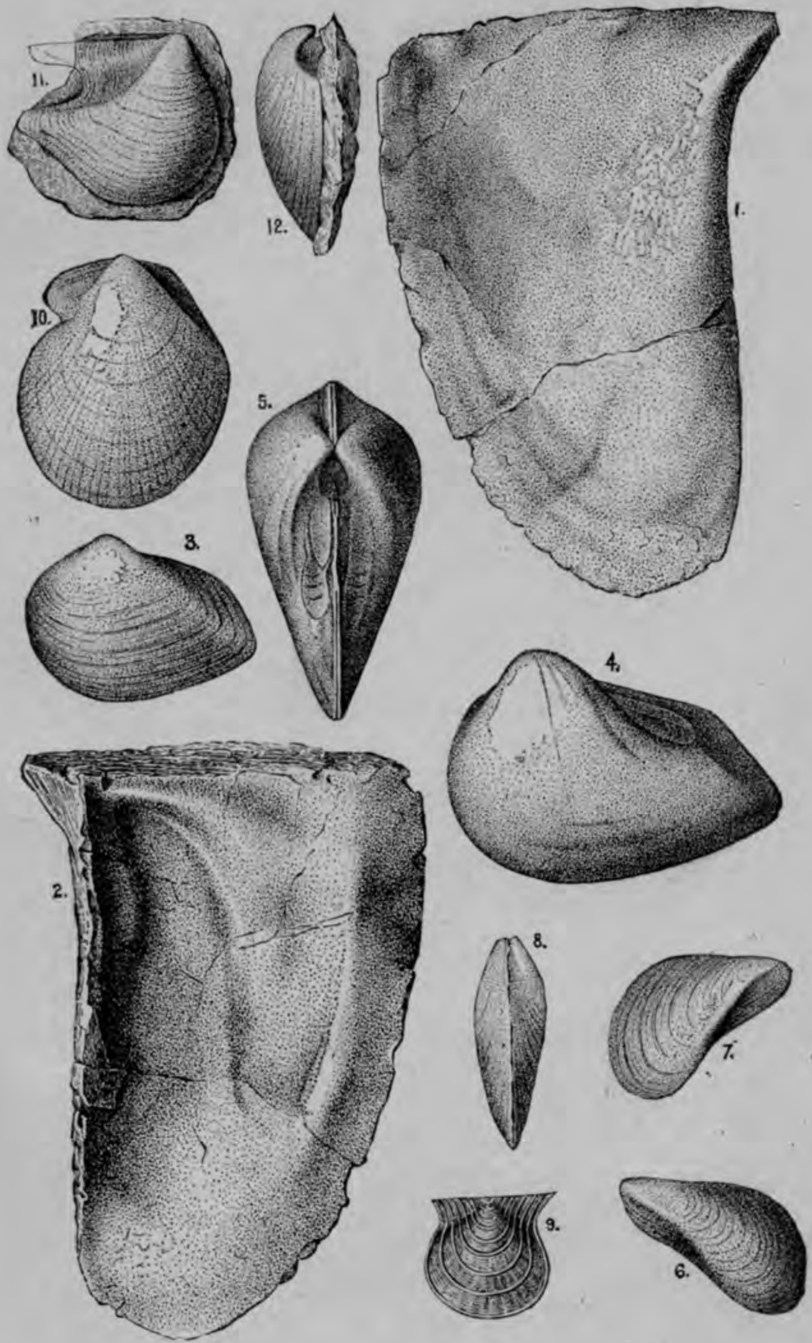
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PLATE 31.

ALLORISMA SUBCUNEATA, *Meek and Hayden.*

Page 148.

Fig. 1. Lateral view of the right valve; natural size.

Fig. 2. Similar view of the left valve of a smaller example.

Fig. 3. Dorsal view of the same example.

EDMONDIA ASPENWALLENSIS, *Meek.*

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Fig. 4. Lateral view of the right side; natural size.

Fig. 5. Dorsal view of the same example.

CLINOPISTHA RADIATA, *Hall.*

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Figs. 6 and 7. Left side and dorsal views; natural size.

NUCULANA BELLISTRIATA, *Stevens.*

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Figs. 8 and 9. Left side, and dorsal views; somewhat enlarged.

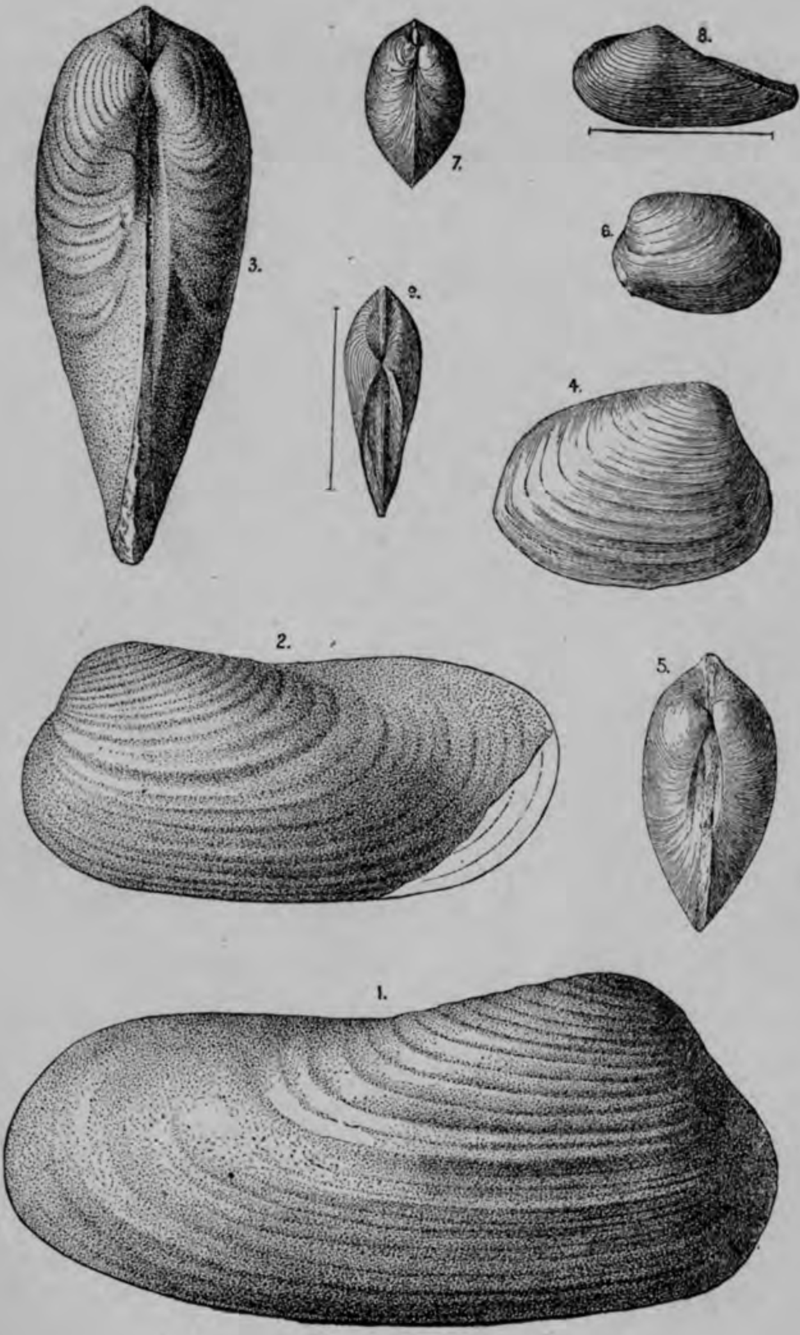
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PLATE 32.

PLEUROTOMARIA SPHÆRULATA, *Conrad.*

Page 161.

Fig. 1. Lateral view of a large example; natural size.
Figs. 2 and 3. Apical and lateral views of a smaller example.

PLEUROTOMARIA TABULATA, *Hall.*

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Figs. 4 and 5. Opposite lateral views of a large example; natural size.

POLYPHEMOPSIS? ———— ?

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Fig. 6. Lateral view; natural size.

PLEUROTOMARIA TUBINIFORMIS, *Meek and Worthen.*

Page 160.

Fig. 7. Lateral view; natural size; the apex a little broken.
Fig. 8. Opposite view of another example.

POLYPHEMOPSIS PERACUTA, *Meek and Worthen.*

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Figs. 9 and 10. Opposite lateral views; natural size.

EUOMPHALUS RUGOSUS, *Hall.*

Page 161.

Fig. 11. Under view of a large example; natural size.
Fig. 12. Upper view of another, smaller example.

NATICOPSIS WHEELERI, *Swallow.*

Page 162.

Figs. 13 and 14. Opposite lateral views of a large example; natural size.

PLATYCERAS NEBRASCENSE, *Meek.*

Page 159.

Figs. 15 and 16. Opposite lateral views of a specimen attached to a fragment of a crinoid stem; natural size.

TEREBRATULA BOVIDENS, *Morton.*

Page 137.

Figs. 17, 18 and 19. Ventral, dorsal and lateral views; natural size.

ORTHIS PECOSI, *Marcou.*

Page 129.

Figs. 20, 21 and 22. Dorsal, ventral and posterior views of a large example; natural size.

SPIRIFER (MARTINIA) PLANOCONVEXA, *Shumard.*

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Fig. 23. A dorsal view; natural size.
Fig. 24. An outline lateral view.

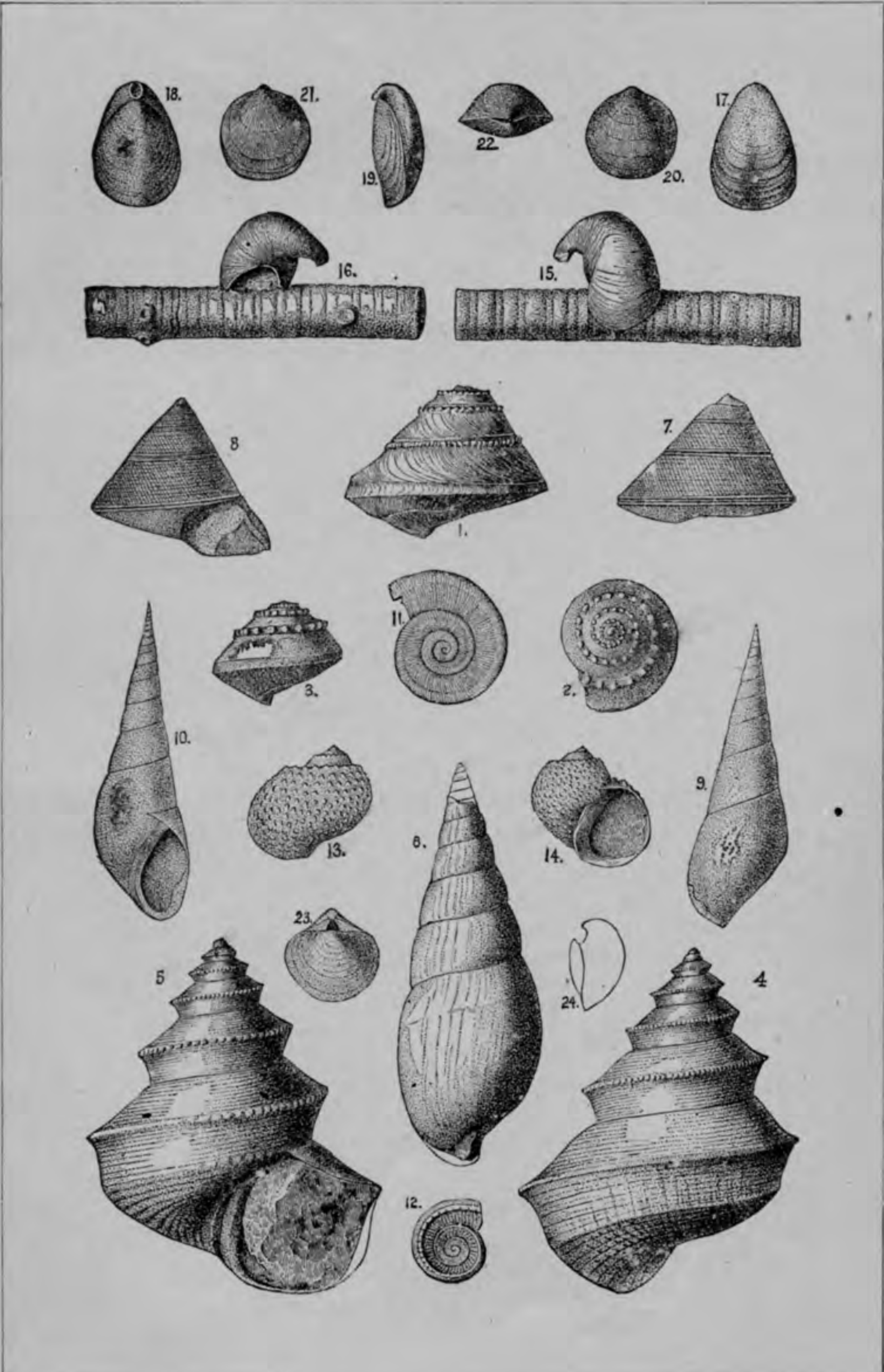
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PLATE 33.

BELLEROPHON CRASSUS, *Meek and Worthen.*

Page 157.

Figs. 1 and 2. Apertural and lateral views; natural size.

BELLEROPHON NODOCARINATUS, *Hall?*

Page 159.

Figs. 3, 4 and 5. Three different views of a large example; natural size.

BELLEROPHON CARBONARIUS, *Cox.*

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Figs. 6, 7 and 8. Three different views of Professor Cox's type specimen; natural size. The specimen has been a little distorted by pressure.

BELLEROPHON PERCARINATUS, *Conrad.*

Page 158.

Figs. 9, 10 and 11. Three different views of an example, showing the lateral as well as the median, nodular ridges.

Figs. 12, 13 and 14. Three different views of another example, without the lateral ridges. The figures of both examples are of natural size.

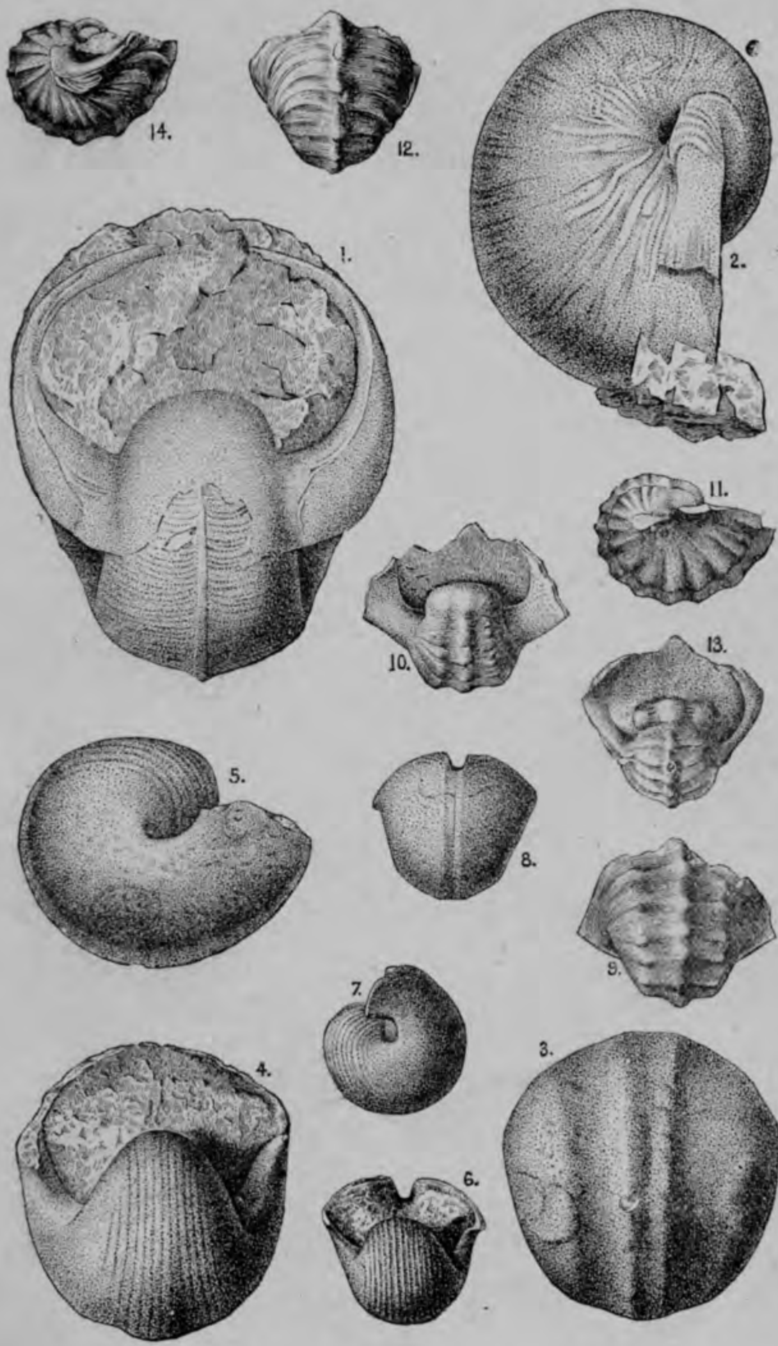
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PLATE 34.

MACROCHEILUS (SOLENISCUS?) PONDEROSUS, *Swallow?*

Page 156.

Figs. 1 and 2. Opposite views of a large example from Southern Iowa; natural size. The outer lip and a portion of the columella have been broken away, so that the obtuse fold of the latter is not clearly shown.

MACROCHEILUS (SOLENISCUS?) PRIMIGENIUS, *Conrad.*

Page 157.

Fig. 3. Lateral view; natural size; showing the columella bearing only a trace of a fold.

MACROCHEILUS (SOLENISCUS) FUSIFORMIS, *Hall.*

Page 154.

Figs. 4 and 5. Opposite lateral views; natural size.

Fig. 6. A similar view of another example. The outer portion of the last volution has been much broken away, showing the callus-thickened inner lip, the columellar fold, and broad groove more distinctly than they are shown in fig. 5.

MACROCHEILUS (SOLENISCUS) NEWBERRYI, *Hall.*

Page 153.

Figs. 7 and 8. Opposite lateral views; natural size. The outer portion of the last volution has been much broken away.

SOLENISCUS PLANUS, *White.*

Page 153.

Figs. 9 and 10. Opposite lateral views of an Illinois example; natural size. This form is perhaps identical with *S. Newberryi.*

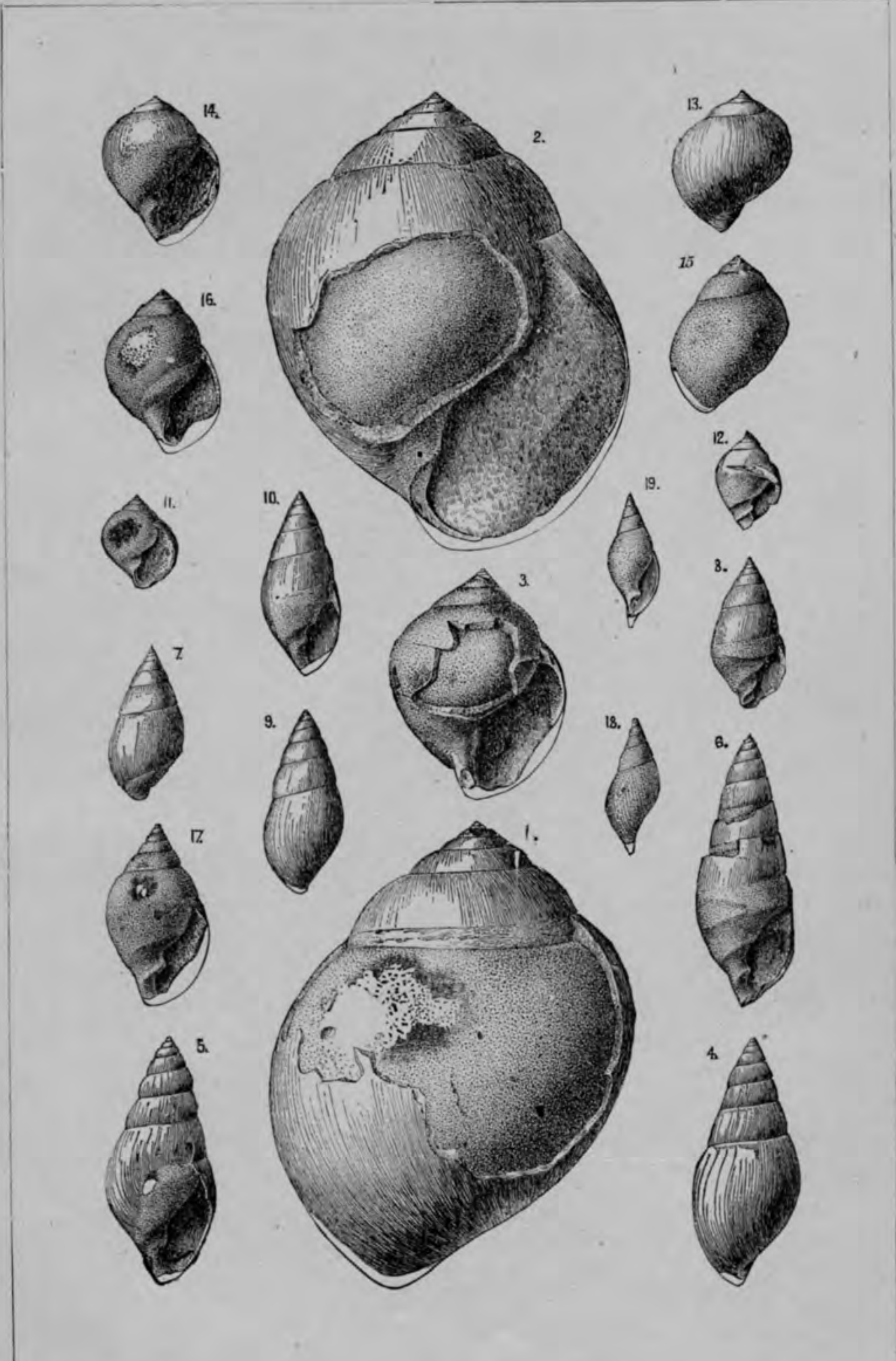
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PLATE 34—Continued.

MACROCHEILUS (SOLENISCUS) VENTRICOSUS, *Hall.*

Page 155.

Figs. 11 and 12. Opposite lateral views; natural size. The former of a nearly perfect example, and the latter broken so as to show the columellar fold and broad groove.

MACROCHEILUS (SOLENISCUS) TEXANUS, *Shumard?*

Page 155.

Figs. 13 and 14. Opposite lateral views of an Illinois example; natural size.

MACROCHEILUS (SOLENISCUS?) MEDIALIS, *Meek and Worthen.*

Page 151.

Figs. 15 and 16. Opposite lateral views; natural size. This example shows the thickened inner lip, but no proper fold.

MACROCHEILUS (SOLENISCUS) PALUDINÆFORMIS, *Hall.*

Page 154.

Fig. 17. Lateral view; natural size. The outer portion of the last volution removed, showing the fold and groove.

SOLENISCUS TYPICUS, *Meek and Worthen.*

Page 152.

Figs. 18 and 19. Copies of Meek & Worthen's original figures.

PLATE 35.

NAUTILUS MISSOURIENSIS, *Swallow?*

Page 166.

Figs. 1 and 2. Lateral and peripheral views of a fragment; natural size.

SPIRIFER CAMERATUS, *Morton.*

Page 132.

Fig. 3. Dorsal view of a large example; natural size.

Figs. 4 and 5. Ventral and dorsal views of another example; natural size.

ATHYRIS SUBTILITA, *Hall.*

Page 136.

Figs. 6, 7 and 8. Ventral, dorsal and lateral views of a typical example; natural size.

Fig. 9. Dorsal view of another larger example, showing two under valves of *Crania modesta* (page 121).

RETZIA MORMONII, *Marcou.*

Page 136.

Figs. 10, 11 and 12. Ventral, dorsal and lateral views; enlarged one quarter.

SPIRIFERINA KENTUCKENSIS, *Shumard.*

Page 135.

Figs. 13 and 14. Ventral and posterior views; natural size

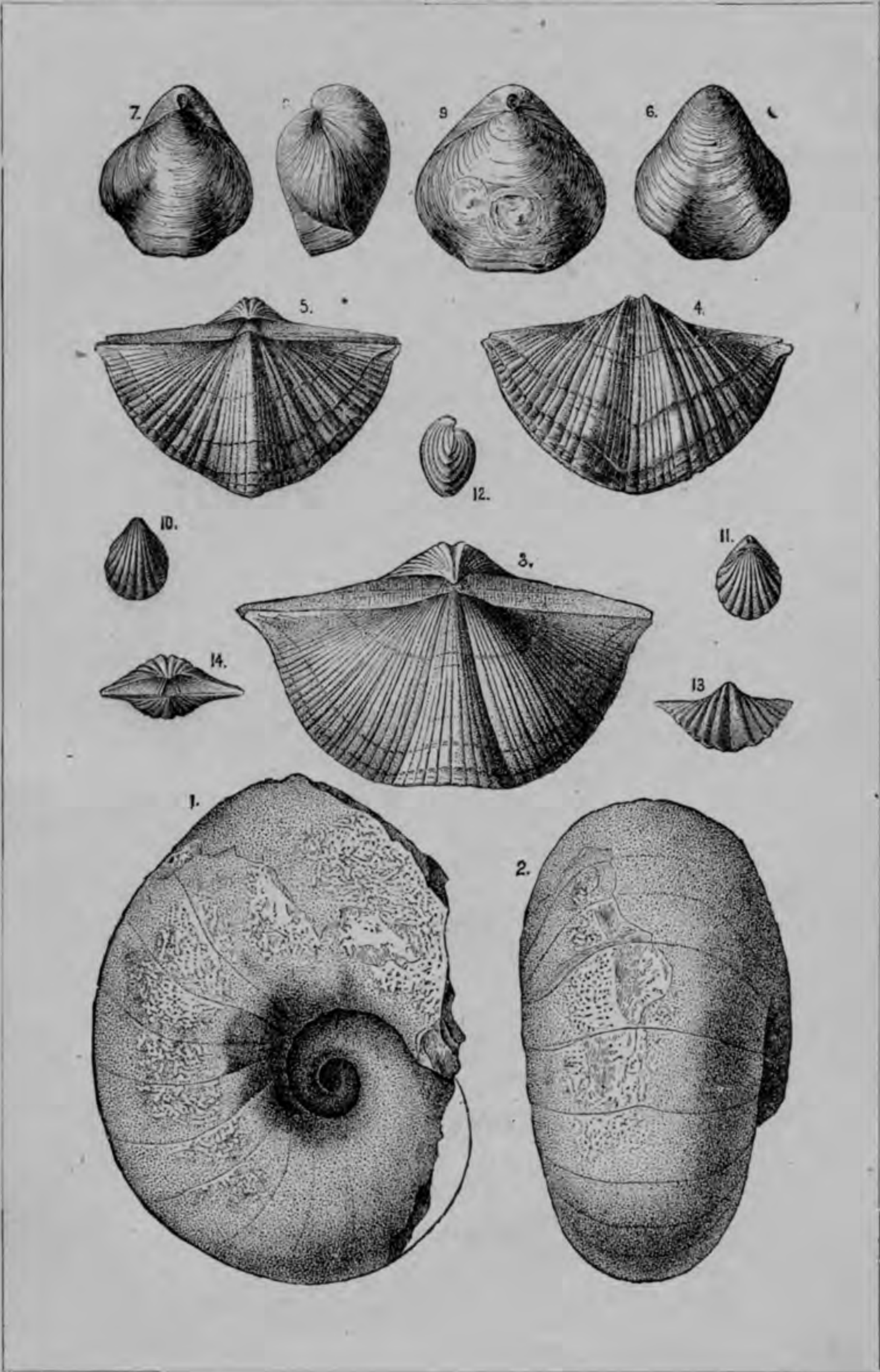
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PLATE 36.

NAUTILUS WINSLOVI, *Meek and Worthen.*

Page 165.

Figs. 1 and 2. Lateral and peripheral views of the type specimen; reduced about one-sixth.

NAUTILUS FORBESIANUS, *McChesney.*

Page 165.

Figs. 3 and 4. Lateral and peripheral examples of the inner volutions; natural size.

ORTHOCERAS RUSHENSIS, *McChesney.*

Page 164.

Fig. 5. Lateral view of a fragment; natural size. Four lower valves of *Crania modesta* (page 121) are seen attached to this specimen.

NATICOPSIS NANA, *Meek and Worthen.*

Page 162.

Figs. 6 and 7. Opposite lateral views; enlarged to about two diameters.

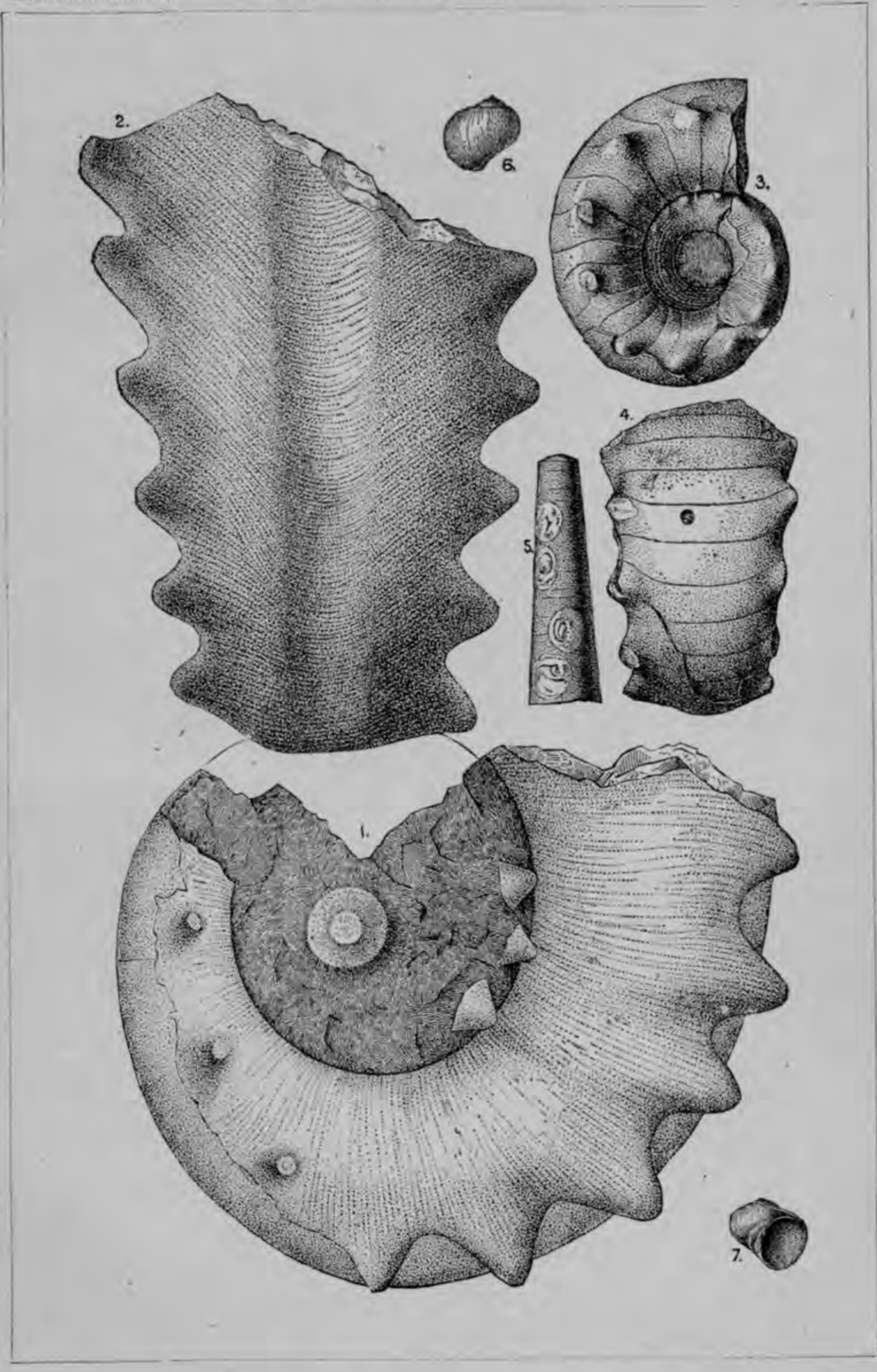
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PLATE 37.

EURYPTERIS (ANTHRACONECTES) MAZONENSIS, *Meek and Worthen.*

Page 168.

Fig. 1. Outline view of the type specimen, so far as it has been determined; natural size.

a, b, c. Crushed and broken legs, as they appear in the specimens; the divisions shown are not all natural articulations.

h, h, h, h, h. Impressions of the angular ends of the dorsal half of the body segments.

m. Hypostoma, in place.

p. One of the paddles or swimming feet imperfect. The division at *i* seems to be a natural joint.

gg. Basal segments of the swimming feet.

M. Mesial appendage of the operculum; 1, 2, 3 are its apparent articulations; *x, x,* and *t, t,* are lateral alæ of the operculum.

o. Position of the mouth.

Fig. 2. Hypostoma enlarged, to show surface sculpturing.

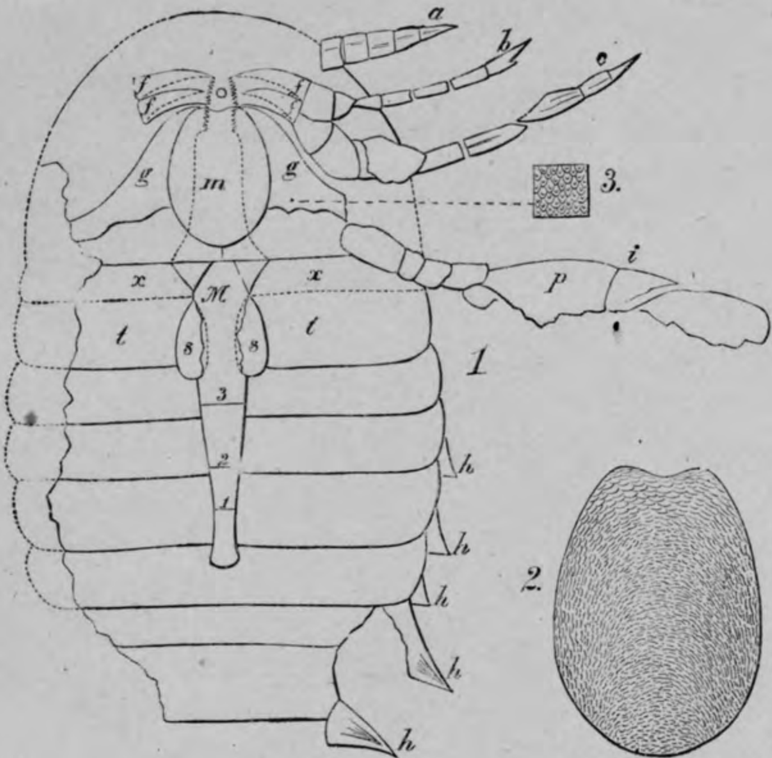
Fig. 3. A portion of basal segment of swimming-foot enlarged to show surface sculpturing.

ACANTHOTELSON STIMPSONI, *Meek and Worthen.*

Page 176.

Fig. 4. Dorsal view of a small specimen, a little enlarged, showing the telson and stylets spread out horizontally; also the legs similarly extended.

Fig. 5. Another example, enlarged three diameters; the animal having been laterally flattened.



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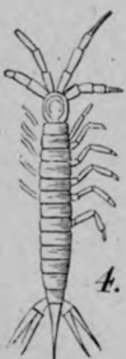

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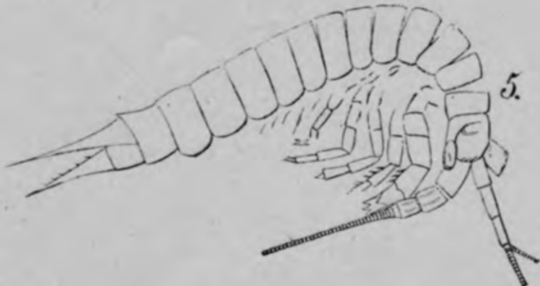

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PLATE 38.

PALÆOCARIS TYPUS, *Meek and Worthen.*

Page 179.

Fig. 1. View of the type specimen, enlarged to three diameters. The specimen has been compressed a little obliquely, so as to make the body segments a little too deep.

Fig. 2. The telson, caudal lamellæ, and last abdominal segment; all enlarged to four diameters.

Fig. 3. An abdominal swimming foot, enlarged to four diameters.

ACANTHOTELSON EVENI, *Meek and Worthen.*

Page 177.

Fig. 4. Dorsal view; natural size; showing the body, stylets and telson.

Fig. 5. Another example, that has been laterally crushed.

Fig. 6. Diagramatic view; showing anterior legs and antennæ; enlarged.

Fig. 7. One of the stylets of Fig. 4; enlarged.

ANTHRAPALÆMON GRACILIS, *Meek and Worthen.*

Page 180.

Fig. 8. Dorsal view; a little enlarged. The upper surface of the carapace is removed.

Fig. 9. Last abdominal segment and caudal parts of the same specimen; enlarged.

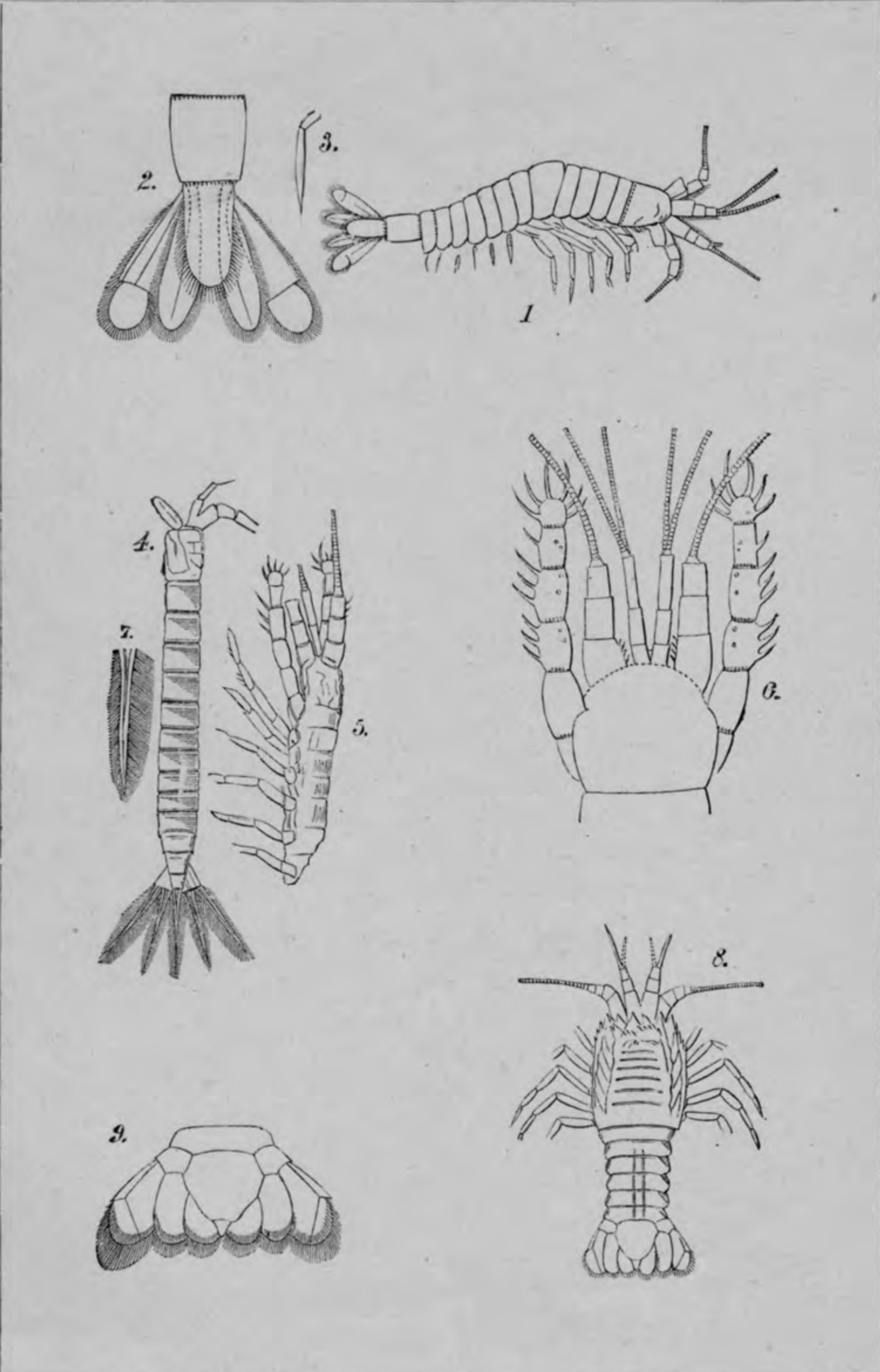
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PLATE 39.

EUPROÖPS DANÆ, *Meek and Worthen.*

Page 170.

Fig. 1. Dorsal view; natural size; partially restored.

EUPROÖPS COLLETTI, *White.*

Page 172.

Fig. 2. View of the type specimen; natural size.

DITHYROCARIS CARBONARIUAS, *Meek and Worthen.*

Page 178.

Fig. 3. Upper view of telson and stylets; natural size.

PHILLIPSIA (GRIFFITHIDES?), SANGAMONENSIS, *Meek and Worthen.*

Page 174.

Fig. 4. Upper view of the head; natural size.

Fig. 5. Similar view of the posterior portion of another example; with the anterior portion flexed under.

PHILLIPSIA (GRIFFITHIDES?) SCITULA, *Meek and Worthen.*

Page 173.

Figs. 6, 7, 8 and 9. Different views of a specimen, showing the body rolled together; natural size.

LEAIA TRICARINATA, *Meek and Worthen.*

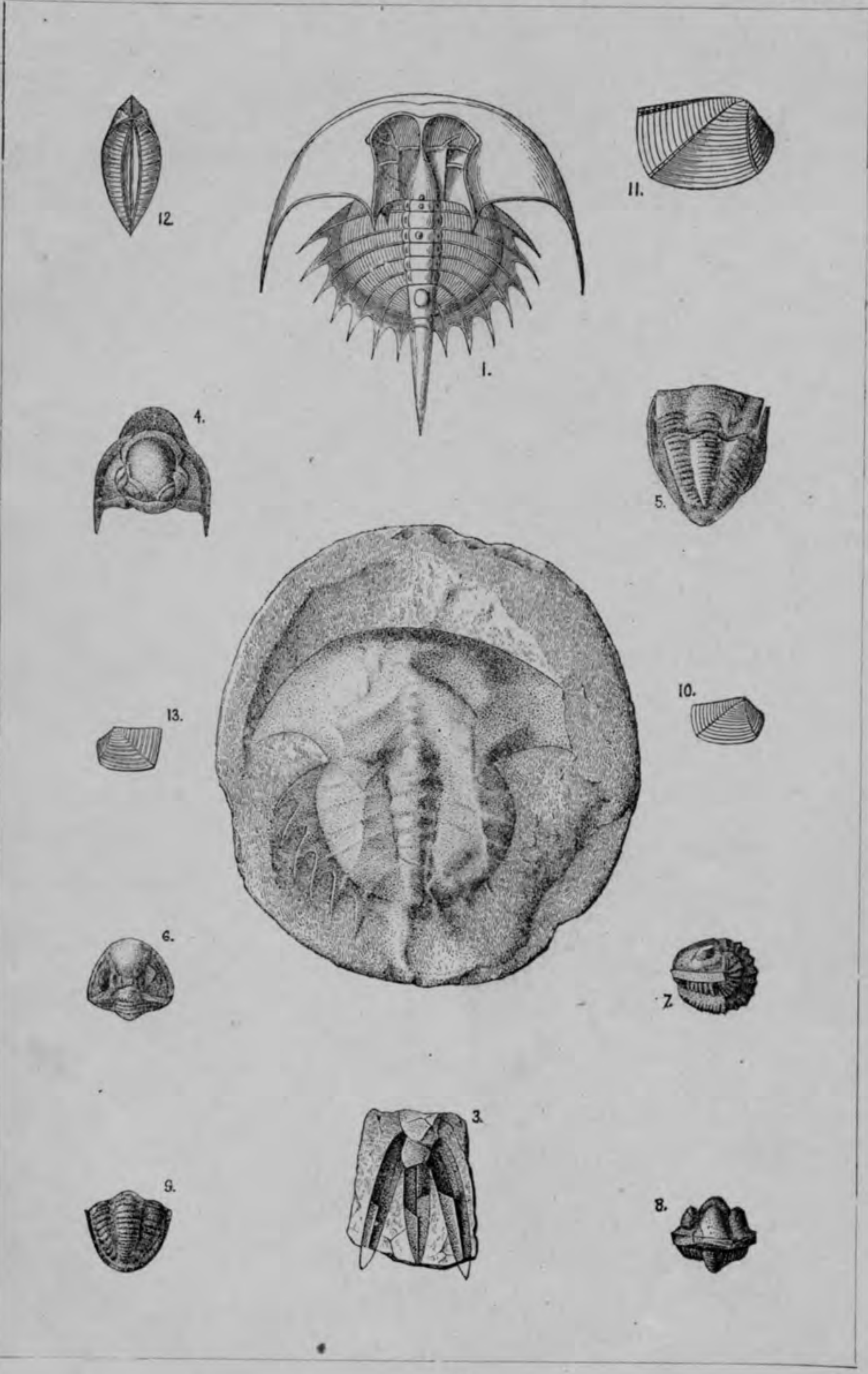
Page 167.

Fig. 10. Right valve; natural size.

Fig. 11. Another example; enlarged to two diameters.

Fig. 12. Dorsal view of another example; similarly enlarged.

Fig. 13. Left valve; natural size.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