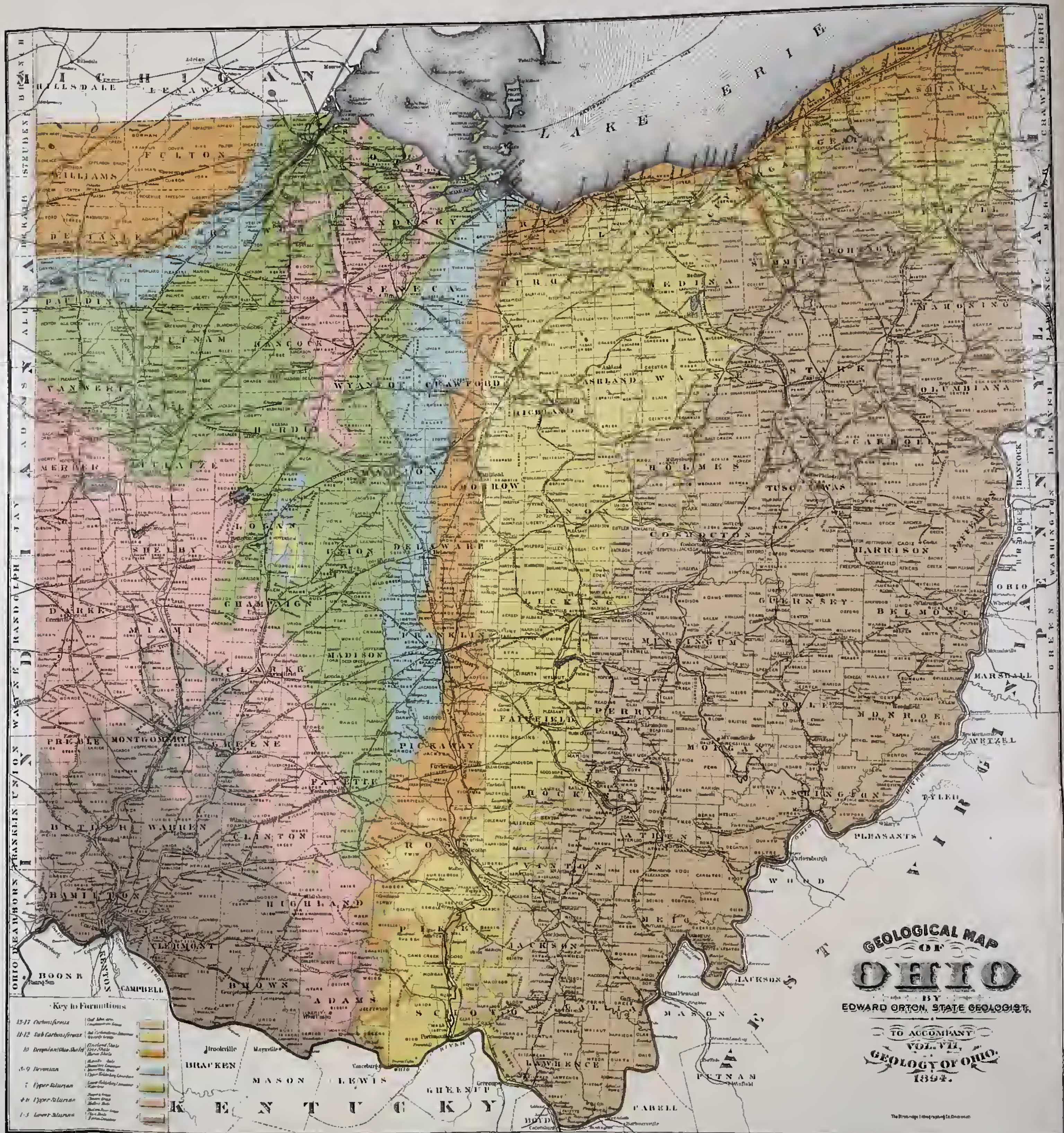
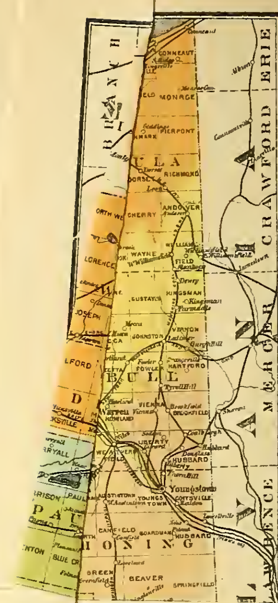

GEOLOGICAL MAP OF OHIO
BY
EDWARD ORTON, STATE GEOLOGIST.
TO ACCOMPANY
VOL. VII,
GEOLOGY OF OHIO.
1894.
Key to Formations
13-17 Carboniferous
11-12 Sub Carboniferous
10 Devonian (Ohio Shale)
Cleveland Shale
Erie Shale
Huron Shale
8-9 Devonian
7 Upper Silurian
4-6 Upper Silurian
1-3 Lower Silurian
LAKE ERIE
MICHIGAN
KENTUCKY
WEST VIRGINIA
INDIANA
PENNSYLVANIA


ERIE
CRAWFORD
MERCER
CONNEAUT
MONROE
PIERPONT
RICHMOND
ANDOVER
CHERRY
WAYNE
KINGSMAN
VERNON
JOHNSTON
HARTFORD
FOWLER
VIENNA
BROOKFIELD
HUBBARD
Youngstown
CANFIELD
BOARDMAN
BEAVER
SPRINGFIELD

REPORT

OF THE

GEOLOGICAL SURVEY

OF OHIO.

VOLUME VII.

ECONOMIC GEOLOGY.
ARCHÆOLOGY.
BOTANY.
PALEONTOLOGY.

PUBLISHED BY AUTHORITY OF THE LEGISLATURE OF OHIO.

NORWALK, OHIO,
THE LANING PTG CO , STATE PRINTERS.
1893.

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EDWARD ORTON, ... STATE GEOLOGIST.

ASSISTANTS.

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Mapping Coal Fields, . . PROF. C. N. BROWN, in charge.
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" " " . . A. F. FOERSTE, Ph. D.
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" . . . . PROF. E. W. CLAYPOLE.
" . . . . E. O. ULRICH.

PREFACE.

It becomes my duty to set forth in this preface a brief account of the present volume, to explain its composite character, in which it differs in some respects from all its predecessors, and, as it is the last official volume that I expect to prepare, to briefly point out the lines, along which the work of the Geological Survey has advanced, and the results that have been thus far attained. By the numbering under which it appears the present volume is counted in with the reports that have preceded it during the last 21 years; but as a matter of fact, it is the outcome of a distinct organization of the geological work of the State.

The Second Geological Survey was organized in 1869 and was under the direction of the late Professor J. S. Newberry up to 1883, although his active work upon it was substantially terminated in 1876. Under Dr. Newberry's direction, Reports of Progress for 1869, 1870 and 1871, and Volumes I, II, III and IV were issued; including also Volumes I and II, Paleontology, togther with a geological map of the State, on a scale of four miles to the inch. In direct continuance of this work, volumes V and VI were issued, under my direction as State Geologist, in 1884 and 1888 respectively. A preliminary report on Petroleum and Gas was also published in this series in 1886.

The Second Geological Survey nominally terminated in 1888, with the publication of Volume VI; but in the subsequent year (1889) provision was made by the Legislature for the continuation of geological work on a small and inexpensive scale, the results to be made known by annual reports. The direction of this work was placed in my hands, but provision was made for only a part of my time. A report was issued in 1890, entitled "First Annual Report of the State Geological Survey, Third Organization." Shortly before the time for publication of the second annual report, I was disabled in health to such a degree that it no longer seemed advisable for me to continue the double duty which I was carrying on; and permission was accordingly obtained from the 70th General Assembly to publish the material gathered for the Second Annual Report together with certain other chapters, presently to be named, under the title of Geology of Ohio, Volume VII.

It was the original plan of my predecessor, Dr. Newberry, to divide each volume of his reports into two parts, the first covering general geology and the second; paleontology. In pursuance of this plan, Volumes I and II were issued in two parts, or, in reality, in two distinct volumes, the volumes in fact, differing in size and in other respects. But when the time came for the publication of Volume III, the finances of the State had become somewhat straitened, and the legislature to which the volume was offered was disinclined to incur the large expense, viz., about $60.000, necessary for publishing the paleontology on the scale on which the two preceding volumes had been issued. The Legislature, however, authorized the publication of the general geology part 1, under the title of Volume III. Considerable material had been prepared under Dr. Newberry's supervision for the paleontological part of this volume. A chapter prepared by Prof. R. P. Whitfield of the American Museum of Natural History, New York, after having been held for several years without any indication that the State would undertake to issue it, was finally published in the Transactions of the New York Academy of Sciences. The edition thus issued was not, of course, designed for general distribution and but few copies could have found their way to Ohio. Through the courtesy of the Academy, I have been enabled to reproduce Professor Whitfield's chapter, and also to use the engraved plates, prepared for the Academy's Transactions. This constitutes Chapter III, Part II, of the present volume. It will be borne in mind that it was originally prepared under the direction of Dr. Newberry and at the expense of the State, for Volume III, Paleontology. When the plates were ordered for this chapter, the preparation of my Second Annual Report was in progress, and the plates are accordingly priuted as belonging to the Second Annual Report. The Survey is greatly indebted to the courtesy of the New York Academy of Sciences in this matter.

A similar state of things was found in the case of a chapter prepared by Mr. E. O. Ulrich of Newport, Kentucky, except that he had received no compensation for his work, this being made to depend on the publication of Volume III. I have made good the promise of Dr. Newberry in this respect, also, and Mr. Ulrich's chapter, viz.: chapter VII, will be found to be of great service and value to students of Ohio paleontology.

Three other paleontological chapters I have been able to add to Volume VII. through the generous and gratuitous contributions of the gentlemen named below, Prof. C. L. Herrick, of Denison University, has thrown a great deal of light on the history and subdivisions of the Waverly group of our series by his methodical study of the paleontology of its different elements. The materials embodied in his chapter had been previously published, in the main, in college bulletins; but they become for the first time accessible to the State at large in the present chapter, viz., Chapter IV, Part II.

Similar statements can be made as to Chapter V, prepared by A. F. Foerste, Ph. D. He treats of the paleontology of a single formation of the Ohio scale, and makes additions to our knowledge, of great interest and value. Part of his chapter has been previously published in transactions of societies; but the same statement applies to it as to the preceding chapter.

Finally, Prof. E. W. Claypole of Buchtel College, contributes a very interesting chapter, viz., Chapter VI, on the great fossil fishes of the Ohio shale. With his chapter there is also included an important contribution in the same line by Prof. A. A. Wright of Oberlin. This chapter may be counted a direct continuation of the work in which Dr. Newberry was so deeply interested, and to which he gave so much time and space in the previous reports of the Survey.

The paleontological chapters thus enumerated are as follows:

Chapter III, Contributions to the Paleontology of Ohio, by Prof. R. P. Whitfield (originally prepared for Volume III, Paleontology).

Chapter IV, The Waverly Group of Ohio, Prof. C. L. Herrick.

Chapter V, The Clinton Group of Ohio, Dr. A. F. Foerste.

Chapter VI, Fossil Fishes of the Ohio Shale, Professors E. W. Claypole and A. A. Wright.

Chapter VII, Lamellibranchiata of the Lower Silurian Formation of Ohio, E. O. Ulrich (originally prepared for Volume III, Paleontology).

The cost of each of the two volumes of Paleontology previously published was at least $60,000, the editions being 20,000. The present volume has been printed in an inexpensive form, and the full equivalent of Volume III, Paleontology, is now furnished to the people of the State at scarcely greater cost than a volume without illustration would require. The choice was necessarily made between a volume issued in this way and no publication of paleontology.

In making up my final volume I found that chapters had been promised on certain other subjects, by the organizations of the Surveys, with which I have been connected during the last twenty-five years. In Newberry's First Report of Progress, 1869, he named among the subjects that were to be studied and reported upon, the Archæology of Ohio. This promise also I have been able to make good, by the publication of a sound and judicious chapter on the subject by Mr. Gerard Fowke. Mr. Fowke has been for many years in the employ of the Ethnological Bureau of the Smithsonian Institution, Washington, and is an expert on all the questions which he discusses. Through the courtesy of the United States Bureau above named, Mr. Fowke was allowed to make free use of the information he had collected while in its employ. The present chapter was thus prepared at merely nominal expense on the part of the State.

The publication of Volume IV of the main series of our reports was ordered by the Legislature on the promise that it should contain an account of the Zoology of the State and also a list of the plants growing within its boundaries. It was accordingly named in the act authorizing its publication," "Volume IV, Zoology and Botany." A botanical list had been duly prepared for the volume by the late Dr. H. C. Beardsley of Painesville; but when the printer called for the copy, it had been in some way mislaid, and was not recovered in time for publication with the rest of the volume. Thus the volume entitled "Zoology and Botany" finally appeared without a line pertaining to the last named subject. This deferred promise I have also been able to make good. Prof. W. A. Kellerman of the Ohio State University, assisted by Mr. W. C. Werner, of the same institution, took upon themselves, without any compensation from the State, the great labor involved in making out a list of Ohio plants. This work has been done with the greatest enthusiasm and fidelity. It combines all the facts of previously published lists with a considerable addition of original determinations, making the list far more complete than any that has appeared hitherto.

Part II of the present volume is thus largely devoted to making good the promises made by the Survey to the State during the last twenty-five years; and while in no way personally responsible for any of these promises, it is a great satisfaction to me to see them amply fulfilled in my last volume.

Part I of the present volume is devoted to Economic Geology. It includes a chapter on the Geological Scale of the State, and is accompanied by a small geological map, printed in colors. It also includes a chapter on the Clay Deposits, and one on the Coal Measures of the State, prepared by the writer. To these there is added an especially valuable chapter on the Clay Working Industries of Ohio, by Edward Orton, Jr.

A large portion of the appropriation made for the preparation of this volume has been used in the construction of maps showing the boundaries of our more important coal seams. These maps, therefore, constitute an integral and important part of the volume. In regard to them and the service that they can be made to render to the economic interests of the State, a few statements are necessary at this point.

In their construction a great deal of faithful labor has been expended. All the outcrops indicated were traversed on foot, with barometer and township map in hand, and the aid of the landowners was constantly sought in securing the results of observations and tests as to the presence of coal seams on their respective farms. The question as to whether the coal had been mined or is still left in the ground is not touched in the maps. They are designed to show the original outcrop boundaries of the seams. Thus, also, it comes about that seams are represented in some areas where they are too thin for working, under present conditions. Their presence as geological elements in the section is sometimes all that can be asserted; but, whenever practicable, the thinner extensions of the seam are left out.

In Chapter IV, Part I, page 270, a classification of our coal seams will be found. The coal seams of the Conglomerate Coal Measures, though possessing great importance at a few points in the State, are not delineated, except in a single instance on the present series of maps. These seams are four or five in number, and one of them, viz., the Sharon coal (Coal No. 1 of Newberry), has been an important element in our coal resources up to the present time. But all the known areas of it are either already worked out or are rapidly approaching exhaustion. It could answer no useful purpose to delineate the original boundaries of exhausted coal fields, and the known portions of the seam that remain untouched would appear insignificant if laid down by themselves.

The Quakertown coal (Coal No. 2 of Newberry) attains considerable importance in one district of the State, viz., in Jackson and Vinton counties. It is here known as the Jackson Hill or Wellston seam. Its areas, at least as they were understood two years ago, are indicated on Map No. 2, by a subordinate boundary.

The remaining seams of this division, viz., the Mercer and Tionesta coals, are nowhere of importance enough to justify their representation on our maps from an economic point of view.

The next great division, the Lower Coal Measures, constitutes the heart and center of the Ohio Coal Field; but the two lowermost seams of this series are too inconstant to justify representation. In Stark county the Brookville seam, or the coal under the Putnam Hill Limestone is locally mined, but such is its uncertainty that no good purpose could be subserved by representing it much beyond its present development.

A similar state of things is found in the case of the Clarion coal in Vinton and Jackson counties. This seam underlies the famous Ferriferous limestone and there is a considerable territory in which it gives promise of being able to support mining in the large way, but it was feared that more harm than good would come by representing it as present in unexplored areas in which while it is geologically due, it has not been proved. The Kittanning coals, Lower and Middle, therefore, are the first seams to which the mapping has been made to apply. Inasmuch as the upper of these two seams, viz., the Middle Kittanning, is immensely the more important of the two, its outcrops are the ones that are represented. But, as already noted elsewhere, the lower seam is separated from it by so small a vertical interval that the one boundary answers almost equally well for both.

A similar state of things is found to hold in the case of the two Freeport seams, Lower and Upper. The Upper, which is by far the steadier and more valuable seam, is represented by a boundary, but whenever the Lower is present in the same areas, the one boundary is generally sufficient for all practical guidance. It is to be carefully noted by all who study the maps, that where the Kittanning and Freeport boundaries appear on the same maps, the boundaries of the former are in all cases to be continued through the areas which are assigned to the Freeport coal.

It would have been more satisfactory if each seam could have had a sheet to itself, but the demands of economy in the accomplishment of our work, necessitated the adoption of the present plan.

The great Pittsburg seam as a matter of course, comes in for a boundary in our maps, as does also another seam a hundred feet above it, which is well developed in three or four counties in the very centre of our coal area. The latter is known in Ohio geology as the Meigs Creek coal. Finally, on map No. 10, the collected areas of the several seams are shown in their outcrops.

In the representation of each seam, the object has been to delineate the boundaries of those portions of it that lie above the natural drainage, but far more care has been taken in running the outcrop or upper boundary than in running the lower, for the reason that when this lower boundary occurs, the character of the territory is already established, as certain to be within the recognized boundaries of the seam. In the drainage boundary there are always enough points definitely located to justify the position given to this line in a general way.

In several of the maps, and notably in Nos. 7 and 8, there has been a slight departure from the general plan in the following particular, viz., the Kittanning coal is indicated in areas where it has descended below drainage, but where one or both of the seams are still known to exist. It would perhaps have been better to have maintained the same system throughout the entire field; but persons of intelligence enough to take interest in the maps will scarcely be misled by the features named. All of the maps are drawn to one scale, viz., two miles to one inch, except maps 9 and 10. Among the advantages to be derived from them, the two named below are especially prominent.

1. *The continuity of the various seams, and their identity with well known seams of adjoining states is fully and finally demonstrated.* Since the publication of Volume V, in 1884, there has been, in fact, no adequate ground for doubt in regard to this subject. The connections of the main seams were fully recognized and they were continuously traced in a general way at that time; so that no open minded student of our geology has since that day, been in doubt as to the true order, but the present maps, with their unbroken lines of outcrop, make the whole subject so plain that even the wayfaring man can henceforth have no excuse for mistaking or confusing their places in the system. The propriety of replacing the local and numerical designations of our coal seams with the names first given to the same seams in Pennsylvania, is fully established by these maps. The laws of scientific nomenclature do not allow us to multiply names unnecessarily for one and the same object. A fossil must always be known by the first name given to it, in connection with adequate description and publication. So, also, an identifiable stratum must retain the designation under which it was first made known to the scientific world. This common law requires us to adopt the Pennsylvania designations of our coal seams, because the latter were first described in Pennsylvania. The Pittsburg and the Sharon seams, especially the former, have always been known in Ohio by their Pennsylvania names, but from lack of knowledge of the true equivalents of the remaining seams, local names and worse than this, numerical designations that have not even the merit that one and the same number is applied to one and the same seam in all instances, have been fastened upon them, and thus the recognition of their identity has been seriously obstructed. In conclusion, it can truly be said that these questions are permanently settled for both the practical man and the scientific student by our maps.

A few questions of subordinate interest remain as to the proper places in the scale of certain seams in particular fields, but the large questions have passed from debatable ground into demonstrated certainties.

2. The second and by far the more important service that these maps are able to render is found in the fact that *they, for the first time, make it possible to determine the areas of our several coal fields.* The areas above drainage can be directly measured, by cutting them out of the maps, with proper care, weighing the several areas in a chemical balance, and comparing their weight with that of some standard area; or, better still, they can be determined by the use of the planimeter. Prof. C. N. Brown has at my instance applied this instrument to the maps under consideration, and the results which were thus attained will forthwith be stated.

Our coal seams cannot, however, be supposed to terminate abruptly with their disappearance below drainage. Some extension of them under cover is believed in by everyone; but very different judgments will be formed by different observers as to the limits within which they can be reasonably expected. Theoretical views will color our opinions on such a question. An estimate made by one who holds to the essentially marginal character of our coal deposits will differ widely from an estimate made by another who counts it entirely possible that all the seams of the Ohio scale could be cut by a single shaft at the center of the field. Any measurement of the acreage of our coal resources must, therefore, in this respect, be a matter of judgment; and so, also, will be the fixing of an average thickness of our seams in the several fields.

In making an approximate determination of our coal lands on this new basis, I have, in the first place, assumed a total breadth of the coal-forming swamps of twenty miles, measured from the average outermost outcrop of the seam, in the direction of the greatest dip. This shows a somewhat larger area of the seam under cover than above drainage. The coals would thus be followed down to a depth of 200 to 300 feet below the surface. It does not seem to me that the most sanguine student of the facts would ask for a larger extension of any of our seams that have been treated in this way, unless an exception be made for the Upper Freeport Coal. The Freeport coals seem to have had a somewhat different history from that of the earlier seams, and for them it is possible that the assigned limit will sometimes be too narrow

The areas assigned to the Pittsburg coal are deduced rather from reported occurrences of the seam in deep borings than from any theoretical views.

In the second place, I have had the areas of the seams in question measured as they are found above drainage or rather until they are fairly under final cover. The boundaries on which this measurement depends are visible and unquestioned.

With areas of coal seams computed in square miles, and with the thickness of each estimated in feet, the problem of determining the quantity of coal in township, county or state, becomes a simple one. The specific gravity of Ohio coals ranges between 1.24 and 1.34. I have taken 1.28 as a fair average. On this basis a cubic foot of coal weighs eighty pounds. An acre of coal one foot thick, yields about 1,750 tons, and a square mile 1,120,000 tons.

The two Kittanning seams show, on the first basis a total area of 3,873 square miles; on the second basis, of 1,847 miles. For the combined thickness of the two seams calculated for this area, I count four feet a fair figure. The contents of the field are, therefore, 17,350,000,000 tons, by the first computation and 8,274,000,000 by the second.

The Freeport coals show, on the first basis, an area of 3,149 square miles, and 1,285 miles by the second. I assume four and one-half feet for the total thickness of this area. The original amount of Freeport Coals in Ohio, is, therefore, 15,880,-000,000 tons by the first computation and 6 476,000,000 tons by the second.

The Pittsburg coal, with an estimated thickness of four feet, has a computed area of 1,250 square miles, and a tonnage of 5,600,000,000 tons. Finally, the Meigs Creek coal shows a tonnage of 2,777,000,000 tons, on an area of 620 square miles and with a thickness of four feet.

The sum of these several results exceeds 40,000,000,000 tons by the first computation and 23,000,000,000 by the second. The total acreage of the measured seams of the State is 8,893 square miles by the first measurement and 5,032 square miles by the second, and the average thickness is estimated as four feet.

But, even were these figures entirely within the mark, there would be large abatements necessary in the computation of our coal resources. In all coal mining a certain percentage of loss must be provided for. It never falls below ten per cent., and it sometimes reaches forty per cent. I will estimate the loss in Ohio mining at twenty per cent.

Again, all of our seams have suffered more or less loss from erosion that took place during or immediately succeeding their formation, and this may be styled contemporaneous erosion. The losses in our best fields from this source are considerable. I will put them at ten per cent. Finally, "wants" occur in every field, and, including in this reduction the areas that have already been worked out, I should be disposed to reduce the figures by at least twenty per cent. These three sources of loss make a total abatement of fifty per cent., thus leaving an available supply of

20,000,000,000 tons by the first computation and 12,000,000,000 tons by the second. Even when thus reduced, the figures pass far beyond all intelligible conception.

For how long a time would such amounts of coal last? That, of course, depends upon the rate of annual consumption. In 1892, the output of Ohio mines was 13,500,000 tons. Since mining has been going on in the large way in the State the production has been doubled in periods of about ten years. At this rate the annual production will reach 25,000,000 tons a year, early in the twentieth century. Supposing it to run steadily at this point, Ohio coal would last about eight hundred years on the basis of the first measurement and less than five hundred years by the second. But, if the rate should continue to advance as it has done heretofore until an annual output of a hundred million tons is reached, the duration of the supply would be correspondingly diminished, viz., to two hundred and one hundred years, respectively.

I look to see our mining engineers avail themselves of the above named boundaries, now for the first time provided for them, and proceed along different lines of theory and investigation to determine the coal resources of particular fields or definite areas.

In conclusion, a few words will be devoted to a review of what has been already accomplished by the several geological surveys of this State, and to a brief consideration of what remains to be done.

1. The general stratigraphical order of our several formations is now fairly well determined; so far, at least, as their occurrence within our State boundaries is concerned. Their correlation with the series of neighboring states leaves something to be desired. This is especially true of the northeastern corner of Ohio.

2. The leading features of our economic geology have been set before the people of the State so that land owners of ordinary intelligence can acquaint themselves with the probable value of their mineral resources. They are no longer at the mercy of men who are able to take advantage of their ignorance.

3. The salient features of our paleontology have been made intelligible to all of our people who take an interest therein.

As to what remains to be done in Ohio geology, it is difficult to speak. The science of geology is constantly lengthening its cords and strengthening its stakes. Every line of investigation opens up larger questions than those which it directly undertakes to settle. New methods of research are coming into use, and old problems must be reconsidered by their aid. It is only the generalities of our geology that have been thus far attacked. Deeper and more thorough work will be demanded in every subdivision of every field. It remains to be seen how much of this more refined study will be carried on at the public expense under State direction. Speculation upon this point is unnecessary.

There are, however, several subjects that could well bear more investigation of the type that has been thus far maintained than they have received. The Lower Helderberg limestone and the Ohio Shale, in particular, furnish excellent subjects for more careful stratigraphical and paleontological determination.

The drift formations, glacial and post-glacial, of the State, have thus far been studied in a very superficial way. It is but recently that methods have been devised for taking better account of their complex history. Closely connected with these deposits, is the consideration of the pre-glacial drainage systems of the State. The little study that has already been given to these subjects reveals their highly interesting character. Further investigation in these lines is sure to bring ample reward.

It cannot be denied that during the progress of the survey, the great interest of Agriculture has received less direct attention than, in the beginning of our work, it was led to expect and much less than its intrinsic importance would warrant it in demanding. There are two principal reasons for this neglect, first, that the geological work proper of the survey has always thus far required the full amount of time and means that were available; second, that the knowledge necessary for thorough scientific work in this direction could not be easily commanded. In short, it may be true that the time has not yet come for a satisfactory treatment of the important relations between geology and agriculture, but the subject is to be kept in view as one of the unfinished problems of the survey. A beginning could perhaps be made with profit at the present time in a preliminary classification of the soils of the State in connection with their native floras. Such a task would require adequate acquaintance with and adequate interest in the several branches involved which include agriculture, botany, meteorology, geology, chemistry and some divisions of zoology.

The building-stones of the State have not received the attention that their growing importance demands. No review has been made of them since the publication of volume V, and the treatment at that time was far from satisfactory, having been condensed from a report made for the 10th United States census. A good beginning of a new chapter on this subject was made four years since by the writer but the loss of the field notes before they were put in shape brought this purpose to naught.

The recent discovery of rock salt in northern Ohio and the establishment of an important business upon this unexpected occurrence have been alluded to in the opening chapter of the present volume, but the facts justify a more extended account for which, to my regret, time and space do not now suffice.

The production of petroleum and gas has been by far the most interesting and important subject in the economic geology of the State during the last ten years. Three separate volumes of the Survey reports have been devoted almost exclusively to it within this period, viz.: Preliminary Report, 1886, Vol VI, 1888, and First Annual Report, 1890. The development has gone on with unabated vigor since the publication of the last volume and a rich harvest of facts remains ungarnered at this time, but the exclusive privileges of this subject could not be further continued without doing injustice to other economic interests. I greatly regret that I have not been able to follow with proper care and detail the progress of the drill during the last four years. I also regret that the want of space forbids the introduction of such of these facts as I have in hand into the present volume.

Two oil fields of considerable importance have been brought to light within this time, viz.: The Monroe county and the Corning fields.

The Monroe county oil is derived from the Logan Conglomerate which is known in the adjacent Sistersville oil field of West Virginia as the "Big Indian" sand. It is identical with the salt water rock of Pomeroy, and also with the great salt water horizon of the Macksburg oil field. Its outcrops constitute the most striking feature in the scenery of the Hocking Valley from Lancaster to Logan and are also finely shown in the picturesque gorge of the Licking river between Newark and Zanesville.

The Corning field derives its oil from the Berea Grit, which is reached in wells about 1,000 feet in depth. These wells produce a moderate quantity of rather heavy oil but they seem to show fair vitality.

The principal feature of the last four years in this connection is, however, the continued development and expansion of the oil production of the Trenton limestone in northwestern Ohio. This production is beyond question the most striking and surprising fact in the economic geology of the country for the last twenty-five years. Ten years ago, it would not have been possible to make a more improbable forecast as to the future oil supply of the country than one which should embody the results of our present experience. The black swamp of northwestern Ohio is at this time the leading source of the illuminating oil of the United States and the source of this oil is found in a lower Silurian limestone.

The last four years have not given us new oil fields in the Trenton limestone so much as important extensions of those already discovered. The counties which were named in the report of 1890 as the chief sources of supply still constitute our main reliance. The principal generalizations that the opening years of this development seemed to warrant have been in the main confirmed and established by the later experience, but a proper study of the newer facts cannot fail to throw important light on the geological conditions of petroleum accumulation.

At the date of the last report, viz., 1890, many facts were adduced showing the rapid decline of the wonderful supply of natural gas that several counties of northwestern Ohio were then enjoying, from which decline the speedy extinction of the supply was inferred, so far as its large use in manufactures was concerned, unless the unworthy applications and reckless waste that were then going on should be promptly arrested. These warnings were disregarded; in one or two instances, they were even resented, as likely to interfere with enterprises that were under way.

The event has proved, however, that the facts that were then apparent were correctly interpreted. The decline went on steadily. Most of the glass factories for example, that were brought into the district on the promise of free fuel have been abandoned or removed. The few that remain are eking out the feeble gas supply with coal, wood and oil. Pumps have been added to almost all of the pipe lines, but even with their aid it has proved impossible to maintain an adequate domestic supply for all consumers during the last two winters.

The outcome is indeed a sorry one. Under judicious control, the gas stored in the Trenton limestone might easily have supplied all northwestern Ohio with the unspeakable advantages of gaseous fuel for household use for at least a quarter of a century. Household use is the highest and, in reality, the only proper use to which natural gas can be applied.

It is a relief to be able to name one gas-field in the state that has, in the main, escaped the prostitution and abuse which all the older fields have suffered. The Thurston field of Fairfield county deserves this distinction. It has supplied gas in large amount, to the city of Columbus, for household use, since January, 1890. For a few months in the summer and autumn of that year, gas was also furnished to manufacturers in various lines, as iron-working, brick-making, lime-burning and the production of steam for power, but under these demands, the supply soon gave unmistakable evidence of being overtaxed. Pressure and volume in the wells and pipe-lines rapidly fell away, and the large consumers were, one after another, obliged to return to coal. The pressure continued to fall until domestic use became dangerous and finally the gas was shut off from the city altogether.

After being closed a few weeks, the wells regained their pressure, but the company had learned by disastrous experience, that it could not maintain the domestic supply of the city and at the same time furnish fuel for rolling mills and brick kilns. Household supply was forthwith resumed and it has not been interrupted for a single hour during the past three and one-half years. The field gives every indication of maintaining the supply for many years to come. Fully half the population of Columbus is now enjoying the inexpressible advantages of an ample and constant supply of gaseous fuel.

Questions are often asked as to the number and order of the reports of the Geological Survey of the State under its several organizations. A list of these publications is given herewith.

Title.	Date.	No. pages.	No. copies.	Geologist in charge.
FIRST GEOLOGICAL SURVEY—1837-8.				
1. First Annual Report..........	1838	134	5,000	W. W. Mather.
2 Second Annual Report........	1838	236	5,000	W. W. Mather.
SECOND GEOLOGICAL SURVEY—1869-1888.				
3. Report of Progress............	1869	176	14,500	J. S. Newberry.
4. Report of Progress............	1870	568	14,500	J. S. Newberry.
5. Report of Progress.....	1871	3	400	J. S. Newberry.
6. Geology of Ohio, vol. I, part II Geology.....................	1872	680	20,000	J. S. Newberry.
7. Geology of Ohio, vol. I, part II Paleontology...............	1873	401 49 plates	20,000	J. S. Newberry.
8. Geology of Ohio, vol. II, part I Geology.	1874	701	20,000	J. S. Newberry.
9. Geology of Ohio, vol. II, part II, Paleontology..............	1875	431 59 plates	20,000	J. S Newberry.
10. Geology of Ohio, vol. III, Geology.........................	1878	958	20,000	J. S. Newberry.
11. Geological Atlas of Ohio....	1879	....	5,000	J. S. Newberry.
12. Geology of Ohio, vol. IV, Zoology and Botany........	1882	1,070	20,000	J. S. Newberry.
13. Geology of Ohio, vol. V, Economic Geology.........	1884	1,124	10,000	Edward Orton.
14. Preliminary Report on Petroleum and Inflammable Gas..............................	1886	76	2,500	Edward Orton.
15. Geology of Ohio, vol. VI, Economic Geology.........	1888	831	15,000	Edward Orton.
THIRD GEOLOGICAL SURVEY—1889-1894.				
16. First Annual Report..........	1890	323	10,000	Edward Orton.
17. Geology of Ohio, vol. VII, part I, Economic Geology.	1893	290	2,500	Edward Orton.
18. Geology of Ohio, vol. VII, (complete.).....................	1894	970	7,500	Edward Orton.

All of these volumes have been published by the State, under the general and sometimes under the entire control of the State printer. The Geological Atlas alone, No. 11 of above list, was published by a private firm.

The distribution of the copies of each volume has been made through the members of the General Assembly by which the publication of the volume was ordered, or, in some instances, by the members of the next succeeding General Assembly. Up to the issue of Volume V (No. 13 of the list) the entire editions, after providing moderate allowances for the geological corps and the State Library, were distributed *pro rata* among the members of the Legislature. No opportunity was afforded for the purchase of copies on the part of those desiring to secure them and no provision whatever was made for maintaining the sets of those who had received the earlier volumes. It is almost incredible that after making the expenditures which the large editions of the earlier volumes necessitated, the volumes should be scattered over the State in such a reckless and wasteful way. Individual members of the Legislatures would sometimes take pains to distribute their quotas to those who had the preceding volumes, but such cases have been comparatively infrequent.

With the issue of Volume V (No. 13) a new policy was inaugurated, to the extent of placing a certain number of copies in the care of the Secretary of State, to be sold at cost of publication. This arrangement has met a real want, as is shown by the fact that the stocks of all the volumes but the last two are entirely exhausted. There is no State office and no State officer that can furnish at the present time either a single complete set or any single volume of the other reports, in answer to the most deserving applicant. Book dealers in the larger cities of the State are in some instances gathering complete or broken sets of the reports, to meet the demands. The prices of the volumes range from $1 to $3.50 per volume. Some of the volumes cannot now be found in the market, at least in complete form. Volume V with its maps seems to have been entirely absorbed and Volume VI is but infrequently offered. It may prove to the advantage of the State to republish some of these volumes, as they have not, by any means, outlived their usefulness.

It remains for me to make acknowledgment of valuable aid and assistance that I have received in the preparation of the present volume.

The mapping of the coal seams was kindly taken off my hands after I had suffered a disablement which incapacitated me for the necessary fieldwork, by Prof. C. N. Brown of the Ohio State University. The credit for this entire division of the report belongs to him and to his assistants. All of the latter displayed great fidelity and diligence, but it is proper that special mention be made of Mr. C. E. Sherman, C. E., chief draughtsman; of G. P. Grimsley, Ph. D., who was engaged in field work for a longer time than any other assistant, and of A. F. Foerste, Ph. D., whose service though brief was of unusually high character, standing as it did for good training and previous experience in similar lines of work.

To the several railroad companies who have furnished free transportation to the officers of the Geological Survey for all or portions of the time in which the work of preparation of volume VII has been going forward, cordial thanks are hereby tendered. The aid so rendered has been of great advantage to the State, helping out the narrow appropriations with which the Survey has been carried forward.

To Mr. W. K. Moorehead, Curator of Archæology in Ohio State University, thanks are due for the generous loan of his map of Fort Ancient, which accompanies Chapter I of Part II.

To Hon. Leo. Hirsch, Supervisor of State Printing, I am under great obligations. He contributed all the assistance possible in every stage of the publication, and it is through his skillful administration that so large and varied a volume is issued at so small a cost to the State.

For the typographical errors in two of the chapters, their authors, viz., Prof. R. P. Whitfield and Edward Orton, Jr., must not be held accountable, as it was not practicable to give them the opportunity of reading their own proof.

Many defects and errors, typographical and otherwise, I recognize, but in extenuation, I may urge that the preparation and publication of the volume have been attended with some peculiar disadvantages, which it is not necessary to explain. In view of the facts, I bespeak the lenient judgment of the reader. E. O

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(IN ENVELOPE.)

GEOLOGY OF OHIO.

CHAPTER I.

GEOLOGICAL SCALE AND GEOLOGICAL STRUCTURE OF OHIO.

BY PROF. EDWARD ORTON.

Owing to the mode of distribution of the volumes of the Ohio Geological Reports, viz: through the members of the successive legislatures that order the publication of the successive volumes, it becomes necessary to introduce each volume as it appears, with a brief review of the geological column of the state, in order to make it certain that the statements which are to follow will be properly understood by those into whose hands the volume may fall. It is never safe to assume that those who receive one volume have any knowledge of or any means of obtaining any other volume of the series.

The geological scale of Ohio comprises strata, named in ascending order, of Lower Silurian, Upper Silurian, Devonian, Sub-carboniferous and Carboniferous age, and also a series of deposits of the Glacial period. The principal divisions are shown in the following table. The thickness that is assigned to each of the elements is not necessarily the average thickness of the various exposures. In some cases the more common measure is given; in others it is counted better to indicate the thickness of some of the best known exposures. In the text, the limits of each formation will be more definitely stated:

The geological order herewith described is further represented in the accompanying diagram. A brief review of each of these divisions will be made in the succeeding pages of the present chapter.

			Thickness		System
18. Glacial drift			0 to 550 feet.		Quaternary.
17. Upper Barren Coal Measures			500	"	Carboniferous.
16. Upper Productive Coal Measures			200	"	
15. Lower Barren Coal Measures			500	"	
14. Lower Productive Coal Measures			250	"	
13. Conglomerate Group			250	"	
12. Sub-carboniferous limestone, Maxville, Newtonville, etc.,			25	"	Sub-Carboniferous.
11. Waverly Group	11e Logan Group......0–350.	500′ to 800′	500	"	
	11d Cuyahoga Shale, 150–450.				
	11c Berea Shale.........20– 50.				
	11b Berea Grit............5–160.				
	1a Bedford Shale.......50–150.				
10. Ohio Shale.	10c Cleveland Shale.	250 to 3,000 feet....	300	"	Devonian.
	10b Erie Shale.				
	10a Huron Shale.				
9. Hamilton Shale (Olentangy Shale?)			25	"	
8. Devonian Limestone, Upper Helderberg or Corniferous, including West Jefferson sandstone			75	"	
7. Lower Helderberg limestone, or Waterlime, including Sylvania sandstone, 50 to 600 feet			500	"	Upper Silurian.
6. Niagara Group.	6d Hillsboro sandstone		30	"	
	6c Guelph or Cedarville limestone, 50-200,		150	"	
	6b Niagara limestone		50	"	
	6a Niagara Shale, including Dayton limestone, 5 to 100		100	"	
5. Clinton Group, in outcrop, 20 to 75 feet; under cover, 75 to 150.			50	"	
4. Medina shale, in outcrop, 25′; under cover, 50 to 150			75	"	
3. Hudson River Group, 300′ to 750′			750	"	Lower Silurian.
2. Utica Shale, not seen in outcrop, but 300 feet thick under cover in northern Ohio			300	"	
1. Trenton limestone, seen only in Pt. Pleasant quarries, if at all, in the state			0–50	"	

The Trenton Limestone.

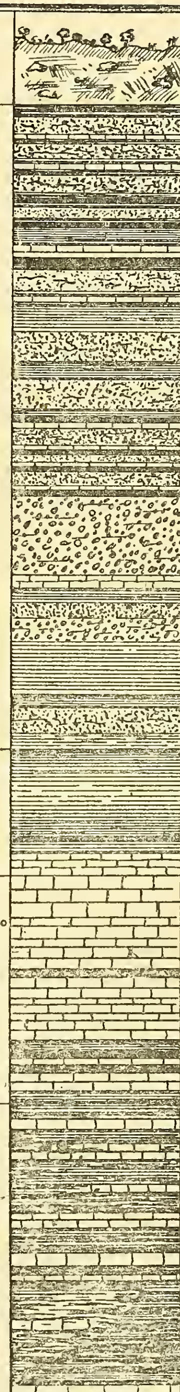
The Trenton limestone is one of the most important of the older formations of the continent. It is the most widespread limestone of the general scale of the country. It extends from New England to the Rocky Mountains, and from the islands north of Hudson's Bay to the southern extremity of the Allegheny Mountains in Alabama and Georgia. Throughout the vast region it is found exposed in innumerable outcrops. As it decays, it gives rise to limestone soils which are sometimes of remarkable fertility; as, for example, those of the famous Blue Grass region of central Kentucky, which are derived from it. It is worked for building stone in hundreds of quarries, and it is also burned into lime and broken into road metal on a large scale throughout the regions where it occurs.

But widespread as are its exposures in outcrop, it has a still wider extension under cover. It is known to make the floor of entire states, in which it does not reach the surface in a single point.

It takes its name from a picturesque and well known locality in Trenton township, Oneida county, New York. The small river, known

GEOLOGICAL SCALE OF OHIO

System		Series		Feet
	18	GLACIAL DRIFT 0-550		200
CARBONIFEROUS	17	UPPER BARREN COAL MEASURES		300
	16	UPPER PRODUCTIVE COAL MEASURES		200
	15	LOWER BARREN COAL MEASURES		500
	14	LOWER PRODUCTIVE COAL MEASURES		250
	13	CONGLOMERATE SERIES		250
	12	SUBCARBONIFEROUS LIMESTONE		25
	11	WAVERLY 500-800	11c LOGAN GROUP {SHALE, SANDSTONE, CONGLOMERATE}	150
			11b CUYAHOGA SHALE	200
			11c BEREA SHALE	25
			11a BEREA GRIT	75
			11A BEDFORD SHALE	50
DEVONIAN	10	OHIO SHALE 300-2600	10c CLEVELAND SHALE 10b ERIE SHALE 10a HURON SHALE	300
	9	HAMILTON SHALE		25
	8	DEVONIAN LIMESTONES 25-75		75
UPPER SILURIAN	7	LOWER HELDERBERG LIMESTONE 50-600		300
	6	NIAGARA SERIES	6d HILLSBORO SANDSTONE	
			6c GUELPH LIMESTONE	200
			6b NIAGARA LIMESTONE	50
			6a NIAGARA SHALE. DAYTON LIME	100
	5	CLINTON SERIES		50
	4	MEDINA SHALES		25
LOWER SILURIAN	3	HUDSON RIVER SERIES 500-1050		600
	2	UTICA SHALES 0-300		300
	1	TRENTON LIMESTONE		50



as West Canada Creek, makes a rapid descent in this township, from the Adirondack uplands to the Mohawk Valley, falling three hundred feet in two miles, by a series of cascades. These cascades have long been known as the Trenton Falls, and the limestone which forms them was appropriately named, by the New York geologists, the Trenton limestone. The formation, as seen at the original locality, is a dark blue, almost black, limestone, lying in massive and even beds, which are sometimes separated by thin layers of black shale. But it is to be noted that a few feet of its uppermost beds consist of crinoidal limestone of great purity of composition. Both limestone and shale contain excellently preserved fossils of Lower Silurian age. By means of these fossils, and also by its stratigraphical order, the limestone is followed with perfect distinctness from Trenton Falls to every point in the compass. It is changed to some extent in color and composition, as it is followed in different directions, but there is seldom a question possible as to its identity. The Trenton limestone forms several of the largest islands, in whole or in part, in the northern portion of Lake Huron, as the Manitoulin islands. From this region it dips, under cover of the lake and also of higher formations, to the southward; but it is found rising again in outcrop in the valley of the Kentucky River, near Frankfort, and possibly, also, at a single point within the limits of the state of Ohio, viz.: in the quarries of Point Pleasant, which are located in the valley of the Ohio River, in Clermont county, twenty miles above Cincinnati. The Point Pleasant beds have a thickness of about fifty feet. This outcrop of rock was definitely referred to the Trenton horizon, apparently on stratigraphical grounds, by the late W. M. Linney, of the Kentucky Geological Survey, a number of years ago; and in the course of the explorations of our underground geological structure, which followed the search for oil and gas in western Ohio, the indications seemed to point to the correctness of Mr. Linney's conclusion, and the Point Pleasant beds have been counted Trenton limestone in several of the last volumes of the Geological Survey. This determination has, however, lately been called in question by Mr. Joseph F. James, of the U. S. Geological Survey, who bases his argument on paleontological grounds. Mr. James holds that it is impossible to separate the Point Pleasant beds from the overlying series, which are referred to the Hudson River age. It is not safe to affirm positively that the determination made by Mr. Linney, and supported by the facts brought to light in the Ohio reports, is beyond question; but it still seems probable that this is the true interpretation. The fossils of the Trenton limestone and of the Hudson River group are identical to a considerable extent.

The thickness of the Trenton limestone proper, as it appears in outcrop in the rocks of central Kentucky, is given by the geologists of that state as one hundred and seventy-five feet. It is immediately underlaid, in this region, by two other limestones, viz.: the Birdseye and Chazy, which have a thickness respectively of one hundred and thirty and three hundred feet, the entire set of unbroken limestones, beginning with the Trenton, and including the two formations above named, being thus about six hundred feet in thickness.

It is altogether probable that these three limestones constitute the solid mass which the drill has so often penetrated in Ohio within the last few years to a depth of five or six hundred feet. The formations, which the geologists separates when they rise to the surface, are counted by the driller as a single limestone, for which he needs no other name than that with which he begins, viz.: Trenton. The several divisions, however, are found to vary somewhat in grain, in color and in chemical composition as well as in the fossils they contain.

Below this great limestone mass a sandstone, more or less calcareous, is reported in many of our deep wells. This is probably on the horizon of the St. Peter's sandstone of the northwest and very likely deserves to be called by this name. It is forty to sixty feet thick, as generally reported, and is charged with the rank salt and sulphur water which is known in Kentucky as Blue Lick water. It must, however, be acknowledged that water of quite similar composition is sometimes found in or between the limestone beds above named as well as in the underlying stratum.

Still deeper, impure magnesian limestones are found, at least in the Ohio series, for the next one thousand feet of descent. This was well shown in the deep wells of Springfield and Dayton. These beds must be referred to the Calciferous period of the general scale, so far as, at least, as their uppermost portions are concerned.

To the question so often asked, and to which a sharp and exact answer is expected, "How thick is the Trenton limestone?" it is thus seen that it is not only not easy, but not even possible to give such an answer, on account of the ambiguity of the term as it is popularly used. The interest of the question, however, is practical, and centers in those portions of the limestone that yield gas and oil. Restricting the scope of the question to this point of view, it can be stated that no part of the Trenton limestone, more than a hundred feet below its uppermost surface, has thus far proved productive of either gas or oil, in the large way.

2. The Utica Shale.

The immediate cover of the Trenton limestone in the locality from which the latter derives its name, is a well-known stratum of black shale, three hundred to seven hundred feet in thickness, and, possibly, in portions of eastern New York, much thicker than the maximum above given. This conspicuous stratum received from the New York geologists the name of Utica shale, from the fact that very many outcrops of it occur in the vicinity of the city of Utica. This bed of slack shale has proved to be very persistent and wide-spread. It must be acknowledged, however, that it is not as well characterized by definite forms of life as most of the strata that receive independent names in the geological scale. It is everywhere, but sparingly fossiliferous; but while only a few of the forms that t contains are found exclusively in this series of deposits, there are still enough, when taken in connection with the lithological characteristics of the shale, to establish and maintain its identity.

The first of the deep wells that was drilled in Findlay revealed, at a depth of eight hundred feet, a stratum of black shale, the fragments of which, brought up by the driller or by explosion of nitro-glycerine in the oil rock, contained what may be styled the most characteristic fossils of the Utica shale of New York, and the black shale eight hundred feet below the surface in northwestern Ohio, was thus positively identified with the Utica shale of central New York. This bed of shale, as proved by the driller, in Ohio has the normal thickness of the formation in New York, viz.: 300 feet, and, taken in connection with the other elements involved, it extended and continued the New York series into the underground geology of northern Ohio in the most unexpected and at the same time in the most satisfactory way.

The Utica shale thus discovered and defined is a constant element in the northwestern portion of the state. Its upper boundary is not always perfectly distinct, as the Hudson river shale that overlies it sometimes graduates into it in color and appearance. But as a rule the driller, without any geological prepossessions whatever, would divide the well section in his record so as to show about three hundred feet of black shale at the bottom of the column, or immediately overlying the Trenton limestone. This stratum holds its own as far as the southern central counties. In the wells of Springfield, Urbana and Piqua a dark-colored stratum is found in undiminished thickness, but apparently somewhat more calcareous in composition than in the locality where it was discovered. From these points southward, according to the somewhat scanty facts that have been secured, the formation thins rapidly until it is apparently replaced by dark-colored limestone bands, known as "pepper and salt rock" by the driller. No great falling off in black shale appears in the Dayton wells; but at Middletown a sharp boundary between gray shale three hundred and ten feet thick (Hudson river), and black shale one hundred feet thick (Utica), the latter directly overlying the Trenton limestone, was reported by a driller whose observations seemed entitled to confidence. The black shale was reported still further reduced in the wells at Hamilton and from that point southward it was not distinctly recognizable. From these and similar facts it appears that the Utica shale is much reduced and altered as it approaches the Ohio Valley, and is finally lost by overlap of the Hudson river shale in this portion of the state and to the southward.

The identification of the Utica shale as a distinct stratum in the lower beds of the series exposed at and near Cincinnati, which has been made by some geologists, is counted doubtful, to say the least, in view of the facts given above.

3. The Hudson River Group.

The very important and interesting series now to be described appears in most of the previous reports of the State Geological Survey under another name, viz.—the Cincinnati group. It is unnecessary to review here the long discussions pertaining to the age of this series, or the grounds on which the change in the name by which it is known has been based. Suffice it to say that the change has appeared necessary to many geologists on paleontological grounds, solely. But for those who have not been convinced by the statements in regard to this subject, a sure ground for the change has been found in the recent discoveries in our underground geology, by which it appears that the Hudson River series of New York can be followed almost continuously, and with but little change in its general character, from the eastward into the state of Ohio, and thus to the outcrops of the formation in the southwestern portion of the state.

The Hudson River group in southwestern Ohio consists of alternating beds of limestone and shale, the latter of which is generally known as blue clay, but which was called in the earliest accounts of our geology, marlite. The proportions of lime and shale vary greatly in different parts of the series. The largest percentage of shale occurs in the two hundred and fifty feet of the series that begin fifty or seventy-five feet above low water in Cincinnati. The entire thickness of the series in this proportion of the state is about seven hundred and fifty feet.

The division that has been proposed and adopted in the previous reports of the Survey into an upper and a lower series, seems natural and convenient, and accordingly likely to be maintained. The lower is designated in the reports as the Cincinnati division and the upper as the Lebanon division. The Cincinnati division has a thickness of four hundred and twenty-five to four hundred and fifty feet, and the Lebanon division a thickness of about three hundred feet. The divisions are separated on both paleontological and stratigraphical grounds. Both of them abound in exquisitely preserved fossils of Lower Silurian time; and in fact the hills of Cincinnati and the vicinity have become classical ground to the geologists of the world on this account.

As the series takes cover to the northward and eastward it retains for some distance the characteristics already described; but as it is followed further it becomes less calcareous. The limestone courses are thinner and fewer in number, and inasmuch as they resist or delay the drill but little in its descent, the entire series comes to be counted shale. One other fact must be noted in this direction. The shale at certain points, and especially on the western border in the northern portion of the state, as noted in the previous section, grows dark in color, so that the boundary between the Hudson River and the underlying Utica divipass with the driller as black shale. The Hudson shales are thin in this northwestern corner of the state, the entire measure running as low as three hundred feet, or even less. It seems probably, in view of this and other facts, that they were lain down in a sea that grew shallow in that direction, viz , the west. At least, there was a perceptibly smaller amount of the fine sediments of which the formation consists brought in as we follow it in this direction. To the eastward the greenish blue shales already named are always found, and the series also thickens considerably in this direction. The Hudson river shales are everywhere fossiliferous, as the fragments of corals and shells brought up in the drillings abundant testify. Some of the fossils are identifiable in the fragments brought to the surface by the driller.

The Hudson River group occupies in its outcrop, about four thousand square miles in southwestern Ohio, but it is doubtless coextensive with the limits of the state, though under very deep cover in large part. The shales of the series in in southwestern Ohio contain large quantities of phosphates and alkalies, and the soils to which they give rise are proverbial for their fertility.

The presence of these fined-grained and impervious shales in so many separate layers forbids the free descent of water through the formation. In its outcrops, consequently, the Hunson River shales have no water supply, and, as found by the driller, they are almost universally dry. The shales give rise to frequent "blowers" or short-lived accumulations of high-pressure gas when struck by the drill, as is found in the experience of many towns of western Ohio within the last few years, and it also yields considerable amounts of low-pressure shale gas at many points in the state, some of which have proved fairly durable.

4. The Medina Shale.

A stratum of non-fossiliferous shale, generally red or yellow in color, and having a thickness of ten to forty feet, directly overlies the uppermost beds of the Hudson River group at many points of outcrop in southwestern Ohio. From its stratigraphical position, these beds were referred to the Medina age in the reports of the Geological Survey for 1869, but the identification was considered as grobable, rather than certain. The occurrence of fifty to one hundred and fifty feet of red shale in the deep borings that have recently been carried forward in northern Ohio, at exactly the place in the general scale where the Medina formation should be looked for, and so much nearer to the outcrops of the formation, that its continuity with these was hardly to be questioned, this fact, taken in connection with the occurrence of like beds of red shale holding the same relative position in all the deep borings in the central portions of the state, gives full warrant for counting the Medina epoch duly represented in the outcropping strata of southwestern Ohio, according to the determination above named. It occurs here only in included sections, its thin and easily eroded beds never being found as surface formations for large areas. There is good reason to believe that the Medina formation is coextensive with the limits of the state, except in the regions from which it has already been removed by erosion.

The red color of the shales is persistent, but there are some well records in which this color does not appear. This is especially true in Allen county, and to the westward and northwestward from Lima. Blue shales alternate with the red in the eastern sections. In the western they replace the latter. Thin beds of sandstone are found in the Medina, especially to the westward. Small pebbles occur in some of these beds.

5. The Clinton Limestone.

The Clinton group of New York appears as a surface formation in Ohio only in the area already named. It forms a fringe or margin of the Cincinnati group through ten counties, rising above the soft and easily eroded rocks of this series, and of the previously named Medina shale, in a conspicuous terrace. It is everywhere a well-characterized limestone stratum. The stone is highly crystalline in structure, and is susceptible of a good polish. In some localities it is known as a marble. A considerable part of it, and especially the upper beds, are almost wholly made up of crinoidal fragments. In thickness it ranges between ten and fifty feet. Its prevailing colors are white, pink, red, yellow, gray and blue. At a few points it is replaced by the peculiar form of hematite ore that is elsewhere so characteristic of the formation. The ore is generally too lean and uncertain to possess economic value, but it was once worked for a short time and in a small way in a furnace on Todd's Fork, near Wilmington, Clinton county.

The limestone contains throughout most of its outcrops a notable quantity of indigenous petroleum, but the only valuable accumulations of oil and gas that have been found in it thus far have been brought to our knowledge since 1885. It is the source of the low pressure gas of Fremont (upper vein), and also of the important supplies at Lancaster, Newark and Hadley Junction. In a few instances it has proved itself an oil rock. Wells drilled to this horizon have in a few instances yielded twenty to thirty barrels a day, the supply being continued for several months.

Under heavy cover, and particularly in the new gas fields named above, beds of sharp sandstone are sometimes interstratified with the limestones. The main reservoir of the Lancaster gas is in fact a sandstone.

In outcrop the stratum is porous, as a rule, and the water that falls upon its uncovered portions sinks rapidly through them to the underlying shale (Medina), by which it is turned out in a well-marked line of strong springs.

In composition the limestone in its outcrops in southern Ohio is fairly constant. All its most characteristic portions contain eighty to eighty-five per cent. of carbonate of lime, and ten to fifteen per cent. of carbonate of magnesia. At a few points, however, and notably at Brown's quarries near New Carlisle, Clarke county, it appears as the sion is somewhat obscure. The entire interval in such instances may purest carbonate of lime in the state. Under cover to the northward it is found more magnesian in composition, being indistinguishable from the Niagara that overlies it. It also becomes shaly and changeable in character at many points, but in this respect it is growing more like the formation as found in western New York. As it becomes shaly the thickness of the series is much increased.

It is everywhere uneven in its bedding in its outcrops, being in striking contrast in this respect to the formations below it and also above it. The beds are markedly lenticular in shape, and extend but a few feet in any direction. They seldom rise to two feet in thickness.

The uneven bedding, the crystalline and crinoidal characters, the high colors, and particularly the red bands, taken in connection with the chemical composition, combine to make the Clinton limestone an exceedingly well-marked stratum throughout southwestern Ohio, and from the hints yielded by the drill in northwestern Ohio, it seems to have much the same character there. It becomes more shaly and much thicker to the eastward. Throughout the northern central and central portions of the state it carries bands of red shale universally.

The fossils of the formation by which it is most definitely characterized will be found described in a subsequent chapter of this report.

The Clinton limestone is directly followed at a number of points in the territory occupied by it in outcrop, by a bed of very fine-grained, bluish-white clay containing many fossils distributed through it, the fossils being crystalline and apparently composed of pure carbonate of lime. Some of them are characteristic of the formation elsewhere, while others are known only in this bed. A similar bed of white clay is reported at the same horizon by the drillers in northern Ohio, and the drillings show the presence of fossils of the same characters. This clay seam can be appropriately designated as the Clinton clay, but it merges into and is indistinguishable from the lowest element in the overlying group. It has been named by Mr. Foerste the Beavertown marl. The Clinton, in its outcrops, is entirely confined to the southwestern part of the state.

6. The Niagara Group.

The Clinton limestone is followed in ascending order by the Niagara group, a series of shales and limestones that has considerable thickness in its outcrops, and that occupies not less than thirteen thousand square miles of territory in Ohio as a surface rock.

The lowest member is the Niagara shale, a mass of light colored clays with many thin calcareous bands. It has a thickness of one hundred feet in Adams county, but it is reduced rapidly as it is followed northward, and in Clark and Montgomery counties it is not more than ten to fifteen feet thick. Still further to the northward, as appears from the records of recent drillings, the shale sometimes disappears entirely;

but in the great majority of wells, especially in Hancock and Wood counties, it is a constant element, ranging from five to thirty feet. The gas wells are often cased in this shale, but a risk is always taken in doing so, as water is liable to be found in the underlying Clinton rocks.

In Montgomery, Miami and Greene counties the shale contains, in places, a very valuable building stone, which is widely known as the Dayton stone. It is a highly crystalline, compact and strong stone, lying in even beds of various thickness, and is in every way adapted to the highest architectural uses. It carries about ninety-two per cent. of carbonate of lime. The Niagara shale, as a rule, is quite poor in fossils. It is apparently destitute of them in many of its exposures; but there are still parts of the state in which it contains a considerable fauna. The best phases of it, in this point of view, are found in Highland county, south of Hillsboro.

The limestone that succeeds the shale is an even-bedded, blue or drab magnesian stone, well adapted at many points to quarrying purposes. It contains many characteristic fossils of Niagara age. It is known in Ohio by various local names, derived from the points where it is quarried. There are several subdivisions of it that are unequally developed in different portions of the state. Like the shale below it, this member is thickest in southern Ohio. It cannot be recognized as a distinct element in the northern part of the state, either in outcrop or in drillings. It may be that its horizon is not reached in any natural exposures of the formation in this part of the state.

The uppermost division of the formation is the Guelph limestone, which differs very noticeably in several points from the Niagara limestone proper. It obtains its name from a locality in Canada, where it was first studied and described. It has a maximum thickness in southern Ohio of two hundred feet. It differs from the underlying limestone in structure, composition and fossils. It is either massive or very thin-bedded, rarely furnishing a building stone. It is porous to an unusual extent. It is generally very light in color, and is, everywhere in the state, nearly a typical dolomite in composition. It yields lime of great excellence for the mason's use. It is exceedingly rich in fossils, containing a large number that is thoroughly characteristic.

Unlike the previously named divisions of the Niagara, the Guelph limestone is as well developed in northern as in southern Ohio in all respects. Not more than forty feet of it are found in its outcrops there, but the drill has shown several times this amount of Niagara limestone, without giving us, however, the data needed for referring the beds traversed to their proper subdivisions. What facts there are seem to point to the Guelph as the main element in this underground development of this formation in this portion of the state.

The Hillsboro sandstone is the last element in the Niagara group. It is found in but few localities, and its reference to the Niagara series in its entirety is not beyond question. In Highland county it has a thickness of thirty feet in several sections. It is composed of very pure, even-grained, sharp silicious sand. Other deposits of precisely the same character are found in the two next higher limestones of the scale at several points in the state. One of these deposits is interstratified with the Waterlime in Scioto, Wood and Lucas counties, and others are imbedded in the Corniferous limestones of central Ohio. The latter have been referred to the Oriskany period, but, strictly speaking, this reference is inadmissible, inasmuch as normal Corniferous limestone with its most characteristic fossils is found below as well as above the sandstone. The subject will be further considered on a succeeding page.

The Hillsboro sandstone is sometimes built up above all the beds of the upper Niagara limestone, but again, it is, at times, interstratified with the beds of the Guelph division. In the latter case it is itself fossiliferous, but when found alone it seems destitute of all traces of life. These sandstones in the limestone formations suggest in their peculiarities a common origin. They all contain many unworn and nearly perfect crystals, and sometimes seem to be mainly composed of the same. Their occurrence in outcrops becomes a matter of interest to us, now that we are called to interpret the varied records of deep drillings throughout the state. What would otherwise be altogether anomalous sections may be rendered intelligible by the known presence of such elements in the scale.

The Salina Group.

This group has appeared in all the recent tabular sections of the rocks of the state, but in the light of facts obtained within the last four years, it can no longer be counted a distinct or recognizable element in the Ohio scale. Newberry gave it the place which it has held in the column, and assigned to it a thickness of forty feet. To it he referred the plaster beds of the Ottawa county peninsula, and certain impure limestones of Put-in-Bay Island. He also recorded the disappearance of what he counted the same stratum a few miles south of the lake shore, in a shaly bed that rests immediately upon the Niagara limestone.

The identifications are, however, incompatible. The limestones of Put-in-Bay and the plaster beds of the peninsula do not directly overlie the Niagara limestone as represented, but on the contrary are separated from it by several hundred feet of the brown, even-bedded, sparingly fossiliferous magnesian limestone that we call the Lower Helderberg limestone or the Waterlime. In other words, the plaster beds of Gypsum are buried in the middle, or above the middle of this great sheet of limestone, instead of being planted at its base. The reference of this formation to the Salina was rendered probable at the time from the fact that all the gypsiferous formations of New York were then counted of Salina age. It has since been proved, however, that gypsum is also contained in the Waterlime of central New York, and it is in like situations that the Ohio quarries are found. There is nothing to excite surprise in these new facts, for both gypsum and salt are the products of geological accidents and can be found in formations of every age, unless it be the oldest. Wherever, by warping of the crust, bodies of seawater have been exposed to evaporation these products are bound to appear.

The Salina period is an important one in the New York scale, a thousand feet of deposits being credited to it, and there are probably some deposits in Ohio that are contemporaneous with it in age; but it cannot be the gypsum-bearing beds of Ottawa county that held this place, unless the formation is made to take in at least one half of the entire series that we now call Lower Helderberg or Waterlime. This gypsiferous series proves to be of considerable thickness and to be wide-spread. It is struck in scores of walls that have been recently drilled in northern and central Ohio. In Sandusky, gypsum was found in quite pure and thick beds, through several hundred feet of the strata through which the drill passed, and in the deep wells of Cleveland, Wadsworth and Akron both rock salt and gypsum are found in large and economically important deposits. The salt beds of Cleveland are found at a depth of about two thousand feet below the surface of the lake, in the latter named stations at a depth of two thousand six hundred and fifty to two thousand eight hundred feet below the surface. Small deposits of gypsum have also been found in the deep wells of Columbus, Newark and many other towns in this same association.

The reference of distinct portions of our geological scale to the Salina period must be discarded for the present, at least, on the grounds that have now been given.

7. The Lower Helderberg or Waterlime Formation.

The interval that exists between the Niagara and the Devonian limestones is occupied in Ohio by a very important formation. This formation was first separated from the previously undivided mass of the Cliff limestone by Newberry in 1869. He found and identified its fossils and showed by means of them and by the position of the stratum in our series, that the rocks of this interval are the equivalents in part, at least, of the Waterlime of the New York scale. The Waterlime of New York is classed by most geologists with the Lower Helderberg series; but Hall counts it the upper member of the Salina group of that state, a reference that seems likely to be ultimately considered the true and proper one. The name is most unhappily chosen. Strictly applicable to only an insignificant fraction of the beds of this series in New York, we are still obliged to apply the designation Waterlime, with its misleading suggestions to all the deposits of the same age throughout the country. The name is in fact a type, or representative of a class of names that ought never to be introduced into science.

Though the last to be recognized of our several limestone formations, the Waterlime occupies a larger area in Ohio than any other, its principal developments being found in the drift covered portions of the northwestern quarter of the state. It has also a much greater thickness than any other limestone of the state, its full measure being at least six hundred feet, or twice the greatest thickness of the Niagara limestone

It can be described as, in the main, a strong, compact, magnesian limestone, poor, as a rule, in fossils, and often altogether destitute of them for considerable areas, microscopic forms being excepted. It is, for the most part, drab or brown in color; but occasionally it becomes very light-colored, and again it is found dark blue in color. Throughout much of its extent it is brecciated, the bed seeming to have been broken into sometimes small and sometimes large angular fragments after their hardening, and then to have been recemented without further disturbance. In addition to this, it contains an immense amount of true conglomerate, the pebbles, many of which are bowlders rather than pebbles, being all derived from the rocks of the same general age, but frequently differing in color from the matrix. A bowlder weighing a ton or more has recently been found in central Ohio, which was broken from the conglomerate phase of this formation. The most striking exhibitions of this phase are found in Lucas county. The surface of many successive layers at numerous points are covered with suncracks, thus furnishing additional proof of having been formed in shallow water near the edge of the sea. In such localities the beds are usually quite thin and are also impure in composition. In these respects, this phase suggests the conditions of the Onondaga Salt Group of New York. These features are very characteristic ones. A rude concretionary structure is also quite distinctive of the beds of this age. The Waterlime in Ohio everywhere contains petroleum in small quantity, which is shown by the odor of freshly broken surfaces. No noteworthy accumulations of oil or gas have thus far been found within it. At some points it carries considerable asphalt, distributed through the rocks in shot-like grains, or else in sheets and films. Thin streaks of carbonaceous matter traversing the rock parallel to its bed planes are one of the constant marks of the stratum in Ohio It is generally thin and even in its bedding, but in some localities it contains massive beds. At some points, as at Greenfield, Highland county, it is remarkable for its evenness, and great value is given to the formation on this account, when combined with other qualities already named. It is frequently a pure dolomite in composition and accordingly it yields magnesian lime of high quality and is extensively burned in the state, rivaling in this respect the Guelph beds of the Niagara. In southern Ohio it has a maximum thickness of one hundred feet, and here it reaches its highest quality in all respects; but in central and northern Ohio it attains the great thickness previously reported. There also, it contains several distinct types of limestone rock. A considerable part of it is very tough, strong, dark blue limestone, while other portions are white, porous and soft.

This formation has a great extension throughout the peninsula and the islands of northern Michigan. It constitutes the greater mass of the island of Mackinac and is also found carrying beds of gypsum and possibly salt in the mainland of St. Ignace and northward. In Mackinac Island the concretionary, conglomeritic and brecciated phases are very strikingly shown. It no doubt underlies all the lower peninsula.

The line of junction between the Niagara and Waterlime is sometimes obscure and no means are at hand for drawing sharp lines of division.

All that has been thus far said applies mainly to the formation as found in outcrop; but well-reamings brought up from considerable depths at various points in the state render it certain that the principal features now given mark the formation below ground as well as above. There is no reason to doubt that the Waterlime has as wide a distribution in the subterranean geology of Ohio as the formations already described. It is to be found in every part of the state in which it is due.

The formation has come into new prominence, through the revelations of the drill, within the last few years. In regard to no other element of the series have the geologists been so wide of mark as in regard to the Lower Helderberg formation. What belongs to it was taken from it and given to a stratum that has no existence in the state; and it was credited with but one-sixth of its real thickness. Its outcrops ought to have shown that it has a much greater thickness than was assigned to it, since they cover several scores of miles in an east and west line. A large amount of additional investigation is demanded to put it in order, and to secure such a mastery of it as to be able to determine from an inspection of any outcrop what place it holds in the general series, will be a valuable service to the geology of the state. Winchell established, approximately, one horizon in it which promises to be of some service, namely, the horizon of the Tymochtee Slate, a bed of dark blue slaty limestone that is found in outcrop in the valley of Tymochtee Creek near Carey, Wyandot county. It is below the middle of the formation and probably within one hundred to two hundred feet of the Niagara limestone. A few other facts can be added that bear upon the same point. The excessively hard and strong dark blue pure limestone of Allen, Hardin and Hancock counties and some adjoining regions, which often has its surface conspicuously marked with sun-cracks, belongs to the middle portion of the formation, but probably above, rather than below the middle.

The purity of the limestone renders it easily soluble in atmospheric water, and more than any other lime of the state it gives rise to subterranean water courses. The most striking example in this line is to be found in the Castalia Springs of Erie county. The Castalia Springs are, in reality, the point of exit of a large volume of under-ground drainage. For fifty to seventy-five miles to the southward there is an entire absence of surface streams, all the water descending promptly through the joints of the limestone, which is here covered with but a shallow deposit of drift.

The Lower Helderberg formation undoubtedly gives rise to the oil rocks of Petrolia, Canada, and of the immediate vicinity. It unquestionably, also, contains many of the salt deposits of that portion of the country, which have been in past time referred to the Salina age.

A single other element remains to be inserted in the Lower Helderberg column, the interpolation of which, at this point, may occasion surprise to those who are conversant with the older statements in regard to our geological scale. The element to which reference is here made is known as the Sylvania sandstone. A remarkable series of deposits of extremely pure glass sand has long been known in Lucas and Wood counties of northern Ohio and in adjacent territory in the state of Michigan. The two best known of the Ohio deposits are those of Sylvania and Monclova, which respectively lie ten miles northwest and west of Toledo. Other similar deposits are known in Wood county. Since the development of the glass industry in northwestern Ohio, following the discovery of natural gas in that region, these sand deposits have been worked on a very large scale in meeting the demands of this new interest. The sand affords a basis for the manufacture of glass of the highest quality. In the Sylvania quarries the sandstone is found twenty or more feet in thickness, and resting upon beds of normal Waterlime, which is exposed a few rods to the eastward. The entire series is sharply inclined here, descending in almost a due west direction at the rate of one foot in seven. The rocks overlying the sandstone, as observed in extensive quarries that are open here, are unmistakable Waterlime, or Lower Helderberg, containing all the characteristic marks of the formation, including its chemical composition, its bedding, its bituminous streaks and its fossils. Further on, the conglomerate phase of the Waterlime, described on the previous page, appears. There is nothing in the whole formation more characteristic than this. At the end of the series, eighty rods to the westward from the sandstone quarry, a few feet of undoubted Corniferous limestone occur, rich in the fossils of the formation and true to its chemical composition. These facts are absolutely decisive as to the age of the sandstone. It lies at least two hundred feet below the Corniferous limestone.

The Monclova or Holland sandstone apparently holds a like position in the series to that of the Sylvania sandstone. The Grand Rapids sandstone of Wood county probably belongs to the same horizon. Again, it is presumably the Sylvania sandstone that was reached in the deep wells of Cleveland and Wadsworth within the last four years, at a depth of over two thousand feet below the surface and under cover of three hundred feet of limestone. At any rate, a sandstone found at this depth has very much the same character as that from the Sylvania quarries.

That there is another sandstone of character similar to that of the Sylvania sand, and which is included in the Corniferous limestone, is beyond question. This formation will be described in the next succeeding section. The Sylvania sand can henceforth be counted an Upper Silurian sandstone and a part of the Lower Helderberg series.

Whether the sandstone beds of Champaign and Logan counties are all to be referred to one horizon remains to be determined by further study. At present such a reference seems very doubtful.

8. The Upper Helderberg Limestone.

All of the limestone of Devonian age of Ohio has been referred by Newberry to the Corniferous limestone, and this term is in general use at the present time. It may be questioned whether it is wise to break in upon this use, but inasmuch as several geologists hold that the Devonian limestone of Ohio covers more than the simple epoch known as the Corniferous in New York, a more comprehensive term, viz., the Upper Helderberg limestone, is on the whole counted decidedly preferable. A two-fold division of this series in Ohio is possible and proper, the divisions, being based on both lithology and fossils. The divisions can be known as the Lower and Upper Corniferous, if the old term is still maintained in use; or, on geographical grounds, as the Columbus and Delaware limestones. For the upper division the designation Sandusky limestone might well be used. In central Ohio, at a few points, there is a marked contrast between the lower and the upper beds, the latter being thin and shaly, non-fossiliferous in the main, and interrupted with frequent courses of black flint. This phase is seen at the state quarries near Columbus. Generally, however, both divisions are calcareous and fossiliferous, and the differences consist in changes of color and composition, in the thickness of the several beds and in the distribution, and also in the kinds of fossils present. The maximum thickness of the Upper Helderberg series in Ohio, so far as present records show, is between seventy-five and one hundred feet.

Included in the lower beds of the limestone there are at many points, deposits of sharp sand of the same general character as the deposits that have been already described under the names of Hillsboro sandstone and Sylvania sandstone. These beds may be known under the name of the West Jefferson sandstone, one of the localities at which the sand is found being near this village. This Upper Helderberg sandstone is not Oriskany in age. It has nowhere been found to underlie the Corniferous limestone, but it is always interstratified with the latter, at least where its place in the series can be fully determined. It attains a thickness of but few feet at most, and is nowhere worked for economic uses except upon a very small scale.

In chemical composition the Corniferous limestone is easily distinguished from all that underlie it. It is much less magnesian than the other members of the Cliff limestone of Ohio, already described. It is never a true dolomite in composition, as the Waterlime and Niagara limestones almost always are. The carbonate of magnesia ranges in it from two to thirty-five per cent., reaching the latter figure in but few cases. The composition of the typical, heavy-bedded lower Corniferous may be taken as seventy per cent. carbonate of lime and twenty-five per cent. carbonate of magnesia. The higher beds of the Columbus stone, regularly yield ninety-one to ninety-five per cent. of carbonate of lime. The upper division, or the Delaware stone, is much less pure in central Ohio than the lower, a notable percentage of iron and alumina, as well as silica, generally being contained in it. It is therefore, seldom or never burned into lime. In northern Ohio, on the contrary, it is often found a fairly pure limestone.

Both divisions, but particularly the lower one, carry occasional courses of chert, that detract from the value of the beds in which they occur. The chert is found in nodules which are easily detached from the limestone for the most part. In some conditions in which the chert occurs, fossils are found in it in a remarkably good state of preservation. The percentage of chert and flint in any section would be considerable, and this fact must be borne in mind in the analysis of drillings from wells that penetrate the formation. The beds of the lower division are prevailingly light-colored, ranging from whitish to gray, drab and brown. The upper beds are oftener blue than otherwise.

The beds of the lower division are, as a rule, much thicker than those of the upper. The lowermost courses are sometimes quite massive. In the state quarries the thickness of these courses is not less than five feet. In the upper division the thickness of the several courses seldom reaches one foot.

Throughout the entire formation Devonian fossils abound in great variety and in great numbers of individuals. They are often found in an excellent state of preservation. The oldest vertabrate remains of the Ohio rooks are found in the Corniferous limestone, a fact which gives special interest to it. The uppermost beds of the lower or Columbus division is, in many places, a genuine " bone bed "; the teeth and plates and spines of ancient fishes, largely of the nearly extinct family of ganoids, constituting a considerable portion of the substance of the rock. Corals of various types are also especially abundant and interesting in this limestone. In fact, the formation is the most prolific in life of any in the Ohio scale. At a few points in central Ohio, the upper division is found in a shaly state and carrying characteristic fossils of the Marcellus slate. This fact was first noticed in its true significance by Professor Whitfield.

9. The Olentangy Shale.

At Prout's Station, seven miles south of Sandusky, Dr. Newberry found fifteen to twenty feet of a highly fossiliferous blue shale, intervening between the Corniferous limestone and the great black shale. The fossils that he found in this exposure are proved to be all of Hamilton age, unmingled with those of the underlying Corniferous limestone; and he accordingly described this stratum, of which there are several other exposures in the same region, as the only Hamilton formation of the entire scale of the state.

It seems probable that this blue shale of northern Ohio is the extension and equivalent of a deposit of shale which Professor N. H. Winchell found in Delaware county and which he named the Olentangy. This stratum is twenty or thirty feet in thickness, is blue in color, calcareous in composition, but almost destitute of fossils. Its stratigraphical position is exactly that of Newberry's Hamilton. It is found in comparatively few sections of three or four counties of central Ohio. When the rocks of this part of the series are traversed by the drill of the well-borer, this stratum is likely to be classed with the limestone below, rather than with the black shale above, and, as already suggested, the incorporation of this element with the limestone might easily serve to expand the measurement of the latter by a small amount.

With this formation the great limestones of Ohio were completed. While they are built into the foundations of almost the whole state, they constitute the surface rocks only in its western half. The Upper Silurian and Devonian limestones of our scale which were formerly known collectively as the Cliff limestone, have an aggregate thickness of seven hundred and fifty to eleven hundred and fifty feet where found under cover; and though differences exist among them by which it has already been shown they can be divided into four or more main divisions, there is still no reason to believe that any marked change occurred in the character of the seas in which they were formed during the protracted periods of their growth. The life which these seas contained was slowly changing from age to age, so that we can recognize three or more distinct faunas or assemblages of animal life in them.

Differences are also indicated in the several strata, as to the depth of the water in which they were formed, and as to the conditions under which the sedimentary matter that enters into them was supplied, but no marked physical break occurs in the long history. No part of the entire series indicates more genial conditions of growth than those that the Devonian limestone, last described, and the latest in order of them all, shows. It is the purest limestone of Ohio. The formation consists almost exclusively of the beautifully preserved fragments of the life of these ancient seas. In particular, the corals and crinoids that make a large element in many of the beds could only have grown in shallow but clear water of tropical warmth.

The change from the calcareous beds of this age to the next succeeding formation is very sharp and well marked, as much so, indeed, as any change in the Ohio scale.

10. The Ohio Shale.

(Cleveland Shale, Erie Shale, Huron Shale, of Newberry.)

A stratum of shales, several hundred feet in thickness, principally black or dark brown in color, containing, especially in its lower portions, a great number of calcareous and ferruginous concretions, many of them large, and all of them remarkably symmetrical, stretches entirely across the state, from the Ohio Valley to the shores of Lake Erie, with an outcrop ranging in breadth between ten and twenty miles. This formation has constituted one of the most conspicuous and well-known features of Ohio geology since this subject first began to be studied. It separates the great limestone series already described, which constitutes the floor of all of western Ohio, from the Berea grit, which is the first persistent sandstone reached in ascending the geological column of the state, and which, in like manner, may be counted the floor of all of eastern Ohio. By the geologists of the first survey it was designated as the *Shale Stratum* or the *Black Slate*. It will be treated in this report under the designation *Ohio Shale*. Newberry divided it into three divisions, which he named respectively the Huron, the Erie and the Cleveland shale. He based the separation of the hitherto undivided mass in part upon the colors of the proposed divisions, the Cleveland and the Huron being counted black shales, and the Erie a greenish-blue shale. The names Huron and Erie were unfortunately chosen, for both are liable to be confounded with current names of other geological formations. The name *Huron* was adopted from Alexander Winchell, but a very different range was assigned to it from that which its author originally claimed. Winchell's "Huron group" extends, in his own words, from the top of the Devonian limestones, "to the conglomerate above the grit stones of Huron county." It is thus seen to include Newberry's Huron, Erie, Cleveland and Bedford shales, together with the Berea grit and Cuyahoga shale. It would have served the interests of geological classification much better to have replaced the term altogether than to have thus restricted it to a small fraction of what it was originally made to cover. The name is also likely to be confounded with the *Huronian slates*, an older and well established division of the Canadian system of rocks.

The Erie shale, in like manner, is sure to be confounded with the Erie clay of the Canada Survey, a name given to an important line of deposits of the Glacial period. Both the shale and the clay have their typical exposures in the same localities and their outcrops are not dissimilar in appearance. It is not, therefore, surprising that the names should be confused in popular use.

But aside from these grounds of objection to the particular names employed, the classification referred to is itself inconsistent with our present knowledge of the shale formations. We have records by the score of wells drilled through the shale at many points in northern Ohio during the last few years, and we have also the results of continued study of the formation in its outcrops. The facts gathered from both these lines of investigation, not only fail to confirm the three-fold division above announced, but they demonstrate the impossibility of applying to the shale formation any system of classification based upon the color of the shales; and as for the fossils, they are so sparingly distributed that they cannot well be used to mark horizons in the formation, aside from the few that will be mentioned later.

10*a*. *The Lower Beds—Huron Shale.*

The Huron shale was defined by Newberry as a homogeneous mass of black, bituminous shale, two hundred to three hundred and fifty feet in thickness, directly overlying the limestone series already described. The objection to this definition is that there is no such mass of shale in Ohio The formation on which the main statements pertaining to the Huron rests, and which furnishes nearly all the examples instanced, is the shale stratum of central and southern Ohio, but this is not merely the bottom portion of the shale series of northern Ohio. It comprises all of the elements of the northern section. In other words, the so-called Huron shale of central Ohio is the full equivalent of the Cleveland, Erie, Huron shale of northern Ohio. It is not a homogeneous mass of black shale, as it has been commonly counted, but beds of blue or greenish-blue shale are frequently interstratified with the prevailing black beds, especially in the middle portion of the series. The top and bottom of the column are generally black shale, and the same thing is true in northern Ohio. These facts show the grounds on which the classification now referred to is based, but the objection to it is that no line of division can be drawn between the Huron and Erie, or the Erie and Cleveland shales. The records of many drilled wells in northern Ohio show that alternations of black and blue shale occur not once only, but scores of times, in the formation.

10*c*. *The Upper Beds—Cleveland Shale.*

The Cleveland shale has a somewhat better chance for survival as a distinct division than the Erie or Huron. The upper boundary of it is tolerably distinct, inasmuch as a belt of black shale generally underlies by fifty to one hundred feet the Berea grit, which is by far the best landmark in this part of the scale, the interval being occupied by the Bedford shale, itself a well characterized formation. In some sections, however, there is no black shale at the point where the Cleveland shale belongs, and in all sections the lower boundary of the formation is likely to be uncertain, unless the bottom of the first bed of black shale found below the Berea grit is in every case taken for the bottom of the Cleveland division. If this is done, the Cleveland shale will be found to stand for very unequal periods of geological time, as the uppermost black bed has a considerable range in thickness. It often falls to thirty feet and sometimes extends to two hundred feet. It is probably the larger half of the great black shale of southern Ohio. It is this element that proves most persistent in the southerly extension of the black shale. The shale that covers the Lower Silurian limestone in central Kentucky is the upper or Cleveland division, as its most characteristic fossils, presently to be named, prove.

The mineral basis of all these shales, whether black, brown, blue or red, is essentially one and the same thing, viz., a fine-grained clay derived from the waste of lands. As supplied to the sea basin, it was originally blue or gray, but a small percentage of peroxide of iron goes a great way in coloring such deposits red; and in like manner, organic matter in comparatively small amount gives them a dark or black color. The organic matter that colors these shales was probably derived in large part, as Newberry has suggested, from the products of growth and decay of sea-weeds, by which these seas were covered like the Sargasso seas of our own day.

These organic matters seem to have accumulated along the shores and in shallow water in greater quantity than in the deeper seas. Hence, if the section of these shale deposits is taken near the old shore-lines, or where shallow water occurred, a larger proportion is black than if the more central areas are examined. The only land of Ohio at this time was to be found in and along the Cincinnati axis, a low fold that had entered the state from the southward at the close of Lower Silurian time, and that had been slowly extending itself northwards through the succeeding ages. Southwestern Ohio was already above water, a low island in the ancient gulf. But the shales on their western outcrop, where they are largely black, are exactly equivalent in age to the alternating and much thicker beds of black and blue shale, the latter being in large excess, that were forming at this time in the central part of the basin, viz., in eastern Ohio. The color of the shales is, from this point of view, an accident, and cannot be safely used as a ground of division. The entire shale formation that we are considering seems to have been laid down without physical break or interruption. It must have required an immensely long period for its accumulation. This is shown not only by the fineness and uniformity of the materials which compose it, and which could not have been rapidly supplied, and by the great thickness of the formation in eastern Ohio, but also by the geological equivalent of the shale in the general column of the country, which furnish even more convincing proof as to its long-continued growth. The Ohio shale, as

Newberry first proved, is certainly the equivalent in the general scale of the Genessee slate, the Portage group and the Chemung group, the last named being itself a formation of great thickness and extent in New York and Pennsylvania. In other words, the shales of our column fill the entire interval between the Hamilton proper and the Catskill group, and in the judgment of some geologists a wider interval even than that named above. As Newberry was the first to show, the oil sands of Pennsylvania are banks of pebble rock that are buri d in the eastward extension of the Ohio shale, but which make no sign within our own limits.

But while definite boundaries for the division proposed can not be laid down or applied within the shale formation, the facts that the top and bottom of the column, on their western out-crops, are prevailingly black, and that the middle of the series is oftener interrupted with light colored beds, are important ones in the history of the formation and deserve to be held in mind. From what has been already stated, it is seen that the composition and thickness of the shale series depend upon where it is measured, whether on the border of the formation or in the interior of the old sea-basin in which it was formed. On the western border of the shales in southern Ohio, in Highland county, for example, the interval between the Upper Silurian limestone, on which the shales here rest by overlap, and the Berea grit, is three hundred feet. In Ross county the same interval is nearly four hundred feet. From both of the measurements fifty feet must be deducted for the thickness of the Bedford shale, in order to give the real thickness of the series now under consideration. In the sections named the shales are mainly black, although blue beds are still recogizable in the series. Passing northwards to Crawford county, the series is found about four hundred and fifty feet thick. In Lorain county, at Elyria, it is about nine hundred and fifty feet, and at Cleveland, about one thousand three hundred feet thick, while in Tuscarawas county, at Canal Dover, the drill descended through one thousand eight hundred and sixty feet of alternating beds of blue and black shale without reaching the bottom of the series, and in the Ohio Valley, at Wellsville, through two thousand six hundred feet of shales, without reaching bottom. In the last two sections the blue shales decidedly preponderate, though the separate black beds can be counted by the score.

The shales are for the most part poor in fossils, except in those of microscopic size. Banks representing a score or more of feet in vertical column often fail to reward a careful search with a single specimen of vertebrate, molluscan or articulate life, and so far as the unaided eye is concerned, they are almost equally barren of vegetable remains. Occasionally, however, fossiliferous bands are found, the contents of which serve to determine the geological age and equivalence of the portion of the series in which they occur.

A calcareous band near the bottom of the series at Bainbridge, Ross county, has yielded a few Hamilton fossils. A band of similiar character near Defiance, and in the same part of the column, yields a few forms in abundance, but not in a very good state of preservation. Newberry reports from northern Ohio a number of forms that are counted characteristic of the Portage group of New York.

The great black shale of the mountains of Virginia, which has generally been recognized as of Hamilton age, is the equivalent of the formation which we are now describing, and carries some of the same fossils that are alluded to in the preceding paragraph.

The Erie shale of Newberry, embracing the central and most of the upper portion of the shale column, has yielded a somewhat larger list of fossils at a few points in northern Ohio, from which the age of the beds is shown to be Chemung, a determination of great importance in Ohio geology. In higher beds of the same blue shale there are found at a few points forms that are referred to as the Sub-carboniferous. Counting this the boundary line between the Devonian and Sub-carboniferous, Newberry took what he deemed the first identifiable horizon above as the base of the last named division, and accordingly drew the line at the base of the so-called Cleveland shale. This boundary is not a definite one, as subsequent investigations have shown, but the top of the upper black or Cleveland shale would answer fairly well for this purpose. It is the first stratigraphical mark that has any claims to persistency above the beds that hold the fossils already named. The fossils of the black shale proper offer no serious difficulty in the way of extending Devonian time to the upper limit of the stratum, and this boundary is consequently assumed as the only one that can be made practically serviceable.

The Cleveland shale, limiting the term to the highest bed of black shale in the series, and which is about fifty feet thick at various points near Cleveland, contains a few fossils, most of which are quite small, but the most striking and remarkable fossils at once of the shale formation and of the entire scale of Ohio, remain to be named. They are the great fishes which have been described under several genera and species, by Newberry and later by Claypole. Some of them belong to the basal beds of the black shale, and others, including the largest, are found near the summit. The first of the series were found at the centers of the great concretions that have been already named as characteristic of the formation. The latter are also found in the uppermost beds of the formation in central and southern Ohio, and also in Kentucky, proving the age of the latter to be the same as that of the upper beds of northern Ohio.

Brief mention must be made of the vegetable fossils of the shales. Fossil wood, derived from trees allied to the pine, is quite common in the lower beds (Huron). The wood is often silicified and the original structure is in such cases admirably preserved. This wood is sometimes found, like the fish remains already noted, at the hearts of the concretions, but occasionally large sized blocks are found free in the shale. On account of its enduring nature it is often found in those beds of glacial drift that were derived largely from the destruction of the shales.

Strap-shaped leaves are occasionally found upon the surfaces of the shale layers. Sometimes they form thin layers of bright coal which deceive the ignorant. Fossil rushes, of the genus Calamites, are also occasionally met with.

But the forms already named are of small account, so far as quantity is concerned, when compared with certain microscopic fossils that are, with little doubt, of vegetable origin, and which are accumulated in large amount throughout the black beds of the entire shale formation, composing, sometimes a notable percentage of the substance of the rock, and apparently giving origin, to an important extent, to the bituminous character of the beds.

The leading forms of these microscopic fossils are translucent, resinous discs, ranging in long diameter from one-thirtieth to one-two-hundredth of an inch. Several varieties have already been noted, depending upon the size, particular shape and surface markings of these bodies.

They were first discovered by Mr. B. W. Thomas, an expert microscopist, in the water supply of Chicago, which is derived from Lake Michigan, and Mr. Thomas afterwards learned that they were washed by the water from the bowlder clays that compose the banks and bottom of the lake. He found the discs present in fragments of black shale, and also free in the clay which was derived from the comminution of the shale.

They were afterwards re-discovered in the black shale of Kettle Point-Lake Huron, by Sir William Dawson, who published a description of the form here found under the name *Sporangites Huronensis*. Sir William counted them at this time the spore-cases of some lycopodiaceous tree.

The facts pertaining to them have of late been more widely published and the attention of geologists in various parts of the world has been called to these and similar forms, and thus there is promise of a speedy enlargement of our knowledge in regard to them. Sir William Dawson now considers the common forms to be the spore-cases of rhizocarps allied to *Salvinia* of the present day. This identification would refer these bodies to floating vegetation on the surface of the seas in which the shales were formed and is thus directly in line with the sagacious interpretation of Newberry, who many years ago attributed the origin of these black shales to a Sargasso sea.

11. The Waverly Group.

The important mass of sediments of Sub-carboniferous age, which is known in Ohio and in some adjoining states as the Waverly group, comes next in the column. The name Waverly was given to these strata by the geologists of the first survey, from the fact that at Waverly, in the Scioto Valley, excellent sandstone quarries were opened in them, the products of which were quite widely distributed throughout central and southern Ohio, as far back as fifty years ago. Associated with the sandstone at this locality, and everywhere throughout the district, were several other strata that were always counted as members of the group by the geologists who gave the name. In fact, the boundaries were made definite and were easily applied. The Waverly group extended, by its definition and by unbroken usage in our early geology, from the top of the great black shale to the Coal Measure conglomerate. This latter element was, in a part of the field, confused with the Waverly conglomerate, afterwards recognized and defined by Andrews, until a recent date, it is true, but the intent of the geologists is apparent, and many of their sections were complete and accurate. If the term Waverly is to be retained in our classification, and it bids fair to be, every interest would be served by recognizing and retaining the original boundaries. The departure from them that has been proposed has led already to more or less confusion. To make the Cleveland shale the base of the Waverly is, as has been already shown, to turn the entire shale stratum into a no-man's land. Aside from a few sections in northern Ohio, where an arbitrary limit was fixed for this upper division, there is no place in the state where a line can be drawn with any approach to a certainty between Cleveland and Erie, or between Erie and Huron. The plan was proposed before the true equivalence of the northern and southern ends of the column had been established. If the fact that the Cleveland shale of northern Ohio forms the top of the great shale of central and southern Ohio had been known, it is doubtful whether any proposal would have been made to break into this undivided and indivisible series, which had been held to underlie the Waverly group, ever since the name was first applied.

11*a*. *The Bedford Shale.*

At Waverly and in its vicinity, numerous sections are afforded reaching from the black shale to the Waverly sandstone courses. This interval ranges from fifty to ninety feet in thickness, and its boundaries are generally clear and distinct. It is occupied with shales, light blue or gray for the most part, but sometimes reddened in the lower portion with peroxide of iron. The latter phase is seen in the excellent section found at Piketon. These shales are thin-bedded, occasionally interrupted with fine-grained sandstone courses, and sometimes carrying ungainly masses of the same material, nodular or rudely concretionary in shape. The beds are almost entirely destitute of fossils, aside from the burrows of sea-worms, which are found on the surfaces of most of the layers, often preserved with great sharpness of outline. At a few points, however, fossiliferous bands, containing a considerable number of species, are found. These have recently been pointed out by Prof. C. L. Herrick, and an account of some of these fossils will be found in his contribution to the present report. All the layers, and especially the upper ones, are generally ripple-marked. In many instances, every sheet, for many successive feet, is marked with the most symmetrical sculpturings of this sort.

This stratum, thus definitely characterized and bounded, received the name of the Waverly shale in the reports of the second Geological Survey for southern Ohio, but in northern Ohio, it was named by Newberry the Bedford shale, the equivalence of the strata not being at that time recognized. The latter name deserves to be universally accepted, being applied to a perfectly distinct and homogeneous formation. The stratum has precisely the same boundaries in northern that it has in southern Ohio, viz. the top of the great black shale and the Berea grit, and, in the main, precisely the same characteristics throughout its whole extent. The description of the stratum at Waverly applies to it at every other point, except that in northern Ohio at a few localities, and especially about Cleveland, there are fifteen to twenty feet of valuable stone included in it. This stone is even-bedded, very strong and durable and it supplies a large quantity of flaggings, caps and sills of the best grade. It is known as the East Cleveland, Euclid and Independence blue stone. In northern Ohio more of the Bedford formation is red colored than in southern, and here it is the top of the formation, rather than the bottom that is thus marked. In the lower beds of the Bedford shale, fossils are, in northern Ohio, at a few points, abundant. They are of pronounced Sub-carboniferous character according to Newberry's determinations, but Professor Herrick inclines to place them somewhat lower in the scale. None of these fossils have been reported south of the lake shore, but the stratigraphical relations of the shale are so clear and its lithological characteristics so persistent and pronounced, that there is not a stratum in our geological column that can be followed across the state in more easily demonstrated identity than this.

11*b*. *The Berea Grit.*

We have reached in our review the Berea grit, the second element of the Waverly series, and not only the most important member of the series, but by far the most important single stratum in the entire geological column of Ohio. Its economic value above ground is great, but it is greater below. In its outcrops it is a source of the finest building stone and the best grindstone grit of the country, and when it dips beneath the surface it becomes the repository of invaluable supplies of petroleum, gas and salt-water. Its persistence as a stratum is phenomenal. Seldom reaching a thickness of fifty feet, its proved area in Ohio above ground and below, is scarcely less than 15,000 square miles, and beyond the boundaries of Ohio it appears to extend with continuity and strength unbroken into at least four other adjacent states. In the opinion of Prof. I. C. White, the Berea grit becomes the famous Murrysville gas sand and also the Gantz oil sand of Washington county, Pennsylvania, but other of the geologists of the state and particularly J. F. Carll, deny such equivalence. As a guide to the interpretation of our series, and especially as a guide to our subterranean geology, it is invaluable.

The stratum was named by Newberry from the village of Berea, Cuyahoga county, where the largest and most important quarries of the formation are located. The name is the most appropriate that could have been selected for this stratum, and inasmuch as it has priority in all fields, it ought to be made to supersede all other names, in adjoining states as well as in Ohio.

From what has been already stated, it will be seen that the Berea grit and the Waverly quarry-stone of southern Ohio are one and the same sheet of sandstone. The identity was missed for a long while in the study of our geology and a wrong order of arrangement found temporary acceptance. The resulting dislocation of our Sub-carboniferous series brought into all our work upon it an element of confusion that is scarcely yet eliminated.

The Berea grit, as seen in outcrop, is a sandstone of medium grain in northern Ohio and of fine grain from the center of the state southwards. In northern Ohio it contains one pebbly horizon over a considerable area, but the seam is thin and the pebbles are small. The stratum is sometimes false-bedded and on the other hand, it is sometimes remarkably even in its bedding-planes. Its main beds or sheets have a maximum thickness of ten feet, but this is an unusual measure and is seldom reached. The formation ranges in thickness from five to one hundred and seventy feet. Occasionally, but very rarely, it fails altogether from the sections in which it is due. Like the Bedford shale below it, it stands for an old shore line, many of its surfaces being ripple-marked and worm burrows abounding in its substance.

It is poor in fossils, but not entirely destitute of them. Fish remains are the most conspicuous, but by far the rarest of the forms it contains. Plant impressions are also unusual through most of the formation, but in northern Ohio there is a certain part of the stratum in which they are quite abundant. They sometimes accumulate in quantity, enough to be known as coal blossoms, the carbonaceous streaks that separate the sandstone beds varying in thickness from a line to a half inch. These carbonaceous streaks are a source of weakness, as a rule, to the stone. Throughout the great quarry district the material of which the stratum is composed is sand as clean as can be found on any sea-beach today. As the stratum is followed into central and especially into southern Ohio it grows more impure as its sand grows finer in grain, a small percentage of clay being held in it at most points.

Under cover it retains the same characteristics in composition that it possesses above ground, ranging from fine to middling grain, and very seldom showing pebbles. It has been proved by many hundred borings in southeastern Ohio during the last few years, and its composition at great depths is almost as well known as in its outcrops.

11*c*—*The Berea Shale—Waverly Black Shale of Andrews.*

A bed of dark, often black shale, fifteen to fifty feet in thickness makes the constant and immediate cover of the Berea grit throughout its entire extent in Ohio. The shale is highly fossiliferous. The bottom layer, which is especially rich in fossils, is very hard and stubborn, being composed of sand bound together with pyrites; consequently this bed when struck in the drilling of wells, is often referred to the sandstone below, rather than to the shale above, but its fossils and its bituminous character favor the reference here given, inasmuch as it marks no new conditions in the history of these beds.

The stratum was first described by Andrews under the name of the Waverly black shale, the typical outcrop being found at Rockport on the Ohio River, but about the same time Meek, who was studying the fossils of the formation in northern Ohio, introduced the designation Berea shale. The latter name is clearly preferable and ought to obtain currency.

In southern and central Ohio, and indeed in almost all of its outcrops, the boundaries of the Berea shale are sharp and perfectly distinct. The Berea grit is its base, and the blue beds of the Cuyahoga shale overlie it. In Cuyahoga county, however, and eastward, the upper limit cannot always be fixed with precision, neither the dark color nor the fossils of the shale disappearing abruptly, but both gradually diminishing. There are, however twenty to forty feet that always deserve to be counted here.

When struck by the drill under cover, the formation uniformly yields a line of facts similar to that already reported. Of the records of the many hundred wells that have been carried down to and below this horizon in southern Ohio and in adjacent territory, during the last few years, there has not a single one been found that has failed to give a place to this little band of black shale. Its services in setting in order our Sub-carboniferous geology have been simply invaluable. It is apparently wanting at a few points in northern and central Ohio. At least some of the drillers who have sunk deep wells here declare that they have found no trace of this stratum.

The Berea shale contains a larger percentage of bituminous matter than the Ohio shale, the amount sometimes reaching twenty-four per cent. It is a source of petroleum on a small scale, as is shown by the fact that in southern Ohio an important ledge of sandstone that belongs just above it is often saturated with mineral tar derived from this source.

11*d*. *The Cuyahoga Shale*

It is impossible to retain for this great division of the Waverly the limits assigned to it by Newberry when he gave it its name. He made it fill the entire interval between the Berea grit and the Coal Measure conglomerate, and according to present knowledge, at least three distinct elements are to be found in every full and normal section of this interval. One of them, viz., the Berea shale, has been cut off from the foot of the column. Another, and a much more conspicuous division, has been taken off of the top of the column, viz., the Logan group. But there still remain one hundred and fifty to four hundred feet of a perfectly distinct, homogeneous and most persistent formation that deserves a name as much as the Berea grit itself, or any other stratum in the Ohio scale, and for which no more suitable name could be found than that which it already bears, viz., the Cuyahoga shale.

It consists of light-colored, argillaceous shales, which are often replaced with single courses of fine-grained sandstone, blue in color, and in southern Ohio weathering to a brownish-yellow. As a constant characteristic there are found through the shales nodules of impure iron ore, generally flat in form, concretionary in origin, and often having white calcareous centers.

By good rights the shale should suffer one more reduction at its lower extremity. Everywhere through the state there is found, directly above the Berea shale, or at a short remove from it, a number of courses of fine-grained stone. These courses are sometimes separated from each other by beds of shale, or they may be compacted into a single stratum. The individual courses also vary greatly in thickness and in color and general characters. Throughout southern Ohio, and particularly in Ross, Pike and Scioto counties, the stratum yields freestone. It is best known from its outcrops on the Ohio River at Buena Vista, where it has long been very extensively worked for Cincinnati and other river markets. The Buena Vista stone, at its best, is one of the finest building stones of the country. The same horizon yields excellent stone near Portsmouth, Lucasville and Waverly. At the latter point it is known as the Waverly brown stone.

Northward, through the state, stone of more or less value is found in the bottom courses of the Cuyahoga, but in Trumbull county, near Warren, the horizon acquires extreme importance as the source of the finest natural flagging that is to be found in our markets.

It would have been well if the thirty or forty feet containing these courses had been cut off from the Cuyahoga shale, in which case the division thus formed would have been well named the Buena Vista stone; but inasmuch as the series does not absolutely require the change, it is left unmodified. The Sharpsville sandstone of White (Second Penna. Survey, Q. 4) belongs to this horizon and is the proper equivalent of the Buena Vista stone.

There are a few sections in which the Cuyahoga shale is more largely replaced by these freestone layers than in the general account above given. In the cuts of the Marietta and Cincinnati Railroad, east from Chillicothe, the freestone appears to constitute a notable proportion, perhaps fifteen or twenty per cent. of the whole material. There are other points at which the stone has no value.

Under cover the Cuyahoga shale retains with great distinctness and persistency the same characteristics that are found in its outcrops. From the deep drillings of eastern Ohio, wherever its horizon has been reached, there are uniformly reported three hundred or four hundred feet of white shales with occasional sandstone layers through which the drill descends rapidly and easily. The Buena Vista courses are also frequently reported directly above or at least near to the Berea shale.

The fossils with which the Cuyahoga shale has b en credited have been largely derived from the division next to be described, while this was counted a part of the shale. As here limited, it is, for the most part, poor in fossils. The surface of many of its beds are marked with the impressions of the cock-tail fucoid, and in its upper portions occasional courses are found in which the animal fossils of this age are abundant and well preserved. The most characteristic and interesting fossils of the Cuyahoga shale, proper, are preserved in concretions, as has recently been shown by Professor Herrick.

11*e.* *The Logan Group.*

The divisions of the Waverly series in northern Ohio as laid down by Newberry, happened to be made at a point where the section is abnormal and incomplete. By atrophy or by overlap, the upper member of the series is wanting in the Cuyahoga Valley, or is at least very inadequately represented there. The missing member is, in volume, second only to the Cuyahoga shale, among the divisions of the Waverly. It is much richer in the fossils of the Subcarboniferous than any of the other members. In composition it is varied and striking, one of its elements being a massive conglomerate, or series of conglomerates, not less than two hundred feet in its largest sections, which extends in unbroken outcrop through at least a half dozen counties of Ohio. No good reason can be found for dividing the Waverly series at all, if a member like this is to be left without a name, or is to be merged with an unlike and incongruous division from which it is as sharply differentiated as any one stratum of Ohio is from any other.

A typical or representative section of this group is scarcely possible, but the most characteristic and persistent part of the series is one of the conglomerates that occurs near the bottom. At all events, coarse rock, if not always technically conglomeritic, is generally found here. Pebbles do not in all cases make a conspicuous part of the rock when it takes a conglomeritic phase. The most characteristic feature of the pebbles in large bodies of the rock is their small and uniform size. The larger pebbles are generally flat. There is, however, a good deal of variation in all these respects. Much of the conglomerate is fairly even in its bedding and otherwise adapted to quarry purposes. Theformation yields in central and southern Ohio quite a large amount of valuable building and bridge stone.

The conglomerate is peculiar in this respect, viz., that it is fossiliferous, containing both animal and vegetable fossils. The usual Sub-carboniferous types of both divisions are found in it. It is interrupted by layers of fine or medium-grained sandstone and sometimes by shale deposits. In central Ohio, there are two fairly persistent beds of conglomerate, as recently shown by Herrick, that can be used in stratigraphical determinations. In a succeeding chapter of this report the divisions that are recognized by the author last named and that are based upon both lithological and paleontological characteristics will be found succinctlyand clearly described. The work of Professor Herrick in this field makes a valuable contribution to our Ohio geology.

The prevailing colors of the coarse sandstone of the Logan group are yellow, red and brown. Some of it is beautifully varigated. Its best developments are in Hocking, Fairfield, Ross, Vinton, Licking, Knox and Wayne counties, which constitute the northwestern arc of the sea-boundary of Ohio in Sub-carboniferous time. South of Ross county it loses most of its pebbles, and south of the Ohio it becomes the Knobstone formation of Kentucky. It is also the Knobstone formation of Indiana, at least in part. In northeastern Ohio the Logan group is also destitute of fossils, and perhaps the conglomerate element proper does not appear here at all.

White gives a generalized section of the rocks of Erie and Crawford counties of Pennsylvania, in Report Q 4, page 66, of the Second Pennsylvania Survey. He shows the presence of six sandstones in the scale, and three of these are common to the Ohio scale as well. The Shenango sandstone of his column is without doubt the representative of our Logan sandstone and Waverly conglomerate. His Sharpsville sandstone is our Buena Vista stone, and his Corry sandstone appears to be none other than the Berea grit. The sandstones of the Pennsylvania column that underlie the Berea grit do not appear as such in the Ohio scale, as has been already shown. By the same token, White's Orangeville shale is an equivalent of our Berea shale, his Meadville shales are our Cuyahoga shale in part, and his Shenango shales are a part of our Logan series.

Interstratified with the conglomerate courses in southern Ohio, are two or more fairly persistent layers of impure limestone. No fossils have been found in them. Similar layers occur in the Logan series of northeastern Ohio, except that in this case the limestones are fossiliferous. They are the upper and lower Meadville limestones of White, and can be followed into Ohio from Crawford county, Pennsylvania, where they were first described.

The Logan sandstone that succeeds the Waverly conglomerate in the full section is an uncertain and inconstant element, for the reason that it plays fast and loose with the stratum last described. Much could be said in favor of counting it the upper portion of the conglomerate. In typical exposures it is a fawn-colored, fine-grained, even-beded sandstone. In this phase of the formation the most favorable conditions for the marine life of the period seem to have been attained, the sandstone being prolific in fossils. The characters above given are quite widely held throughout the state. The Logan sandstone is often found directly underlying the lowest coal seam.

The Olive shales of Read are probably the exact equivalent of the Logan sandstone in age. They seem to take its place in the central counties in part. Overlying the coarse rock in Knox and Coshocton counties, Read reports more than three hundred feet of sparingly fossiliferous shales, to which he gives the name here used.

Diverse as these elements are, they are blended and interlocked in the Logan group, leaving it in stratigraphy and fossils a well-defined and easily followed series throughout all parts of the territory in which it is due, except in possibly a small area in northern Ohio, as already noted, and even here, there is no difficulty in recognizing the presence of this series. The several elements are, however, of smaller volume here than elsewhere. Under cover, throughout southeastern Ohio, the series is in the highest degree persistent and regular, much more uniform, indeed, than in its outcrops. It consists of two hundred feet or more of prevailingly coarse rock, almost everwhere pebbly in spots, but interrupted with sheets of shale, yellowish and reddish colors being the characteristic ones. It has considerable interest in connection with gas, oil and salt water in Ohio, being the reservoir of the brines of the Hocking and Muskingum valleys, and furnishing in the latter large supplies of gas in the early days of salt manufacture in this state. It is also the "Big Indian" sandstone of the oil well drillers of western Pennsylvania, West Virginia and Southeastern Ohio.

The Sub-carboniferous series of Ohio has now, with the exception of a single element next to be named, been passed in review. It is seen to be a very sharply characterized series, a most persistent sandstone, though not a thick one, lying near its base, bedded in shale and covered also by shale, the lower shale being often red in color and the roof shale being always black, and another sandstone or conglomerate stratum, two hundred feet or more in thickness, forming the upper member of the series; these two persistent sandstone formations being separated from each other by three hundred or more feet of light-colored, soft, argillaceous shales. No conditions could be more favorable for tracing such a group under ground than the conditions here found, and consequently the records of deep drillings in southern Ohio become almost as clear and legible as if the rocks through which the drill has passed lay exposed to the light of day.

The real, though not the formal separation of this group from the underlying shale is due to the late Professor E. B. Andrews, and constitutes one of his most important contributions to our knowledge of Ohio geology. He was the first to show that the great conglomerate of Hocking, Fairfield and Licking counties is Sub-carboniferous in age, and he further called attention to a highly fossiliferous, fine-grained sandstone overlying the conglomerate, to which he gave the name of Logan sandstone, from its occurrence at Logan, Hocking county. Up to this time this conglomerate had been universally counted as the Coal Measure conglomerate. Read made know the existence of a heavy body of shale, which he called Olive shales, overlying the conglomerate and replacing the Logan sandstone in Knox, Holmes and Richland counties.

As both conglomerate and sandstone have their typical outcrops at Logan, no better name can be found for the formation, which must include conglomerate, sandstone and shale, than that here adopted, viz., the Logan group.

The maximum thickness of the Logan group is not less than four hundred feet. Its average thickness is perhaps two hundred feet. It has received less study than the rest of the series, and it is only within the last three years that divisions have been recognized in it by means of which a measure of order can be given to its principal outcrops.

12. The Sub-carboniferous Limestone.

This element is of comparatively small account as far as its surface outcrops are concerned, in Ohio, but it gathers strength to the southeastward, and is shown in several well records of the Ohio Valley, in the eastern part of the state, as a stratum fifty or more feet in thickness. It was recognized as a member of our geological column by the geologists of the first survey, but Professor Andrews was the first to assign to it its proper place, and to show its true equivalence. He designated it the Maxville limestone, from a locality in southwestern Perry county, where it is well exposed in beds that aggregate fifteen or twenty feet in thickness. Still heavier deposits of it are found in the valley of Jonathan's Creek, in Muskingum county, near Newtonville. Professor Andrews collected at these points the fossils by which its age was determined to be that of the Chester limestone of the Missouri and Illinois sections.

In its best development, the limestone is a fairly pure, fine-grained, sparingly fossiliferous rock. It breaks with a conchoidal fracture. In fineness and homogenity of grain it approaches lithographic stone and has been tested practically, in a small way, for this use. It is seldom even or regular in its bedding. It is light drab or brown in color, and often is a beautiful building stone, though somewhat costly to work.

The fire-clay found associated with it at several points in southern Ohio is one of the most valuable deposits of this sort in our entire scale. The outcrops of the limestone occur in Scioto, Jackson, Hocking, Perry and Muskingum counties. It is reported in some of the well records of Steubenville, Brilliant, Macksburg, Clarington and at several other points in eastern Ohio.

There remains to be briefly described the great Carboniferous system of Ohio. An extended and more careful review of its composition will be given in succeeding chapters of the present volume, and it will be enough, at this point, to set in order its more striking features. There is a question as to the divisibility of the lower portion of the series. The Pennsylvània geologists describe as the conglomerate series a number of strata, including several beds of coal, limestone and iron ore, that have been counted members of the true Coal Measures in most of the volumes of our Ohio geology. The grounds for such division are, without doubt, much more imperative when the formations are studied in Pennsylvania and the Virginias. So far as the Ohio series is concerned, it is not probable that any division would have been called for on this ground, but, for the sake of the general order, the classification recognized in Pennsylvania and to the southward will be adopted here.

13. The Conglomerate Group.

This group consists of three great sandstones, between which and in which are distributed two thin but persistent limestones and four coal seams, several of them of considerable value. The order is shown in the table below. A fifth coal seam is occasionally found.

Conglomerate group.	HOMEWOOD SANDSTONE.	
	(Tionesta Coal).	
	Upper Mercer Group.	Ore. Limestone. Coal, No. 3 a. Newberry.
	Lower Mercer Group.	Ore. Limestone. Coal, No. 3, Newberry.
	MASSILLON SANDSTONE, UPPER.	
	(Quakertown Coal). Coal No. 2, Newberry.	
	MASSILLON SANDSTONE, LOWER.	
	Sharon Coal—Coal No. 1, Newberry.	
	SHARON CONGLOMERATE.	

This group has an average thickness of two hundred and fifty feet, though the range of the formation is considerable.

14. The Lower Coal Measures.

This division includes the most important section of the Coal Measures, so far as Ohio is concerned.

In it are found six seams of coal, four horizons of limestone, two of which are marine in origin, and several valuable iron ores and fire-clays. A detailed account of the composition of this important division will be found in the succeeding chapter, and the reader is, therefore, refered to it for details as to the structure of the group. Its thickness can be counted about two hundred and fifty feet.

15. The Lower Barren Measures.

For the same reasons that have been given under the preceding head, no detail will here be entered into as to the composition of this formation, further than to say that it comprises from three hundred to five hundred feet of strata which have been of little economic interest. Though included in the Coal Measures they are well described by the title which they bear, the Barren Coal Measures, the coal seams that are included in them being thin and wanting in persistency.

16. The Upper Coal Measures.

This division is also to be treated in a succeeding chapter. Its thickness may be taken as two hundred and fifty to three hundred feet, but its upper boundary is lacking in definiteness.

17. The Upper Barren Measures.

The upper Barren Measures complete the geological column of Ohio so far as its bedded rocks are concerned. In other words, the latest formed rocks of our scale are included in this division. They are to be looked for in the southeastern portion of the state. Belmont and Monroe counties contain the most of these exposures. While they are included in the Coal Measures by the name above assigned to them, a question has been raised by some geologists as to whether they should not be referred to the succeeding age, viz., the Permian. The argument for this is based upon the character of the fossil plants that they contain. The formation is but poorly shown in Ohio, and no ground appears upon which an easily recognized classification could be established.

18. The Glacial Drift.

Over the various bedded rocks of at least two-thirds of Ohio are spread in varying thickness the deposits of the Drift. The boundary which marks the farthest advance of the Drift formation, enters Ohio in Columbiana county, passes eastward through Stark into Wayne county, where it bends sharply to the southward, following in that direction as far as Holmes county. From this point its general direction is southwesterly. It leaves the state in Brown county, crossing the Ohio River into Kentucky, a small part of which is included in the Drift formation. A number of prominent points can be noted by which the boundary can be well designated. Newark, Lancaster and Chillicothe, for example, are situated almost exactly upon the Glacial boundary. The Drift deposits are separated by a vast period of time from the bedded rocks of the geological scale of the state. Many millions of years would undoubtedly be needed to fill the interval between the latest formation of the state, viz., the Upper Barren Coal Measures, which mark the period when rock-making in Ohio was brought to an end, and the deposits of the Glacial Drift. These deposits consist of beds of sand, gravel and clay, variously intermingled and distributed. Bowlders or large blocks of rock, make a conspicuous contribution to the drift deposits. The clay, by reason of the distribution of these bowlders through it in large amount, is named the Bowlder clay. Another designation of it is Till, by which name a deposit of similar age and origin is recognized in Great Britain. Although the most recent of our geological formations, and separated from the present but by a few thousands, or tens of thousands of years, the questions as to its origin are still anomalous and perplexing to a remarkable degree. We can give a much better account of the formations of Paleozoic time than we can of this series that almost merges into the present. Suffice it to say that all geologists now believe that the Drift series is the product of two great lines of events which have worked separately in part, and in part have worked in combination.

The Bowlder clay, which is the most characteristic of the Drift deposits, is now known to have been formed under land ice. It can only be explained by the passage over the regions in which it is found of a sheet of land ice, advancing slowly from the northward. The beds of gravel and sand, on the other hand, which make the latest formation of the drift, are the results of a re-arrangement of the materials of the Bowlder clay in shallow basins of water. The bowlders which constitute so marked a feature of the Bowlder clay can be, in multitudes of instances, traced directly to the ledges of rock from which they were derived. Many of them must have been transported from the Canadian highlands, a journey of not less than five hundred miles. Upon the University farm, within the limits of the city of Columbus, representatives of various formations of Canada and northern Michigan have been found, as, for example, portions of the conglomerate which has its outcrops at the Bruce mines along the north shore of the River St. Mary's, in Canada. Fragments of the Marquette iron ores and of Keewenaw Copper are also found there; bowlders of the Pictured Rocks, or Potsdam sandstone of the south shore of Lake Superior also occur. All of the material of the Drift is derived from regions to the northward. A large portion of that which covers Ohio, at least in the central portion of the state, is derived faom the formations that come to the surface in the northern parts of the state. The limestone and the shale of these regions has made very extensive contributions to these beds. The black shale, especially, proved an easily wasted formation, as the ice sheet attacked it, and it gave way to such an extent that it disappeared entirely from large areas which it must have formerly covered. This is attested by the vast amount of shale which can be recognized in the Bowlder clay. As the ice advanced, it exerted great disturbing force upon what was then the surface of the state. A sheet weighing scores of tons to the square foot and moving forward with irresistible force, holding in its foot fragments of the hardest rocks of the continent, could not fail to leave the traces of its advance by smoothed and striated rocks, which occur everywhere along its path.

There is a question among geologists as to whether the Glacial deposit can be best explained by a single ice period, or by recurrent ice periods. The question is still under discussion, but the weight of opinion on the part of those best qualified to judge seems to be in favor of the latter theory at the present time. But all of the questions pertaining to the origin and history of this formation must be counted far from being definitely settled. The average thickness of the drift deposits cannot be given without providing at least for very wide departures from any general figure. The greatest thickness yet observed in the state is five hundred and thirty, feet, which was reached in a boring that was begun near St. Paris, Champaign county, several years ago. The five hundred and thirty feet of Drift there found, did not exhaust the Drift deposits, but the driller was obliged to abandon the work before he had reached bedded rock. The estimates of average thickness that are occasionally made are entitled to but small consideration. The valleys of the old surface of the state are packed full to a depth of several hundred feet, while the original up-lands that bound the valleys may be covered by but a few feet or by a few scores of feet. It is sufficient to say that the amount of material thus brought down and distributed over the state is vast in amount and that its deposit has added immensely to the value and resources of the state. The soils of three quarters of Ohio are derived from the Drift and are consequently much more varied in composition and, at the same time, of more uniform excellence, than they could have been if derived solely from the underlying bedded rocks. The water supply of the same portion of the state is almost wholly dependent upon the Drift formation. There are entire counties in which the bedded rocks do not once come to the surface, and in which they have, consequently, no effect upon the character of the surface.

GEOLOGICAL STRUCTURE.

The chief formations of the state have now been passed in brief review. As to the geological structure of Ohio, or the mode of arrangement of these several formations, as far as their departures from the position in which they were formed is concerned, a few general statements must suffice.

The annals of the geological structure of Ohio are comparatively short and simple. All the movements that have affected its strata have been of the continental type, *i. e.*, slow and gentle and unaccompanied by fractures, displacements, or the formation of well-marked arches and troughs. The dominant forces in all movements which we can trace have been two-fold; first, that growth of the continental nucleus to the southward which began in the earliest era and which was maintained throughout paleozoic time, and, secondly, the system of northeast and southwest foldings of the eastern border of the continent, which culminated in the formation of the great Appalachian mountain system. The latter division of these forces is the more conspicuous. It was displayed in the first emergence of the rocks of the state above the surface of the sea. The approximate date of this emergence is the close of Lower Silurian time.

The Cincinnati Axis.

Under the above designation, the most important fact in the early history of the geological structure of the state is known. The best account that has been given of it is that of Newberry which is found in Geology of Ohio, Volume I, page 90. This account needs to be supplemented by the facts given in Volume II, page 411, and in Volume VI, page 46.

About the close of Lower Silurian time a broad and very flat arch made its appearance in Ohio at its southwestern corner. This arch had already traversed Tennessee and Kentucky in a northeasterly direction, and upon the geology of these states it exerted a profound influence. Newberry counts this elevation due to the same cause by which the great mountain arches of the Atlantic border were long afterwards formed, namely, the crumpling of the crust, due to its contraction by cooling, the force acting at right angles to the Atlantic coast line. The direction of the Cincinnati axis is approximately the same as that of the later axes of elevation, namely, north of east and south of west. In Ohio and Indiana, this important feature proves to be much less simple than was formerly supposed. This has been shown in Geology of Ohio, Volume VI, page 41. The main axis is there proved to have, in western Ohio and in Indiana, a northwesterly instead of a northeasterly trend; but a subordinate elevation branches from it on the western border of Ohio in Mercer county and traverses northern Ohio to the shore of Lake Erie. Possibly it crosses the lake basin into Canada.

There are probably other lines of slight elevation in southern Ohio that go back for their origin to an early date. The few facts that we have, bearing on the structure of the Lancaster gas field, for instance, seem to point to such a date of the uplift upon which its gas production depends. But such conclusions can be derived only from the results of the drilling of deep wells, and consequently the facts will be scanty and cannot be worked out minutely, or with absolute certainty.

The movements to which the Cincinnati axis is due, were in reality profound and long continued, and their influence on the geology of this portion of the Mississippi, were far-reaching. All the dips of the strata in the southwestern quarter of the state stand in close connection with the formation and growth of the Cincinnati axis. These dips are mainly southeasterly in direction and are satisfactorily accounted for by the uniform growth of the Cincinnati axis while the strata were in progress of formation. So far as known the Cincinnati anticline is nowhere, in southern Ohio or in the states of Kentucky and Tennessee, distinctly associated with the accumulation of petroleum; but in central and northern Ohio and also in Indiana, its influence in this connection has lately been found to be important and of vast economic interest. A slight modification may be required as to the date of the origin of this great feature in the latter areas. The Indiana gas field, which is probably the largest continuous gas field thus far discovered in the world, is wholly conditioned by and dependent on the broad up-lift which is the immediate and direct extension of the Cincinnati axis. It is certain, however, that the movements of the strata in the territory last named, by which petroliferous accumulation was provided for, occurred at a much later date than that assigned for the original emergence of the Cincinnati axis at the southward. Upper Silurian and Devonian strata are distinctly involved in the low arch in which the gas and oil are gathered. The same thing is true of the broken structure on which the oil productlon of Hancock and Wood counties in northern Ohio, depends. This district can be referred to the Cincinnati arch only by a very liberal interpretation of this great structural feature of the state. The details of this structure are traced out at some length in Geology of Ohio, Volume VI, chapter III.

The Appalachian Folds of Eastern Ohio.

The rock flexures of eastern Ohio are invested with much more general interest than the facts pertaining to the far more ancient and obscure Cincinnati uplift. The cause of this greater interest is found in the economic importance of the former in connection with oil and gas. The anticlines of eastern Ohio are unmistakably part and parcel of the great series to which the Allegheny mountains of Pennsylvania and Virginia belong. These folds are exceedingly well developed in central Pennsylvania. The whole system of Paleozoic rocks is there bent into enormous arches in which two or three miles of length are compressed into a single mile. Nowhere in the world is there any more striking and beautiful exposure of rock arches than here. The number of distinct folds is considerable; but as the series is followed to the westward the flexures become less crowded and less pronounced, until in western Pennsylvania they no longer constitute the dominant features of the country. They are flattened and reduced until the pitch of the strata falls as low as one or two degrees, and the beds now traverse the summits of the arches without any fracture whatever. It has been found by the experience of the last twenty-five years that these unbroken arches are the main repositories of the oil and gas that have acquired such extraordinary value within this period, especially in Pennsylvania. The further westward the arches are followed, the feebler they are found to be; consequently, only the lowest of the Pennsylvania series pass into Ohio. But the same law holds beyond state boundaries, and the folds which are due to the same general cause, that originate and run their entire course in Ohio, are even lower and weaker than the lowest of Pennsylvania. They no longer take an important part in the topography of the regions which they traverse, and they can be detected only by close and continuous series of measurments. Sometimes they are represented only by a suspension of the usual dip, the beds taking a terrace-like arrangement for a small space. They are, however, still found, to some extent, effective in the separation of the contents of the porous rocks of the series involved. Consequently, the driller for oil and gas makes constant inquiry as to the location of the axes or anticlines of eastern Ohio. It is not pleasant to be obliged to answer that these important structural lines have not been as yet laid down upon our maps, but this is the fact in regard to them. As already implied, the feebler the axes, the greater must be the difficulty in tracing and locating them. Labor enough has been spent on this line of questions to have accurately located all of our anticlines, if they could have been followed with the same ease and certainty with which the arches of western Pennsylvania are traced. But aneroid measurements are not sufficient, as a rule, for this sort of work in Ohio. Nothing less than profiles run by the engineer's level affords a sure basis for the determination of our feeble folds. But the running of such lines across a rough country is expensive and, furthermore, can be done only under careful geological guidance, for the reason that the determination of the strata on which the whole work turns, involves an accurate knowledge of the entire geological section that is concerned. The scale on which it has been possible to carry on field work in Ohio for the last few years has been so very small that it has been out of the question to attempt the determination of many lines by the methods here noted. A careful examination was made by the Survey of the Baltimore and Ohio railroad from Newark east to Bellaire, to catch, if possible, the arches that cross this road. A like examination was made of the southern portion of the Cleveland, Lorain and Wheeling railway and a less careful examination of the Cleveland and Pittsburg railroad on Yellow Creek. Private surveys have also covered considerable territory in Muskingum, Morgan, Guernsey and Harrison counties, the results of which have been, in part, available to the Survey.

The results of all the observations made to date can be summarized in few words.

The Fredericktown Anticline.

The first axis known to enter the state from Pennsylvania north of the Ohio river, is a very feeble fold, named by Prof. I. C. White, in the Geological Reports of Pennsylvania, the Fredericktown axis, the name being taken from the small village on the Little Beaver, in the southwest corner of Pennsylvania. The axis gives rise to the Smith's Ferry oil field and probably also to the weak gas production of East Liverpool. But it is not known that any value is attached to it northward. It apparently crosses the Ohio Valley near East Liverpool and traverses the Pan Handle of West Virginia for a few miles ; probably it recrosses the river near Toronto. Its feebleness is shown by the fact that, though crossing the river twice, it has not had the slightest apparent effect on the course of the stream.

The Wellsburg Anticline.

Another weak line of elevation comes into Ohio from West Virginia, a few miles below Steubenville. It may be called the Wellsburg anticline, a gas field of considerable promise having been found ten years ago near the West Virginia village of this name. The gas of Brilliant, on the Ohio side of the river, must apparently be referred to the same elevation. If this axis is assumed to run parallel with the line already indicated as the Fredericktown axis, it will be found to cross Captina Creek near the Captina coal mines where, as is well known, a distinct uplift is seen. If extended still further to the southward, this line would cross Monroe county a few miles east of Woodsfield.

The Salisbury Anticline.

The next fold to be indicated lies six to eight miles northwest of the Fredericktown axis. It may be called the Salisbury anticline, from the fact that it was first located near the station of this name on the Cleveland Pittsburg railroad, in the Yellow Creek Valley. The extension of this axis, if it crosses the state line into Pennsylvania, has not been noted. As seen in tracing the well known coal seams of the Yellow Creek Valley, the fold is very slight, but is still an arch and may reasonably enough be expected to show some economic interest in portions of its extent.

The Cadiz Anticline.

This fold is probably entirely confined to the territory of Ohio. It is somewhat more distinct and of greater force than any of those already named. Its best marked development thus far is to be found in the center of Harrison county. The summit of its low arch lies one to two miles due east of the court house in Cadiz. The general fact of an uplift at this point was noted as far back as 1874 by Prof. J. J. Stevenson, who refers to it in his report upon the geology of Harrison county, Volume III, page 201. It has been traced through two townships to the northward of Cadiz; its extension southward is probably indicated either by the Barnesville gas field, which lies about two miles northwest of the village, or by the low arch that was found by the work of the Survey in the section already named along the line of the Baltimore and Ohio railroad, a mile east of the railway station at Quaker City. If the latter identification is true, it would be to this arch that the short lived gas production of the last named town is due. The former reference seems, however, the more probable.

A slight change in the direction of either this line of elevation, or the one last named, viz., the Salisbury axis, would reach and explain the well known oil field of Macksburg. Though at no time a great oil field, Macksburg has been of considerable economic importance at times during its development, while in scientific interest, it is not inferior to any oil field of the country. It was here that the "terrace structure" as connected with oil accumulation was worked out by F. W. Minshall, Esq., and the verification of his discovery by the detailed work of the Ohio Geological Survey, makes a contribution of great significance and value to the geology of petroleum. If still continued southward, this line would cross the Muskingum Valley near Lowell.

The Cambridge Anticline.

The next arch or fold to be noted, is like the one last named, though feeble, still distinctly traceable. It was first recognized by Prof. J. J. Stevenson in his report on the geology of Guernsey county, Geology of Ohio, Volume III, page 220. As determined by the instrumental work of the Survey, the summit of the Cambridge arch, lies very near the western boundary of the corporation limits; but the developments of the drill seem to place the axis a mile or so further eastward. As to its extension, the uncertainty already confessed in regard to the axes previously named exists. From the occurence of gas and oil near McConnelsville, a slight relief in the rock formatlons must occur at that point. If Cambridge and McConnelsville are joined by a straight line, this line would be in fair accord with the facts previously indicated in this section.

The recent oil production of Corning, in the southeastern corner of Perry county, must be explained by some low fold of the strata in this territory, and this fold may be designated as the Corning axis, but there are not facts enough at hand to determine its exact location or its extension.

CHAPTER II.

THE CLAYS OF OHIO, THEIR ORIGIN, COMPOSITION AND VARIETIES.

By Prof. Edward Orton.

In Volume V, Geology of Ohio, published in 1884, a chapter prepared by Edward Orton, Jr. was devoted to the clays and the industries established on them in the state. The chapter contained an excellent review of the various substances which the comprehensive title above given includes. In its first section was discussed the question as to the origin and composition of clays. In the second section the several divisions of the clays of Ohio were pointed out, so far as their places in the geological scale are concerned, and in the third section a careful review was made of all the leading lines of manufacture in which the clays of the state at that time were being employed.

In the several years that have passed since the publication of Volume V there has been a great expansion of clay working industries in Ohio and in the country at large. One of the most important of these industries in the state at the present time has been introduced within this period and other older lines of manufactures have been greatly increased and strengthened during the same interval.

Districts from which the coals have been mainly taken are the principal theaters of this development; and it is now evident that the clays which have hitherto been entirely neglected, after the coals ceased to be mined in the large way, will prove far greater sources of wealth to such districts than the coal itself ever proved to be. Higher grades of labor and more stable industries are built on the clays than the coals could be made to support. The remnants of coal in such places are generally ample to supply cheap fuel for the manufacture of the clay, for a few years, at least.

The new and general interest with which the subject of clay is now invested demands more than a simple supplement to the chapter contained in Volume V. There is need of the same elementary and extended statements that this chapter presented and since it cannot be presumed that the volume in question is accessible to the great majority of persons who are now disposed to study the subject for the first time, it has been deemed best to furnish to all such readers as intelligible an account as possible of the origin and classification of clays and shales, as well as a description of the uses to which they are being applied in the state at the present time. This, however, will involve a repetition of the statements and discussions of the former chapter on the subject; and inasmuch as the mere change of form in the statements for the sake of change can be of no value, the materials of the previous chapter will be used in the present report with all freedom. The divisions of the chapter of Volume V will be for like reasons employed in the present report, with but slight modifications. The present chapter will be devoted to the origin, composition and varieties of clay.

SECTION I.

The Origin and Composition and the Varieties of Clays.

Origin of Clay.—What is clay? No substance entering into the composition of the earth is more commonly met or more familiarly known. All persons of ordinary intelligence have a more or less definite idea as to what is meant by the word. As ordinarily used, clay denotes any earthy substance which can be worked up with water into a plastic mass and then retain the shape into which it has been formed, when dried. Clay and sand are two of the most common products of the decomposition of the older rocks that constitute what is familiarly known as the crust of the earth. They enter into almost all soils and generally their aggregates make nine-tenths of these soils. Desert plains and barren mountain sides as well are largely covered with clay or sand. And the same is true to a great extent of the floor of the sea, especially that portion of it that constitutes the margins of the continents.

So wide a range of distribution naturally suggests great variety of composition in the substances that are called clay and the most casual examination confirms this expectation. Varying and ever-changing proportions of sand, iron oxide, lime and organic matter and fragments of many kinds of rocks are found associated in masses to which we are obliged to give the name of clay. Strictly speaking, however, the term applies to a single mineral, viz., silicate of alumina or kaolinite. This mineral in a pure state is of comparatively rare occurrence, and large and accessible accumulations of it become of great economic value in many parts of the world. But it is this mineral that makes the basis of all clays. The percentages of it vary indefinitely in their composition and, as already stated, other substances in considerable variety are united with it under a common designation. The larger the percentage of kaolinite, the more characteristic is the clay containing it.

Kaolinite is not an original product of the earth's crust. It is always the result of the decomposition of other and more complex mineral aggregates. The one great source of it is felspar in one or the other of its leading divisions. The most abundant mineral in the crust of the globe is quartz or crystallized silica. Quartz, including the silica derived from it, forms one quarter of the portion of the earth which we know as its crust. Next to quartz in abundance is felspar, or rather the group of felspathic minerals. There are three or more well-marked divisions of the felspar family, viz., orthoclase or potash felspar, albite or soda felspar, and anorthite or lime felspar. All of these are complex minerals. Orthoclase may be taken as the type of the group. Its composition is thus expressed in chemical terms, K_2,O, Al_2O_3 6 SiO_2. In other words it is a double silicate of potash and alumina. It appears that in nature, when the opportunity for original composition among the elements was offered, their natural affinities were never satisfied with the formation of the simple compounds of silica and alumina, or silica and potash, but these substances were obliged to enter into double combination. As above described, the case is really much more complex than has been here represented. Silicates of both potash and soda and also of lime and magnesia are all found in the same mineral aggregation, which must be designated by one or the other of the general terms used in the classification of the felspars. But one of the substances named above is quite likely to be in the ascendant and gives character to the compound. But if the silicate of alumina is to be sought for in a complex mineral, how does it attain the separate existence in which it becomes so serviceable to us? In other words, how does clay originate from felspar?

Clay is a product of the decomposition of felspar through the agency of the atmosphere. Though seeming so bland and harmless, the atmosphere is charged with agencies that will dissolve the firmest rocks of the earth's crust. The oxygen, which is one of its main constituents, the carbonic acid and the water that are always present in it, though the latter occur in small and in varying proportions, constitute, when taken together, an almost universal solvent. Soil waters also, containing the acid products of vegetable decomposition, become a powerful agent of rock disintegration and decay. Under the combined agencies above noted granite rocks, and particularly those containing potash felspar, pass through a rapid process of decomposition. At least one phase of the process is the decomposition of the silicate of potash of the compound mineral, through the agency of the carbonic acid of the air. The carbonate of potash thus formed is soluble and is removed as fast as set free in drainage or in surface waters, while the silicate of alumina remains behind as clay. The granite rocks of which the felspar was a leading component contain also quartz and mica and various other minerals, some of them in relatively large amounts. These accessory minerals become blended with the silicate of alumina in the process of decomposition; and it is the product of this result that we call clay. The silicate of alumina is its base and its characteristic element, but disseminated in the mass are grains of quartz, flakes of mica and indefinite proportions of lime, iron and other elements, together with fragments of various minerals and rocks in all stages of disintegration and decomposition. Clay, therefore, is not silicate of alumina pure and simple. For this compound we have the specific name already given, viz., kaolin. This word comes to us in a somewhat modified form from the Chinese language. It is said to be derived from two words (Kau-ling), meaning "high ridge," reference being made to some locality from which large deposits were derived.

Physical Properties of Kaolin. Kaolin is a definitely constituted mineral and can therefore be represented by a chemical formula, which is as follows: $Al_2 O_3$, $2SiO^2$, $3 H^2 O$. The proportions of the different elements are shown herewith, viz:

Alumina,	39.80	Geikie's Text Book, p. 81.
Silica,	46.30	
Water,	13.90	

or, discarding fractions, we have, Alumina, 39, Silica, 47, Water, 14. The color of the mineral is white. Its specific gravity ranges from 1.5 to 2.2. Its hardness varies between 1 and 2. It is soft and meagre to the touch when dry, and plastic when wet. It takes, also a definite crystalline form, that of thin plates. This, however, it very infrequently assumes. Derived, as it is in most instances, from the decomposition of felspathic rocks and chiefly from the decomposition of granite and gneiss, kaolin is very seldom found pure in nature. In other words, the usual product of such decomposition is clay and not kaolin. But the name of the mineral is commonly applied to masses of high-grade clays, from which the finest work can be manufactured. The deposits are generally found bordering masses of easily decomposed felspathic rocks. The particles of kaolin are exceedingly fine and hence are easily held in suspension in water and can be transported for long distances; but part of them, carried by water to lower levels, accumulate there in such settling basins as are naturally furnished. With the clay, fine particles of sand and rock are also transported which are subsequently removed from the so-called kaolin deposits by repeated washings. Most of the kaolin used in the arts has been subjected to this last mode of treatment. A new method has recently been invented in which separation of the clay is effected by regulated air blasts.

In the decay of felspar, it happens that many of the grains of the undecomposed mineral are set free along with the products of chemical change. A fine mechanical division of the mineral is also accomplished by ordinary abrading agencies, as those of streams and waves. The felspar particles constitute almost as fine-grained a mass as the kaolin itself, and they are often mistaken for clay, but they *do not become plastic in water*, and by this means can be distinguished from clays proper. It is thus seen that finely divided felspar, known as felspathic mud, must be distinguished from decomposed felspar, though a superficial examination would easily confound the two products. As a necessary result of the mode of origin already described, more or less of this felspathic mud is ordinarily associated with deposits of clay.

Chemical Properties of Kaolin.—The physical properties of kaolin have been described in the preceding paragraph. It remains to describe with equal brevity the chemical behavior of the mineral. Its most marked chemical characteristics are its insolubility and its infusibility. Kaolin is not affected by any of the ordinary chemical agents, nor by the high temperatures that we are able to produce. Out of the latter fact grows one of its most important uses, viz: the supply of refractory materials for the various needs of metallurgy and other lines of manufactures. Kaolin shares this character of infusibility to some extent with one or two other substances, as, for example, with quartz, which is pure silica, and also with talc, which is silicate of magnesia. But it easily stands at the head of the list of refractory substances and is indispensable in many of the arts of practical life.

But while kaolin, taken by itself, is infusible even when exposed to the highest temperatures, in the presence of compounds of lime, magnesia, iron, potash, soda and certain other elements, it readily combines with these substances and forms double silicates, similar to those which constitute the felspars of the granite rocks, the history of which we have already briefly followed. The substances last named are accordingly called, in these relations, fluxes. Named in the order of their effectiveness in this work, the principal fluxes are potash, soda, iron, lime and magnesia. Even small percentages of one or more of these substances in admixture with the clay will destroy the value of the latter as a refractory substance. So, also, with the felspathic mud, already described. Containing, as it does, the potash, soda and lime of the original minerals, it is ready to take part in the mischievous reactions which render the clay fusible. On the other hand, the finely divided silica of the original mineral, which is sure to be left in greater or less amount from the decomposed granite in intimate admixture with the kaolin particles, detracts nothing from the latter in its heat-resisting properties. In almost all high-grade clays a notable percentage of free silica is found. This is the only impurity that can be allowed in clay without detracting from its value as a refractory body. For many uses the silicious clays are not inferior to the purest kaolin.

The fluxing elements already named, and particularly potash, lime and iron, are so widely distributed in nature, and especially in the older felspathic rocks, that it cannot be expected that they would be wholly wanting in the products of decay of the latter. Only in the rarest instances, as already stated, in another connection, will the kaolin particles be found without admixture. Whenever they occur, the deposit, if easily accessible, acquires considerable commercial value. The great mass of clays consist of these more or less impure products that have been already described. No chemical formula can be given that will include them, but they vary from one another indefinitely and endlessly. The only thing essential to their retaining the name of clay is that a considerable percentage of the kaolin base, namely hydrated silicate of alumina, must enter into all, giving them the quality of plasticity when wet, which is the commonly accepted characteristic of this group of substances. The name of clay is, probably, sometimes applied to compounds containing as small an amount of the hydrated silicate as ten per cent.

From the statements already made it will be seen that the clays of high grade are likely to be found near the rocks from the decomposition of which they are derived. They have been transported but short distances from the places where they were disengaged. In point of fact they are often found intermingled with undecomposed rock in the very ledges which gave rise to them. The well-known Cornish rock of southwestern England, widely used in porcelain manufacture, is an example of this mode of occurrences.

Clays of this character, however, constitute an extremely small percentage of the immense group of argillaceous deposits. The great majority of them have been transported by the ordinary agencies of rivers and seas far from their original sources and have been variously blended with other products in the course of their removal. Entering into stratified rocks of various grades and names, these clay deposits pass through an unending cycle of change. Formed from the waste of the dry land in one geological period, they may themselves become the dry land of a succeeding period, to be again removed and built into new rock formations; and to each stage the proportions and associations of the clay may be different from any that have preceded it. Much of the clay that takes part in the formation of the present surface was originally discharged from the felspathic rock to which it is to be traced in the earliest stages of the earth's history. The felspathic decomposition accomplished in our own period is a relatively insignificant source of the clays that are available to us for any of the uses to which we apply them. The soft beds from which we make our building and our paving brick to-day, if we could follow them through all their history, might lead us back at least in part to the original granitic crust that constituted the first dry land of the globe. Certainly a considerable part of the clay that we are at present using in Ohio is taken from beds of Paleozoic age.

Classification of Clays.

There is no scientific, or, in other words, there is no exact classification of the clay deposits of the earth's surface possible at the present time; but for the sake of convenience, we divide them roughly into a few general divisions. One of the commonest of these popular divisions is that which classifies argillaceous material into two groups, namely, *clays* and *shales*.

Clays and Shales—This distinction is recognized in geology also. It does not necessarily mark any difference in quality or in chemical composition, though many of the leaner varieties of clay will be found under the head of shale; but it is based upon the presence of a thinly stratified or fissile structure in the latter which is wanting in clays proper. This structure is called lamination. It is quite possible for materials of identically the same chemical composition to be found in both divisions. The clays proper lack this fissile texture, but between well-marked types of the two extremes every gradation can be recognized. The line separating such a series into clays and shales will be an altogether arbitrary one.

The clays may contain such large amounts of one or another of the impurities already mentioned as of common occurrence in these deposits that they can be named from these impurities. Thus we find calcareous clays, silicious clays, ferruginous clays, carbonaceous clays.

Similar divisions of shales are recognized, but in addition to those already named as calcareous, silicious, carbonaceous, or bituminous and the like, we sometimes speak of argillaceous shales implying a decided preponderance of the last named element. We also recognize alum shales, pyritiferous shales and various others. Shales differ among themselves very much as to hardness and other physical properties. Some of them break up easily into clays, under the action of water, while others can with difficulty be made to show the plasticity which is the first test of all true maltered argillaceous deposits. Shales must be carefully distinguished from slates, with which they often agree closely in appearance and in general composition. Slates are shales or other argillaceous deposits that have been hardened and otherwise metamorphosed by heat combined with high pressure. Slates are among the most durable rocks, while almost all shales are perishable upon exposure.

As a rule, shales originate in deeper water than clays. The lamination which is characteristic of them may take its rise either from intermittent deposit of the materials composing them, or from the effect of the pressure of the overlying beds, or from both these factors combined.

Several varieties of shale have been found to be better adapted to important lines of clay manufacture than even the higher grades of clay, and a great enhancement of value is in progress in respect to such deposits.

Varieties of Clay.

Bearing still in mind that the divisions of argillaceous deposits which we find it convenient to recognize are for the most part popular and not scientific, and furthermore that the exact boundaries of these divisions cannot be laid down, we can separate, for our present purpose, all of them into two main groups, viz., high grade clays and low grade clays.

		Uses.
HIGH GRADE CLAYS.	1. Kaolin.	Manufacture of fine ware.
	2. China clay.	" " " "
	3. Porcelain clay.	" " " "
	4. Fire clay (hard).	Refractory materials.
	5. Fire clay (plastic).	" "
	6. Potters' clay.	Earthenware, etc.

		Uses.
LOW GRADE CLAYS.	1. Argillaceous shale.	Paving block, etc.
	2. Ferruginous shale.	Pressed brick, etc.
	3. Silicious clays.	Paving block, sewer pipe, etc.
	4. Tile clays.	Roofing tile, draining tile.
	5. Brick clays.	Pressed brick, ornamental brick,
	6. Calcareous shale.	Common brick, etc.

The first division comprises all clays and shales that contain in conjunction with not less than fifty per cent. of kaolin base little else but finely divided silica. The amounts of the fluxing elements are in all cases small, rarely aggregating as much as five per cent. and generally falling below three per cent. Oxide of iron constitutes much the largest single element of these fluxes. In almost every case the potash is low. Such a division as is suggested here would leave out some highly refractory clays, it is true, but the good properties of such would seem to result principally from the silica they contain.

The second division includes all ordinary clays and shales. They may range in kaolin base from ten to seventy per cent., but they always carry a notable percentage of the fluxing elements. The alkalies generally make two to five per cent., while lime, magnesia and iron add two or three times as much more. Coarse sand and rock fragments often make a conspicuous part also. These low qualities of the clay more frequently result from a surplus of fluxing element than from a deficiency in kaolin base.

In the present discussion of these several varieties of deposits, special consideration will be given to those that are found represented in the geological scale of Ohio. Kaolin, china clay, porcelain clay and pipe clay, as they are ordinarily designated and distinguished, do not occur within its boundaries, but all the other divisions named above are found in great abundance and in great variety. Brief descriptions of these several divisions as they occur in Ohio will be given at this point.

1. *Fire Clay.*—Between kaolin proper and the purest fire clay of the state no true line of division can be drawn. In chemical composition they are identical, as seen in the following analysis:

1. Mineral Point clay. (*Wormley.*)

2. Sciotoville clay. (*Lord.*)

	1	2
Silica.	49.20	43.78
Alumina.	37.80	46.82
Combined water.	11.70	13.77

but in popular language they are separated into distinct groups. The name "kaolin" has generally been given to deposits derived directly from the decomposition of felspar, though it is not strictly confined to such products. But the term "fire clay" is restricted to clay deposits of more or less purity that are found in our several series of stratified rocks and notably in the underclays or slates of coal seams. Coal Measures are universally Clay Measures as well.

It must be distinctly borne in mind, however, that the designation as commonly used in the state at the present time is no guarantee of the quality of the deposit to which it is given. The name is applied indiscriminately to all underclays of coal seams without any reference whatever to their grades or composition. Hard clays that come fully up to the kaolin standard are grouped promiscuously with soft or plastic deposits that may be very low in the kaolin base and very high in all the elements that impair the quality. The truth is, the word has lost its proper restriction of meaning, and unless its appropriate limits are restored it would be better if it could be dropped altogether. A fire clay, properly speaking, is what its name indicates, a refractory clay, and therefore a clay of high grade. It becomes white by calcination. The term becomes positively misleading when applied to fusible clays that will melt into slag at moderate temperatures. But by far the largest use of it in the state at the present time is in application to this last named class of clays. In this report the designation will be limited as strictly as possible to refractory clays.

Fire clays are divided into two well-marked and contrasted groups, viz., non-plastic and plastic clays. The former constitute our chief supply in Ohio. Non-plastic fire clays are sometimes known as rock clays and also as flint clays. They exhibit when broken a smooth conchoidal fracture. On exposure to the weather they crumble into small but angular grains, beyond which the disintegration does not advance perceptibly. Their particles, even when finely ground, do not show the ordinary plasticity of clay. In this respect, one of the most important and characteristic of all the clays departs notably from the definition of the very class to which it belongs, but it is held in its place by its chemical composition and behavior. Moreover, by repeated and prolonged grinding, a growing measure of plasticity is imparted to the mass.

Plastic fire clays do not necessarily differ in appearance from other plastic clays, but chemical analysis shows the ground of their separation. The best of them equal the best of the hard clays already described, closely approaching kaolin in composition, and they are of equal value for refactory materials.

To the question so often asked, as to what the peculiarity of the hard fire clays depend upon, no full and satisfactory answer can be given. The more probable explanation is that the clay has assumed a definite or at least an incipient crystalline form. Under the microscope it is sometimes seen to consist of bundles of minute rods, crowded close together, while the soft clay lacks this feature altogether, or contains only fragments of these rods. The difference between the two groups of clays does not depend on the amount of alumina nor on the impurities they contain, as a superficial examination might lead us to conclude. Whatever the explanation may prove to be, the line of demarkation between them is clear and well defined.

None of the plastic underclays of the state, so far as known, show the high quality which would justify the application of the term "fire clay" to them; but they are all universally known by this name and it seems a hopeless attempt to restrict the term to its true signification.

2. *Potter's Clay.*—Between the plastic underclays of the state that are called fire clays and the clays that are known as potter's clays, there is no difference whatever. The names are strictly interchangeable in common use. When potteries are drawing their supplies from them, they are likely to be named in accordance with the fact; but otherwise they are known under the former designation. As a rule, however, the most characteristic clays of this division are decidely inferior in composition to the fire clays. They contain large proportions of the fluxing elements and always show a high degree of plasticity. The last named quality it obviously an essential one and governs all the rest. The clays of this division are used not only in stoneware, but also to a considerable extent in sewer pipe, fire-proofing, flue linings, paving blocks and ornamental brick.

3. *Brick Clay.*—The last of the divisions made in the rough classification that has here been attempted, comprises a large variety of clays and shales, which are more or less used in the manufacture of sewer pipe, paving blocks and common building brick. It includes all the coarser forms of clay and the numerous varieties differ so widely among themselves that no definition can be given beyond the simple statement that all contain more or less silicate of alumina in their composition.

SECTION II.

The Clay Deposits of Ohio.

To understand the distribution of the clays in Ohio, we must acquaint ourselves with the geological scale in the state, and of the areas covered by its several formations. All the varieties of argillaceous deposits that have been enumerated in the preceding section, so far as they have present or prospective economic value, viz: shales, brick clays, potters' clays and fire clays, will be included in this review.

GEOLOGICAL SCALE OF OHIO.

Formation	Subdivisions	Thickness		System
18. Glacial drift			0 to 550 feet.	
17. Upper Barren Coal Measures			500 "	Carboniferous.
16. Upper Productive Coal Measures			200 "	
15. Lower Barren Coal Measures			500 "	
14. Lower Productive Coal Measures			250 "	
13. Conglomerate Group			250 "	
12. Sub-carboniferous Limestone, Maxville, Newtonville, etc.			25 "	Sub-carboniferous.
11. Waverly Group.	11*e* Logan Group, 0–350′	500′ to 800′	500 "	
	11*d* Cuyahoga Shale, 150–450′			
	11*c* Berea Shale, 20– 50′			
	11*b* Berea Grit, 3 to 160′			
	11*a* Bedford Shale, 50–150′			
10. Ohio Shale	10*c* Cleveland Shale...	250 to 3,000 feet		Devonian.
	10*b* Erie Shale			
	10*a* Huron Shale			
9. Hamilton Shale (Olentangy Shale?)			25 "	
8. Devonian Limestone, Upper Helderberg or Corniferous, including West Jefferson sandstone			75 "	
7. Lower Helderberg Limestone or Waterlime, including Sylvania sandstone, 50 to 600 feet			500 "	Upper Silurian.
6. Niagara Group.	6*d* Hillsboro sandstone		30 "	
	6*c* Guelph or Cedarville limestone, 50′–200′		150 "	
	6*b* Niagara limestone		50 "	
	6*a* Niagara Shale, including Dayton limestone, 5′ to 100′		100 "	
5. Clinton Group, in outcrop, 20′ to 75′; under cover, 75′ to 150′			50 "	
4. Medina Shale, in outcrop, 25′; under cover, 50′ to 150′			75 "	
3. Hudson River Group, 300′ to 750′			750 "	Lower Silurian
2. Utica Shale, not seen in outcrop, but 300 feet thick under cover in Northern Ohio			300 "	
1. Trenton limestone, seen only in Pt. Pleasant quarries if at all			50 "	

1. The lowest, or oldest argillaceous stratum that is known to be worked, or to have been worked for economic use in Ohio is the Medina shale, No. 4, of the table above given. As will be seen from the table, it has a thickness of twenty-five feet in its outcrops, which are wholly confined to southwestern Ohio. In fact, it scarcely appears as a surface formation at all, even there. Its soft and easily eroded beds account for this fact. It is mainly found in included sections and the number of them is not large. The Medina shale is reddish, whitish, yellowish, or blue in color. The first named color is most characteristic. In composition the shale undoubtedly contains a considerable percentage of lime and magnesia, occurring as it does between two great limestone formations, but no analysis is at hand. It has not appeared to be of value enough to justify any outlay in this direction, since but a single application of it to economic uses is known in the state. Twenty years ago, one of the most conspicuous beds of the shale exposed in the state was worked to a moderate extent for the manufacture of common drain tile in connection with the ordinary clays of the Drift. The locality is on the National Road in Miami county, as the road descends from the east into the valley of the great Miami River. The clay is said to have proved satisfactory in the

very common use to which it was here applied. It was used, not because it was counted superior in any way, in quality, to the drift clays that were worked with it, but because it was obtained with less trouble and expense than they. It cannot reasonably be expected to bear high heat without melting, on account of the large amount of lime in its composition.

The same line of remarks would apply to the numerous beds of shale that occur in the Hudson River formation, which directly underlies the Medina shale. There are about eight hundred feet of this formation shown in the state and its outcrops occupy six thousand square miles of our territory. The upper part of the formation is rich in shale, beds of five, ten, or fifteen feet of it frequently occurring interstratified with the limestone sheets. No instance is known, however, in which an attempt has been made to turn these calcareo–argillaceous beds to economic use. The latter are marls rather than shales. A similar line of facts is also found in certain argillaceous deposits of the Clinton and Niagara divisions of our shale. At the top of the first named series of beds a very fine-grained deposit of bluish-white clay occurs. It is locally known as the Clinton marl, Beavertown marl, etc. Calcareous fossils are distributed through it. The marl is but one to four feet in thickness. If there were more of it, it is possible that some use could be found for it, since the fineness of grain is unusual.

The Niagara shale (6a of the scale above given) is another of these calcareo-argillaceous deposits that deserve the name of marls in part, at least, of its extent, rather than of shale. There is a large body of this formation, its maximum thickness, which is reached in Adams County, being a full one hundred feet. In so considerable an extent there must also be considerable range in quality, and it seems by no means unlikely that some parts of the Niagara shale wlll prove well adapted to use in clay working o some sort.

The next formations that deserve mention in this list are numbers nine and ten of the scale, viz: the Hamilton or Olentangy and the Ohio shale, respectively. The Hamilton (No. 9) has no where been worked as a basis of clay manufacture and does not seem likely to be. There are but few outcrops of it to be found and what there are give no promise of special adaptation to practical uses. This stratum has a thickness of fifteen or twenty feet only.

It is somewhat different with the Ohio shale (No. 10), at least so far as its possibilities are concerned. This is a great formation, ranging in its outcrops between two hundred and fifty and four hundred feet in thickness. Under cover, as it is followed to the eastward, it is continually strengthened until on the Pennsylvania border it has been proved by drilling to be more than two thousand five hundred feet thick. Its outcrops are of large extent, occupying a belt ten to twenty miles wide that reaches entirely across the state from north to south.

It is not a simple or homogeneous formation, but consists of alternating bands differing slightly from each other in composition. The two leading types included in the formation are a black shale and a greenish-blue shale, but several other varieties are occasionally met. All of them are hlghly silicious in character, but the black shale contains eight to ten per cent. of organic matter that gives to it its color, while the greenish-blue variety derives its characteristic tint from silicate of iron. The black shale is found at the bottom and generally again at the top of the formation, while the blue shale characterizes the middle of the series. But no three-fold division based upon the facts above given can be anything but misleading, for the reason that there are more likely to be thirty or three hundred alternations than three. It is, however, true that beds of black shale are almost certain to be found at the bottom of the series, while at the middle of the column more or less blue shale is present. The alternations are very frequent in this last named division, as a rule, as is shown in a multitude of well records.

There is but one point in the state where large use has been made of this series, viz., Columbus. It has been here employed in the manufacture of sewer pipe of thoroughly approved quality and also of common and of building brick in the large way. In both cases it is the greenish shale, or some variety of it, that has been brought into requisition. The possibilities of the formation have scarcely been touched as yet, however. There will, without doubt, be found large uses to which parts of it will be found well adapted.

The Bedford shale (No. 11*a* of the scale) is the next argillaceous deposit in our series that deserves mention. It cannot in all cases be distinguished from the underlying series that has just been described Where the latter, for example, has the blue color that occasionally marks it, and where the Bedford also has the same color, no line of demarkation can readily be drawn between them. The only means of distinguishing the two series in such cases would be by noting the fossils that they severally contain; but the characteristic fossils of each are few in number and uncertain in occurrence, at least in the great majority of its outcrops. A ready means for the determination of the Bedford shale is, however, at hand in most instances. It is generally a *red* shale and is thus sharply distinguished from the hundreds of feet of shale below it that are really continuous with it, and also from the great series that overlies it with but one or two interruptions in the way of sandstones which occupy the interval.

The Bedford shale can therefore be described as a stratum twenty to eighty feet thick, red or light blue in color. In the great majority of instances more or less of it is red, while bands of grey or blue shale are sometimes intercalated. This color is its characteristic mark and by means of it the stratum has been proved a very persistent one, having been followed under hundreds and even under thousands of feet of cover in the drilling of deep wells to the east and south of its present outcrops.

It is at present used at but one point in the state in the large way. The Akron Vitrified Brick Company employes the red shale in the manufacture of a pressed brick that is certainly not surpassed by any like product of the state. The shale is mined and worked at or near Independence. The great possibilities of this stratum for such applications have been recognized and indeed demonstrated for many years. It is surprising that but one practical attempt has been thus far made to render it available for economic uses.

The Cuyahoga shale, (No. 11*d*) a great stratum one hundred and fifty to four hundred and fifty feet in thickness, consists of light colored grey or blue shales that has unlimited possibilities of service in the practical way, but which has been almost completely ignored thus far. Its day is, however, sure to come. Its adaptation to paving block manufacture in particular will be recognized, and it will be at once demonstrated as soon as it is used, that no better material for this purpose is found in our entire series than the Cuyahoga shale can supply. It has a broad outcrop and is available for use in every county in which it is due from the Lake shore to the Ohio Valley. Without doubt different sub-divisions will be established in the formation when it comes to be generally used. Particular beds will be discovered adapted to particular kinds of clay manufacture.

The Subcarboniferous limestone horizon (No. 12) holds a far more valuable argillaceous deposit than any that has yet been described in our series. The limestone itself is an uncertain deposit, but its place in the series is well marked. In a few instances in southern Ohio, and in a much larger number of instances in Kentucky, a hard fire clay, known as flint clay, comes into the section. This clay is one of the two or three strictly first-class clays of the state. It has been worked largely at Sciotoville and Portsmouth, and is accordingly commonly designated in Ohio as the Sciotoville clay. Other outcrops of it occur near Logan, Hocking county, and here it is called the Logan clay. It has been used in manufactures here also, to quite an extent. Wherever found, its great value is at once recognized. It becomes a basis of manufacture of fire clay products in the strictest use of this word. Furnace linings and other similar uses demanding refractory quality of high grade absorb the entire product of this seam. A single analysis exhibits the general characteristics of the Sciotoville clay. (*Lord*).

Silica	50.95
Alumina	39.49
Alkalies	.30
Magnesia	.28
Water	9.18

These figures show a deposit approaching absolute purity, and attest the very great value of the clay. Unfortunately the deposits of this seam in Ohio are few in number, and they are also capricious to a high degree, even within the narrow limits in which they are represented at all.

The clay deposits of Ohio that have now been described, with the exception of the one last named, would scarcely enter into the account of the practical clay working of the state as at present carried on. We should be told in making this review that we had not yet reached the clays of the geological columns; that the latter are all to be found, with the single exception noted above, at a higher level in our series than our examinations have yet covered. As far as general use is concerned, this is entirely true. The coal measures of the state at the level to which we have now come in our review, are also the clay measures of the state. Every coal seam is normally underlaid by a bed of clay. Further, it is often *overlaid* as well by clay or shale. Sometimes the coal fails to appear where it is due and clay may occupy the place that belongs to it. The thin coal-measure limestones, in like manner, often rest on clay or are covered by such deposits after the fashion of coal seams. It thus results that we find argillaceous deposits by the score, through the entire series of the Conglomerate group and the Coal Measures proper, including the Barren Measures. A brief catalogue of the principal horizons, so far as the latter are known, will now be given.

13. The Carboniferous Conglomerate Group.

As is well known to all students of our geology this group embraces several great sandstones and conglomerates, four or five coal seams, some of them of wide range and one, at least, of considerable economic value, two thin but persistent limestones, three or four iron ore seams, and a half dozen argillaceous deposits that are severally known as fire clays and shales. The order of the Conglomerate group is as follows:

Tionesta sandstone.
Tionesta coal.
Tionesta clay and shale.
Upper Mercer ore.
Upper Mercer limestone.
Upper Mercer coal.
Upper Mercer fire clay.
Lower Mercer iron ore.
Lower Mercer limestone.
Lower Mercer fire clay.
Massillon sandstone (upper).
Quakertown coal.
Quakertown shales.
Massillon sandstone (lower).
Sharon shales.
Sharon coal.
Sharon clay.
Sharon conglomerate.

The elements of interest to us in the present connection are the following: Tionesta clay and shale, Upper Mercer clay, Lower Mercer clay, Quakertown clay and shales, Sharon shales. These elements will each be briefly characterized in the order that has been followed thus far in the chapter, viz., the ascending order.

The lowest coal seam of our series, the true designation of which is the Sharon coal, but which is also known as the Mahoning Valley coal, the Youngstown coal, the Akron coal, the Massillon coal, the Jackson Shaft coal, rests on a thin deposit containing a small amount of clay, which in turn is supported by the massive Sharon conglomerate. No one would venture to call this particular underclay as it generally appears, a fire-clay. It is highly silicious and would serve as refractory material of fine grade. It resembles in composition and character the gannister of the English miner. No use has thus far been made of it in Ohio and it is not therefore included in the list of our clay resources.

(*a*) *The Sharon Shales.*—This series directly overlies the Sharon coal in most sections. In thickness it ranges from one to fifty feet. In its most characteristic form it is a dark blue, sometimes an almost black shale, carrying at certain levels heavy nodules of iron ore, which in the early days of iron manufacture in western Pennsylvania and northeastern Ohio were drawn upon to a small extent for furnace supplies; but they are not likely to be further molested. Near the bottom of the series and overlying the coal, the shale frequently contains abundant and characteristic fossil plants. The shales proper have lately become the basis of one of the largest sewer pipe industries of the Un ted States, at Akron and in its immediate neighborhood. The same deposit is also worked in Akron in one of the largest roofing tile works of the country. The shale is generally high in iron oxide, the amount of this substance ranging between 10 and 15 per cent. So important a proportion of iron as this in a clay would be sure to impress a particular character on all the products manufactured from it. The excellent color of the Akron sewer pipe, which has done so much to commend it in the general markets of the country, is mainly due to the abundance of this element.

(*b*) *The Quakertown Clay and Shale.* The deposits here named occupy a few feet (5 to 30) between the two divisions of the Massillon sandstone, when such a division occurs. They can, with a great deal of propriety, be referred to the Quakertown coal, from which they take their name, one body of the clay lying under and one directly over the carbonaceous streak that is the sole representative of this coal seam in a large part of the area where it is due. The argillaceous deposits of this age are worked in but three counties of the state at the present time, so far as known, viz., Summit, Portage and Stark counties. In Summit they furnish the stock for the important potteries of Springfield, and in Portage for the Mogadore potteries. The Massillon Fire Brick Company has developed the most valuable deposit yet known on this horizon and so far the only one of its kind. It consists of four to five feet of hard fire clay, immediately underlying the carbonaceous streak which represents the Quakertown coal. The bottom of the fire clay is thirty feet above the Sharon coal, which has been mined in the same territory. This clay resembles the hard, or "number one" fire clay of southern Ohio in its general appearance. It contains, as the latter clay does, abundant traces of vegtation which consist in the main of the rootlets of Stigmaria or old coal plants. This seam has been made the basis of an important fire brick manufactory, though other first class clays are also worked here.

Overlying the coal streak ten feet of shale are found adapted to coarser clay products, as paving blocks.

(*c*) *The Lower Mercer Clay and Shale.*—We reach in our ascent the best marked horizon of the entire Conglomerate Measures, that, namely, of the blue or Lower Mercer limestone. This limestone constitutes one of the vital nodes of this series. Above it is found an iron ore that often proves valuable. Under it is a coal seam for which not very much can be claimed, but which in three counties in the state supports a few small mines. Below the coal is an argillaceous deposit, sometimes shale, but generally clay, which is worked in a large way and increasingly, for various clay products. This horizon is the basis of important manufactures in Stark, Tuscarawas, Muskingum and Hocking counties and particularly in the latter. The Columbus Brick and Terra Cotta Works, located at Union Furnace, is a large and well-established enterprise. There is considerable range in the quality of the formation throughout the state, but it nowhere yields clays of especially high character. The average composition would be without meaning or significance of any sort. A single analysis from the Union Furnace field is here introduced as showing as well as any one analysis can, the general type of clay that belongs here. The figures are as follows. (*E. Lovejoy, E. M.*)

Water	3.72
Silica, combined	34.27
Alumina	27.64
Si ica, free	23.92
Iron	1.39
Lime	.50
Magnesia	.64
Potash	2.70
Moisture	1.15

The shale or clay that immediately ovcrlies the Lower Mercer limestone gives promise, in its appearance, of adaptation to economic uses. At the bottom of it, the place of the Lower Mercer ore is found, and for three or four feet directly above the ore the clay is exceptionally light colored. The stratum is nowhere thick, however, and no instance is known of its being brought into use.

(*d*) *Upper Mercer Clay and Shale.*—The Upper Mercer coal (number 3 of the numerical series) is not a seam of economic importance in any part of our coal field. It is not worked in even the the smallest way at more than a single point in the state, viz., Canfield, Mahoning county, where it is known as the Bruce coal. It has here a thickness of about thirty inches. But though generally too thin to be considered, at least under present conditions, as worth mining, it is nevertheless a persistent horizon. There is almost always a few inches of coal at its proper level. Its clay is even more persistent than the coal seam. A bed of light-colored, plastic clay can be found at this level in every county in the state in which it is due. It has been practically worked in but few instances and therefore it is be judged mainly by its outcrops. But it seems safe to say that the deposits of this age contain a large amount of argillaceous material of at least fair character. At Haydenville, Hocking county, it is extensively worked under the name of the Mingo Clay. It is one of the most valuable clay deposits of the entire series that is included within the Haydenville coal field, the series ranging from the Mercer to the Freeport horizon. As shown by a single analysis, it has the following composition: (*Reed.*)

Silica	69.92
Alumina	23.46
Alkalies	1.45
Oxide of Iron	2.00
Magnesia	.40
Lime	.48
Water	3.84

The deposit is eight to ten feet in thickness here. Much can be expected on the Upper Mercer horizon in cross sections of the coal field, when clay comes to be required in larger quantities and in greater variety than the present demands.

(*e*) *Tionesta Clay.*—A few feet, fifteen or twenty, above the deposits of the age last named, another valuable bed of clay is sometimes found which can be designated by the name given above. But it must be confessed that this horizon is one of the undetermined and therefore of the uncertain horizons of the Conglomerate Coal Measure series. Whatever name shall be decided upon for the deposit, it is certain that a more or less persistent clay formation occurs in many counties of the state, as above described. It is used and valued highly in the Union Furnace works already named. A single analysis cannot, of course, go far toward showing the character of a widespread deposit, but the following results give the general composition of the seam as shown at the point last named. (*E. Lovejoy, E. M.*)

Silica	33.42
Alumina	25.80
Free Silica	28.39
Oxide of Iron	1.39
Lime	.51
Magnesia	.64
Alkalies	2.70
Water	6.51

The description of this stratum completes the list of the principal clay and shale beds of the Conglomerate Coal Measure group. It remains to enumerate the beds of like composition and character in the Coal Measures proper. This great series embraces the following elements, viz.:

Upper Barren Coal Measures.
Upper Productive Coal Measures.
Lower Barren Coal Measures,
Lower Productive Coal Measures.

The list of principal clay deposits of the Lower Coal Measures is as follows, viz.:

Upper Freeport clay and shales.
Lower Freeport clay and shales.
Middle Kittanning clay and shales,
Kittanning clay.
Freeport limestone clay.
Putnam Hill limestone clay and shales:

These deposits are named in descending order.

1. The Putnam Hill Limestone Horizon.

The Putnam Hill limestone covers a coal seam which is designated in Geology ot Ohio, Volume 5, as the Brookville coal. This identification is called in question, though not positively denied, by some geologists who have written upon the qnestion, but for want of a better title, the designation can still be maintained. A valuable deposit of clay is found in the central Coal Measure counties at the level herein named. It is especially well-developed in Muskingum county, where it is worked on the large scale. But it extends in good volume and good character through Coshocton, Tuscarawas and Stark counties, where it is also worked quite largely; and, further, it is found in promising condition in Perry, Hocking and Vinton counties to the southward. Like the Lower Mercer clay of the Union Furnace section, it yields on calcination, at least as it is found in the vicinity of Zanesville, a buff or cream-colored product. This clay is the main reliance of the great tile manufactory of Zanesville. In its chemical and in its physical structure it meets the demands of this very important industry better than any other deposit that has been found.

It has also been sent out in the large way from the Zanesville district to North Baltimore, Wood county, where a Cleveland company is engaged in the manufacture of pressed brick. The clay here named furnishes a buff brick of great beauty and excellence, natural gas being used as the fuel for burning.

In the Zanesville field the clay seam proper ranges from three to ten feet in thickness, with a general average of six feet, but for thirty feet below the limestone in many sections nothing but shale and clay are found. It is generally divisible into an upper or plastic portion and a lower and more silicious division. The seam is largely worked at Canton in the manufacture of paving brick. A single analysis of it, as it is found at North Industry, near Canton, gives the following result:

(*Stein and Schwartz.*)

Moisture,	6.45
Combined Water,	5.41
Silica,	63.09
Alumina,	20.17
Oxide of Iron	2.12
Alkalies,	2.76

The lower portion of the seam at the same point was analyzed by itself, with the following result:

Moisture,	10.42
Combined Water,	12.72
Silica,	41.15
Alumina,	28.78
Oxide of Iron,	3.38
Alkalies,	3.55

This lower half of the seam is known as fire-clay, but the analysis shows that it certainly cannot rank high in refractory qualities.

This horizon must be counted as without doubt one of the valuable clay deposits of the state. Its use has only been begun as yet. The areas occupied by the seam in the district named are large and the exposures in natural sections are abundant. It can be mined under cover to good advantage, the limestone furnishing a strong and excellent roof for the workings. A certain part of the seam in the vicinity of Zanesville is highly esteemed as a source of refractory material. The Harris Fire Brick Works, six miles above Zanesville, on the west side of the river, make use of the lower part of the formation. The series found at this point is as follows:

Putnam Hill Limestone.	
Putnam Hill limestone shale,	11 feet.
White clay,	4 to 5 "
Dark clay,	2 "
Fire clay,	2 "
Sandstone and sandy shale,	5 "
Brown clay,	14 "

The beds known as fire clay in the table above, and the sandstone and sandy shale underlying it are what are used for the brick manufacture and the product serves an excellent purpose in the construction of the kilns for the manufacture of pressed brick, in the great factories of Zanesville.

2. The Ferriferous Limestone Clays.

This deposit must not be omitted, as it occupies a well-marked place in our series, especially in the southern counties, of our Coal Measures. It underlies the limestone coal of the district named above, having a thickness of two to six feet. It is light-colored, of the plastic variety, and appears to be of fair quality, but no important use is known to have been made of it as yet. As clay industries are developed in the districts in which it occurs, it will no doubt be found able to make some contribution to their supplies.

3. The Kittanning Clay and Shales.

Under this head we come to the great clay horizon of the state. Its importance far outweighs that of any other clay seam of our scale. Indeed, it is probably equal, in value, to all other sources of clay in the Coal Measures combined. The geological position of the Kittanning clay is easily remembered. It belongs between the Ferriferous limestone and the Lower Kittanning coal. Often it fills the entire interval between these well-known beds. In some sections, however, where the interval is unusually expanded, a sandstone occurs and the clay and shale are consequently reduced to some extent thereby. In its more important fields it ranges in thickness between eight and thirty feet. In some districts it is merged, with only the interruption of the Lower Kittanning coal seam, into the clays that belong next in the ascending series, viz, those which come in below the middle Kittanning coal. In this case the combined deposits constitute a section measuring not less than fifty feet. The Kittaning clay horizon proper is seen at its best where it enters the state from Pennsylvania, and again where it leaves the state in its extension into Kentucky. In both of these localities of the Ohio Valley, viz, in Columbiana and Jefferson counties, on the one side, and on the other, in Lawrence county, it shows large volume and excellent quality. In Tuscarawas, Stark and Muskingum counties, also, and, in fact, in the other central counties of the coal field, it is scarcely less developed.

As a rule, the horizon produces a white plastic clay, almost always of fair quality and, in places, of the highest excellence. The plastic clay is the foundation of the great pottery industries of Eastern Ohio, where it is worked on a very large scale. A second, and even more valuable phase of the clay is found at a few points in Stark, Tuscarawas and Carroll counties. The formation here yields a hard or flint fire clay of quality scarcely inferior to the best clays of the country. This phase is known under the name of the Mineral Point clay. It is largely worked and manufactured at the village of this name, and at Canal Dover, as well, and the products have an excellent name in all markets, for their refractory quality.

Analyses of the Mineral Point clay have been often published. A single one will be quoted here, fairly representing the formation. (*Lord*) The figures show a clay of great excellence.

Combined silica	35.39
Alumina	31.84
Combined water	11.68
Percentage kaolinite base	78.91
Free silica	17.13
Titanic acid	1.68
Sandy material (total)	18.81
Susquioxide of iron	0.67
Lime	0.50
Magnesia	0.19
Potash	0.59

Of the ordinary phase of the deposit, viz., the white plastic variety, abundant analyses are at hand, but it is hard to find any one that can be called thoroughly representative. In the discussion of clays in manufactures in a succeeding chapter, numerous analyses will be found. The products of this horizon are used on a great scale in the finer pottery manufacture for saggers, also in part for the manufacture of Rockingham and yellow ware; and, lower still in the scale of value, for stoneware. These clays are a main dependence of great sewer-pipe factories, and also are sometimes used in making fire-brick of ordinary quality. An enormous amount is now being turned to account in the manufacture of paving brick. By reason of the uses and adaptations above named, the Kittanning clay seems certain to hold for all time to come the first place in our clay horizons.

4. The Middle Kittanning Clay.

As already stated, this stratum is in some instances merged into the Kittanning clay proper, but it deserves a name and place of its own in our scale. At one locality, viz., Oak Hill, Jackson county, it yields a "No. 1," or hard fire clay, and is there made the basis of an important fire-brick manufacture. It carries in many of its outcrops, nodules of iron ore, which interfere to some extent with its availability as a source of clay for manufactures. No peculiarities of composition can be claimed for it, according to present knowledge, but it reinforces in an important way, the deposits of the horizon already described, which directly underlie it.

5. The Lower Freeport Clay.

For the clay seam that underlies the Lower Freeport coal, no great development can be asserted and no great peculiarity of composition can be claimed. At one locality, viz., in the vicinity of Moxahala, Perry county, the seam has been found in the condition of a hard or flint clay, but of only moderate excellence. It carries enough oxide of iron to shut it out from the highest grade. Usually the clay is of the ordinary type of the plastic under-clays of the Coal Measures. It is possible that special adaptations will be found in some of its outcrops when the demand from our clay manufactures becomes more extensive.

6. The Upper Freeport Clay and Shale.

Much more can be said for the agillaceous deposits of this horizon than for the two last named. They are found in large volume and extend much more widely throughout the Coal Measures than the coal from which they derive their name. At several points in its extent, the Upper Freeport clay has assumed a hard or flinty phase, and then becomes a refractory clay of greater or less excellence. In western Pennsylvania this phase is known as the Bolivar clay. In the Muskingum Valley, below Zanesville, it has been worked to a small extent, under the name of the Ballou clay.

The common phase is found to be well adapted to all ordinary uses in almost all parts of the state. It is certain to become one of the main dependencies of the future clay-working industries of those districts in which it occurs.

The detailed description of the persistent deposits of clay and shale of the state series, will not be carried beyond this point in our review. The Lower Barren Measures that follow the Lower Coal Measures, next in ascending order, contain vast deposits of shale, the true value of which is just beginning to be understood and appreciated. It is the paving brick industry that has, for the first time, shown the possibilities of service that they contain. These shales are distributed through the entire series, but about the middle portion of this division, some deposits of peculiar excellence have been developed, particularly in the Sunday Creek Valley. That part of the series bounded by the Cambridge limestone below and the Crinoidal limestone above, seems admirably adapted to paving block manufacture. No true fire-clays are known in this division until its summit is reached in the Pittsburg coal. A fire-clay of some promise has been noted underlying this great coal seam at a few points in Athens county. It is not known that any test has been made by which its character or value can be determined. At a single point in eastern Ohio, viz., at Bellaire, a bed of shale twenty feet or more in thickness directly underlies the Pittsburg coal. This deposit has lately been made the basis of a promising paving block and sewer-pipe plant.

Certain deposits of red shale and clay, by which the Barren Measures are made conspicuous, will doubtless be found on suitable trials to furnish materials adapted to some of the uses to which like deposits are being turned in other portions of our scale. It seems quite probable that they can be made into pressed brick of high quality. These red bands are very wide-spread and persistent, and attention will no doubt be soon directed to them.

It can be seen from this review that every portion of our Coal Measures can be depended upon for a supply of argillaceous material, fire clay, potter's clay or shale, covering a wide range of composition, from nearly pure kaolin to brick clays, and adapted to nearly all the lines of manufacture in which these substances are employed.

CHAPTER III.

THE CLAY WORKING INDUSTRIES OF OHIO.

By Edward Orton, Jr., E. M.

The manufacture of clay wares of all kinds in Ohio has experienced very great expansion in the last decade. Next to the mining of coal, it is probable that clay working occupies the highest position in those industries which depend upon the natural mineral resources of the state. It a prophecy without risk to say that it will be only a short time until clay working becomes the more important of the two, as our coal deposits have been subjected to a yearly increasing strain for over half a century and are becoming every year less accessible in location and smaller in area, while on the other hand, the clay deposits have so far been only barely touched and still yield new measures of their enormous value and extent as attention is turned to their exploration.

The expansion which has prevailed in the last decade in the clay business has several causes: one of them is the natural increase which has blessed alike all of the healthy, well-located industries of the state; a second reason is the recent adaptation of brick to the paving of city streets, which has opened a new and virgin field to our manufacturers, and thirdly: the comparatively recent discovery of the great value of the shale deposits of the state in the manufacture of the grosser forms of clay wares.

A careful statement of the origin of clays and the geological and geographical distribution of the shales and clay deposits of Ohio, as well as a discussion of the relation that these shales and clays bear to each-other, will be found in the preceeding chapter of this volume.

It is the intention to confine this article to a description of the various clay working industries established in the state, giving such information in regard to the development of each and the underlying principles of manufacture and to the chemical technology of the processes as has been found current among the clay workers of the state, or has been available from other sources. In order to properly take up the discussion of these questions it is fitting that a brief review of the main points as to the origin, composition and properties of clay should be first presented, even though it duplicates to some degree the work of the preceding chapter. The present review is written from a practical standpoint.

SECTION I.

GENERAL CONSIDERATION OF CLAYS.

(a.) *Origin.* Pure clay is a hydrated silicate of alumina, composed of one portion of the sesquioxide of aluminum united with two portions of silica and two portion of water. Clay in this sense may be represented by the chemical formula.

$$Al_2, O_3, 2\,Si\,O_2 + 2\,H_2\,O.$$

Clays in this popular meaning of the term are something very different from the pure mineral. They are compound minerals or mixtures of minerals, having no definite proportions of base to acid, no definite composition either chemically or mineralogically, but all containing some of the real mineral clay and all retaining something of its physical and chemical characteristics.

Pure clay, Kaolin, or Kaolinite is not a natural mineral, but is derived from the decomposition of another. Feldspar, which is a silicate of alumina and some alkaline base like potash soda or lime, is a hard stony rock bearing no resemblance to clay in any respect. This feldspar, when exposed to the action of water containing carbonic acid gas in solution, is dissolved or broken up and the alkaline base is carried away in solution; leaving the silicate of alumina alone.

This origin of kaolins from the decomposition of feldspar rock is thoroughly established and cases are frequently found where a bed of feldspar is covered or surrounded by the kaolin formed from its decomposition and extending down into the crevices of the rock wherever the water has had a chance to penetrate.

But while it is likely that many of our beds of kaolin owe their origin directly to beds of feldspar, still it is not to this source that we owe our enormous deposits of clay.

Feldspars are very widely disseminated in other minerals and form a notable part of granitic and gneissic rocks, which form a large part of the earth's crust. Granite consists of quartz, mica and feldspar. Quartz is not affected by any of the natural atmospheric or aqueous agencies now at work, and mica but slightly so, but the feldspar, as has already been shown, is sensibly attacked.

When the feldspar is thus decomposed the bond which held the quartz and mica firmly together is gone, and these minerals are partly washed away and partly retained in mixture with the kaolinite which has been formed. Granite is not of any permanent composition chemically, but is always composed of varying proportions of these three minerals. Hence, the clay resulting from granite would vary with the variations of the parent rock, as well as from the great variations which attend the conditions of its formation. Also, nearly all of the clay deposits of the world are formed from the decomposition of the earlier rocks, and have been successively deposited in water, hardened into rock, eroded again by the rains and frosts and ice of centuries, and again deposited. No one knows or can guess how many times our clays have been thus treated, and each transfer is of course accompained by the further mixing and blending of clays with each other and with the detritus of all other rocks.

In the light of these few statements on the origin of our clays, it is not a source of surprise that they vary but that they retain as much of a family likeness as they do.

(*b*) *Composition.*—As has just been indicated, we must expect to find their chemical and mineralogical composition varying through a very wide range. Indeed, there is some difficulty in determining how much the pure clay base may be mixed with silica and other minerals and still be called a clay. There is hardly any common rock which does not contain it. Limestones when they disintegrate and dissolve away leave a residue of clay behind them; sandstones will generally become plastic if ground fine with water, from the presence of the same mineral.

This irregularity of composition led at first to great misunderstanding of the nature of clays. It is only in the light of their origin that we can understand the anomalies which their composition presents. Pure clay or kaolinite has a percentage composition of

Silica ($Si\ O_2$)	46.3.
Alumina ($Al_2\ O_3$)	39.8.
Water (H_2O)	13.9.

which may be represented by the chemical formula $Al_2\ O_3\ 2Si\ O_2\ 2H\ _2O$.

Impure clays contain less alumina and water and more silica and other elements beside. The researches of the late Professor Cook first demonstrated that in any clay the silica could be separated into two kinds: viz:—that combined with the alumina as a hydrous silicate, and that free from combination and present as quartz or sand. It is possible that free uncombined hydrated silica is present in some clays, but this form is certainly rare. By a chemical process it is possible to make a separation of the silica into the two named classes, and on assembling the alumina, combined water and the combined portion of the silica together, and finding their ratio to each other it was found that a body was obtained having the same percentage composition as kaolinite. There were naturally some variations due to the errors of the chemical process employed and probably to the presence of other silicates than those of the clay proper, but while the kaolinite bases thus found were sometimes too silicious and sometimes too aluminous, nevertheless the essential identity of the base of all clays was established. This chemical proof of the identity of the presence of one kaolinite base in all clays has been a strong support of the theory of their origin, and their origin in turn leads us to expect what by research we find in the composition.

Clay then is found, both by this theory of its origin and the discriminating use of chemical analysis, to be a mixture of a kaolinite base with a large variety of other minerals. The most important of these associated minerals is quartz, or free silica, or sand, as it is variously termed. It is found in all clays, to some extent. Even the purest kaolins contain small fractions of a per cent. of it, and on the other extreme it is hard to say where a sandy clay ends and an argillaceous sandstone or freestone begins. There is a great difference in the size of the grains of quartz, some clays being very coarse and others are so very fine grained that it becomes impossible to separate the sand from the clay by any mechanical process, like washing in water.

Feldspar and mica are found in almost all clays. Sometimes the mica can be plainly discerned by the eye. Feldspar cannot be distinguished from sand by such means, but its presence is highly probable in many clays. Both feldspar and mica contain the alkalies in combination with silica and alumina. Hence we can most easily understand the presence of the alkalies in a chemical analysis of clays, when we believe them to exist in these minerals. It is not possible to imagine free alkalies existing in a mineral which owes its origin to slow deposition in water and the presence of some comparatively insoluble silicates, like feldspar or mica, seems necessary to explain their continual presence.

In this connection, the question arises, how can feldspars remain undecomposed or unkaolinized during all the exposure to water and air which must have been their lot. Possibly the formation of kaolin on the surface of a grain of feldspar serves as a shield to shed water from the inside of the grain and possibly the retention of the feldspar in the mass of tough and plastic clay protects it from continual attack by the elements. It seems likely that the mica minerals contribute more largely to the potash of clays than the feldspars, as they are very much less affected by the agencies of decomposition.

The oxides and other compounds of irons are an almost invariable constituent of clays, and probably next to the silica, they are the most important. The oxides, both as sesquioxide and protoxide, free or hydrated, are the commonest forms, but the carbonates of iron are not uncommon, and sulphides are an occasional and very injurious impurity. Possibly iron combined as silicate is sometimes present.

Iron is the great coloring agent of clays. The tints vary from the lightest buff to strong cherry red and from drab to blue or green. The amount of coloration is not proportional to the amount of iron, however, as perfectly white china clays have been found in analysis to contain over one per cent. of iron, and other clays containing this amount might show a strong yellow or pink color. The effect of the iron on the color of a clay is much increased by the burning process, and the colors produced in burning vary from cream color to perfectly black—almost all tints being represented, but the reds, browns and greens predominating. The condition of the iron has much to do with its coloring power. If it is disseminated in little grains or crystals it has but small effect on the color of the clay; the more intimate the mixture or combination the greater its effect.

The amounts of iron found in clays vary from minute fractions of one per cent. to twelve or even fifteen per cent. of the whole.

Lime and magnesia are found in small but persistent amounts in nearly all clays. These alkaline earths are probably present in many cases as silicates, as they are insoluble in water and nearly so in acids—but many clays contain notable amounts of carbonates of lime and magnesia. These carbonates are sometimes present as small pebbles or grains of limestone, brought into their present position by the glacial agencies of recent geological time. In this condition they do very great harm to the clay in manufacturing processes. When intimately mixed with the whole substance of the clay their effect is less apparent. Clays of this description generally burn to a greenish color, or even cream colored, if the lime is present in large amounts. The cream colored bricks which are found so commonly in Canada, northern Michigan, Wisconsin and Minnesota are manufactured from this class of clays.

Titanic acid is found in nearly all clays. Its presence was viewed with much interest for some time, and is attributed to the mineral menaccanite or titanate of iron, but titanic acid is so nearly chemically inert that it is not commonly determined in an analysis. It is weighed in an ordinary analysis partly with the silica and partly with the alumina. It is not known to have any effect on either color or fusibility.

Organic matter is a frequent but not an important constituent of clays. In many of the Ohio clays and shales large quantities of decomposing carbonaceous matter was in suspension in the water which was depositing the beds of clays; and as a result the shales or clays are colored bluish or black. When a clay is colored by this cause it can readily be detected, as a comparatively low heat is sufficient to drive out the organic matter, leaving the clay to be colored by its mineral constituents. It is not often that organic matter is a source of any detriment to a clay; it is generally so finely divided or present in such volatile organic compounds that it leaves the clay sound and solid after the gases are expelled by heat. When it occurs as small lignitic grains, as it sometimes does in the clays of later geological age, it is a possible source of porosity after burning. In some parts of the Huron shale, there is so much organic matter that it greatly facilitates the burning of the clay, just as some black band iron ores contain enough organic matter to aid in their own calcination.

Rare minerals containing barium, strontium, lithium, cobalt, copper, zinc and such bases, and phosphoric, sulphuric, and hydrochloric acids, are liable to be occasionally found in clays, but are not frequent enough to be of any real importance in practical work.

Thus we have seen that mineralogically clay is a compound of a clay base with sand, feldspar, mica, and other silicates, colored by iron oxides, or organic matter.

Chemical analyses of clays generally state the ultimate quantities of the various elements represented, but fail to give any idea of their mineralogical structure. This can be in part remedied by such an arrangement of the elements as was first devised by the late Prof. Cook, of the New Jersey Survey, and which was followed in Vol. V of the Ohio Survey, and has been used largely in the present report. This method of reporting an analysis classifies the clay into kaolinite base, sterile impurities like quartz and titanic acid, and deleterious or fluxing impurities including the strong bases such as iron, lime, magnesia and the alkalies. This system requires, however, that an extra determination shall be made for each analysis, separating the silica into the combined and the free. The chemical processes employed in this separation are far from satisfactory, however, and since the essential facts of the kaolinite base theory have been generally adopted it seem not inadmissible to divide the silica into free and combined, by calculation of the kaolin ratio from the percentages of alumina and water present. This has been done in most of the new analyses made by the Survey for the present report. No table of analysis has been prepared for presentation in this section of the report, but special pains have been taken under each separate industry described, to present such analyses as were available in that particular branch. Attention is therefore invited to the succeeding tables to illustrate the general statements relative to composition of clays made here.

(*c*) *Properties.*—The properties of clay which make them indispensable to mankind are three fold:

1st. Plasticity when wet, by which it can be formed into the multitude of shapes that suit our convenience.

2d. Permanence when burnt, which enables us to fix these useful forms in material at once cheap, ornamental and durable.

3rd. Refractoriness or the ability to stand high and long-continued heat without fusion or loss of form.

Plasticity is a quality which is shared by very few other minerals and very few other artificial compounds capable of standing heat. It has never been satisfactorily explained by any one who has worked upon the subject. The late Prof. Cook, of New Jersey, has done more for the subject than any one else. He found out by microscopical examination of kaolins that the mineral generally presents a distinct tendency to crystallization. Some kaolins are composed of masses of hexagonal plates or scales piled up in long bundles or faces and masses of unattached scales. When they present this appearance they are very little plastic. By grinding a sample of such clay fine, and working and kneading it with water, it gradually becomes plastic however, and an examination under the glass then shows that the crystalline structure is much broken up, and that the still perfect scales or crystals are embedded in a homogenous matrix composed of the waste of the other crystals which have been destroyed by the grinding and kneading. Other clays, already naturally plastic, show no plates at all, only a homogenous matrix. These points indicate that the plasticity of a clay depends on the extent to which this tendency to a crystalline structure has been destroyed in the treatment that the clay has received. This theory is in harmony with the facts as presented by the clays of New Jersey, which are of more recent geological formation and of different character from those found in Ohio. In Ohio, the clays and shales all belong to the Carboniferous or older geological formations, and it seems probable that some other agency than crystallization has made many of our clays and shales non-plastic which once were so. In default of any adequate explanation, it may be suggested, that long and intimate association of the clay base with its silica and its other constituents, the influence of enormous pressures for age after age of geological time, possibly the influence of low metamorphic heat and the binding, cementing action of the tarry organic compounds produced by the slow change of the vegetable matters incorporated into the clays, have combined to make many clays non-plastic. Most of these can be made plastic again by grinding and kneading with water, but many fail to develop much of their old plasticity. Beside these clays, which are now difficultly plastic, there is a class of clays found in the Coal Measures of Ohio and adjoining states which is entirely devoid of plasticity and no known treatment is sufficient to induce any marked return to the plastic state. Such clays are known as *flint* clays and are only known as clay at all by their behavior under heat and by the fact that an analysis discloses that they are generally nearly pure kaolins in composition. The action of frost and water on these clays is to crumble them to a fine, sharp sand; grinding with water leaves them still gritty and with no more plasticity than a sand rock would develop under similar treatment.

The origin of these clays is altogether unexplained. Occurring as they do, remarkably pure clays in the midst of very impure ones—they must have been deposited in much the same way as the plastic clays around them. They even contain pebbles sometimes, which shows the existence of currents through the swampy tracts of which they formed the floor. Organic acids, such as are, developed in swamps, are supposed by some to have aided the vegetation in withdrawing everything of a soluble nature from the clay, but this does not account for their freedom from silica. The subject is full of interest and greatly needs more time and attention than the Survey was able to devote to its study.

Permanence in clay ware depends on the way in which the chemical changes during burning are brought about and the temperature to which the clay is ultimately subjected. If the heat applied has been only sufficient to drive out the water of hydration, the resulting material will be porous and friable, and while it will have shrunk very sensibly in volume and is not soluble in water or organic acids, still the action of frost is sufficient to crumble it to dust on account of its porosity and attraction for moisture. If the heat has been carried up gradually above this point, the clay will be found to continue to shrink and grow more hard and dense and more impervious to water until finally, if the heat be stopped at the right point, the clay will have become practically impervious and very hard, strong, and tough. Clay in this condition is a new chemical compound composed of a mixture of all its bases combined with all its acids, forming a mineral as nearly indestructible as any known to man. Small bits of pottery made in the earliest times of prehistoric man come down to us as fresh and unaltered by the centuries of exposure as they were when made. Records made in hard-burnt clay are imperishable except to animate force. If the heat be continued above this most favorable point the clay begins to deteriorate in some of its qualities. It may grow harder but less strong, or it may become spongy and vesicular like lava, or it may melt into a fragile glass, but whatever the change, it is a retrogression. What the temperatures are at which these various results are obtained varies entirely with the nature and composition of the clay under treatment. Some clays require only a low heat to develop their best qualities, others demand the highest heats attainable in metallurgical practice.

Refractoriness or infusibility is the last property of clays which makes them of such great value to man. This subject naturally becomes involved with a consideration of the causes and conditions which contribute to *permanence*, as in both, the action of the clay under fire is the subject of discussion. The qualities which a clay develops while burning are obviously largely dependent on its chemical and mineralogical composition. As has been pointed out, the heat which is applied and the way it is applied and the kind of atmosphere which surrounds the clay under heat, have an important bearing on the qualities it shall develop. But the composition is of first and foremost importance and not only the ultimate composition but the method of combination of its various parts.

Kaolin or the kaolinite base of clay is practically infusible in the highest heat obtained in metallurgical practice. Quartz, its chief and bulkiest impurity, is likewise infusible in practice. Both can be fused in the flame of the oxyhydrogen blowpipe. But intimate mixtures of clay and quartz, even in the absence of all other impurities, are not as infusible as the ingredients are separately and the application of intense and long continued heat tends to form a new chemical compound having all the silica combined with all the alumina in a new relation of base to acid.

Fusibility of a clay has been in the past considered as depending mainly on the relative amount and character of its impurities other than quartz. Both quartz and kaolinite being infusible the idea has been that the metalic oxides present formed the entering wedge which destroyed a clay infusibility. There is much to be said in favor of this view, as it is an open fact that clays do stand high temperatures substantially in the order of their purity.

However, the drift of opinion now seems to be toward the theory that the fire qualities of a clay will depend on its total aggregate composition, in which all of its bases are combined with all of its fixed acids. This aggregate composition is best expressed by means of the "Oxygen Ratio."

By the oxygen ratio is meant the ratio existing between the oxygen of the silica and any other acid elements, against the oxygen existing in the alumina, iron, lime, magnesia, and alkalies or other bases present.

It is the peculiar quality of silica in the capacity of an acid to unite with any indefinite quantity of bases, and the only present means of classifying these miscellaneous compounds is by the ratio of the oxygen in their bases and acids. By this means silicates can be classified as being subsilicates, protosilicates, sesquisilicates, bisilicates, trisilicates, etc., or nearest to one or other of these standard compounds, as the case may be.

In considering this theory of the importance of the oxygen ratio of a clay it is not meant to disparage the important influences exerted by its feldspathic and ferruginous impurities; but only to point out that a given amount of these fluxing impurities would probably cause clay of a certain oxygen ratio to vitrify at a comparatively low heat, while another clay containing the same fluxing impurities, but of quite a different ratio, would still be unaffected at the same temperature.

The ferruginous impurities of clays consist, as has been before stated, of both of the oxides of iron, anhydrous or hydrated carbonates of iron, sulphide of iron, sometimes sulphate of iron, phosphates of iron, titanates of iron and possibly silicates of iron. In all of this array of minerals it is to be expected that the action of the iron would vary; it is known to play two important parts as free or uncombined sesquioxide of iron, and free protoxide of iron, and is now believed by many chemists to act in a third and still more important role as hydrated sesquioxide of iron, chemically combined with the alumina and silica to form an iron clay. Instances of this substitution of part of one base for another are not infrequent in chemistry. They are called double-salts. For instance, alum is a sulphate of alumina but an iron alum may easily be made in which part of the alumina is replaced by the similar oxide of iron. This iron alumina sulphate them becomes a fixed chemical compound, only broken up by chemical means. This theory, based on the part that iron plays in clays, goes further to explain the various and confusing reactions of iron in clays than any yet brought forward. For instance, two clays of the same iron content are found to be of entirely different color on burning, one being red in every particle and the other of a light color with here and there a dark grain. The latter will stand a large increase of temperature with no further change than shrinking somewhat, and the black grains becoming black blotches of a fluid cinder. The red clay, on being brought up to the same heat successively grows closer grained, then vitreous or glassy in fracture changing color from darker to lighter red, and then through the brown colors till finally the vitreous fracture disappears, the clay turns black in color and porous and vesicular like lava and worthless for any purpose.

In the light colored clay the iron was present as grains of sesquioxide; heat and the influence of the gases of the fire reduced this finally to ferrous oxide; in this condition the fluxing action began to assert itself and combination between any accessible free silica and the iron ensued, forming black ferrous silicate; this would rapidly continue to absorb such additional quantities of silica from the clay as would satiate its affinities at that temperature; and the iron has now done its worst in this clay.

In the red clay the iron is assumed to be present as an iron alumina silicate. All parts of the clay alike are equally permeated by it and colored by it. As the heat is increased the iron, affecting every part of the clay causes a fritting or incipient fusion of the clay with its other constituents. When this process is complete the clay presents a glassy fracture, a very hard structure, non-porous and having no affinity for water, and generally a brown red color. If now the heat be still increased the iron begins to be affected by the reducing gases of the fires, and to be reduced to a lower state of oxidation in which combination with the alumina of the clay is impossible. This reaction then continued, results in the complete destruction of the valuable qualities of the clay; it becomes porous, light in weight, brittle and rotten in texture, unable to stand either blows or friction. Also the phenomena presented in the changes of color of clays under the action of reducing and oxydizing atmospheres lend additional strength to this theory.

Take several samples of fire clay, such as is used for pipe or stoneware, and subject them to a strong reducing or carbonaceous atmosphere for a time; if one sample be quickly withdrawn and cooled it will show itself probably of a gray or bluish color in its whole structure, indicating the presence of a ferrous oxide in very small quantities. If the balance of the white hot samples now be allowed to slowly cool in a light draft of air they will become yellow, red or brown according to the quantity of this iron, aside from the free iron which the clay contains, which will manifest itself by small blotches of black cinder for every grain which lay exposed to the surface. This change in color is due to a re-oxidation of the iron in its long exposure to heated air during the cooling process. Also it very seldom happens that a clay is found which will yield up its iron contents by solution in boiling hydrochloric acid. Yet any free iron oxides, or ferrous silicates or other iron compounds are readily decomposed by this means. Hence the inference that part of the iron is present as a double silicate of iron and alumina which like the simple silicate of alumina is not attacked by hydrochloric acid.

These and other reasons make the assumption a probable one that iron plays its most important part in the chemistry of clays as a chemically combined constituent of the clay base.

The action of lime and magnesia in promoting the vitrification and fusion of clays is a power ul one if the bases are present in large quantity.

Nearly all clays contain small amounts, probably united in the feldspathic minerals present; when the amounts of lime and magnesia are larger they are most frequently present as carbonates. These carbonates are not often present in the fire clays but they are a frequent and important constituent of the shale beds of Ohio. The carbonates are sometimes finely divided and intimately mixed with every portion of the clay, as in the slip clays used by potters for glazing, on account of their low melting points, or are disseminated in grains and pebbles as in the clays of glacial origin. When in this latter form the clay is useless, except for the commonest and crudest purposes, as the particles of lime having become caustic by heat, slack on exposure to the air again and mark the surface of the ware with unsightly pit holes. Besides assisting materially in lowering the melting point of the clay, these alkaline earths exercise an important action on its color. The famous cream-colored brick clays of our northwestern states contain twenty to thirty per cent. of lime and magnesia and this is sufficient to disguise the presence of five per cent.of iron.

In smaller quantities seven to twelve per cent. of the earths are sufficient to make the vitrification of the clay occur at so low a heat that it still retains the bright red color due to its iron and the strength that it is capable of giving.

If the clays contain less than seven or eight per cent. of lime and magnesia and the heat used in burning be high the clay generally becomes a dirty green in color by the formation of lime and iron silicates.

The alkalies, potash and soda are the most powerful fluxing agents which clays contain. They are present, as has been explained, as feldspathic and micaceous minerals and are therefore ready to begin to melt as soon as the temperature rises. Free oxide of iron is the least obnoxious state in which iron can be present in a clay, since it requires more temperature to get it to unite with the minerals around it than a previously formed silicate of iron would require. So also the potash and soda are in condition to do the most harm to the melting point of the clay, being already combined as silicates.

The actual amount of any of these active fluxes, which a clay can contain and retain its fire qualities is impossible to say. The result of these fluxes depend on the amount, on the state of division of the clay, and the state of division of the fluxes, and on the character of the silica with which they are associated, and also largely on the number of fluxes represented. It is a general rule in the theory of fluxing compounds that a mixture of bases will make a more fusible compound than an equal amount of any of the bases separately.

(*d*) *The Changes Occurring in Clay by Burning*. In forming a conception of the qualities that a clay will develop on burning, its composition, considered as to its oxygen ratio and as to the probable effect of each separate impurity, is seen to be of the greatest importance.

But in attempting to develop these qualities which its composition indicates, it is necessary to understand the chemical and physical changes which take place in all clays when subjected to heat.

Clay when heated, first loses the water which has been mechanically added to it, to render it plastic and soft. This water having been mechanically added to the clay, has no chemical ties to break in coming out again, and therefore evaporates at all temperatures and at the temperature of 212° F. is converted into steam. Therefore it is necessary to raise the heat so slowly as to allow all of this moisture to escape as vapor before the clay becomes heated above the boiling point of water, for the generation of steam would of course tend to destroy the structure which has been imparted to the clay and which it is important to keep. After the moisture has been thoroughly driven out, the temperature may be increased with much more speed. For purposes of investigation, if the heat be raised at a slow rate and the clay weighed at frequent intervals, it will be found that no change in weight occurs (after the moisture is expelled) while the clay is successively raised past the melting point of tin, lead, zinc and antimony, and that it is considerably above this point, probably not far from 1,000° F. or a low red heat, hardly perceptible in daylight but clearly perceptible in the dark, when the clay next begins to lose weight. When this heat is attained, the combined water, which has been a chemical part of the clay heretofore, is expelled and the clay loses weight to this extent. A pure kaolin loses about 14%, and any other clay less, in proportion to the amount of real clay it contains. If there is any organic matter in the clay it will probably be driven out at about this stage in the burning. It depends on the kind of organic matter; if it were sawdust mechanically added to the clay to induce porosity of structure, it would require further heat to remove the charcoal produced; if it were hydrocarbons and coaly materials existing in the clay naturally, they would probably be driven out at this heat. If there is any sulphide of iron present in the clay it begins to decompose at this temperature, giving off free sulphur, which oxydizes at once to sulphurous acid, and usually in the presence of the superheated steam and air to sulphuric acid.

These reactions are beautifully illustrated in the successive changes of vapor which discharge from the stack of a kiln which is burning wares made from a sulphurous clay. First of all comes a copious cloud of steam while the moisture is being driven off; then a period during which no gases are seen to emerge except black smoke after each fire is replenished with coal, then the combined water beginns to appear in the form of steam, and soon the steam is reinforced by a blue permanent smoke which still floats away into the atmosphere after the steam disappears. When occasionally this blue smoke is brought down to the surface of the earth it is found to be intensely irritating to the lungs of man and beast, and fatal to vegetation. The production of the first sulphuric acid is accomplished while the water of hydration is still passing off, but the cloud of sulphuric acid still continues to come after no more steam can be detected by the eye. Sometimes the gases from sulphurous clays are not blue as have been described, but brown or reddish in color. This may be due to the simultaneous expulsion of carbonaceous matters and sulphuric acid, and the reaction between these two. The production of all these gases and their expulsion from the mass of the clay is easily effected if the temperature of the clay is kept nearly stationary while the expulsion is in progress. The heat must not be allowed to fall below the initial point, and it must not be allowed to go much above, for as fast as the clay loses its combined water, it undergoes a great physical change, a closing up of its pores, a general shrinking and settling together of its molecules, so that it becomes more and more difficult for the gases of the interior portions of the clay to find their way out through the dense layer of the exterior.

It is by a failure to recognize and obey this simple law that 90% of the losses in burning clay wares occur. All clay workers appreciate the importance of burning slowly at first, but very few realize that the real time to go slow is midway in the process of burning, or more explicitly while the combined water or "water smoke" is being driven off. After a kiln of clay ware is lit and the moisture is dried out, the heat may safely increase as fast as convenient till the water smoke begins to appear. At this stage the heat must be simply maintained until the steam ceases to issue from the stack or until every part of the kiln has attained the dull red color in daylight and been held at that point for a few hours.

If this precaution is not observed and the heat is allowed to increase on the ware before the water is all expelled, the escaping steam from the inside of the ware being confined by the denser layers surrounding it, causes the clay to swell or puff up like a loaf of bread under the action of yeast. This comparison is not an idle one. A piece of bloated clay ware and a loaf of light bread have both been made porous and spongy by the efforts of an imprisoned gas to escape from confinement.

This action, variously named as puffing, bloating, blowing, swelling, blistering, blubbering, manifests itself in very many ways in the different kinds of wares which are made out of clay. As might be expected from the principles involved, the larger the mass of the clay the greater danger of bloating it, and the longer the heat must be held stationary to allow the escape of the gases. Large objects like fire bricks, glass pots and glass furnace blocks and retorts contain a notable quantity of calcined clay or ground brickbats from which all water has been expelled. This produces an open structure and allows the escape of the gases from the interior. Great care and long time has still to be taken in burning these objects. But in the case of large paving blocks, where no calcined clay is used and where the body clays are generally somewhat plastic and easily fusible, the difficulty is much increased, as the clay tends to begin to vitrify at so low a heat that the opportunity of expelling the combined water before the outer layers of the clay become dense is much diminished.

In pottery and pipe-making, less trouble is experienced on account of the thinness of the section of the ware. This change of structure in a clay by bloating may be very marked or very slight. If the action has been very slight no change in structure can be detected by the naked eye, but a change in color is apparent, perhaps in a narrow band or small area furthest from the surface of the ware. As the action increases, the deepness of the color increases, the size of the areas affected increases, and soon the discolored areas are seen to be minutely porous or full of holes and cells. Further increase of the action is marked by an increase of all these symptoms and the object begins to swell out of its proper shape. The last stages are so excessive in some cases that the clay has become so porous and cellular that it will float on water.

In this discussion, combined water has been mentioned as the cause of these phenomena. It is the common cause, without doubt. Iron pyrites or any form of sulphur which is decomposed by heat at the same temperature is able to cause the same phenonena and is harder to control than water alone. It is possible that organic matter may have the same action in some cases.

If the clay has been safely brought through to this stage of its burning with no changes of physical structure except the shrinkage and closing up of its pores and general consolidation of its particles, there is generally no further fear of trouble in burning it. The heat may be raised as rapidly as is convenient and as high as the fusibility of the clay will allow without danger to the structure. There are, however, exceptions to this general line of facts. If a clay contains sulphate of lime or any other sulphates not decomposed at low red heat, they are likely to be decomposed at a still higher heat, to give off sulphuric acid and cause a set of phenomena very similar to those caused by the combined water. There is this difference, however, that bloating from combined water or sulphides nearly always proceeds from the center of the mass outwards, while porosity produced by sulphates or sulphuric acid begins on the outside and proceeds inward as the temperature sufficient to cause it proceeds by absorption toward the center of the mass. Instances have been seen of this kind of bloating where a still unaltered core was surrounded by a porous envelope, when the burning process was stopped before completion of the bloating. This is due to the fact that the body of the clay had become compact and solid before the heat necessary to decompose the sulphate had been attained and gases generated near the surface of the clay were unable to make their escape, which is never the case where combined water is the cause of the bloating.

The presence of sulphate of lime in small quantities is not likely to do any harm, for it is comparatively soluable in water and if the clay is washed, as in the pottery process, small quantities of this mineral will be removed. If the clay is not washed but merely tempered with water, this water becomes a solution of sulphate of lime and when the clay is dried before and during the burning process, the sulphate is carried to the surface of the ware in small quantities and deposited there as a white incrustation. If the clay contains a small quantity only of the sulphate, it is probable that the action of the water will prevent any of the bloating effect being accomplished.

There may be other agencies besides those which have been indicated which are the cause of this second bloating of clays. The question has not been, by any means, probed to the bottom as yet, but it seems tolerably certain that in the cases mentioned the action is substantially as has been described.

The phenomena which clays show when undergoing the changes due to excess of heat are very various. Some clays simply get soft and pasty and become more and more fluid as the heat is raised. Such clays generally contain a good deal of the alkalies and alkaline earths. Many good fire-clays, when their refractory qualities have been over-taxed show their failure in this way.

Other clays do not melt at any heat but seem to undergo a complete disunion of their former chemical compounds and become perfectly worthless. Clays in which iron is the chief impurity and in which it is believed to be in chemical combination with the clay base, generally behave in this manner. Some few clays cannot be made to undergo chemical dissolution or even fusion under any heat which metallurgical practice brings to bear on them. These clays fail by the fluxing and scorifying action of the slags to which they are exposed. They are simply dissolved away.

In addition to the facts which are presented to us in the application of heat to clay, there are other phenomena which are due to the chemical character of the flames which give off this heat. If the clay is burnt in an atmosphere which is always free from unconsumed carbon, the colors it develops will be clear and bright. If the fire places are badly constructed and the fires badly managed, clouds of smoke will be produced, which darken the color of the wares. Sometimes the coloring is done intentionally, by what is termed "smudging" the kiln, or making a very dense smoke for a time just before and during the glazing of the ware.

Sometimes the idea is advanced that this darkening color is due to the absorption of carbon from the smoky flames while the surface of the ware is sticky with the glaze. This is not so. The variation in color produced in clay wares by changes in the quality of fire employed is due to the oxydizing or reducing action of the gases on the oxides of iron present on the clay.

It is not probable that the quality of the flame affects anything else except other metallic oxides, artificially employed in the clay for fluxing or glazing effects.

The oxides of iron have proven themselves to be very sensitive to these influences. It is a fact that oxide of iron, if it has once been affected by a reducing influence, is far more susceptible to an oxydizing influence than it was at first. A clay which has been burnt in a steadily oxydizing atmosphere shows, for example, a steel gray color. Now burn the same clay in a fire alternately reducing and oxydizing, if the sample be withdrawn and suddenly cooled when the fire is reducing, or has been so lately, the color will be still gray or blue. If the ware be left to cool slowly in the hot air of the kiln, it will be strongly colored by the iron, much more so than that which had never been reduced. Potters who are engaged in producing stone ware, have to watch this point with the greatest care, and use all pains to prevent their fires from burning smoky, for they know, practically, what has just been stated, that "smothered ware is always dark colored."

The influences which the burning of a clay have on its ultimate qualities, are thus seen to be very great. While the composition of the clay limits the qualities which can be obtained from it, while no amount of skill, in burning, can make a bad clay into a good product, yet, unless the burning be substantially right, the finest clay in the world is easily injured or ruined, and unless these principles, which underlie the burning of clay, be understood by those in charge, there is likely to be a constant production of wares which are either inferior or a total loss. Now and then a kiln will be burnt which happened to avoid the transgression of any law, but, as a general thing, the loss in each kiln will be a noticeable percentage. Part of this belongs to defects of the kilns employed, perhaps, but the importance of manipulating the burning in accordance with the natural laws is none the less sure.

e. The testing of clays. As to the best means of testing a clay with regard to its fitness for manufacturing any kind of ware, it cannot be claimed that much that is new or valuable has been added to already existing methods in the last decade. Those establishments which are engaged in manufacturing clay products on a large scale and of a high grade, usually have perfected a system of testing clays for their own processes, which is, in effect, merely their regular process, carried out in a small and rapid way. Small testing kilns fired by gas or oil, which can be heated up and burned in a few hours, are sometimes employed. Some few works, where the artistic effects sought are of the highest class, and where the use of the highest skill of the potter's art is called in play, employ skillful chemists, not so much in testing the nature of the crude clays employed as in working out and keeping control of the delicate problems of glazing and coloring.

It is a fact, and one to be regretted, that there is no really valuable way to find out what a clay can be made to do but to try it. It may be tried in a crude and ignorant way, and rejected, or it may be tried in the light of all the technical knowledge available on the subject and found useful. Instances of this kind are not uncommon, but, after all is said and done, the proof is by trial alone.

There are certain aids to a proper trial of a clay which are beginning to find use in clay works in the country. Among them are various forms of pyrometers for measuring the heat employed in burning. An instrument which is accurate and convenient and portable has long been needed in the clay working industries.

There are a large number of patented pyrometers in the market, none of which have proved their usefulness to the clay-worker. Those depending on the expansion of a metallic bar by heat are not conveniently portable and are easily deranged and the bar is constantly liable to give out, as the temperatures employed in clay working are much higher than the metallurgical processes for which these bar expansion pyrometers are especially designed.

A new pyrometer in the market depends on the expansion of a column of air enclosed in a strong but thin metallic tube. This instrument is claimed to be very accurate but is very expensive. One of the comparatively recent forms of heat measuring appliances is the Lunette Pyrometrique or pyrometric telescope invented by M. M. Mesure & Novel and manufactured by E. Ducrete, of Paris. This instrument is an optical one and depends on the use of two nicol prisms, one fixed and the other capable of revolution on its axis, and separated from the other by a quartz disc or plate. In looking at a radiant heated object with this instrument, the light transmitted, when the two prisms are at a certain position with respect to one another, is almost colorless. When the movable prism is revolved on its axis by means of a graduated hand wheel, the color changes through the usual range of colors produced in the polariscope. There is one point in this array which presents a reasonably sharp tint, and that is when the green colors fade away to be replaced by red. In using the instrument, the operator sets the prisms in the colorless relation, as indicated by the zero mark on the hand wheel, and fixing his gaze on the hot object to be measured proceeds to turn the hand wheel when the colors run through the green series and into the pink or reds. The transition point between the two tints is selected as the reading point, and when this has been determined by rotations backward and forward, the number of degrees of rotations are read off from the graduated hand wheel. This figure can then be turned into degrees, Centrigrade or Fahrenheit, if desired, by comparison with a scale of known heats and readings taken from them by the Lunette.

This instrument has been in use by the Survey during the visits paid to clay working establishments in all quarters of the state. A very large number of readings were taken and the instrument was found to be consistent with itself on all occasions. The heat of a certain fire being read by one man several times would give a series of closely agreeing readings, and different parties, including some who had never seen such an instrument before, were able to get the same results. Occasionally a man would be found whose eye failed to distinguish the minute shades of color on which the value of the instrument depends, and to such a man the pyrometer would be useless.

By this careful and extended examination of the instrument, undertaken with a view to determine its fitness to be used as an instrument of daily reference in clay works, many valuable facts were ascertained which will be presented in connection with the latter part of the work, but the general conclusion arrived at is as follows: 1st. It is the lightest, most portable and simpiest of all the pyrometers of moderate price now in use in this country. 2nd. Its use is recommended as an instrument of control for superintendents, managers and foremen in charge of clay factories, and not directly in charge of the burning processes. By its use, any irregularity in the progress of a burn, any retrogression of the heat by carelessness, or any undue increase of the heat by ignorance can be detected. 3rd. A fixed temperature reads the same on the Lunette by day or night, where the unassisted eye is greatly deluded by light or darkness in judging the heat of a kiln. 4th. This instrument or any other pyrometer is not recommended as a means of finishing the burning of a kiln of any kind of ware, or it is not recommended to supersede the trial piece system now in use, for the guidance of workmen in the performance of their duties. The final heat to which a kiln of clay ware is to be subjected is a matter of very great delicacy and can only be determined by the most careful and vigilant attention and skill.

In no clay working process now in operation is it possible to command such extreme regularity of composition of the materials that the burning processes can be brought to a termination by means of the accomplishment of any special temperature or heat. The burning of each lot of material must be concluded for itself and the use of trial pieces made of the same mixtures at the same time under the same conditions, and of the same bulk as the articles being burnt forms the safest and easiest guide which the nature of the case admits.

Dr. Seger, a German chemist and technologist, has perfected a system of tests for temperature, which, while they are ingenious, are in reality but little more than a modified form of the trial piece system. The theory of the process involves making a fusible base mixture of ordinary potter's materials, clay, flint and spar, and perhaps the glazing materials as well. To separate portions of this base he adds successive portions of silica or flint each larger than the last and increasing in regular order. These separate compounds are each infusible in proportion to the amount of silica added to the fusible base. By taking a well known mixture of predetermined thermal qualities far a starting point and another for a finishing point and dividing the intervening space into as many aliquot parts as he desires, he obtains a fairly regular set of melting points.

The compounds are mixed and molded into pyramids about $\frac{3}{8}$ of an inch on each side of the base and one to two inches high. When the melting point of each one of these is reached it indicates it by drooping over to one side and gradually fusing.

This system is ingenious and to potters who are in possession of all the materials and machinery for making the mixtures, as well as the knowledge of the principles of fluxing involved, it is possible that this idea may be useful; but for the clay worker in the commoner forms, it is not likely to find any extended field of usefulness. In fact, the variations of the clays used in all manufacturing processes are liable to be so constant and so great that it seems doubtful if the pyrometer will ever find any very important field of usefulness. As an instrument of control in the hands of those in charge it is certainly valuable now. As a means of regulating the process and finishing it at the right time it is not likely to ever become highly useful.

The usefulness of chemical work to the clay worker has often been questioned and in the pottery industries of the country, which are really a chemical industry, based on chemical laws and principles, it is astonishing to find so little use of the literature of science. Whatever has been accomplished in these lines has been by the crudest kind of experiment and by personal transfer of knowledge from one to another Nearly all the radical steps or changes have been introduced here from Europe, where much more has been accomplished by way of chemical control of the process.

It is doubtful if there are many clay working establishments in the country now that are really able to utilize the services of a competent chemist. What is much more needed and more directly beneficial to these great industries is that the young men growing up in the business should be sent to the best technical schools available for special courses on the chemistry and technology of the subject. The State University provides free instruction for the young miners of the state by the establishment of a short mining course which is designed to teach what will be most directly useful to them. Why should not the other industries of the state receive similar recognition?

Many works that are not now able to employ or even to use a chemist would be infinitely benefited if they were managed by a man who had had the benefit of this scientific and chemical training in addition to the practice of the shop, and it seems that in this way only will the use of science be brought to bear on the problems of clay working.

SECTION II.

The Present Condition of the Clay Working Industries of the State.

The healthy and vigorous condition of the clay working industries of the state has been alluded to before, and it is because their present status is so inadequately represented by the most recent notice which they have received in the volumes of the survey, that the present chapter has been prepared.

The industries represented are practically the same as in the report of nine years ago; in the department of pottery manufacture, the china business has been formally introduced, and the whole of the now enormous trade in clay paving material has sprung into existence mostly in the last five years. It is a matter of regret that accurate figures showing the productions of Ohio as a clay producing state are not accessible. Statistics of this subject are in process of compilation by the Census office at Washington, but no data from the census of 1890 are yet furnished the public. Wherever possible, approximate figures of the production of 1891 were obtained, but these give us only an idea of our own status and none as to our relative advancements.

However, there is no doubt of Ohio's supremacy in this line in every department unless, perhaps, the manufacture of fire brick, in which Pennsylvania has had the lead for many years and whose deposits of clay for this particular purpose are larger and probably better than ours.

Also it is likely that the production of common building brick is larger in some of the eastern states than in Ohio, on account of the enormous consumption of the large eastern cities. But as the production of common bricks is more nearly a commercial question and less a technical problem than any other branch of clay working, it is not material to the points at issue.

The clay working industries of Ohio may be divided into several well defined groups. The classification is somewhat different from that adopted in the previous report: in this chapter it has been designed to treat under one head all materials manufactured to fill one purpose and the classification is the most easy and most natural one; but in some groups, notably in the manufactures of pipe and hollow goods, it is found that articles which unmistakably belong in this section by the processes of manufacture, find their field of usefulness in another class of work and do not conflict or compare with the regular products of their class.

In the principal groups however there is no such difficulty of classification. The clay working establishments comprise manufactures in not less than twenty-five distinct lines. These may be divided into the following general groups:

1st. The manufacture of pottery.
2d. The manufacture of paving material.
3rd. The manufacture of pipe and hollow goods.
4th. The manufacture of refractory material.
5th. The manufacture of building material.

It may be said that the last three groups are all substantially brick making industries. This is so in one respect, but the extreme divergence of the qualities sought in the manufacture of each kind of material and the differences of material and the processes involved, justify their separate consideration.

I. THE MANUFACTURE OF POTTERY.

The manufacture of pottery is the oldest form of clay working known to man. His earliest efforts to establish a home are coupled with the need of utensils to contain the supplies for his immediate necessities.

In Ohio the manufacture of primitive stoneware began along the valleys on the margin of the Coal Measures where the fire clays had been mellowed and softened into plasticity by the exposure of centuries. From such beginnings the industry has grown to the present importance.

The pottery manufactures of Ohio may conveniently be divided into the following classes.

(*a.*) Earthen wares.
(*b.*) Stone wares.
(*c.*) Yellow and Rockingham wares.
(*d.*) C. C. wares.
(*e.*) White granite wares.
(*f.*) China wares.
(*g.*) Ornamental pottery.

A more detailed description of pottery makes necessary a much closer division, classifying the higher grades of pottery in many groups according to the method of decoration or special character of body employed. But these distinctions belong to the technical treatise on pottery only and not to a document for general use.

(a) Earthenwares.

Earthenwares are perhaps the lowest form of pottery manufactures. The technical distinction between earthenware and stoneware lies in the degree of heat used in the burning, or rather the degree of change which it is desired to produce in the body of the ware by heat. Earthern wares are expected to be comparatively soft burned and porous, and except in certain cases where the glazes are used, they are not fit for containing liquids. The types of earthenware most familiar to the public are the red and yellow flower pots which are sold in such enormous numbers every fall for the preservation of the summer's floral treasures.

The production of earthernware in Ohio, while it includes the production of flower pots, etc., on a small scale in a good many small shops, is represented by only three large and responsible concerns, all located in the Zanesville district.

The clays suitable for the production of earthenware have a very wide range of composition. Inasmuch as it is not designed to bring the clay to a state of vitrification in burning, any clay of suitable plasticity and color will fill the requirements. Even the purer grades of Drift clays are occasionally utilized. The earthenware manufactures of Zanesville have, however, been developing a specialty in cuspidors, which they find it necessary to glaze inside. On account of this specialty the clays suitable for use are narrowed down very greatly and it is necessary to select a clay which has refractory qualities sufficient to make it stand up well, and not vitrify to any extent at the heat required to melt a glaze composed of about two-thirds Albany slip clay and one-third oxide of lead. The Albany slip, the great stoneware glaze, will be further described under that head; it requires more heat to melt the slip alone than the clay body of earthernware will stand without vitrification and hence the addition of lead oxide is necessary to cause the lower melting point of the glaze.

The choice of clays is also controlled by the color of ware which it is desired to make. The staple articles manufactured are flower pots, jardiniers, cuspidors, vases and umbrella stands.

One manufacturer uses a body composed of two parts of an excessively tough plastic clay, probably of glacial origin, not unlike the ball clays used by whiteware potters, one part of a white hard refractory fire clay and one part of red loam designed to add color. This body has not much excess of refractory power, though it is successfully glazed. It has a fine red color characteristic of typical earthenware. Another manufacturer uses a fire clay obtained from the horizon of the Putnam Hill Limestone. This clay, however, has too little heat resisting power to be a profitable one and its color is not a clear yellow, but shades off into brown by any excess of heat.

The best clay used for this purpose is a very sandy stoneware clay, which has so much silica and so little clay in its composition that it has no tendency to vitrify at any heat necessary to use.

The processes used in these factories are practically the same as in the manufacture of stoneware and will be sufficiently described under that head. The clay is prepared by washing, in two establishments, and grinding, in the third. For the production of a mixed body like the first one described. the washing process is necessary as a means of getting uniformity of color. But where porosity and openness of structure is desired in the ware, it would seem that washing would not be the best method of preparation of the clay. The superior ease of using the washed clay on the jolly wheels on which the production of these cheap articles so largely depends is doubtless the reason why this method of preparation has been selected.

The kilns used for the burning of earthernwares are not characteristic of that business or specially adapted to it. There are several kinds in use. The Akron square, end-fired kiln, the up draft muffle, and the old-fashioned updraft stoneware kiln are all used successfully. In one case a stoneware manufacturer has built a double decked kiln, in which he burns stoneware in the lower chamber, and the hot gases from below are used to burn the flower pots in the upper story. He thereby burns his flower pots for nothing, as no heat is produced which the stoneware does not require for itself. This is a possible arrangement only on wares like flower pots, where the heat they receive may be more or less varied, with but small effect on the ware. Glazed cuspidors could not be treated in this way as the heat must be gradually raised on these articles till the glaze is melted, and then stopped at once.

The details of setting, drawing, etc., will be touched on in connection with stoneware. The most original part of these industries at Zanesville is the method of decoration which has been devised. The wares are painted in oil paints, decorated with flowers and other rapidly executed ornaments, varnished and dried in hot closets at 200 to 225 degrees F.

The effects produced are really creditable and the jardiniers and cuspidors of this description have made their more costly competitors in the yellow and whiteware industries a world of trouble in the last four years.

Almost all the decoration is done by women and girls and the rapidity with which it is done is wonderful. The prices of these hand-painted cuspidors vary from $1.50 to $3.00 per dozen according to shape, size and decoration.

The following tables gives the available statistics in this industry:

EARTHENWARE.

Name.	Location.	Output 1891.	Present cap'y.	Hands.
Samuel A. Weller.........	Zanesville....	$ 68,000	$ 100,000	60
J. B. Owens, Pottery Co.	'	In construction.	100,000	60
Roseville Pottery Co....	Roseville......	40,000	60,000	45

(*b*). Stoneware.

Stoneware is defined as that kind of pottery which is made from a natural clay and whose burning and glazing is accomplished in one operation. It is distinguished from earthenware on the one side, by the fact that it is always glazed and generally it is vitrified in its body texture, and it is distinguished from yellow and Rockingham wares on the other side, in the fact that its burning and glazing is done in one operation instead of two.

Stoneware is a crude form of pottery, but a wonderfully useful one, especially to those engaged in farming and marketing of farm, orchard and dairy products.

Stoneware has until comparatively recently been confined to such uses as have been indicated, for containing fluids, and semi-solid materials but a promising trade is now growing up in the manufacture of a special kind of stoneware for cooking purposes, which can be used directly on a fire or stove with safety and great convenience.

In geographical distribution the stoneware business occupies the same general limits that it did ten years ago. The largest district is at, and near to, Akron in Summit county. The Zanesville district has made great progress and now makes a good second to Akron. Besides these two well defined districts, there are quite a number of large and well-appointed shops in various out-lying points. The Rock House district of Hocking county has ceased to play any part in the business as a commercial factor.

The clays used in the manufacture of stoneware are confined to one well defined class, and no great variations are detected in analyses from a number of points in the state.

The qualities which a clay must have to fill the various needs of a stoneware potter are essentially as follows:

1st. It must be plastic, so that it can be spun and moulded into any desired shape, without the expenditure of any excessive power in preparation or the use of excessive strength in turning. There is a great difference in clays in this respect which in others meet equally well the demands of the business.

2d. It must be refractory enough to stand up well and keep its shape at a heat sufficient to melt the clays which are used for glazes, or to take a good salt glaze on its surface. This condition is of the utmost importance; a fusible clay will cause the manufacturer a regular percentage of loss in every kiln, which can be avoided entirely by using a stronger clay.

3rd. While keeping its shape at this heat, it ought to be undergoing a process of vitrification which, while not being sufficiently marked to make the ware brittle or glassy, still makes the body practically impervious to water. Much stoneware is now made which does not fill this condition, as it is not vitrified at all and depends upon its glaze to make it impervious.

4th. When burnt with a continuously clear fire or oxydizing atmosphere, it ought to present a clear and uniform tint, varying from light straw yellow or buff when rather soft burnt, to a clear stone gray or blue color when hard. If the clay shows, on short exposure to a smoky flame, a brown tint or scum, it will be undesirable, as it is always likely and almost sure to be exposed to reducing influences in a 40 hours' burn, and a brown color is unpopular in the market.

5th. Blotches, pimples, blisters or any other eruption on the surface of the ware, which are due to impurities in the clay and not to faults of burning, will rule the clay out, no matter if all other qualities are correct.

It may seem that it would be a difficult matter to secure clays in which these various qualities are united, but such is not the case. The average clays in use in both the two stoneware districts fill this description well, with here and there a case which fails to some extent in one or other of these points.

The following table of analyses has been prepared with a view to illustrating the chemical character of such clays as are in actual use and are giving good results.

One clay, however, was selected as being an undesirable one for use as a stoneware clay, and its analysis very clearly shows the cause of this failure to develop the proper quality. Also a few analyses which had never been completed, and one which shows such a marked difference from the other as to throw doubt on its accuracy, are included in a second table.

TABLE I.

ANALYSES OF STONEWARE CLAYS.

	1	2	3	4	5	6	7	8	9	10
Silica (combined)	25.60	28.61	23.88	27.68	27.74	25.40	29.35	25.48	30.36	32.33
Alumina	19.08	23.01	19.31	22.95	23.08	21.13	23.05	20.80	24.88	26.60
Water (c mbined	5.57	8.03	5.08	6.74	6.88	6.29	7.39	5.72	6.96	7.57
Clay base	50.25	59.65	48.27	57.37	57.70	52.82	59.79	52.00	62.20	66.50
Silica (free)	43.73	34.79	45.91	36.58	35.73	40.81	35.85	42.65	33.19	24.11
Titanic ac.d	.29	.35	...	...	...	...	.55	...	...	...
Sandy impurities	44.02	35.14	45.91	36.58	35.73	40.81	36.40	42.65	33.19	24.11
Oxide of iron	1.26	1.50	...	1.28	1.31	1.28	.99	1.20	1.17	2.00
Lime	.60	.41	...	.45	.51	.51	.58	.42	.56	.47
Magnesia	.63	.62	...	.37	.46	.18	.58	.37	.47	.63
Potash	2.14	1.26	...	1.81	1.71	1.42	1.45	2.28	2.27	3.2[illegible]
Soda	.02	...	...	.15	.22	.38	...	.27	...	.26
Fluxing impurities	4.65	3.81	4.80	4.06	4.21	3.77	3.60	4.54	4.47	6.56
Moisture	.94	1.97	1.02	2.05	2.18	1.65	1.11	1.00	1.38	2.48
Grand total	99.86	100,57	100.00	100.06	99.82	99.05	100.90	100.19	100.24	99.65

The clays represented in the first table are as follows:

No. 1. Brumage's Stoneware Clay, Roseville, Ohio.

No. 2. Allen's " " " "

No. 3. Walker's Clay, used for cooking wares, Roseville, Ohio.

No. 4. Zanesville Stoneware Co., clay ground in tracing mill for hand turning.

No. 5. Zanesville Stoneware Co., same clay washed and pressed for use in jollies.

No. 6. Bagley & Roberts, Zanesville, clay for cooking wares.

No. 7. Uniontown Stoneware Clay.

No. 8. Akron Stoneware Clay. Average of several samples selected from the ground clay used in several plants, and mixed.

No. 9. New Brighton, Pa. Stoneware clay, from the factory which is supposed to produce the finest American stoneware.

No. 10. Salineville, O. Stoneware clay deficient in fire qualities.

TABLE I.

The analyses of this table comprise a fairly full representation of the clays of the Zanesville district, but only give one analysis of the more important Akron district. This one analysis is one of uncommon value, however, as it represents in itself an average.

The analyses referred to before as incomplete or unsatisfactory, are given below:

	1	2	3	4
Silica	72.10	68.24	69.05	72.26
Alumina*	19.38	22.61	21.37	19.23
Impurities	2.27	2.59	2.58	.96
Water	6.25	6.56	7.00	7.55
	100.00	100.00	100.00	100.00

*By calculation.

1-2-3. Old analyses of the Akron stoneware clay from the Springfield clay pits.
4. Greentown stoneware clay.

A careful study of these figures, even the incomplete ones, shows a substantial uniformity in the character of clays used for this branch of pottery manufacture. The following facts are deduced from the table, which may prove of value to anyone wishing to investigate a clay as to its fitness for this business:

1st. The average of ten accurate and skillfully made analyses of clays now in use shows:

Clay base	56.65
Sandy matter	37.45
Fluxing matter	4.44
Moisture	1.57
	100.14
Total silica	65.09

The oxygen ratio of this clay being calculated, shows it to be:

Oxygen in silica : Oxygen in bases : : 34.72 : 11.52 or 3 : 1

or that the clay in fusion is practically a trisilicate.

The extremes from this average are found to be three pounds and ten pounds. No. 3 is the sandiest clay of the lot, showing:

Clay base	48.27
Sandy Matter	45.91
Impurities (by dif.)	4.80
Water	1.97
	100.00

Oxygen ratio, acid : base : : 2.66 : 1

This clay is used in making cooking pottery which differs from ordinary stoneware in that it must be open and loose in structure to rapidly convey the heat through its body, and allow rapid expansion and contraction, and it depends on the glazes entirely for retention of its fluid contents.

No. 10, the opposite extreme of the series, is a clay used in making a fair article of stoneware. It is what is called a tender clay or, in the language of stoneware men, it is not "*safe*." The slightest excess of heat results in the ruin of some ware and extra precautions have to be adopted in cooling it down, to prevent cracking. The defects are such as to affect the pockets of those who make it rather than those who buy the marketable ware.

The trouble lies in its readily fusible nature. Clays used in glazing it have to be softened with lead or borax and even then though a beautiful glaze is produced there is very little margin between melting the glaze and sagging the ware.

The chemical character of this clay shows the reasons for this condition of affairs.

Clay base	66.50
Sandy matter	24.11
Fluxing matter	6.56
Water	2.48
	99.65

Oxygen ratio, acid : base : : 2.15 : 1

or, but little over the bi-silicate ratio.

The preparation of clays for use in the stoneware pottery is accomplished in two different ways, (*a*) by grinding, (*b*) by washing. Each process is specially adapted to the preparation of clay for certain shapes and sizes of ware and also to different kinds of ware.

Many well equipped stoneware shops contain both a washing and a grinding plant in order to avail themselves of the advantages of each kind of clay.

In the Akron district a number of the smaller firms have united to build a washing plant at the clay mines, some five miles from the factories, and the clay is mined and washed at the cheapest price and delivered to the stockholders according to their requirements.

Those works which have only one method of preparation of their clay are usually strong partisans of the benefits of that method. But the candid judgment of the majority assigns to each process its advantages.

The preliminary preparation of clay does not cut much figure in this country; in some foreign places much stress is laid on the proper weathering of the clay, but many of the best works in the United States use the clay absolutely without regard to this point. That weathering has the advantage of slacking the clay down to a fine state of division, and decreasing the labor of the machinery, is a point generally recognized.

The Grading Process is the old and standard process of preparation. The simplest device used in Ohio for this purpose, consists of a circular trough about twelve inches wide and twelve inches deep. Either three wheels in echelon or four wheels at equal intervals are made to run around this trough, and their iron tires are forced into the clay by heavy weights of stone or iron resting on the axles. This was devised as a horse power machine, and is still used as such wherever the industry is developed on a small scale; in larger places, the revolution of the wheel is managed by use of a small engine.

The improved machine in use for this same purpose in larger factories is variously called a "tracer" or a "chasing mill."

The principal features are a circular iron pan, stationary on the floor, in which revolves a horizontal, oblong frame, carying heavy iron wheels, about thirty-six inches diameter bytwo inches face, on its two extremities. While this frame is continuously rotated by a vertical shaft with large over-head gear, the wheels are made to work slowly from the circumference to the centre of the pan and return, this motion being actuated by a small pinion working in an endless rack. Thus the wheels are made in the course of one complete round of the pinion to cover successively every point in the floor of the pan. A charge of clay consisting of one thousand to two thousand pounds is dumped in, wet with buckets of water and ground from one to two hours.

The expenditure of power is very heavy compared to the results achieved. The character of the work done, is everywhere urged as the chief recommendation of the machine. The grinding part of the process has much less to do with securing this, than the kneading and stirring caused by the wheels and scrapers as they revolve; and another point of undeniable weight, is the fact that each panful of clay is homogenous and of even temper.

These machines are made by several shops around Akron. Messrs Taplin, Rice & Co., and the Turner, Vaugh & Taylor Co., of Cuyahoga Falls, both have a high reputation for the perfection they have attained in the manufacture of these machines.

In one or two works in the state a new departure has been inaugurated, in the use of the same kind of wet pans that are employed in sewer pipe or brick factories. This machine will be described in detail later on. In regard to its use in this connection it would seem a sensible change. As to the cost, a wet pan is as cheap or nearly as cheap as the tracer and it has the advantage of requiring far less power in proportion to the work it is capable of doing. In a wet pan the clay is forced by the scrapers to pass under the wheels continuously. In ten minutes in the wet pans, the clay is ground more than in an hour in the tracer, and there is far less likelihood of any lumps remaining unreduced. The chief objection urged to it is that the tempering is so rapid that the clay requires frequent wetting or it becomes too dry and that in emptying a charge while the pan is in revolution the temper of the first portion removed will be softer than the last portion. The tracer has to be stopped to empty it and the product is therefore all alike. The capacity of one wet pan would be sufficient to grind clay for the largest factories now in operation, which are using three or four tracers for the same purpose.

The washing process has been introduced largely into the stoneware industry in the last ten years. Prior to that the only attempt at washing clay was by boiling it in iron pans. The washing plants now in use are in all respects similar to those used in all branches of the pottery industry and need be described only once to answer for all.

The theory of the process is to beat the clays into a thin "slip;' or fluid pulp with water, and then after sifting out all coarse particles, remove the water and soluble impurities of the clay by filtration.

The machinery is substantially the same everywhere. The clay is reduced to a slip in the blunger, a vat generally of wood but sometimes of iron. An upright shaft driven from overhead by gears, revolves in the center of the tub and three or four stiff blades arranged like a propeller are fixed near the bottom. As the clay is shoveled into this tub of water it is kept constantly in motion and reduced to a pulp. Sometimes the blunger is a double one and has two shafts and two sets of arms, which are set so that their circles of revolution overlap. The shafts revolving in contrary directions give an extremely vigorous action to the machine, and it is wonderful how hard and rocky a clay can be reduced to a fluid pulp in these machines.

The screens are the next machine employed. They are generally made of fine brass wire cloth stretched on rectangular frames which are rapidly shaken back and forth by a high speed crank or eccentric. The slip is delivered from the blunger on to the screen at its highest point which slopes away at a small pitch toward either side. The liquid and fine clay run through, are collected and conducted to an agitator. The coarsest particles, including gravel, coarse sand, chips, etc., are retained on the wire and by the constant vibration are carried down and off the screen into troughs to receive the refuse. The fineness of the mesh for stoneware is about one fortieth of an inch; it is not considered best to use too fine a mesh in this business.

The agitator is the counterpart of the blunger, except as to size and strength of its driving mechanism. It generally is made big enough to hold four blungers of slip and its function is to keep this slip in suspension to prevent the settling of clay.

The next machine is the pressure pump, which is used to take the slip from the agitator and put it into the filtering press against whatever head of pressure may exist there. There is nothing peculiar about this pump except that it must be strong and ought to be provided with extra facilities for packing, etc. Some are arranged to work in oil and impart their alternate suction and pressure to the slip without coming in contact with it. The latest and best devise for effecting this purpose is a compressed air plant made purposely to work up to a pressure of one hundred and twenty-five to one hundred and fifty pounds. The slip is run into a strong tank by gravity, and is forced out again by air pressure into the press. This absolutely does away with the constant wear and tear of the pump. Only a factory of large size can afford to use this plan, as the cost of putting it in operation is rather heavy.

The press or filter is the most ingenious and most troublesome part of the washing machinery. It consists of a series of iron or wooden frames suspended on iron side bars. These frames are covered with single or double layers of stout canvas or duck, made for the purpose. Through the center of each frame is a hole also lined with duck. When a press is in order, ready to fill, these frames or chambers are squeezed up tight against each other by a powerful screw at one end of the press. The canvas between the edges of the iron frames makes a tight gasket or joint and the holes in the center coincide all the way through, so that between the canvas of each two frames, there exists a duck-lined cavity, communicating by the central hole with the similar chambers on either side of it. When the slip is pumped in, it fills these cavities and the water soaks out through the canvas and drains away, leaving the clay behind. When the cavities are filled and no more slip can be pumped in at a pressure of one hundred and twenty-five pounds to the inch, the operation is complete. The screw is loosened, the frame separated and the clay is disengaged in flat leaves or plates one to two inches thick and weighing thirty-six to forty pounds each in the ordinary sizes.

The plates of washed and filtered clay are now tempered to the required consistency in a pug mill of vertical design and simple construction. The cost of the various machines for such a plant, will run from $1,000.00 to $1,500.00, according to details, without the power.

Washing plants are constructed by several machine shops in the state. The following make a specialty of this business: M. Patterson & Co., E. Liverpool; H. J. Boyce, E. Liverpool; The Bonnot Co., Canton. The Griffith & Wedge Co., Zanesville, and the South Zanesville Machine Co.

Such is the process of washing clays. The machinery has been greatly perfected in late years and fine grade clays can hardly be sold now until they have been washed and dried again to atmospheric condition.

The use of steam in assisting to disintegrate the clay in the blunger has been tried with very great success in a few places in Ohio. The warm water does its work quicker, the liquid filters much faster, and the men engaged in handling the wet clay in the winter time are relieved from the suffering from cold.

The peculiar quality of washed clay is its fineness and eveness of structure. No two particles of the original lump are together in the washed clay. To a certain extent, the waxy toughness of the original clay is gone; the result is more granular, though finer grained clay, which under the hands of the turner usually works "short." The clay is purer by the removal of whatever may be of a soluble nature, like lime salts. Iron existing in the form of grains is very apt to be removed with the coarse sand. Clay by this process is not considered so "safe" in the kiln as ground clay, on account of its fine, close-grained body, and liability to checking in cooling. For working into small wares, up to two gallon jars and crocks, in the jollies, it is far preferable to turned clay.

In order to test the amount of impurities removed by the washing process, analyses were made of the same clay, both ground and washed, at the plant of the Zanesville Stoneware Co. The figures are given in No. 4 and No. 5 of the table. In this case the chemical changes produced amount to nothing. There is no doubt however that some clays do contain impurities which are largely removed by this treatment. The salts of the alkalies do not seem to be affected by washing, which proves that they must be present as insoluble silicates. The highest potash per cent found in the table (No. 10) is from a washed clay.

The qualities of ground clay which make it useful are its toughness and strength. There is a structure to the original clay which washing destroys, and which grinding only develops. For ware to be made by hand by the spinning or turning process, this is a very important thing. Ground clay is just as impure as the natural clay and fuses just as readily, but on account of its more open structure, it is safer in the kiln. For large ware, from two gallons up, t is almost a necessity, as it stands up so much better.

The cost of washing clay varies greatly, according to the quantity which the press is required to do. To operate a 72 leaved press, to its maximum is the labor of two (2) men. They can take out five presses a day, or about 14,000 pounds of clay. This is at the rate of thirty six cents per ton. By increasing the number of presses and subdividing the labor the price may be reduced. If steaming the blunger increases the speed of the operation as it is claimed to do, the cost could be materially reduced. Twenty five cents per 2,000 pounds would be a low figure for the cost of washing and fifty cents is much nearer the average. The cost of grinding is difficult to estimate closely. The duration of a grind depends on the size of a charge, and the hardness of the clay. It is not less than one and one-half hours on the average, or 7 charges per day at 1,200 pounds per charge—8,400 pounds = .20 tons per day per mill. It would occupy the time of one man to tend this mill, and this clay would cost 30 cents. By using more mills the labor cost could be reduced somewhat. There is not much odds in the labor cost of clay by the two processes.

The selection of the clays for the stoneware industry has been discussed and their preparation for use in the potter's hands. In both of these subjects, there is much room for chemical and technical investigation and discussion. In the actual fashioning of the wares from the proposed clays, there are but few points of a scientific nature involved. The problems are mainly mechanical and industrial ones. However, as the processes employed in all branches of pottery, from the highest to the lowest, are substantially the same, a brief description of the various steps will be given in this conection.

Pottery is manufactured by three different plans; 1st, by turning; 2d, by jollying in molds; 3rd, by casting. Turning clay by hand was the original method, the two latter processes are out-growths from it. Stoneware ten years ago was nearly all turned; now there is probably fifty per cent. of it jollied; all of the lighest pieces of simple shape, are produced in this way.

The steps to the production of turned ware from prepared clay are wedging, turning and drying.

In wedging the clay, a lump is cut off of a proper size and weight to make the desired object. This is cut in two by a wire and united again by a violent blow, kneaded, cut and reunited again, and so on for a few moments. This treatment is supposed to work out air blebs and make the clay solid and dense. The turning or spinning is done on a rapidly revolving horizontal disc. The clay is slapped down against this so as to adhere and revolve with the disc. On wetting it and covering it with fine pulp of clay, and pressing it with the fingers it can be made to take any shape when in revolution. There is great art and skill in doing fine turning. The men take great pride in the possession of this skill and frequently vie with each other in trials of it.

The turner works by a standard known as the "day's work". A day's work is a definite number of gallons of each kind and size of ware; it is a very complicated standard and one which ought to be abandoned, as a turner now makes frequently seven or eight days' work in a day. The standard varies greatly in different districts; fifty-six gallons of one of the standard sizes is a day's work in one place, while eighty may be the number in another, and also in making twenty gallon crocks only three or four would be a days work, which does not compare in labor and time with making sixty or eighty one-gallon pieces, or thirty or forty two-gallon pieces.

The ware from the turning wheels is set on board shelves in open racks, where it slowly dries and sets in a solid shape. After twenty-four hours it is removed to a hot room, or oven, or steam heated shelves, or other appliance for completely drying the moisture from the clay. All breakage in drying after the ware is moved from its original position on the shelf, belongs to the manufacturer. The loss of all cracked or defective ware on the shelves falls on the turner.

When dry, the ware is stacked in piles in the slip room, which constitutes a sort of storage from which the manufacturer can choose the materials with which to set the kilns in whatever order may be most advantageous to him.

The production of ware by the jolly is much more rapid. The clay is tempered for this purpose to a soft pulp or slush. The jolly is a wheel like the turner's wheel, provided with a hollow head, which is made to receive a large assortment of different sized molds, by the use of appropriate rings for each size. The jolly is also provided with a variable speed arrangement, by which the operator can run his wheel fast or slow by the pressure from his foot.

Each jolly is provided with from one thousand to three thousand molds, made in sets for producing the various kinds of ware. The molds are of plaster of paris and are made from uniform standards which have been turned to size in a lathe. In a common sized stoneware shop there will be from fifty to three hundred molds of each shape and size, in the largest pottery shops working on whitewares a wheel may be run all day on one kind of ware and though each mold be used twice, as they generally are, and sometimes three times a day, this would necessitate the possession of from one hundred to one hundred and fifty dozen molds of a kind. The mold to be filled is brought by a boy, emptied of its piece of ware, partly filled with soft clay and given to the jolly man, who sets it deftly into his whirling wheel and with his hand forces the clays to cover the inside of the mold evenly. He then lowers a pivoted arm, which bears a scraper or "shoe" fitted to produce the exact inside shape of the ware. As the wheel and mold revolve the shoe turns up the clay to the desired form and the surplus collects and is removed by the operator. A common stoneware jolly man will make six-hundred pieces per day, all sizes as they come; a good man will make one-thousand pieces. Many articles are now made in half on the jolly and the two halves united while still fresh. Jugs, bottles, fruit jars, cans, etc., are made this way now which were formerly altogether turned, as the constriction of the neck, makes it impossible to shape it in one operation by a jolly and then withdraw the shoe. These double wares, take more time to produce than single wares, but are greatly cheaper than hand turned goods. A good man will make five hundred jugs a day by this process.

As soon as the mold is filled the boy takes it away to the drying closet, close behind the wheel. The heat in these closets is kept up by steam pipes or hot air fans or other devices. Here the water of the clay is evaporated from the surface of the mold and the ware shrinks away and loosens in its case. The air currents may be quite strong in these dry closets, as well as the heat quite high, as the most of the evaporation of the moisture is from the porous mold and the surface of clay itself is not exposed. In the drying of hand turned ware on its open shelves, great care has to be used to protect the ware from any draft, but no precautions are necessary on drying in mold.

When the ware is removed from its mold, it is fettled, or trimmed and smoothed up; this is done on wheels turned by hand generally. The handles are put in at this stage and the surfaces and edges of the ware are finished fit for the kiln.

The system on which jolly work is done is uniform in nearly all branches of pottery. The jolly man is paid for the finished product of his wheel, and he pays all his assistants, carrier boys and finishers, from his own wages. Sometimes as many as five boys and women are needed to tend the labor of one jolly man. Wages made by good jolly men are frequently very large, far out of proportion to the skill demanded.

Casting, as its name indicates, is a process by which a piece of ware is made by pouring a slip or paste into a dry porous mold. As the dry mold absorbs the water greedily, the clay is deposited in the surface of the mold. After the operation has gone on long enough to deposit the requisite thickness of clay in the mold, the mold is inverted and the remaining slip is poured out. The mold is then dried in the hot closets as before and when dry, is taken apart in two or more pieces and the casting remains.

This process is adapted to the manufacture of high grade wares, vases, filigree work, bottles, etc., which can scarcely be made by the usual processes.

These three processes are common to all branches of pottery making and will not receive any further mention in the succeeding parts of this section. The succeeding steps diverge from this point according to the kind of ware which is being made.

Stoneware, being distinguished from the other pottery processes, by the fact that it is burnt only once and that glaze and body are developed together, is therefore ready to be treated with the glaze at this point, before being taken to the kilns for burning.

The glazes uniformly employed in stoneware manufacture are natural clays of a highly fusible quality and which give brilliant color and finish to the ware. These natural glazes are called "slip clays." They are found in all parts of the country. Ohio has a number of deposits. But really good and serviceable slip clays are rare and valuable. In a general way, any very fine grained, impure clay is a slip clay, yet it is only when its qualities have been tried and proved that it is of any value.

The slip clays used by Ohio stoneware potters are mainly as follows:

1. The Albany Slip from Albany, N. Y.
2. The Rowley Slip from Northern Michigan.
3. The Brimfield Slip from Summit county, Ohio.
4. The Kaolite Slip.

These are named in the order of their importance. Albany slip is the finest, single, natural clay glaze known in the country and, while its qualities can be enhanced by mixture with other clays, it alone will make, on clays which are refractory enough to stand the required heat, a wonderfully fine and beautiful glaze.

The peculiarity of this kind of a glaze is that it never cracks or "crazes"; it is itself a clay; it is burned into another clay; the chemical changes of burning affect glaze and body alike, and when the operation is finished there are no artificial conditions of expansion and contraction always at war with each other in the body of the ware.

The fault of all these natural glazes is, that they require a good heat to bring them to thorough fluidity and thus many clays which would make a fair grade of ware are rejected as being too easily fusible for the glazes. Potters have frequently tried to remedy this fault by use of the common fluxes, lead oxide, or litharge, borax, spar, etc. It is a possible thing to make a glaze of which slip clay is the base and which is fusible at a low heat, but many of those who have tried to do it so far, have too little technical knowledge to do so successfully.

The addition of lead or borax alone will reduce the temperature of fusion but it destroys the beauty of the glaze; instead of being a clear velvety black or reddish black color, it appears thin and washy in color and irregularly spotted with specks of coloring matter.

An attempt has been made to counteract this clearness by the use of a little manganese in imitation of the Rockingham glazes, but while a softened slip glaze thus treated is improved, it still lacks the original quality. The cause of the failure of these attempts, is, in many cases, the addition of a quantity of some base like lead, without any acid to satisfy its affinities. The glaze has the desired qualities naturally except as to fusibility. Then a satisfied compound which is fusible and colorless or of the same color as the slip should be added, so that the mixture will fuse easier without undergoing a radical rearrangement of its nature.

The chemical constitution of these natural glazes has been investigated by the Survey to some extent and the results will be found incorporated in the following table, Table No. II.

TABLE II.

ANALYSES OF STONEWARE SLIP CLAYS.

	1.	2.	3.	4.	5.	6.	7.
Silica (combined)	17.02	14.33	12.85	15.65	12.00	12.04	26.85
Alumina	14.80	12.46	11.17	13.57	10.42	11.08	21.61
Water (combined)	5.18	4.36	3.90	4.75	3.64	4.58	5.56
Clay base	37.00	31.15	27.92	33.97	26.05	27.70	54.02
Silica (free)	38.58	46.26	31.09	47.98	48.40	30.20	34.16
Other acids	Phosphoric acid, .15	.....	Phosphoric acid, .10	.....	Phosphoric acid, 9.0 Sulphuric acid, .65	.....	.....
Sandy impurities	38.73	46.26	31.19	47.98	49.14	30.20	34.16
Oxide of iron	5.85	5.79	3.81	7.77	5.36	5.07	5.38
Oxide of Manganese	.14	.....	.....	.....	.....	.....	.....
Lime	5.70	6.84	11.64	2.55	9.88	15.99	2.83
Magnesia	2.48	3.28	4.17	1.47	4.28	6.36	1.59
Potash	3.23	4.39	2.90	2.63	.87	2.18	2.28
Soda	1.07		.71	.88		.50	.15
Fluxing impurities	18.47	20.30	23.23	15.24	20.39	30.10	12.23
Moisture and carbonic acid	4.94	1.46	15.66	2.90	4.41	12.00	.....
Grand total	99.14	99.17	98.00	100.09	100.00	100.00	100.41

1. Albany slip clay, average sample from three or four lots of the clay. *Orton.*

2. Albany slip clay. *Langenbeck.*

3. Rowley slip clay. *Orton.*

4. Brimfield slip clay, Summit county. *Orton.*

5. Kaolite slip clay.

6. Springfield slip clay, from Sharonville, Hamilton county. *Langenbeck.*

7. Bronhar clay, Zanesville. *Langenbeck.*

Nos. 6 and 7 are not in use as slip clays, as far as is known, but were tested with a view to determine their fitness.

The Springfield slip clay was found to be an easily fusible clay, which gives a greenish yellow glass, very similar to that produced by the Rowley slip.

The No. 7 Bronhar clay is used in making a fusible body for tiling, and is not used as a glaze at all. It requires too much heat to melt it.

An examination of these clays for their oxygen ratio reveals the following tabulated facts:

TABLE II*a*.

No.	Oxygen in acid.	Oxygen in base.	Ratio.	Oxygen in alumina.	Oxygen in fluxes.	Ratio.
1	30.72	12.28	2.50 : 1	7.11	5.17	1 : .72
2	32.37	11.28	2.80 : 1	5.80	5.77	1 : 1.
3	23.44	11.93	1.96 : 1	5.20	6.73	1 : 1.29
4	33.94	10.58	3.20 : 1	6.32	4.26	1 : .67
5	32.21	11.09	2.90 : 1	4.85	6.24	1 : 1.28
6	22.53	13.03	1.73 : 1	5.16	7.87	1 : 1.52

Judging from these figures, these clays are fusible in the following order:

6 : 3 : 5 : 1 and 2 : 4, and from the reports gathered among the potters, these figures are borne out in practice.

The general character of the natural glazing clays thus is seen to be as follows; excessively fine grained sandy clays of about the following average composition,

Clay base	31.00
Sand	39.00
Fluxes	21.00
Volatile (water and carbonic acid)	9.00
	100.00

their oxygen ratio is about as follows:

2.5 acid to 1.0 base and 1 alumina to 1 flux.

Calling to mind the average analysis of the stoneware clays, which constitute the body which these glazes are used to adorn, we see the wide difference best expressed in the oxygen ratio:

3 acid to 1 base and 10 alumina to 1 flux.

The colors which these slip clays burn, varies entirely with the heat to which they are burned. The Albany slip and the Brimfield slip are both dark colored, normally. The Albany is in itself a perfect glaze, however, and becomes glossy and bright alone, while the Brimfield has a muddy black color, without luster, when used alone. The Rowley slip and the Springfield slip both burn to a yellowish green glass, due to the high amounts of lime and magnesia in both. They are neither suitable to use alone. The finest raw clay glaze in use, is a mixture of the Albany, Rowley and Brimfield clays. The Rowley adds fluidity, the Brimfield adds dark color to counteract the light color of the Rowley, and the Albany gives its own fine tone to the whole. Ware glazed with this imitation can be detected by an expert as soon as he sees it—it has a lustre, a clearness and a brilliancy all its own.

In addition to the natural glazes, three or four of the most enterprising of the stoneware potters are bringing a line of ware into the market, which is glazed with a white translucent glaze of artificial preparation. It is a simple white glaze, such as is familiar to every whiteware potter, but it has to be modified to suit the stoneware body.

In using the natural glazes, the stoneware men meet no problems of any difficulty, but in adopting an artificial glaze to a natural clay, and burning both together, there is much skill required; if the glaze fluxes too early, it will be bubbled by the escape of the gases of the clay through it; if it be too hard to run, the ware will suffer.

The results when this glaze is successfully used are beautiful, the stone gray color of the ware is softened and reduced to an even tint.

The same potters are turning out a fancy red glazed ware, which is probably a compound of the three slip clays named before, mixed with the other constituents of a clear artificial glaze and softened a little. The colors attained are similar to the mixture of the natural slips, but clearer and brighter and more uniform, a result which has been accomplished by the use of machinery and expedients similar to those used in the manufacture of yellow and white ware glazes.

It is a note-worthy fact that nearly all these improvements and speclties are worked up and introduced by potters who have been or are at present manufacturing some higher class pottery, usually yellow and Rockingham wares. Their knowledge of the theory of artificial glazes enables them to devise and work out these improvements, which would never come except in some such way.

The foregoing remarks on the glazing of stoneware are all directed to the slip glazing. At present the importance of slip glazing is on the increase; some works produce little else but slip glazed ware. But this state of affairs is of recent occurrence. The standard outside glaze of stoneware in the past has been the salt glaze, so called because it is made by throwing salt into the fires and allowing the vapors to ascend through the kiln and attack the surface of the hot ware. The salt glaze is a silicate of soda formed by the decomposition of the chloride of sodium and the liberation of hpdrochloric acid gas or volatile chlorides. It has the merit of being cheap and easy to apply, and it answers well enough for the outside surface of the ware, but it is usually much crazed and easily permeable to water. The glaze on the outside of the ware answers no very useful effect except making it easy to clean and wash.

The different facilities with which different clays will take a salt glaze depends, probably, on the amount of free silica they contain and its fineness of division. The difference is very marked. Some which will receive the salt retain a granular appearance which is not sharp to the feel, though it is rough; it is as if the glaze had gathered together in minute pools like beads of prespiration, instead or spreading evenly. Occasionally the glaze is perfectly smooth like an artificial glaze.

There are chemicals which operate to interfere with the formation of the salt glaze. Chief among these are the sulphate and carbonate of lime. The nature of the action of these bodies has been much disputed. The view which seems to be supported most closely by the facts, is that the interference is a mechanical one and not chemical as has been generally assumed. The sulphate of lime and the carbonate are soluble in water in the order named and if these bodies exist in clay they are apt to be dissolved, in part or in whole, and as the water evaporates from the surface of the ware in drying, these salts are left in a whitish deposit on this surface.

Now when the kiln is very hot and the salt vapors are produced in the fire holes and ascend through the wares, this film of lime protects the real surface of the clay, so that there is but little free silica or even silicate of alumina exposed to the action of the salt fumes. The temperature at which the limesalts are decomposed to' form a lime silicate is a little higher than the heat at which the salt is generally used, hence the salt fails to do its work simply because it fails to meet the surface of the clay. Now if the kiln be made hotter and the salting be kept up, a glaze is finally produced, but it is greenish yellow in color, indicating clearly that at the increased temperature the lime salts finally united with the soda to produce a lime-soda-silicate glaze, which, at the lower heat, was not formed at all. But this glaze is of a dirty color, and requires too much heat for the safety of the ware. Hence its formation offers no relief to the interference caused by soluble lime salts in the clay.

The color of a piece of salt glazed ware depends on the amount of iron in the clay and the kind of fire which was maintained in the burning. The effect of the oxydizing and reducing atmosphere in the color produced by iron has been alluded to in the general remarks on the action of heat in clays. Its application to the pottery business is vital. Potters all know, practically, that clear fires throughout a burn will probably produce clear ware and that a choked draft or smothered fire will, infallibly, produce red or brown ware. Two or more of the stoneware makers are using oil fires, in order to get the advantage of perfect combustion of an oxydizing heat. The clear color of the ware, in their opinion, gives them an advantage which offsets the increased cost for fuel.

Oil will not be available for fuel purposes much longer, however, and the problem must be attacked on other lines. The use of fire places, which are, practically, gas producers, and the use of combustion chambers to effect perfect combustion of the gases from the fires, or, perhaps, the direct production if it produces gas in a separate plant and its use in the various kilns, will be the lines along which improvement will come.

In cases where the iron in the clay is high and the wares are always an off color, and the clay is in all other respects just what is wanted, it is convenient and profitable to use a slip of a pure clay, or better still a white china clay. This is done in a few places in the state and outside, and one of these places has a very high reputation for the beauty of its wares. The slip is applied just as the black glazes are, and when the ware is salt glazed the thin layer of pure clay unites with the salt fumes to produce a beautiful white salt glaze better than any natural stoneware clay can produce. The expense of the clay is an item which has to be considered. New Jersey white clays suitable for th s purpose cost from $6 to $15 per ton at the mines.

After the necessary work in making and slipping the ware has been done, it is ready for setting in the kiln. In most stoneware shops this is in charge of the man who does the burning. Each burner prefers to supervise the setting of each kiln, in order that he may be familiar with its contents and every peculiarity which call for variations in his treatment of the kiln under fire.

The general principles involved in setting stoneware are:

1. To secure a steady and even draft through all parts of the kiln, and allow no short cuts from the fires to the stack.

2. Secure solidity and good equilibrium in putting the ware in position. The bottom of each tier rests on "bats" of stiff clay for leveling pieces and each tier must be supported from the others by "chucks" of stiff clay.

3. The black glazed ware which is to be burnt simultaneously with the salt glazed ware must be protected very carefully from the salt fumes which instantly will bleach the dark colors to a light yellow.

4. The heavy and large sized wares must be collected in the centers of the kiln furthest from the points of admission of the fires in order to

allow the heaviest sections of cl-y to have the longest time to season under the heat before the vitrification begins.

Setting stoneware, like burning it, is an art which can only be learned by actual practice, and which is likely to be costly practice, unless it is learned by slow degrees under the tutelage of one who knows how it should be done.

As in all other clay working processes the burning is the most important stage. Imperfections in the steps already described are imperfections at the end of the process and as such, affect the value and quality of the ware. They grow no worse nor better; but a little negligence or mismanagement in burning may ruin a large quantity of ware, good and bad alike, and make it not only imperfect but valueless.

The care, the skill and the knowledge of all clay working enterprises are bound, in the nature of the case, to center around the burning.

In regard to the theory of the burning it is not necessary to make any detailed statements; it is no way different from the general theories already laid down, except that due consideration must be given to the extremely thin section of the clay in the most of the ware. A great deal of it does not exceed one-fourth inch in thickness and the heaviest sections in the bottoms and corners of any large crocks is hardly more than seven-eighths of one inch in thickness.

In such a thin section it is obvious that the chemical changes of burning are likely to progress very rapidly. The duration of a burn varies with the size of the kiln, etc., but ranges from twenty-four to ninety hours. Fifty-five hours is the average figure for the Akron district, thirty for the Zanesville district.

As the process is usually carried out, about half this time is spent in warming the kiln up and getting the ware up to a black heat. This is the critical point. When the ware is seen to be dull red throughout then the finishing can be rapidly brought forward. The temperature used on stoneware kilns was the subject of some attention. The following measurements were made by the Lunette pyrometer.

TABLE. III.

Name of pottery.	Kind of ware.	Heat, deg.	Remarks.
Bagley & Roberts, Zanesville, Ohio	Cooking wares	1,852	Average of three readings taken from top of kiln when it had been cooling down for 30 minutes. Old fashioned plain updraft.
Muskingum Stoneware Co., Zanesville, Ohio	Black glazed and cooking ware	1,875	Kiln had been cooling about one hour when test was made. Updraft muffle kiln. Do not think the temperature had run down as much as preceding.
Zanesville Stoneware Co., Zanesville, Ohio	Black glazed ware	1,922	Kiln measured at best heat with all conditions favorable. Albany slip nicely melted.
Pittsburgh Clay Manufact'ing Co., New Brighton, Pa		1,890	Kiln measured at best heat. Trials of Albany slip melted and feldspar was melted but not cleared.
Gelhart & Goodman, Atwater		1,892	Kiln measured just before its last fire, but still had an hour or so to increase the temperature.
United States Stoneware Co., Akron, O.		1,987	Kiln had been salted about an hour previous. Do not think the heat had sensibly declined.
A. S. Weeks & Co., Akron, Ohio		1,892	Kiln had been salted about an hour previous; heat just began to go down.

Taking the measurements made under the most satisfactory conditions, Nos. 3, 4, 6, 7 the results 1,922, 1,980, 1,987, 1,982, average, 1,970, show a closer agreement than was expected. These results are themselves the averages obtained in readings in different parts of the kilns. The maximum temperatures on these four results show 2,010, 2,010, 2,045, 2,045, average 2,027, and the minimum temperatures show more variations naturally.

The other potteries tested were either distinctly past the maximum temperature of the process or distinctly below it, and therefore were not considered in the averages.

Surprise may be felt that the heats assigned are so low. Conversations with clay workers has generaly shown a very erroneous view of the heats they employ. A table in the appendix will show the relative heats of the clay working and iron and steel working processes as measured by the same instrument and the same observer.

The kilns are naturally the most important, the most discussed and the most interesting appliance of the stoneware pottery.

An examination of the types of kilns in use in the potteries of the state and a comparison of these types with those used by other clay working industries, indicates that there is much in common in their construction and principles. However, there is much less variation among the kilns used for burning stoneware than in kilns of the same type used for pipe or brick.

Examining the kilns in use in Ohio stoneware potteries the following facts have been classified:

Name of kiln.	Akron Dist	Zanesville Dist.	State.
Akron Squuare Downdraft	29	00	29
" Round Downdraft	18	2	20
Muffle Updraft	2	17	19
Plain Updraft (old style)	0	10	10
Totals	49	29	78

Factories represented in this list, 32.

It is thus seen that the Akron district, including all northeastern Ohio, uses nearly all downdraft kilns and the standard square Akron kiln is the most popular. It is to be noted, however, that the newest works, almost all of them, are building the round kilns, and the new kilns being built in all works are mostly all round.

The Zanesville district, on the other hand, goes on record as using almost entirely the updraft kilns, the only two downdraft being in comparatively new plants.

It is impossible in the space assigned to give any adequate description of the technical points, pro and con, in these different kilns. But a very brief description will be given of each type and as nearly as possible the consensus of opinion, in regard to their qualities, from those who are best situated to know.

The Akron Square Kiln, the most widely used of any one kind in the stoneware business, is a rectangular structure about fifteen wide by thirty feet long outside. The inside dimensions are about twelve wide by eighteen or twenty feet long; the roof is a groined arch, about seven feet above the floor at the spring and ten feet at the center. The peculiarity of the kiln is that it is fired at the ends exclusively. There are either two or three fire holes at each end, opening inside the end wall of the kiln into a common combustion chamber the full width of the kiln and about eighteen inches wide. This combustion chamber is formed by the erection of a fire wall or flash wall across the kiln, parallel with the end wall and extending from the floor to within about twelve or eighteen inches of the spring of the arch. This combustion chamber becomes the hottest part of the kiln and it greatly assists in the combustion of the flames and smoke from the fires and keeping the reducing influences at a minimum. The kiln has a cross flue in the center leading to a stack on one side or the other. This stack for one kiln need not be twenty-five feet high by four square feet internal area, but is usually made three or four feet wide by six or eight feet area. The floor of the kiln is checker work, allowing free passage of the gases into the side flues, which run from end to end of the kiln joining the main flue at the center. The door is in the center of one side. The kiln may be built double with only one wall between two kilns. The strong points in favor of this kiln are:

1. The compact form, and the small amount of yard room which it requires; this is a great advantage in grouping kilns closely around the factory so as to make short distances to handle the unburnt wares.

2. The common combustion chamber, through which the gases must pass before entering among the wares, reduces the liability to smothered or dark colored ware as much as is accomplished in any down-draft burning kiln.

3. The fire holes are capable of very close regulation and get more of the gas producer effect than any fire hole in use in the stoneware business.

4. The kiln is considered the "safest" one for large wares, on account of the heat being introduced wholly at the ends which causes the middle of the kiln to always hang back in burning, and large pieces being set in the middle, have the greatest time to get up to the finishing heat.

5. It is easy to set and draw, as the courses of ware are all straight and at right angles to the long way of the kiln.

On the other hand, the following points are against:

1. The cost of the kiln is high. The brick work is more in quantity for the capacity of the interior than in the round kiln and the strength of the bracing and bridging required to hold the roof up is excessive. The

cost of an average kiln is from $1,500 to $2,000, with a capacity of 7,000 gallons per burn.

2. The heat is irregularly distributed, being greatest at the ends and least in the center.

3. The fuel consumed is higher in proportion to the output. From unofficial figures furnished by several manufacturers on each side, it appears that the round kiln will burn ware with from ten to twenty per cent. less coal per 1,000 gallons.

It is thus seen that there are many things to be said pro and con about this kiln. In one works, one of these kilns was burned fifty-one times, in fifty-two consecutive weeks and no money was spent in repair in that time. A record of this kind can only be accomplished by the best of care and management.

The Round Downdraft Kiln, regarded by many as the stoneware kiln of the future, is built in all sizes from sixteen to twenty-five feet in diameter. The latter is the largest size used in the stoneware business, and it is not in favor with those who have to operate it. The prevalent sizes are twenty and twenty-two feet which hold respectively 7,000 and 9,000 gallons. Of course these figures as to capacity depend on the kind of ware being set. They are intended to represent the average.

The kiln is usually about seven feet high to the spring of the arch from the floor, and the fire places arranged at equal spaces around the circumference, number from seven to ten.

The fires are smaller than those used in the Akron kiln. Some are arranged with the Akron fire hole, more often they used the incline grate bars and open front. The "bags" or "pockets" inside run from 4 to 6 feet up the wall. The floor is checkered and is usually built from eighteen to thirty inches higher than the level of the surface of the yard and higher than the bottom of the fire holes. This is the most important point in the construction of the kiln, and stoneware men, more than any other class of clay workers, have realized the value of the raised floor, in getting the heat down to the bottom and making an even burn. It saves at both ends; it takes less draft to operate the kiln and less coal to burn it. The points for and against this kiln are conversely the points of the square kiln; they will be merely recapitulated. In favor:

1. Cheapness of first cost and repairs. A twenty-foot kiln of the best material and construction can be put up for $1,000 to $1,200.

2. Heat is distributed evenly at all points around a center; there is no hot end or cold spot.

3. Economy in fuel.

Against:

1. Takes up more room.

2. Is easier to smother, but if the burner knows his business, there is less need of smothering as it is easier to drive the heat to the center of

the round kiln from all sides than it is to the middle of a square kiln from both ends.

3. The round kiln is thought by some to be safe on small wares but not safe on thick sections, as the temperature rises too much alike all over the kiln and gives no place of an especial security for the large pieces.

4. The round kilns are certainly harder to set and draw.

Downdraft kilns of the two kinds are thus seen to be the mainstay of the Akron district.

It is claimed that it is entirely possible to burn a kiln containing nothing but black glazed ware in a downdraft kiln, which has been used previously as a salt glaze kiln—and that the results are good. No instance was found where this was being done.

The Muffle Updraft Kiln is the commonest kiln in use in the pottery trade. All the yellow, white and china pottery in the country is burnt in it. Its adaptation to the stoneware potteries originated with a firm of Pennsylvania potters, who had been in the yellow ware business and took some of their old ideas and appliances with them. Its use in Ohio was begun about six years ago by the Zanesville Stoneware Company, of Zanesville. It has become the main kiln of the Zanesville district.

In construction it consists of a circular bench containing the fire places which are equally spaced around the center. Each fire place, which is a regular inclosed furnace, with iron doors, delivers its heat partly to an inside pocket and partly through a horizontal flue to a central stack. The kiln proper is built on top of the fire bench. It is round and tapers to a small diameter about twenty-five feet above the floor. An arched crown, with numerous perforations, is sprung across the inside about eight feet from the floor. The bags run up within a foot or so of this crown, and the central stack runs through the crown and assists to support it. A door affords access on the level of the floor, which is solid.

In operation the kiln is filled with ware up to the level of the top of the bags and the heat is, therefore, entirely by radiation from the bag walls, the central stack and the floor, which is heated by the radial flues uniting at the center. The gases from the fires do not come into contact with the ware at all, except on the topmost course and then but slightly.

Such a kiln, it will readily be seen, is slow to heat up and slow to cool—sudden changes in the fires cannot affect the ware quickly and there is, practically, no reducing action from the fires.

These kilns are especially adapted to the production of slip glazed ware, either black, red or white; they are useless for salt glazing. There are several works in the Zanesville district which do, practically, all their work with these kilns.

The points in regard to the kiln are as follows:

1. *Cost.* A kiln which will hold six thousand gallons of pans or closely nested ware, or three thousand gallons of ware as it comes from the shop,

will cost $1,000 to $1,350, well built and of good fire brick in all the essential parts.

2. *Repairs* are heavy, if the materials are not first-class. If the best fire brick are used in the beginning, they will be light. Repairs are expensive, owing to the shape of the fires and flue system under the kiln floor.

3. *Fuel.* This kiln undoubtedly uses more fuel to the one thousand gallons than the downdraft. A comparison between the two kilns could not be had.

4. The convenience of setting and drawing are not equal to the downdraft kilns, owing to the interference of the central chimney.

5. The safety of the burning is the strongest feature of the kiln. With any reasonable care there is no need of any loss, while a downdraft kiln is hardly ever burned off without the rejection of more or less damaged ware.

In one works in the state there are three kilns in use: One square, Akron kiln of six thousand gallons capacity, one round downdraft of eight thousand gallons capacity, and one sixteen foot muffle of three thousand gallons common capacity. The manager of the works placed himself on record, as follows:

The best kiln, all things considered, the round downdraft.

The hardest to burn, the Akron kiln.

The easiest to burn, the Muffle.

The safest kiln, the Muffle.

The most expensive, high fuel and slow production, the Muffle.

The old-fashioned updraft kilns are not important as a commercial factor in the business and are dropping out of use. They are used for producing salt glazed ware in factories where the muffle is used for the black glazed articles. In the smaller and outlaying potteries these old updrafts are still the only reliance.

The cooling and annealing of stoneware after the burning is finished, offers no special difficulties. It occupies from two to three days, according to the weather. The critical point in cooling is when the ware is at a black heat, just below redness. The kiln can be left open for several hours until the kiln begins to look dark red. Every air inlet at the bottom of the kiln is then shut up tight, and daubed with mud, and the vent holes in the crown are opened so that what little draft gets into the kiln passes out upwards. The connection to the stack is broken soon after the fires are shut down.

The cost of manufacturing stoneware was approximately obtained in several places in each important district. The following figures represent the average of five estimates, prepared by five stoneware men, independently:

Clay,	.51 cents.
Fuel,	.46 "
Pottery work,	1.00 "
Common labor,	.91 "
Office supplies and contingent expenses,	.42 "
	3.3 cents per gallon.

Average selling price, 4 cents per gallon.

The following facts, as to the magnitude and importance of the industry, have been prepared. The figures are not as accurate as would be desirable. In default of better information they will suffice to give some idea of the present situation.

TABLE III.

STONEWARE STATISTICS.

Name of manufacturers.	Location.	Number of kilns.	Number of employes.	Annual capacity in gallons.
Whitmore, Robinson & Co	Akron	9	85	2,500,000
Akron Stoneware Co	"	5	....	2,000,000
United States Stoneware Co	"	4	50	1,200,000
The E. H. Merrill Pottery Co	"	4	....	1,200,000
The Ohio Stoneware Co	"	2	20	700,000
Markel, Inman & Co	"	2	20	700,000
Cook, Fairbanks & Co	"	2	20	700,000
F. H. Weeks	"	3	20	700,000
A. J. Weeks	"	2	20	700,000
The Diamond Stoneware Co	"	2	20	Building
The Champion Stoneware Co	Canton	3	30	1,200,000
Canton Stoneware Co	"	3	30	1,050,000
Massillon Stoneware Co	Massillon	3	25	850,000
Myers & Hall	Mogadore	....	....	....
T. S. Monroe & Sons	"	....	....	....
Shattuck & Hill	"	....	....	....
The Standard Pottery Co	Salineville	3	27	900,000
Gerhardt & Goodman	Atwater	2	20	600,000
Kuntz & Sons	Limaville	1	12	400,000
Zanesville Stoneware Co	Zanesville	3	25	900,000
Muskingum Stoneware Co	"	2	25	600,000
South Z. Stoneware, Brick and Paving Co	South Zanesville	2	18	500,000
South Z. Clay Manufacturing Co	" "	2	18	500,000
Midland Pottery Co	Roseville	1	30	500,000
Bagley & Roberts	Zanesville	1	6	125,000
L. S. Kildow	Roseville	1	6	125,000
W. B. Lowry	"	3	6	125,000
Wilson & Williams	White Cottage	2	8	175,000
Reed Bros. and Settles Estate	" "	2	5	150,000
Burley & Winters	Crooksville	2	16	400,000
Crooksville Stoneware Co	"	2	16	400,000
Star Stoneware Co	"	2	30	750,000
Diamond Stoneware Co	"	2	30	600,000
Convay, Watt & Allen	Deavertown	2	30	600,000
Buckeye Stoneware Co	Saltillo	2	15	500,000
Small country shops in Roseville, Potters Ridge, Saltillo, Crooksville, McLuney and Hopewell districts	McLuney	52	100	2,000,000
Totals		133	100	24,350,000

In addition to the tabulated data the total quality of ware actually manufactured in 1891 was made the subject of inquiry and the results collected indicate that the production of the state was very close to 13,500,000 gallons, with a value $540,000.00; of this quantity the Akron district produced a little over 7,000,000 gallons, the Zanesville district about 4,000,000 gallons, and outside shops 2,500,000.

The markets reached by Ohio stoneware are only limited by the confines of the country. It is shipped to the Pacific coast, and north and south. Some competition has been introduced in the western states, by potteries being located there, but Ohio still manufactures far more ware than any other state in the union.

(*c*.) Yellow and Rockingham Wares.

The technical distinction between stoneware and yellow ware lies in the fact that yellow wares pass through a burning process to develop the body of the clay, and a second firing to develop the glaze which is put on after the first or biscuit burning. In this respect the yellow ware process is exactly like the processes used in the higher grades of pottery, while it resembles the manufacture of stoneware in being composed of natural clays entirely.

The yellow ware is glazed with a clear glaze, composed largely of lead oxide, which developes and adds luster to the natural buff color of the clay.

The Rockingham wares are glazed with a similar glaze brown or black by the addition of manganese; this is either applied solid or spattered over the yellow glaze in blotches.

The clays for yellow wares should be very plastic, smooth, potters clays, free from impurities or fine specks, with enough iron to give a fair color to the ware.

They need not be refractory, as the heat used in glazing is low, and the intention is only to burn the clay to its best physical strength. In a general way, any good stoneware clay will make good yellow ware but the converse of this assertion is not true.

Two analyses of yellow ware clays have been made as follows:

	1.	2.	3.
Silica, combined (by calculation)	28.41	29.93	32.33
Alumina	24.12	25.12	26.60
Water combined	7.77	7.75	7.59
Clay	60.30	62.80	66.50
Silica, free	31.89	29.61	24.11
Titanic acid	1.20	....	....
Sandy matter	33.09	29.61	24.11
Iron oxide	1.46	1.57	2.00
Lime	.59	.57	.47
Magnesia	.68	.51	.63
Potash	2.42	1.95	3.20
Soda	....	....	.26
Fluxing matter	5.15	4.61	6.56
Water	.86	2.63	2.48
Grand total	99.40	99.64	99.65

No. 1. Yellow ware clay from East Liverpool. E. Orton, Jr.
No. 2. Yellow ware clay from East Palestine. " "
No. 3. Stoneware clay from Salineville. " "

The two yellow ware clays are seen to be surprisingly close in chemical character. The analysis of the Salineville clay was appended to illustrate that it was out of its place as a stoneware clay, and that it was by composition and what is known of its physical properties admirably fitted to the yellow ware business. Its easy fusibility as a stoneware clay would hardly affect it at the lower range of temperatures used in burning yellow wares, and would probably only suffice to make the body of the ware compact and strong.

The average character of the two clays which are now in actual use is

Clay base	61.50
Sandy matter	31.35
Impurities	4.88
Water	1.80
Total	99.53

having an oxygen ratio of:

Acid, 2.57 to base 1.
Alumina, 9 to flux 1.

which indicates that the clays selected for this purpose are intentionally of a more fusible quality than stoneware clays, in order that the best strength of the clay may be developed at the low heats used in burning and glazing. Notwithstanding this, there are at least two establishments engaged in making stoneware and yellow ware from the same clays in the same pottery.

Preparation of the Clay. More stress is laid on suitable weathering than in the stoneware business. There is but little chemical change involved, merely the physical changes due to exposure.

The mechanical treatment is by washing altogether; no other processes are in use so far as is known. The washing is in all respects the same as for stoneware, except that the screens for sifting the pulp are of a much finer mesh—sixty to one hundred mesh instead of forty.

The pottery processes are largely confined to jolly and mold work; very little hand turning is done.

In burning small and delicate clay wares, it becomes necessary to find a way to separate the wares into small portions so that the weight of one piece on another shall not deface or bend it. This is accomplished by what is known as saggers. They are variously shaped and sized boxes or cases, made of refractory, open-grained clay ware, which will stand a high heat and much handling. The ware is packed into these saggers which are then set in the kiln until it is filled with these cases piled one on another, the bottom of one forming the cover for the next. Between each, a thin coating of clay is put so as to make the saggers airtight or nearly so. The expense of burning in saggers is largely in excess of the direct burning in stoneware. The cost of heating up the large mass of clayware in the saggers on each burn is no slight item. The expense of the labor and material in making them is still more important. In a good sized pottery two or three men are generally kept busy all the time in making saggers. In East Liverpool, there are two or more establishments who do a large business in manufacturing nothing but saggers and other potters supplies.

The kilns used are the regulation muffle updraft kilns employed in burning all kinds of pottery and described in connection with stoneware.

In some potteries, however, there are used double decked kilns, in which white, or CC wares are burnt in the lower compartment and the first or biscuit burning of yellow ware in the upper story. This is the same device used by stoneware men to increase the profits, by burning flower pots with the waste heat of the stoneware. This process is a great saving of cost, but in the nature of the case is not as good for the uniform quality of the ware, for where two kinds of ware are burnt in one kiln the burning is bound to be adjusted for perfection of one grade, and the other must take what heat it can get.

The temperature employed in burning yellow ware is low. Only one opportunity was afforded to measure a kiln of yellow ware at its highest heat. The temperature in this case showed by the lunette 1,710 degrees at the top peep-holes and 1,680 degrees at the bottom, or practically 1,700 degrees on the kiln. This is about 175 degrees cooler than a stoneware kiln. The trials at this point were light buff and could be scratched with a knife with difficulty.

The biscuit burning is intended to be hotter than the gloss burning, in order to take out all shrinkage that the ware is to undergo before the glaze sets on it.

The ware as it comes from the kiln or biscuit burn is cleaned with brushes, inspected and sent to the glaze room. The glazes used in this pottery are the simplest kind; they are composed of lead (litharge) flint (silica) spar (felspar), paris white and a small amount of white clay. The ingredients are not fused together and then re-ground as is done in manufacturing fine white ware glazes, but are merely ground in a glaze mill with water till the slip feels perfectly smooth to the fingers. This glaze is used just as the stoneware glazes are used. The porous biscuit ware absorbs the water and leaves the fluxes in a thin, uniform layer on the surface.

The ware is taken from the glaze room to the packing room for the gloss burning and is there put into saggers again, but each piece is kept carefully from any other by stilts, piers and other devices; these are made of a very refractory pure clay, and though the glaze melts fast to them wherever it touches the ware, the difference in the nature of the clay is such that it is easily broken loose with but slight marks on the piece of ware.

About one-third as much ware can be put into a kiln for the gloss burn as can be put into the same kiln for a biscuit burn. The burning processes are short in duration as vitrification is not desired.

The list of articles manufactured from yellow wares has been gradually narrowing down for some years past. The main articles now made are bowls, nappies, pie plates, pitchers, tea pots and chambers. Trade is as good as ever but the list of articles has been cut here and there. There used to be a good trade in spittoons which has almost completely gone to the earthenware industry and to metallic and rubber goods.

The following list comprises the yellow ware manufacturers of the state:

Manufacturers.	Location.	Kilns.
The C. C. Thompson Co	East Liverpool	8
The Globe Pottery Co	"	5
John W. Croxall & Sons	"	4
The D. E. McNicol Pottery Co	"	3
McDevitt & Moore	"	2
S. & W. Baggott	"	2
John Patterson & Sons	Wellsville	2
Whitmore, Robinson & Co	Akron	2
E. Palestine Pottery Co	E. Palestine	3
Fisher & Co	Cincinnati	2
Total		33

(*d. e. f.*)—C. C. Wares, White, Granite and China.

The three kinds of wares included in this list, which constitute the different varieties of white pottery, are all closely allied and are all of them so little connected with the mineral resources of the state that it has been considered best to treat them together.

The materials from which white pottery is made comprise a good many other articles than clays.

Clays however constitute the base of the mixture and as may be eypected only the purest and whitest varieties can be used.

In earthen, stone and yellow wares we have seen how the careful attention of the potter must be directed to the clays which constitute his body material.

We have seen that these clays contain a clay base mixed with silica and fluxes in varying proportions, and that the potter is compelled to search among the mineral deposits for these clays in which the proportion of sand and flux are naturally united to secure the ends which he has in view.

In making the body mixture for white pottery, the process is reversed. The potter's skill is now directed to compounding a body from its elements, which, when ultimately finished, shall possess all of the qualities which an exacting market demands.

The clays for his purposes are limited to those of a pure nature. Every tinge of iron or impurity which goes into his wares is to be corrected only by the use of expensive chemicals.

The china clays or kaolins of commerce come from very many sources. Every state which carries the Appalachian mountain range across it, contributes more or less to the supply of pure kaolin and Kentucky, Indiana, Texas and other localities are producing more or less of this mineral. The best or at least the most expensive clays are imported from abroad. Large quantities come annually from England, Germany and other countries.

Ohio, has so far failed to produce or indicate the presence of one pound of pure white clay. The geological formation of our state contains only sedimentary formations. No granite or feldspathic rocks occur on the surface any where in the state and we naturally therefore expect to find only such clays as are formed elsewhere and are brought here mingled with the detritus of many other rocks.

The clays brought into the state for pottery purposes are many of them devoid of much plasticity and the potters find the need of a tough, waxy, thoroughly plastic clay. To fill this want, the ball clays are used, some from this country but the majority brought over from England.

To counteract the excessive shrinkage of these pure clays the potter uses what he calls "flint." It is practically pure silica, being made out of the finest white sand, ground to an impalpable powder. But silica, in connection with the pure clays, would make so refractory a mixture that it would be impossible to vitrify or make solid by heat; therefore it is necessary to add felspar, which takes the place of the impurities of the stoneware clays. This felspar is ground to a powder like the flint.

The mixture of these ingredients then is the body of white pottery; kaolins for the body, ball clays for plasticity, silica to counteract shrinkage and felspar to make the mixture fusible. The proportions of these ingredients each potter keeps to himself. Each one has his own recipes, which he has worked over for years perhaps, and which he knows and understands fully. These recipes are his secret, his stock in trade and recipes for body and glaze are to potters a merchantable article.

The variations in this body which are made to produce the three grades of wares, CC, White, Granite and China, are not important in theory, they are mostly changes in the quality of the ingredients. CC, was a term originally for " common clay" wares and means a low grade of white pottery. The ingredients are the same kinds as those used in the best grades, but the off color varieties and cheapest goods are used altogether, and the slight cast of color, due to iron, which will creep into white ware bodies is not counteracted by the necessary chemicals, but instead, a glaze is used which hides the color of the body from view and makes the surface appear nearly as well as if the body were of a good color.

In white granite, the best materials of each class are bought; the color of the body due to iron, is corrected by adding a minute quantity of cobalt oxide, the yellow of the iron is thus neutralized by the blue of the cobalt, and a green color is produced. When the ware is seen in bulk the green is easily detected, but in a single article it is much less apparent than either the yellow or blue cast would be.

The aim in white granite is to produce strong white pottery, able to resist a sharp blow, and able to bear scrutiny as to its tint. It is not supposed to be thoroughly vitrified or to have any approach to translucency.

In china the aim is to produce a body which shall become more thoroughly vitrified or fused in its nature and which shows a power to transmit light like an opaque glass.

This can only be attained by giving it such a composition that it can be vitrified at the ordinary heats employed by the potter. This increased fusibility is of course brought about by the increased use of fluxes. China which is fluxed by felspar is called technically spar china. It shows a yellowish color to transmitted light. China in which a part of this spar is replaced by calcined bones or phosphate of lime, is called bone china; it shows a bluish white color to transmitted light and a much more delicate beauty under all conditions.

China bears the same relation to white granite, that stoneware bears to earthenware; its burning is accomplished only by use of all the care, watchfulness and skill which accompany the production of any clay ware that owes its value to its vitrification.

The method of preparation of the body for these various kinds of ware is substantially alike. The ingredients are collected in a charging car or box, each one being carefully weighed. They are shoved into the blunger and united in the most intimate mixture by the formation of a fluid slip. The screens employed are brass or silk gauze from 100 to 160 mesh to the inch. The strained slip is run through a magnet box in some potteries to try to separate out any magnetic particles of iron from the machinery or clays.

The pressing and pugging offer no peculiarities.

The pottery processes are also much the same as described before, except that as the wares grow more costly, the value of the machinery and appliances increases in like proportion.

The use of every mechanical contrivance which can assist them is freely adopted by potters of this grade.

The burning is accomplished in just the same way as in yellow ware, except that the saggers are made of better material and are glazed inside to prevent the ware from becoming soiled by any efflorescence from the sides of the saggers.

The heats required vary of course with the kind of body compounded. The best practice in making the white granite body is to make a rather refractory body which requires a high heat to bring it to its proper degree of combination. When such a body is given the proper heat, it is stronger and tougher than one which matures at a lower temperature, and consequently the weight of clay used for each piece may be decreased a little, and the ware becomes lighter and more delicate without loss of strength.

The heats employed in burning white granite and CC ware were tested in one factory of each kind with the following results:

	Top of kiln.	Bottom of kiln.	Average.
CC ware	1,930	1,950	1,940
White granite	2,160	2,010	2,085

But there is no probability that these temperatures stand for these respective classes, as the body is bound to vary in its chemical qualities according to the composition which the potters give it and in this they are regulated each by his own preference. The limits of variation in which a good body may be produced are rather large.

The glazes used in the white ware potteries are much more complex than the yellow ware glazes. The nicest problem the potter has to handle, is the adjustment of his glaze to his body. The defects of the glaze are made manifest in many ways; it may "craze" or even "shiver." The first term is applied to the formation of fine cracks all through the glaze which destroys its beauty and makes it permeable to liquids. This occurs when the composition of the body and the glaze are not suited to each other, and they contract at different rates on cooling. If the lack of adjustment is great, the glaze will craze at once; if the difference is slight the crazing may begin months after the ware has been sold. If the difference is excessive, and the glaze is a thick heavy one and the ware is rather weak or porous in structure the contraction of the glaze is sometimes powerful enough to crush the piece, or chip pieces out of the surface of the ware. This is called "shivering".

Glazes may also devitrify, or become opaque or stony in nature instead of clear and glossy.

The adjustment of a glaze to a body would not be beyond the range of even ignorant experimenting, if the body and glaze could be kept always the same, but the composition of these elements is bound to constantly vary; the purest kaolins vary just as poor clays do; and, above all, the composition of the felspar, which is depended on to unite the elements of the pottery into a fused or vitrified material, is subject to considerable fluctuation.

Consequently, the same body and glaze will work well or ill, even if mixed with never failing accuracy in the compounding room, on account of irregularities of the materials.

It seems that the composition of these bodies could be regulated with the most valuable results by the use of chemistry in the pottery. It would be useful in keeping track of variations of the strength of supplies and still more so, in keeping the body of one uniform composition.

As before suggested, it is not a chemist that is wanted as such but it is a manager who can understand and use the work of a chemist. The compounding and manufacturing of white pottery is a chemical industry; it deals with chemical material and is governed by chemical laws, and yet the business has been groping along in the dark for decade after decade using the most expensive "cut and try" methods for the accomplishment of every improvement.

White ware glazes are usually what is called "fret" glazes. The constitutents have been weighed out, mixed and melted in a sagger into a fluid, which solidifies into a solid cake when cool.

The sagger is then broken off from the cake of glaze which is broken up and ground with the addition of a certain amount of other materials.

The grinding of the fret is done in mills lined with French buhr stone, an intensely hard silicious rock. The reduction to the necessary fineness is a slow operation.

The value of the fret glaze over one in which the ingredients are merely mixed into a slip is very marked. The essential part of the glaze is already a chemical compound. It is impossible for its components to segregate out or to produce soft and hard spots on the glaze, if it has been united once, all gases expelled and all chemical changes effected. When applied on the ware and brought up to the melting point it quickly fuses again, while the freshly compounded glaze has to make a chemical combination out of a mechanical mixture in the same time.

Glazes are colored to produce effects in the wares, by the use of metallic oxides. Very little white ware is decorated in colors, under or with the glaze. This class of work is mostly confined to ornamental pottery.

In burning the ware in the gloss kiln there is the danger of leaky joints between the saggers or cracks by which the sulphurous gases from the fire will get among the ware.

Any metallic oxides like lead or manganese are readily affected—the results generally show a bluish white film or scum in the ware.

An instance was observed of a piece of ware thus affected which could be wiped bright by a piece of cloth, but after a few moments exposure to the air the film would reappear. This phenomenon was probably due to the presence of an inconceivably fine film of metallic lead, reduced to this condition from the lead oxide of the glaze by contact with reducing gases in the kiln. This film on being polished showed the bright metallic surface of the lead, but it speedily became clouded again by the oxydising action of the air.

The decoration of the ware after it is finished is a separate branch of the business. The colors used are enamel paints or readily fusible glazes colored with metallic oxides and used as paints. The ornamentation is chiefly by "transfers" papers or "prints", though some finer ware is decorated by hand painting.

The development of the white ware business in Ohio sprung from the manufacture of yellow wares at East Liverpool, and the constant improvement of these wares, by bringing on the better materials from other states. The industry is most flourishing. The following table shows the number and location of the manufactures.

TABLE IV.

CC Ware Potteries

The C. C. Thompson Co	East Liverpool	8 kilns
The D. E. McNicol Pottery Co	"	4 "
Cartright Bros	"	5 "
Goodwin Bros	"	8 "
Cartwright & Green	Leetonia	2 "
George Scott & Sons	Cincinnati, O	....
Brockman Pottery Co		....
Total	Total kilns	27 kilns
Total firms		7

WHITE GRANITE POTTERIES.

		Burning kilns.	Decorating kilns.
The Knowles, Taylor & Knowles Co	East Liverpool	17	12
The Potter's Co-operative Co	" "	8	4
Wm. Brunt, Son & Co	" "	7	4
Vodrey & Brother	" "	4	2
Wallace & Chetwynd	" "	4	4
The Harker Pottery Co	" "	6	4
The East Liverpool Co	" "	4	2
The Sebring Pottery Co	" "	3	2
Burford Bros.	" "	4	2
Homer Laughlin	" "	4	2
The Standard Pottery Co	" "	4	2
J. Wiley & Sons	" "	5	....
Mountford & Co	" "	2	....
Jas. H. Baum	Wellsville	3	....
The Pioneer Pottery Works Co	"	4	....
East Palestine Pottery Co	East Palestine	3	....
Toronto Pottery Co	Toronto	7	....
Steubenville Pottery Co	Steubenville	7	4
Row & Co	Tiltonville	3	....
Akron Queensware Co	Akron	3	2
Bell Bros	Findlay	6	....
Brewer Pottery Co	Tiffin	8	4
Brockman Pottery Co	Cincinnati	5	....
George Scott & Sons	"	6	2
24 firms having in use		127	52

CHINA POTTERIES.

Knowles, Taylor & Knowles	East Liverpool	6
Burgess & Co. Bone china	"	2
2 firms		8

POTTERS SUPPLY COMPANIES.

Knowles, Taylor & Anderson Co	East Liverpool.
E. O. Connor	"
Mountford & Co	"
Burgess & Co	"
Garner, Devon & Co	"
E. L. Milling & Mining Co	"
The Golding & Sons Co	"
7 firms	

Pottery machine shops—making a speciality of the machinery used in potteries.

M. Patterson	East Liverpool.
A. T. Boyce	" "
The Bonnot Co.	Canton.
Griffith & Wedge	Zanesville, O.

The growth of the industry has been enormous in the last ten years.

The position of Ohio as a pottery producing state cannot be given from official data. An intelligent estimate made in East Liverpool places the White Pottery production of the country about as follows:

Ohio	50 per cent.
New Jersey	33 "
Scattering	17 "
Total	100

So that, according to this estimate Ohio and New Jersey have changed places in the last ten years.

East Liverpool is now the largest pottery producing center of the United States and aside from Staffordshire, England, ranks among the first of the world.

(*g*.) Ornamental Pottery.

There is only one pottery in Ohio devoted entirely to the production of ornamental wares; that is the now famous Rookwood Pottery of Cincinnati. The wares of this institution have met with constantly increasing favor in the last few years and the business which was organized and begun at a heavy expense and rewarded its patrons with a loss at each annual meeting, has at last been put on a paying financial basis and is expanding. The struggles of this infant industry to obtain a foothold make an interesting story. Its success now safely attained is all the more flattering.

The character of the wares of this pottery are unlike any other. They have earned a name and place by themselves, in the records of ornamental pottery.

The body clays used in the production are largely from Ohio and adjoining territory. The only object aimed at in this stage is the production of a good, strong body. Its color, for a large part of their wares at least, is immaterial. The preparation of the body material offers no new or unusual points.

The decoration is of the highest order; competent and trained artists being employed at liberal rates of compensation.

The characteristic of the work is that it is almost all underglaze decoration. The figures are painted in enamel paints on the bisque ware and the glaze is put on over all. The problems which arises are of the most complex nature—the expansion and contraction of the glaze must be not only suited to the body, but the effect of these patches of enamel paints must be seen and provided for and as all kinds of composition are required in the colors, the adjustment of any possible glaze to all of the various conditions it is required to meet seems well nigh impossible.

The underglaze decoration while it is more difficult to perfect than any other is the most valuable of any.

The work of the artist is indestructible to anything except the force which shatters the work as a whole. The decorations of the white ware potter are sometimes beautiful and well executed, but the work is external to the ware and not an integral part of it and use will gradually destroy its beauty.

The success of this institution has caused several attempts to be made to start others, all of which are unsuccessful so far.

Much artistic skill in parallel work is being expended in the production of flooring and encaustic tile by the different tile companies of the state, but this will be touched on in a later part of the work.

II. THE MANUFACTURE OF PAVING MATERIAL.

The manufacture of Clay Paving Material is a new industry in this state and country and in the scale and manner in which the business is conducted, it is a new one to the world as well. Bricks have in the past been used to pave streets in a small way and in isolated cases for a long time, but the growth of the modern traffic in vitrified, imperishable materials designed and guaranteed to bear the severest traffic for terms of years is a new and valuable industry.

The enormous bulk which the industry has attained in the last five years is wonderful and the mental activity which has enabled a people to so quickly grasp the main principles and with so few blunders carry a new industry forward to a permanent success, is only another instance of the energy and intelligence of the nation and the state.

The manufacture of paving materials has been made the subject of special inquiry in collecting the materials for this report, and while the results have rewarded the effort, it is a matter of regret that the experimental and chemical work which was undertaken was necessarily so much limited.

The Clays. The choice of materials for the manufacture of vitrified clay ware has been the subject of much discussion among the public and some research by interested parties.

The production of vitrified clay wares has not been confined to paving brick or rather the ability to so rapidly and successfully produce vitrified paving brick, has come from the long experience gained in the manufacture of vitrified sewer pipes, by which the processes of preparation of the clays, the kilns and much general information on the subject of clay working has been a heritage of unlimited value.

The use of vitrified wares has been steadily on the increase and is not confined to sewer pipes and paving material; building materials in the shape of foundation blocks, roofing tiles, and even bricks for ordinary construction are either required to be vitrified or become specially valuable by possession of this quality.

In making a scientific study of the chemical qualities of clays for producing vitrified materials, it is found that there is nothing about the character of the clays of any one branch like paving bricks or sewer pipe to distinguish them from the clays used for vitrified wares in general, and it is therefore necessary to consider under one general head all the clays used in producing material of this kind.

Before making use of the word "vitrified" any further, it is proper to carefully define what is meant in this technical use of the term.

In its general acceptation, vitreous means glassy; a vitreous fracture means a glassy fracture and nothing else.

But in discussing the burning of clay wares, the word *vitrified* has come to mean rather that the material has entered into the preliminary stages of fusion, and that its chemical ingredients have begun, if not thoroughly completed, the process of chemical union by heat, rather than that the fracture of the material under question is a glassy one. The appearance of the ware cannot be made the test of this condition. A glassy fracture is rather the exception than the rule in vitrified wares. Many wares are vitrified in this special meaning of the term, which are strong in fracture.

The test of vitrification is the ability of the material to absorb water. Glass, as the type of a vitrified body, will absorb none. Clay wares absorb water freely even after the shrinkage which comes with the expulsion of the combined water has taken place. But when the chemical union of the clay ingredients begins, the appetite for water begins to cease, and in many clays will absolutely cease as the vitrification becomes perfect. In other wares, more sandy and coarse grained in nature, it is impossible to bring about such chemical union by heat as to destroy the power of the material to still absorb water.

Therefore in the special sense in which this word is used, a piece of clay ware which still absorbs water freely after exposure of a high heat, is not *vitrified*. It is *as much vitrified* as it will ever become by the use of heat, but it does not contain those elements which make a fusible compound.

It therefore becomes necessary to set a standard of absorption which must not be exceeded if the ware is to be called vitrified. What this amount must be will be carefully considered under the head of Tests for Paving Material.

The physical appearance which enables us to conclude in a general way as to the right of a ware to the name vitrified is mainly its smooth conchoidal fracture, and the absence to the eye of pores in the substance. There may be cracks, and fissures, and holes, for which the machine or process of manufacture is responsible, but the mass must not be porous. As to the fracture, the breaks or surfaces exposed follow no regular cleavage lines, but pursue their way in plane surfaces of larger or smaller area, without any regular arrangement. It is impossible to convey adequately by words the peculiarity of fracture which comes from vitrification. But it is something which the natural sense of any one very readily teaches him to detect by observation.

The qualities which a clay must have in order to be profitably made into vitrified ware are:

1st. A combination of refractoriness and fusibility; there must be refractoriness to enable the ware to stand up and keep its shape unaltered during the process of vitrification. In most clays this process begins somewhere in the neighborhood of a good red heat, and increases in perfection as the heat is increased until the clay melts or until the iron changes its condition and the clay puffs and cinders without undergoing fusion.

In other words, in order to produce vitrified wares at a *profit*, there must be a margin of heat-resisting power which shall enable the burner to conclude his operations with confidence as to the degree of non-absorbtion he has produced without too great fear of having destroyed the shape and condition of the articles under heat.

Thus in the nature of the case, the burning of clay ware to a vitrified condition is an operation of risk; the two qualities, refractoriness and fusibility are, as it were, in contention in the clay. If the heat is not high enough or maintained long enough, the vitrification will be imperfect. If it be too high or long continued, the ware will begin to sink out of shape. It will therefore be readily seen that the clay which is valuable to the makers of vitrified ware is one which matures slowly under the action of heat; one which will begin to vitrify and continue to progress in that condition at a temperature considerably below the point where softening and loss of shape begins.

2d. Assuming that this proper balance between refractoriness and fusibility is present, the next quality of value is the possession of sufficient plasticity to make the working easy and perfect. Many clays fail in this respect. They may have been plastic once, but they have in a large measure lost this quality, and the use of expensive mechanical work is necessary to bring back enough of the quality to make the working of the clay profitable or the results merchantable. Too great plasticity is as much of a drawback as too little, however, for the passage of a plastic material through a die or constricted area is, in the nature of the case, sure to produce a certain rearrangement of the structure of the material, and this structure in the manufacture of clay ware is in every case a detriment to the strength and solidity of the ware.

Here again is a condition of balance between opposing influences. This condition is, however, one in which the mechanical faults are concerned rather than the chemical, and this subject is therefore less important in view of the fact that it is possible to greatly influence the mechanical structure of the clay by varying the treatment to which it is subjected.

As a rule, the conditions which afford the easiest success and the least trouble from this cause are when two or more clays can be economically mixed, one of which shall give to the mass a plasticity and obedience to the influence of pressure which will allow it to be worked without great expenditure of mechanical energy and with satisfactory smoothness of surface and finish, while the other ingredient shall, by its rough, gritty and granular nature, prevent the too free and rapid motion of the particles on each other, and the ensuing faults of structure. It is rarely that a clay or shale is found which in itself unites these fire qualities and plasticity, while the number which can be made satisfactory by judicious mixing is very large.

3d. In addition to these all-important qualities, the amount and character of the iron is worthy of mention. On the state and quantity of the iron depend two things (a) the color of the ware, (b) the smoothness of the surface.

If the iron be too low in quantity it is impossible to obtain a good red brown or dark colored ware, and it is the general demand of the makers and the buyers of vitrified goods that they shall be dark in color. Many people will wrongly reject an article on the ground of its light appearance or light colored fracture, while at the same time it may be vitrified past the point of its best qualities.

Also, if the iron be present as grains of iron ore or sulphide, it not only does no good to the general color of the ware but it does great harm by the formation of blotches of silicate of iron which destroy the surface smoothness and damage its color and appearance. This holds good more of sewer pipe than it does of paving brick, because smoothness of surface is a really valuable quality in securing the flow of thick and sluggish fluids like sewage.

These three qualifications are the important ones to consider in the selection of a clay for use in making vitrified wares. The conclusions as to these questions may be, perhaps, indicated by analysis, but must come to actual trial to form a proper basis for confidence.

The clays which are actually found in use in the state for these purposes may be divided into three classes:

1st. Shales, Carboniferous and others; 2d. Impure fire clays; 3d. River clays, or sedimentary deposits of recent geological date along the valleys of the large rivers.

The drift clays, brought here by glacial agencies, do not figure as available material, for it is only in small patches and isolated cases that these clays are used at all. They are, as a rule, too readily fusible, or they fuse too quickly when they begin to fuse, and in addition they are so contaminated with lime in small pellets that they are likely to ruin the wares in which they are used.

The following analyses have been made in the Laboratory of the Survey, and collected from other sources, which illustrate the character of shales and clays used for vitrified ware:

TABLE V.

ANALYSES OF SHALE CLAYS USED IN THE MANUFACTURE OF PAVING BRICK AND SEWER PIPE.

Elements.	1	2	3	4	5	6	7	8	9	.10	11	12	13	14
Silica (total)	57.15	58.30	57.10	49.30	57.45	55.60	58.20	58.38	57.28	57.40	53.38	56.18	52.19	56.61
Alumina	20.26	19.67	21.29	24.00	21.06	24.34	22.47	20.89	21.13	21.20	19.36	26.70	14.61	21.63
Water (combined)	5.50	5.15	6.00	9.40	5.90	6.75	6.15	7.53	5.22	7.75	....	....	5.62	....
Clay and sandy impurities	82.91	83.12	84.39	82.70	84.41	86.69	86.82	86.80	83.63	86.35	....	....	72.42	....
Oxide of iron	7.54	7.43	7.31	8.40	7.54	6.11	5.63	5.78	8.52	6.57	14.86	7.43	10.00	7.08
Lime	.90	.84	.29	.56	.29	.43	.62	.44	5.79	1.00	1.48	.52	....	1.11
Magnesia	1.62	1.35	1.53	1.60	1.22	.77	.98	1.57	2.13	1.40	1.06	1.12	....	1.41
Potash	3.05	3.04	3.44	3.91	3.27	3.00	3.08	4.68	....	4.10	....	....	....	3.51
Soda	.58	.73	.61	.19	.39	.09	.42	.34	....	1.00	....	....	....	.48
Fluxing impurities	13.69	13.39	13.18	14.63	12.71	10.40	10.73	12.81	16.44	14.07	....	....	4.96	....
Moisture	2.70	2.65	1.30	1.20	1.90	2.65	1.65	....	....	....	....	....	12.62	....
Total	99.30	99.16	98.87	98.54	99.02	99.74	99.20	99.61	100.07	100.42	91.14	91.95	100.00	....

No. 1. Shale used by Bucyrus Brick & Terra Cotta Company, mined at Glouster, Ohio, on horizon of Cambridge Limestone. Lord, Chemist. Average sample.

No. 2. Same shale with addition of one-fourth leached drift clay, added to increase plasticity; same place. Lord, Chemist. Average sample.

No. 3. Shale from Royal Brick Company, Canton, Ohio, from the horizon of the Putnam Hill Limestone; Average sample. Lord, Chemist.

No. 4. Shale from Waynesburgh Brick & Clay Manufacturing Company, from the Middle Kittanning horizon. Lord.

No. 5. Shale from the Ohio Paving Company, Columbus, Ohio, mined at Darlington, Ohio, on Lower Kittanning horizon. Average sample. Lord, Chemist.

No. 6. Shale and fire clay mixture, from the A. O. Jones Company, Zanesville, from the Kittanning horizon. Lord, Chemist.

No. 7. Shales and fire clays mixed from the T. B. Townsend Brick Company, Zanesville. Freeport shales and Kittanning. Fire clays. Lord, Chemist.

No. 8. Shales from Columbus Sewer Pipe Company, from Huron shale horizon. Average sample. Macpherson, Chemist.

No. 9. Bedford shale northern Ohio; Chemist not given.

No. 10. Same shales different sample and another chemist; name not given.

No. 11. Shales from Royal Brick Works, Canton, Putnam Hill horizon. Kind of sample not stated. Rattle & Nye, Chemists.

No. 12. Same shales at another opening, kind of sample not stated. O. Wuth, Pittsburgh, Pennsylvania, Chemist.

No. 13. Shales from Holloway Paving Brick Company. North Industry; from L. Mercer horizon. Kind of sample not stated. Stein & Schwartz, Philadelphia, Chemists.

No. 14. Average of first ten analyses.

The three last anlyses in the table are by reputable chemists and command respect on that account, but the extraordinary character of the results, show that the samples are not indicative of the average composition of the shales, and the results are excluded from the averages on that account.

The analyses of the Bedford shales are given as being of interest and pertinent to the subject, though, as far as is known, they have never been used for paving or sewer pipe purposes.

This table of results shows a most unexpected regularity in the character of the shale clays from the various horizons of the state, and by inference we form a new opinion of the probable character of the other great shale formations now practically untouched.

These clays show an average composition of

84.78 clay and sand,
13.22 fluxes,

98.00

with a variation in ten samples of only 4.1 per cent. in clay and sand, and 6.04 per cent. in fluxing ingredients.

An examination of the oxygen ratio of the average clay shows

Acid, 2.19: base 1.
Alumina, 2.72: fluxes 1.

or nearly a bisilicate with over a quarter of its oxygen derived from fluxes. This composition indicates a very ready fusibility, which is what the facts bring forth.

None of these shales require a high heat to vitrify them ; many of them will cinder hopelessly if they get a high heat for a short time only. They all of them owe their fusibility partly to the large amounts of earths and alkalies present. It is probable that the iron retards rather than assists in bringing about the fusing action, as it is observable that vitrification begins in all these clays while the iron is still in the sesquioxide form as evidenced by the handsome color, and that long exposure at a comparatively low heat will to a large extent perfect the vitrification ; but as the heat is raised the color darkens until the iron finally breaks up the combination which has existed, by its conversion to the lower oxide.

Thus while we have in this table the records of a set of very easily fusible clays, we also have, as is determined by the experience of those using them, that peculiar quality or balance between refractoriness and fusibility which allows the vitrification to be made practically complete without going over the danger line of temperature.

The shales constitute a new and valuable addition to the mineral wealth of the state, especially valuable in the production of vitrified wares, but the importance ot the fire clays of the state which have for years constituted almost the entire source of material for vitrified wares must not be overlooked.

The table of analyses here appended shows the composition of a few of the fire clays in use in the state :

TABLE VI.

ANALYSES OF FIRECLAYS USED IN PAVING BRICK AND SEWER PIPE.

Elements.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Silica, (total)	54.53	51.72	51.82	62.81	57.80	64.10	70.00	57.75	59.75	65.90	77.65	59.20	58.10	56.71
Alumina	27.88	30.10	28.69	21.41	25.54	21.79	19.35	28.66	27.45	24.20	12.78	26.10	29.60	33.72
Water, (combined)	8.87	9.95	9.67	6.52	8.35	6.05	5.39	8.35	5.45	4.80	4.10	8.55	8.70	6.89
Clay and sandy impurities	91.78	91.77	90.18	90.74	91.69	01.94	94.65	95.76	92.65	94.90	94.53	93.85	96.40	97.32
Titanic acid	1.26	1.35	.72	1.26	....	....	....	....	....	....	....	....	....	....
Oxide of iron	2.41	1.94	2.77	2.65	2.51	2.51	2.22	1.94	....	2.00	3.32	2.70	1.20	....
Lime	.42	.62	.77	.58	.25	.10	.15	.15	.75	.80	.55	1.05	.40	.29
Magnesia	.68	.53	1.41	.85	.61	.58	.34	.24	.65	.54	.45	.75	.54	1.58
Potash	3.31	2.74	2.57	2.89	2.51	2.62	2.90	2.55	3.58	2.30	1.30	1.53	1.75	1.01
Soda	.12	....	.25	.21	.18	.03	....	....	....	....	....	....	....	....
Fluxing impurities	6.94	5.83	7.77	7.18	6.06	5.84	5.61	4.88	4.98	5.64	5.62	6.03	3.89	2.88
Moisture	.76	1.05	1.72	1.47	2.25	1.10	....	....	....	....	....	....	....	....
Total	100.24	100.00	100.39	100.65	100.00	98.88	100.26	100.64	97.63	100.54	100.15	99.88	100.29	100.20

1. N. U. Walkers, sewer pipe clay, Columbiana county........................Lord.
2. Freeman's sewer pipe clay, Jefferson county.................................Lord.
3. Island Siding Clay Jefferson county, fit for sewer pipe...................Lord.
4. Same clay, another sample...Lord.
5. E. Palestine paving brick clay, Upper Fresport horizon..................Lord.
6. Massillon Fire Brick & Stone Co., mixture of fire clay with shale and surface clays used for paving bricks.................................Lord.
7. Toronto sewer pipe clay, top.................................Chemist not known.
8. " " " " bottom.......................... " " "
9. Average, top and bottom, Toronto.......................... " " "
10. Empire sewer pipe clay.. " " "
11. Elliottsville sewer pipe clay.................................. " " "
12. " " " " .... " " "
13. Croxton Run sewer pipe clay.................... .... " " "
14. N. U. Walker's sewer pipe clay...Reed.

These analyses were for the most part collected from the previous report on clays and from other sources. Only two analyses, Nos. 5 and 6, were made for the present investigation, and from samples which are valuable or important.

The series of analyses from the seventh onward were made from the excellent sewer pipe clays which are worked along the Ohio valley from Toronto northwards, but they lose force from our ignorance as to how samples were taken and to whom the work is to be attributed. It is likely that the analyses indicate clays of greater purity than the results would show if the analyses could have been made from good samples of the finely ground material. However, the results as they are, are interesting and show far better than mere description the general character of the vitrifying fire clays.

The average of these analyses shows a clay composed of

	93.41	per cent. clay and sandy matters
with	5.65	per cent. of iron and fluxes.
	99.06	

This shows on being calculated an oxygen ratio of

2.40 acid to 1 base, and
7.7 alumina to 1 flux.

which shows a clay more fusible than the stone ware clays and yellow ware clays, but far less fusible than the shales.

These indications are borne out by the facts, as the clays of the Ohio River Valley, while they vitrify fairly well in the shape of sewer pipe where the thickest section of the ware is not to exceed 2 inches and most of it less than 1¼ inches, when made into paving bricks or blocks, are very difficult to vitrify sufficiently to stand a good absorption test.

This will be more fully discussed in the paving brick tests later in this article, but suffice it to say that a clay of such a composition as this average shows, would not be suitable for paving material without the admixture of some more fusible clay. It also seems likely that there is a decided difference in the thermal qualities of the shales and fire clays which their analyses and oxygen ratios fail to show.

It cannot be stated as a fact or even a theory of well established likelihood that such a fact exists, but if such were the fact it would explain a number of questions which are very difficult to answer or explain.

If the theory concerning the role of iron in clays, as part of the hydrous silicate base of the clay, be true, then these shales in which this condition is best shown will depend on the thermal qualities of an iron-alumina silicate, about which as a separate ingredient or mineral we know nothing. The fire clays of the river district contain their iron largely as granular iron oxide and sulphide, in which the iron acts directly as a flux from the beginning and is to be classed as such.

The actual temperature used in burning these two classes of clay throws little light on the problem.

The following measurements were made in kilns of sewer pipe and paving brick which were at the highest temperature and just ready to finish the burning:

1.	The A. O. Jones Co., Fire clay and Shales mixture	1,860
2.	The Logan Fire clay Co., Fire clay and Shales mixture	1,712
3.	The Massillon F. B. & S. Co., Fire clay and Shales mixturel	1,890
4.	The Nelsonville Sewer Pipe Co., Fire clay	1,920
5.	The Canton & Malvern Paving Brick Co., Pure Fire clay	1,920
6.	The Crown Sewer Pipe Co., ½ Shales ½ Fire clay	1,820
7.	W. B. Harris & Bros., Shales and Drift clay	1,800
8.	The Canton Brick Co., Shales only	1,800
9.	The Hill Sewer Pipe Co., Sandy Shales	1,920
10.	Akron Sewer Pipe Co., Sandy Shales	1,900
11.	The Buckeye Sewer Pipe Co., Sandy Shales	1,875
	Average	1,860

In this table, the quality and appearance of the mixture used is very much alike in Nos. 1, 2, 3 whose temperatures are 1,860, 1,712, 1,890 respectively.

The qualities of 4 and 5 are very sinilar and both show the same temperature, 1,920.

The shales used at numbers 7 and 8 are not especially similar in appearance, the temperatures coincide at 1,800.

The shales at 9, 10, 11 are similar in composition except that the clay used at 9 was more croppy and sandy than usual and showed the effect in its fire qualities.

Whether this suggestion as to the part that iron plays be the true reason or not, suffice it to say that there is not the difference of temperature or duration of exposure in that temperature which the difference in the average analyses or oxygen ratios would lead us to expect.

As has been before indicated it is probable that there are few clay deposits in the state which are able to satisfy all of the conditions of fire qualities and physical qualities also. But the Coal Measures abound in the materials which are capable of giving the proper qualities by judicious mixture.

The following table of analyses was furnished by the Haydenville Mining and Manufacturing Co., who manufacture the Hayden paving and sidewalk blocks in one plant, and fire proofing and sewer pipe in another, side by side. The value and benefits of maxing are well exemplified in this case for out of the clays of this table, they are able to produce material of the best quality and reputation in each of the lines they have developed.

TABLE VII.

	1	2	3	4	5
Silica, total	69.92	76.24	62.05	61.86	62.10
Alumina	23.46	16.87	27.71	26.02	22.71
Iron Oxide	.20	.16	.60	.63	3.69
Lime	.48	....	.15	.19	.71
Magnesia	.40	.50	.20	1.26	.86
Alkalies	1.43	1.09	2.40	.31	3.65
Water	3.84	4.90	6.67	9.98	6.03
Totals	99.73	99.86	99.78	100.25	99.75

E. M. Reed, *Chemist.*

No. 1. Soft Lower Mercer.
No. 2. Hard Lower Mercer.
No. 3. Soft Brookville Clay.
No. 4. Out-crop Lower Kittanning.
No. 5. Middle Kittanning.

These clays are all fire clays, and it has been the policy of these firms to confine their production to fire clay goods. However, it is highly probable that even more beneficial results are attained by the mixture of fire clays and shales. The vitrifying action in the shales is usually earlier to begin and relatively slower in its progress than in fire clays, but many shales are so near the danger line of fusibility that the margin of profit is much diminished by the results of the least negligence or mismanagement. If to such a shale, a good hard fire clay be added in proportion of one-fourth or one-third and the machinery be such as will effect an intimate mixture of the two, the result is all that would be desired, being refractory enough and yet easy to vitrify, having still a good dark color and some glaze.

Instances of the use of the good qualities of shales and fire clays conjointly to do what neither would profitably do alone are very common in the state. Some of the best vitrified goods in the market are produced from such material.

The use of the sedimentary clays of the Ohio River in the production of vitrified wares began some six or eight years ago at Middleport. Ohio is now represented by three factories, two at Middleport and one at Addyston, below Cincinnati.

These clays evidently owe their origin to deposition in eddies of the Ohio River, as they alternate with deposits of sand and gravel. Where they occur, they are 20 to 30 feet deep, almost without a pebble or stone in them. They present the cheapest form of clay which can be used for paving material, as they can be dug by steam shovel for a nominal cost and the work involved in preparing the clay for use is almost nothing.

The plastic nature of the material is against it however as it is difficult to prevent faults of structure in producing the brick.

An analysis of the clay from a large test of twelve car loads from Columbia which was worked into vitrified wares of high grade shows the following composition:

Silica (total)	63.73		
Alumina	17.17		
Water (combined)	4.90		
Clay and Sand	85.80		
Oxide of iron	5.85		
Lime	.58		
Magnesia	.97		
Potash	2.33		
Soda	.67		
		Clay and sand	85.80.
Fluxes	10.40	Fluxes	10.40.
Water (free)	2.96	Water	2.96.
Total	99.16	Total	99.16.

E. Orton, Jr., *Chemist.*

The oxygen of ratio of this clay shows:

3.12 acid to 1 base and 2.77 alumina to 1 flux

which indicates a clay less fusible than the average shales, but much more fusible than the fire clays.

Under fire this clay vitrifies beautifully, but unfortunately it begins to bend and lose its shape also, unless the burning is managed with great dexterity.

The quantity of these clays along the banks of the Ohio River is enormous, and the discovery of the vitrifying qualities coupled with the close proximity of shales and fire clay clays, at various intervals, forms a most valuable addition to the mineral resources of the state. The general character of the vitrifying clay deposits may be summed up as follows:

Shales, enormous in extent and area, difficultly plastic, but easily vitrifiable.

The fire clays, less in volume and accessibility, but still present in large quantity; fairly plastic, but more difficultly vitrifiable.

Sedimentary clays, limited in area but of enormous bulk in their district, the cheapest of all to dig and prepare—too plastic and easily vitrifiable.

There are instances in each division of clays which fill the wants of the manufacturers just as they are naturally found. It can hardly fail, however, that as the industry gets older and the qualities of the output become further tested by use, that the brick makers of the future will avail themselves of the advantages of mixture. Each class of minerals is deficient in some quality. Any two can be united to better effect than either alone, and in large areas, the geological conditions admit of this being easily and cheaply done.

The preparation of clays—As in the selection of clays for the fabrication of vitrified ware, we have seen that no line can be drawn between the various industries represented, so also in the preparation of clays for the actual manufacture of the different wares. The methods of preparation are common to all.

The treatment varies more with the peculiarities of the clays themselves, than it does from the character of ware to be made. For instance, it is true that more tempering and plasticity is required in making sewer pipe than brick, yet the variations in tempering different clays for brick are greater than the general differences between the tempering in sewer pipe shops and paving brick factories.

Both shales and fire clays are minerals in which the natural plasticity has been to a large degree lost, and it can be brought back only by the expenditure of power.

The general treatment for both involves grinding the material in its dry or natural condition to a powder, more or less fine, and tempering the powder to the desired consistency with water in pug mills or wet pans.

Grinding—Dry grinding is universally accomplished in Ohio by use of the machine called a Dry Pan. Preliminary to the grinding, the clays are sometimes crushed to a uniform size, but this is unusual and in most places unnecessary.

The Dry Pan is a horizontal iron pan, revolving on a central vertical shaft and driven by a heavy gear wheel above or below. In the pan are placed two heavy iron mullers or wheels, with faces from six to fourteen inches wide and weighing from 2,000 to 6,500 pounds each. These are held in position by horizontal axles which are arranged to slide in grooves up and down so that the wheels may run up on the top of any thickness of clay that may be introduced into the pan. These wheels revolve only by the tangential friction of the rotating pan floor, and scrapers are so set as to catch the clay and throw it in a stream under the mullers. The floor of the pan is solid under the wheels, but outside of the area covered by the wheels in revolution, the bottom is made of grates made in sectional plates which can be removed and replaced with ease.

The clay being crushed fine under the wheels, flies out over the grates by centrifugal force and falls through the grates or is forced through by the scrapers or is carried back under the wheels. When it falls through the floor plates, it is caught in a circular wooden box and is carried around by scrapers attached to the pan floor to a point of discharge.

The capacity of a dry pan varies with the size of its screen plates and with the kind of clay on which it is working. It is highest on brittle flaky shale, and lowest on wet plastic clays. If the clay be too wet or plastic it cannot be treated in a dry pan at all.

The maximum quantity which is on record for one dry pan in ten hours is two hundred tons of rocky fire clay. The clay was fed from an elevated shute into the pan by gravity by the labor of one man and passed through screen plates of one-eighth and three-sixteenth aperture. There is no record in this state to compare with this for efficiency, so far as is now known.

Under average conditions and with average clay a good dry pan will grind one hundred tons in ten hours through one-eighth screens; one hundred and twenty-five is frequently accomplished in good weather and with dry stock; in wet weather and with snowy or frosty clay, seventy-five tons would be good work.

There are a number of Dry Pans of a special merit on the market. Each one has some special feature which recommends it. They can be divided into two classes=wooden frame and iron frame pans. The wooden frame pans are made for much less money and their makers and many of their users contend that they require far less repair than the iron frame pans; the elasticity of the wood gives the necessary relief from the shocks which are constantly occurring. This may be true, but on the other hand it may be said that the wooden frame pans will require more power to operate them, as it is nearly impossible to keep the bearings in line, since the joints of the frame and the bolt holes will work loose in a short time and are bound to become more flexible every month the pan runs. The iron frame pans are neater in appearance and occupy less space, are easier to get around to fill and repair and keep in line; they suffer from shocks it is true, and it may be true that the repair bills on a year's run would be higher; this would have to be proved by records of the two kinds on the same clay, etc., to make the assertion good.

There are some nine or ten varieties of iron dry pans in use in Ohio. Among them the Frey Sheckler Co. of Bucyrus takes the lead, having in two years sold more pans in this state than any other firm doing business here. Their pan unites more good points than any other in general use though several pans have been built but not yet extensively marketed, which would equal it in every way.

Among the other pans deserving special commendation are the Bonnot pan of Canton, the Carlin of Pittsburgh, the Penfield of Willoughby. The Turner Vaugh & Taylor, of Cuyahoga Falls, and the Hayden of Columbus must also be mentioned.

The average price of a nine foot dry pan of the best design is $1,000 to $1,100.

The wooden frame pans are used more generally in sewer pipe shops than in brick factories, probably because the sewer pipe shops are largely old and the brick factories have been built since the use of the iron dry pan has become popular.

The makers of wooden frame pans supply a much more nearly uniform machine than those who make pans with the iron frame. The price including the timbers framed ready for erection is about $700 and $600 will often buy the bare castings. The frames are of 12x12 oak usually and are made as strong as they well can be.

The wooden frame pan is probably wasteful of power, but requires less mechanical skill and care, than the iron frame. In wooden frame pans, that made by Jas. Means of Steubenville divides the honors with the Stephenson Pan of Wellsville, among the clay working establishments of the state.

The fineness to which it is advisable to grind in the dry pan before allowing the fine material to escape for more accurate sizing in the screens, is a question on which some experimenting could profitably be done. The usual practice is to use plates with about $\frac{3}{32}$ aperture when new; as the plate wears the apertures rapidly become larger, so that as the different sections are put on at different times, one can find spaces any where from $\frac{3}{32}$ to $\frac{1}{4}$. The action of the pan is much more vigorous and effective when the fine material is kept screened out, for if fine dirt and coarse together are allowed to run under the wheels for a few revolutions they pack into a dense cake which prevents any effective work at all. On the other hand it would seem foolish to allow material to escape from the pan to go to the screen which is not yet prepared to pass through it. The proper course lies between the extremes; the pan plates ought to be so regulated that not less than 66 per cent. of the product will go through the screens and probably 75 per cent. is in most cases the better proportion. If the screen plates are too coarse no useful result is accomplished, for the tailings from the machine must all be returned to be reground, and energy is being expended in elevating and screening material which cannot go through the screen.

The screening of the ground clay from the dry pan is the next step in the process.

The dirt from the pan is usually dropped into a bucket elevator and carried up a sufficient height to get proper head room, so that the material passes to all subsequent operations by gravity alone.

The methods of screening clay in use are three:

1st, by fixed inclined screens; 2nd, by rotary screens; 3rd, by shaking or vibrating screens.

The inclined screens are the simplest and cheapest and the most frequent in use. The clay is merely delivered to the surface of a shute about thirty inches wide by ten to fifteen feet in length. The bottom of this shute is the screen material which may be sheet metal perforated with round holes, or sheet metal perforated with parallel slots, or wire cloth. The first material is the best on every account and the last is the worst.

The screen shute is given whatever pitch the clay needs to run down freely. The greater the pitch the more rapid the movement of the clay and the finer the screenings will be through any size screen; the less the pitch, the slower the movement, and the nearer to the size of the openings will the grains be. The objections to this screen are:

1st. It requires a high building to give it proper room for operation. In a small brick plant it requires the use of an additional story to the machinery building. In a sewer pipe shop this point is of no weight as the building is high enough, necessarily.

2nd. The quantity which one screen, thirty inches by fifteen feet, can run through per day is limited, and for the production of a large quantity of ground clay, a large number of screens must be maintained and kept in order. One screen to one dry pan is the usual allowance, yet if the conditions are anything like favorable the dry pan will overwork two screens of this character.

3rd. The screen requires frequent attention or it will become coated with fine clay until it fails to do its work. One screen will require occasional attention in good weather and frequent attention in bad weather. Two screens take the time of a boy constantly to make them do their maximum.

The points in favor of this screen are, 1st, simplicity and cheapness; 2nd, no power required to operate it.

The rotary screens are finding some considerable use in the state at present. There is hardly a sewer pipe plant in the state that has not tried them at some time or other. They are finding more extensive use in brick works than elsewhere.

There are a number of different kinds of rotary screens. The following types have been seen and the workings observed:

1. A cylinder or truncated cone made of perforated metal with its frame work outside of the screen, so that material introduced at the higher end works gradually down to the lower end and lies in the bottom of the cylinder all the time it is in the screen.

2. A similar cylinder, with its frame and spider wheels *inside*, by which the dirt is kept in agitation all the time.

3. A similar cylinder, covered with wire cloth, and provided with a set of flites or buckets inside which carry the dirt up on one side and throw it violently against the cloth on the opposite side. The dirt in this case only travels along the bottom as it falls from one bucket and is caught by the next.

4. A hexagon or octagon frame, like No. 1, which has the advantage of carrying the dirt up on its angles and letting it slide back with some force when its equilibrium is overcome.

Of these four types—Nos. 3 and 4 will screen m re clay than either 1 or 2 of the same dimensions—they will also use more power. No. 4 is the most efficient rotary screen for the power it uses. No. 3 is the most efficient in screening dirt regardless of power consumed. They are all equipped with various automatic devices for keeping the screen cloth clean from adhering clay; generally knockers or weights dropping in quick succession on the cloth are used. In spite of all the mechanical ingenuity expended on this subject there is absolutely no rotary screen in use in the state that does not require practically all the time of one attendant man or boy to keep it in efficient operation.

In several cases, a boy was seen at work side by side with elaborate automatic appliances supposed to do away with his services.

The objections to rotary screens as a class are: 1st. That they use up a good deal of power in doing their work; 2nd. That they require constant attention; 3rd. That they require much repair.

The points in favor of them are, 1st. That with good construction and careful attention they can be made to do a very large amount of service per day. 2nd. That they occupy but little space and require but little head room or elevators.

The shaking screens in use in the state are manifold, but so far as is known, there is only one which is regularly manufactured by a machinery house. The majority of them are the invention and manufacture of the various manufacturers and superintendents who have had the troubles of the other systems to endure, and have tried a new plan as a possible relief.

The following shaking screens have been observed in use in the state:

1st. A screen made of perforated metal forty-eight inches wide by twelve feet long, suspended on iron rods from points eight to ten feet above, the amount of inclination being about two feet in twelve, or one in six. The dirt was thrown into the upper end in one stream but divided by a "V" shaped plow, it covered the whole area of the screen. The vibration was given by a small crank and connecting rod and the necessary jerk and recoil was effected by making the frame strike a solid post.

This arrangement, which cost not over $50.00 and required not over one-fourth horse power, screened two hundred tons in a day with no attention but an occasional sweeping by a boy.

2nd. The same general style, but narrower, suspended by flat steel spring bars and driven by eccentric. This screen invariably gave trouble until the method of suspension was changed to round rods, instead of flat springs, which speedily crystallized and broke. The eccentric also uses more power, and wears out faster and is more expensive to repair than the simplest crank.

3rd. A screen box, about thirty inches to ten feet long, pivoted at the lower end and shaken from side to side at the upper end by a rapid crank motion; this inclination about three feet in ten.

This is, all things considered, the best shaking screen in use—it is cheap—simple—and requires less power to run it than any other, and it will do more work per square foot of surface. The motion of the screen from side to side is quicker, but less violent than the longer sweep from end to end of the first shaking screen described. The jar of the latter is hard on a weak building.

The general results obtained, indicate that where a high building is to be used, the incline screens are the best as by duplication the capacity can be brought up to any demand. Where a low building is to be used and the quantity of work is large, the shaking screens will be found the best and of the shaking screens, those which accomplish the main movement of the clay down the screens, largely by gravity and the short lateral motion, back and forth, by power.

The fineness to which it is advisable to reduce the clay for making a vitrified ware varies with the qualities of the clay. If the clay is refractory, it should be ground fine; if it is easily vitrified it need not be made so fine.

If it is plastic it may be left coarse, if it is rough it must be made fine. The effect of fineness of division in the clay in the character of the ware is noticeable; it increases the danger of bloating, and increases the danger of bad structure by too great plasticity, but the results are firmer and stronger knit. For paving material it is beneficial in increasing the wearing qualities, and in sewer pipe it assists in getting an even smooth surface.

The clay from the screens is allowed to fall into a storage bin if the tempering processes are to be done by a wet pan, or go direct to the pug mill if the tempering is to be done in that machine. The use of a storage bin for tempering by pug mill is very rare, but it has many advantages to recommend it.

The *tempering* of clays for the use in the finishing machinery, is one of the most important steps in the process. Mismanagement in grinding and screening results in lost time; mismanagement of tempering affects the value of the ware produced.

The two methods in use are by Wet Pans and by Pug Mills.

The wet pan process is used in almost all of the sewer pipe factories, and in many brick works, while the use of pug mills is nearly limited to brick works and similar works.

The wet pan is a counterpart of the dry pan except that its bottom is solid instead of perforated and its mullers are generally narrower in tread and lighter in weight.

The usual wet pan muller has a face five or six inches across and weighs from 1,500 to 4,000 pounds. The scrapers are not so long nor set so deep, nor with so flat an angle in the wet mill as in the dry.

The framing, be it iron or wood, is just like the dry mill and the gearing, etc., are also just the same or a little lighter.

The mode of operation consists in running a charge of clay from 600 to 1,200 pounds into the pan from a large box or shute with proper valve for controlling it. While the clay is running in, the water is also turned on, and is being mixed with the clay by the combined action of the scrapers and mullers. When clay and water are added in sufficient amount, they are shut off and the grinding progresses. As the clay gets more uniformly wet and plastic the wheels cut through it cleaner and grind and crush the particles as they pass under. The grinding action is not to be overlooked in this process. The mixture secured is intimate in proportion to the length of the grinding; two and one half minutes will temper a charge for brick thoroughly; for sewer pipe four or five minutes ought to be consumed. As the tempering progresses the operator adds water as is needed. When the charge is ready to withdraw it is taken out by a shovel. The blade of the shovel is made of wood about 18x24 inches, and the handle is a heavy bar of wood, 3x4, pivoted on a ring bolt near the blade end.

The shovel is lowered into the pan where it is instantly filled by the clay sliding upon it. It is then lifted out and dumped into the boot of the elevator or conveyor which is to take it away.

This operation is always done by the operator who does the tempering. One man can run two wet pans comfortably, filling, tempering and emptying in rotation so that one pan is grinding a charge while the other is being emptied and filled.

There are two devices in use for emptying the wet pans automatically. The first and simplest device has been perfected simultaneously by two men, working independently. It consists of the shovel arrangement just described, actuated by machinery, so that it comes down, pauses a moment, raises, dumps and comes back again with no help but starting and stopping. This device simply saves labor on the part of the temperer, but he must be there just the same and paying attention to his work just the same. It accomplishes the work so much easier and quicker however, that it is alleged that the capacity of a wet pan is increased from twenty to thirty per cent. by its adoption.

The other self-emptying device is that employed on the Carlin pans made in Pittsburgh. It consists of a movable section in the side of the pan rim, which is hinged solidly against the frame of the pan. In this case the bottom of the pan revolves but the rim is stationary. When the pan is grinding the movable section is out in its place as part of the rim When the charge is ready to empty, the section is moved inwards slowly by a screw worked by a hand wheel, and all clay striking it is swept out of the pan into a belt or table. The action is that of a movable plow. entering from one side and plowing the contents of the pan out into the receptacle beyond.

Neither of these devices make any great difference in the expense of tempering; the only difference is in the slightly increased out put. The character of the tempering given by a wet pan is the most thorough and efficient it is possible to give clay. The grinding action is a very important adjunct to the tempering. When a hard gritty shale is being used, and it fails to develop the proper plasticity in being treated by pug mills it is necessary to add a plastic clay to assist it. But a wet pan will make any clay plastic that has the elements of plasticity in it. Also in mixing clays, a pug mill merely stirs the particles together. A wet pan grinds them together so that it often happens that the result cannot be detected as a mixture.

In mixing two clays of different fire qualities together by pug mill, the ability of the mixture to keep its shape depends practically on the character of the mineral in excess. Thus a soft vitrifiable shale, would allow a brick to bend under heat if there were fifty per cent of the shale used with fifty per cent of the refractory fire clay, but if the ingredients of the two clays were worked together until practically united, it is probable that twenty-five per cent of fire clay would sufficiently elevate the melting point of the shale.

The defects of the wet pan as a tempering machine are 1st. Its cost, which is two to three times that of the pug mill. 2nd. The fact that it has to be put on the bottom floor of the building on account of its weight and vibration and thus generally necessitates a second elevation of the clay. 3rd. The clay is tempered in batches and even with the utmost fa thfulness it is impossible to always get each batch of an even temper. 4th. The clay will sometimes absorb water so fast that it will become quite dry and hard in temper in two minutes after a copious addition of water. In treating a clay of this nature, the first portions removed from the pan are likely to be more soft than the last portions of the same batch.

As to capacity, one good wet mill, well handled, will temper sufficiently for brickmaking all the clay that one dry pan will grind. For the additional plasticity, required by sewer pipe machinery, an additional pan will be needed to keep one dry pan working constantly. Instances are on record of one wet pan taking all the clay from two dry pans but this is exceptional.

The pug mill, as a tempering device is the oldest machine employed The principle on which it is founded is the Archimedes screw. A revolving bar is equipped with knives, or cutting bars, or propellers, set so as to form an interupted screw thread. These knives or "paddles" stir the clay up and pass it slowly forward in the direction the screw is running. Pug mills are now made horizontal for use in large brick works. The older pug mills used in small brick yards and potters pug-mills are still vertical. The trough in which the screw works is either of iron-bound wooden staves, or sheet iron, and the shaft is usually made of forged iron and the paddles are either cast solid to slip on this shaft one after another, or are made in two pieces, a cast stub which slips on the shaft as before and a wrought iron or steel blade which bolts fast to the stub and can be removed or repaired with no trouble. The gears which drive the mill are either single or double according to the work which is put on the mill.

The clay is run into the mill in a continuous stream at one end and is immediately wet with nearly all the water which it requires, further addition of water is effected, if necessary, when the clay has progressed part way down the pug mill. The discharge of the pug mill may be either free or under pressure. Some of the recent forms of pug mills are regular brick machines, forcing the clay out through a constricted opening and cutting it off in small shavings by a revolving cutter outside of the delivery. One mill forces the clay out through a dozen or more holes, one and one half or two inches in diameter and cuts the bar up in sections from one to two inches long.

The closed delivery pug mills are more efficient in getting uniform plasticity and uniform structure of the tempered clay, than the open top mills. In the latter there is no pressure brought on the clay, it is continually and loosely stirred until it is tipped out at the discharge opening in a loosely granular condition.

The advantages of the closed pug mills over the open ones are manifest in the work they do, but the increase of power consumed is very great. The character of the tempering done on a rocky clay not possessed of much natural plasticity is poor and the power consumed is nearly as great as that used in a wet pan.

In the open mill, much less power is used and the work done is still poorer in quality.

The advantages which can be claimed for the pug mill are,

1st. Cheapness of first cost and small expense in repairs.

2d. The action is continuous and if clay and water be within the control of the temperer, more uniformity is possible than can be attained in the wet pan. Under ordinary conditions, however, this advantage is lost, for not one in ten of the plants using pug mills have any storage bin for securing a regular flow of clay, but are made to depend on the supply of clay that falls from the screen, which in turn depends on the dry pan. It is not possible to secure an even supply of clay for feeding the pug mill in this way. Any inattention, any variation of the dryness or hardness of the stock, any choking of the screen, or any one of a thousand conditions is always interfering, and the result is a constant fluctuation, a feast or a famine, at the pug mill. Hence the temperer has to face the difficult task of adding the proper amount of water to a clay supply which does not remain constant two minutes at a time and it is needless to say that no man can maintain uniformity under such conditions.

When a storage bin is situated above the pug mill and the clay from the screens falls into this bin, then there is nothing to interfere with the maintenance of a steady stream of clay except the constant difficulty, which is inherent in the nature of the case, of getting any supply of ground clay to feed freely or run down grade without choking and banking up. Ground clay is like snow; it will amalgamate on very small excuse, and in order to get a mass of ground clay to "run" at any regular rate it is necessary that not only every natural advantage should be given it, but that the temperer should have some ready means of dislodging and stirring it up.

The storage bin should be as tall as is feasible, should be larger on the bottom than the top, the supply should strike in the center of the bin and the outlet should leave the center of the bin at the bottom, and the outlet should be smaller when it leaves the bin than at the bottom, in order to prevent choking in the spout. Even with all these precautions observed, the clay will require to be dislodged frequently.

It is possible to arrange a screw, or other mechanical appliance at the bottom of a bin of clay which shall deliver a constant supply as long as any clay remains in the storage bin. In order to use the pug mill to temper clay advantageously this provision would be worth all it costs.

3d. Pug mills are a good means of uniformly wetting and mixing clays which by nature are already plastic. In such clays the use of the grinding action is not only unnecessary but is detrimental.

The use of each of the two forms of tempering apparatus is thus seen to have its own especial field of usefulness. The wet pan in tempering rough, hard and rocky clays and shales; the pug mill in tempering soft plastic clays; the latter can be used in tempering dry, ground clays of any nature, but the results are not as good as they ought to be, except when the natural plasticity of the clay is high. Where mixtures of clay are used to effect changes in the chemical character of the material the use of a wet pan is nearly indispensable to good results.

The use of hot water in tempering has a very beneficial effect in many cases. Aside from the comfort to the men who handle the wet brick in cold weather, and the assistance to the drying of the ware when it comes warm from the machinery, the disintegrating effect of hot water and steam is more pronounced and complete than cold water.

The processes of preparation have now been described. They are common to all industries using hard or rocky clays for vitrifying purposes, and are used for the preparation of clay for many other purposes beside. At this stage the clay passes to the special machinery required in making the kind of ware under discussion.

Brick Making Machinery. The manufacture of bricks by machinery is accomplished in several ways, and with a great variety of machines. As paving brick are liable to be made in any one of the processes it is necessary to give an outline of all the different means employed. The bulk of the paving brick manufacture—all that is important—falls under one of two plans which will receive careful consideration. Bricks are made at present in the following ways:

1. By hand moulding.
2. By soft mud machinery.
3. By stiff mud machinery.
4. By dry press machinery

Hand moulding is not employed to any extent in making paving material. It is still used in making fire brick and in making common brick.

Soft mud machinery is used to a limited extent in paving bricks and to a large extent in making fire brick and building bricks. The process is characterized by using the clay in a very soft and pasty state and by the fact that the soft clay is forced into molds like those used in hand molding, and these molds are then removed, emptied, cleaned, sanded and replaced by hand to be refilled by the machine. This process will thus be seen to be but an imperfect attempt to perform by machinery the same processes originally carried out by hand. There are a number of different machines of this class, but all unite the same essential principles and attain similar results.

Stiff mud machinery, is that now almost universally used in paving brick plants, and is becoming more and more important in the manufacture of all kinds of bricks for building and refactory purposes. The clays in stiff-mud machines, are tempered to a plastic state but are not soft and pasty. They are able to retain their shape under considerable weight when taken fresh from the machinery, and the process unites the benefits obtained by wetting the clay, with those which accrue from the easier handling of the product.

The dry press process, as its name indicates, takes the ground and sifted clay, and by the exertion of great pressure forces it into a compact and dense brick, without the use of any moisture. The products of this process are used in a limited extent for making fire brick, but are ordinarily applied to the production of fine building material. Some few dry pressed bricks have been tried as paving material with nearly always unfavorable results.

The character of the wares made by these four processes may be briefly described as follows:

Hand-molded bricks are irregular in shape, generally more or less porous or open grained, owing to the lack of all pressure in their format on and to the large amount of water used in tempering. They are devoid of any cracks, cleavages or laminations resulting from the arrangement of the particles of clay by the power that formed the brick. The material used is generally poorly prepared and not homogenous but if clays of suitable composition were used and were ground fine and tempered with the proper machinery, a brick could be produced by hand-molding whose structure would more closely approximate our ideal than can be made by any other method.

Soft mud bricks have most of the good points of the hand-molded bricks so far as structure are concerned; they very rarely show faults like laminations or cracks; they are usually open grained and porous on account of the large quanties of water used in their tempering. This loose knit structure can only be remedied by the use of compressive force after the brick have been partly dried and become stiff enough to benefit by such treatment.

A brick which has had this treatment becomes one of t e best in structure that it is possible to make. But such a process of manufacture becomes an expensive one, on account of the necessary division of the drying into two stages.

The stiff mud bricks have usually a dense compact arrangement of their particles and possess good strength, but are apt to show evidences of the influence of the machinery in their structure. This process is the cheapest way to manufacture bricks from tempered clay, but no machine has yet been devised which is capable of continuously producing material whose structure is even approximately what is desired and needed by the paving brick industry. The advantages of the process are such however as to indicate that success will be attained by overcoming the obstacles which interfere with this plan, rather than by developing the useful points of any of the other ystems of brick making.

Dry press brick possess the most dense, even grained structure and the highest specific gravity of any kind made. But as a result of the process of manufacture, the brick is an agglomeration of grains which owe their conjunction to pressure. If the clay is easily enough vitrified to unite its various particles at a safe heat and form one coherent mass instead of many thousand separate masses, then the dry pressed brick would be the best and cheapest known. But the facts are, that no one has ever succeeded in producing to any profit a dry press brick in which this has been continuously accomplished. The grains of clay may vitrify, but do not unite. The green brick is an agglomeration of separate particles which can be separated by friction. The burnt brick is the same, and while each grain may be vitrified to non-absorption and the brick as a whole be nearly non-absorbent, still the particles will easily yield to the disintegrating effect of friction.

In the bricks made by the wet processes, the preliminary cohesion is accomplished by water, and burning merely perpetuates the bonds already formed. In the dry press brick, the kind of vitrification required to establish a bond between the particles would be scarcely less than fusion.

Hence it is to the stiff mud processes that we must look for the paving bricks of the future.

The machines in use for the manufacture of brick by the stiff mud process can be classified as, 1. Plunger machines; 2. Auger machines; 3. Combination of these principles

Plunger machines are those in which the tempered clay is introduced in a cylinder, or press box, and forced out through the die by pressure of a piston operating from in rear of the clay.

This is the simplest and most natural method of forming clay or any plastic material into a required shape or size.

The character of the bar of clay produced by being thus thrust out of a die or constricted opening by pressure from in rear, is a very important field for study. To begin with, there are certain qualities which it is thought probable are inherent in any bar of clay which is formed by expulsion from a constricted opening. A study of the product obtained from a large number of different machines, working on different clays indicate this very strongly.

When plastic tempered clay is put under pressure before a constricted opening it issues forth and its flow from this opening appears to operate under the same laws that govern the flow of fluids. That part of the clay will be in most rapid motion, which is furthest from any solid frictional surface, just as water in the center of a stream flows faster than its edges. Hence the center of a bar of clay is sure to move faster than the outside. These conditions become less marked in producing a large bar than in a medium sized one. A bar having a section 6 x 11 inches has but little tendency to drag on the outside and run ahead in the center, because the inside area bears so large a proportion to its surface. There are about two inches square area to every lineal inch of surface in such a bar In a bar 3 x 4 there is less than one inch square area for each inch of surface. Hence the center will be more likely to run ahead in the small bar.

But if we reduce the size of the bar to 1 x 4 the tendency to run ahead in the center again nearly disappears, for while plastic clay under pressure acts like a fluid, it is a very stiff fluid, and in sections where the surface is so large in proportion to the area the retarding effect is nearly equal all over the bar, and it comes out at nearly equal speed in all parts of its section.

The sizes of aperture then at which the clay develops the greatest tendency to run at unequal speeds, lies in the limits of those sizes that are now used for producing end cut bricks and paving blocks—that is from 2 x 4 to 4 x 5. In either larger or smaller sizes the tendency diminishes.

The effect of this tendency has an important bearing on the structure of the bar of clay. If made of clay which is a little too dry in temper it will break into pieces showing on one side of the fracture a cup-shaped cavity, and on the other a conical projection. If the temper be a little soft, the corners of the bar will tear back or ruffle up, making an utterly unsaleable article If the clay be tempered well, but too little plastic in its nature, the corners of the bar will show a multitude of cracks going down into the clay for quite a distance and trending forward at an angle toward the center instead of at right angles to the flow. If the clay be too plastic, the center is liable to flow so much more freely that division lines are formed between the outside and the center and these slipped surfaces or laminations can not be made to unite again, by any subsequent repressing, and naturally these cracks or laminations are a detriment to the strength of the burnt brick.

These various phenomena which have been mentioned are all due to the one general cause—the flow of the plastic clay through the die and they are faults which are inherent in the case, and not the result of the kind of machine used, or rather of the way in which the pressure which causes the flow is applied.

Besides these faults, which are common to all, plunger machines are likely to have another which is characteristic of them only—that is the imprisonment of air in greater or less quantity in the substance of the clay from which it cannot escape.

The pressing chamber is filled with a mass of more or less granular clay at the beginning of each stroke. The motion of the piston forward rapidly consolidates the mass and the air has only the chance to escape by the leakage of the piston head or through the die with the clay. Vents on the surface of the chamber serve but small useful purpose, as they speedily choke with clay and only drain the space close to them. As the air goes out with the clay through the die it generally occupies the space between the slipped or laminated surfaces and thus assists in keeping them apart. Sometimes large cavities are formed and if the clay is too soft it sometimes swells up like a loaf of bread from imprisoned air.

There is no way yet devised which does away with the introduction of air in bricks from a plunger machine. As would be expected the more granular and sandy the clay is, the less the trouble amounts to, but the limit of sandiness will be attained before the trouble is cured.

One of the most promising attempts to do away with the trouble has been made by Mr. H. B. Camp at Cuyahoga Falls. He uses a packer which by constant strokes catches and consolidates the soft granular clay from the tempering machinery into a large round bar, this is cut off in chunks or crumbs of seventy-five to one hundred pounds weight and is dropped into the clay cylinder of his machine. This lump is as nearly the diameter of the cylinder as will allow it to be dropped in and the air in the cylinder is on the ends and outside of the lump of clay where it can most easily make its escape when the pressure comes on it.

An application of this idea to the feeding of other forms of plunger machines will undoubtedly assist in reducing this most troublesome defect in their product. Aside from these faults, 1st, those common to the production of a bar of clay by any means and, 2nd, those due to imprisonment of air in the bar, the plunger process affords a result of high excellence.

By careful attention to keeping the conditions of plasticity, sandiness, richness, etc. as favorable as possible and using every means to keep air out of the clay, this process can probably be made to yield better results than any process in which a bar of clay is formed. In the nature of the case, mere pressure on a plastic mass of clay imparts no structure other than that due to flow.

The plunger process is subject to one peculiarity or limitation, that is, the intermittent character of the flow. This is a feature which cannot be eliminated; it does not interfere with the production of a good bar while the flow is in motion, but it limits the methods of removing and handling the output to those plans which employ a good deal of handling by men instead of machinery. No automatic devices have as yet been successfully applied to handling the output of plunger machinery, and the intermittent character of the flow threatens to stand in the way of such improvements. The methods of handling a bar of clay for the production of bricks will be discussed under the head of auger machinery.

There are several types of plunger machines applied to brick making.

1st. The pipe press, in which sewer pipe and hollow goods are made, is also used to a small extent as a means of making brick. The machine will be described in detail under the head of sewer pipe, for the manufacture of which it was devised. It consists of a vertical clay cylinder surmounted by a vertical steam cylinder. The piston rod is continuous from the clay piston to the steam piston, and the pressure is therefore, a direct one from the steam to the clay. It is an extravagant machine in the use of steam, but its simplicity and lack of wearing and breakable parts make it one of the favorite machines in use.

2nd. The same principle has been used in the horizontal steam press, this is used for brick and small sizes of hollow goods. It is made usually double ended, a steam cylinder in the middle and clay cylinder at each end, so that instead of losing the steam on the return stroke it is used in making ware; also two kind of ware can be produced at once, which is of great importance in some places and in any place it saves the loss of time in changing dies frequently.

3rd. The Penfield Plunger consists of a pair of press boxes of rectangular section, situated on either side of a central vertical shaft. The pistons are connected together by a pair of connecting frames of heavy design, and the rear side of each piston carries a chilled roller. On the main shaft a large cam is keyed fast and in its revolution it forces the piston frame backward and forward, the motion being received from the cam and conveyed to the frame by the rollers alluded to before. Proper dies bolt into the ends of the press boxes. The press boxes are filled with clay from above by a vertical pug mill which surmounts the entire frame of the plunger machine. This pug mill receives its clay on top and works it down and into the press boxes wherever the vent is open.

This machine has been used largely in the past in making common brick; it has been used to some extent in making paving brick. It is a good machine for working a plastic clay and making building brick, For making paving brick from gritty non-plastic clays, and made at a very stiff temper, the machine has proved itself too complicated and too expensive in repairs, and the simpler method of getting the pressure by steam direct is much preferable.

The use of Auger Brick Machinery is growing in importance in the manufacture of paving material and all other kinds of brick as well.

There are several reasons for this increase: 1st, it produces a continuous stream of clay which allows of the utmost economy in handling the output and getting the utmost duty from the employees in charge. 2nd, it is always driven by power from shafting and hence the use of steam in the engine can be made economical, while in plunger machinery actuated by steam, the use of the steam power is divided and the requirements do not admit of very high efficiency being attained. 3rd, the machines are capable of doing more work in a specified time than any other of equal cost.

The main underlying principle of the auger machine is the use of a continuously revolving screw to carry the clay forward and force it out of the die. The mechanism as usually arranged, consists of a cylindrical or conical, horizontal iron case with an opening at the rear end on top for the admission of clay, and a movable front which carries the die and former.

Inside this clay cylinder is fixed a horizontal shaft carrying the fittings which give it its character as a screw. Sometimes these fittings are nothing less than a cast iron screw cut in sections which slip over the shaft one after the other. Sometimes the fittings are merely blades forming a slightly interrupted screw and sometimes they are a set of steel forged knives set at variable lead at different points on the shaft. However the effect is obtained, in all cases the essential elements of the screw are there, and its action on the clay is just the reverse of the action which takes place when a carpenter bores a hole with an auger. The chips from an auger are carried back from the point of production the clay is carried forward toward the outlet.

The front end of the shaft is equipped with a casting designed to gather up the clay delivered to it by the knives or blades in rear, and force it out of the aperture in front.

This casting is a solid, chilled iron screw, made in a single thread or double thread according to the kind of bar which is to be produced.

The shaft, which is unsupported at its working end, is held firmly in position in two long bearings and is driven by powerful gears, either single or double. The backward thrust of the auger shaft is of course equal to the forward push it gives the clay, and this has to be provided for by a carefully adjusted step or bearing designed to take the continual strain and wear without heating.

This is a short description of the main points of an auger mill. There is a great variety in use and many which have attained special excellence in securing the maximum out-put with the minimum wear and breakage.

Auger mills are divided into two distinct grades—those which make a side cut brick and those which make an end cut brick.

By a side cut brick is meant one which has been cut from a bar of clay whose cross section at right angles to its line of flow is equal to the area of the side or largest plane surface of a brick.

Similarly an end cut brick is a section of a bar of clay whose cross section represents the end or smallest plane area of a brick. The mechanical problems met in producing these two kinds of bars vary quite widely.

In a side cut machine the bar of clay produced is about four and a fourth inches high by eight and three-fourths inches wide. A brick represents a section of this bar two and a half inches long. The power required to force clay through so large an area is not great, the back thrust of the auger shaft is not very heavy and the general working of the machine is easy.

The clay in side cut machines is often carried forward by a double thread instead of a single, and nearly all side cut auger points are double threaded, so that the clay is simultaneously delivered at the end of the auger in two streams which unite into one bar as they pass out of the die.

In an end cut machine, the bar of clay produced is about two and a half inches wide by four and a half deep, for common sized brick.

To force clay at a rapid rate through so small an opening requires the use of great power and great strength in the machine and good arrangements for receiving the back thrust of the auger shaft.

The auger is a single threaded one—delivering one stream of clay only.

Some machines are adapted to produce both side cut and end cut brick—they do it in two ways: 1st. By merely changing dies of a side cut machine, inwhich case the volume of clay, delivered by the auger is merely split up into two or three end cut streams instead of one side cut stream.

The end cut bars of clay thus produced are not perfect bars except in outward form; they are in reality a divided or split bar and the arrangement of the particles of clay in various parts of the bar is not alike; this will usually cause the bar to crook or warp in drying. Other objections can be raised against this method of making end cut brick.

2nd. By changing the auger and auger cases and dies of an end cut machine to a side cut outfit, side cut brick can be produced as well as in a machine especially made for the purpose. If both kinds of brick are needed, the proper thing to do, is to buy an end cut machine of good design and capable of making the desired quantity of end cut brick in a single bar of clay. This machine will then be useful in either capacity, but if a side cut machine be used to make end cut brick it is either at the risk of over-taxing its strength in producing a single stream of clay, or in making an inferior out-put in making two or more streams at once.

The general characteristics of the bar of clay produced by auger machinery are well marked. To begin with, the bar has the same disposition to defects, due to its passage through a die, which were carefully set forth in treating of the bar produced in plunger machines.

Aside from this structure, the gathering and assembling of the particles of clay by the constant revolution of a screw unavoidably causes their arrangement around a center point.

The mere fact of the particles arranging themselves around a center is not detrimental but when the clay is plastic it tends to slip over the polished surface of the auger and the smooth surfaces thus produced do not readily unite again, and as the clay is pushed forward through the die these separate successive waves or layers of clay coming from the auger are readjusted into layers of clay around the center of the bar. Thus the tendency of the auger machine to arrange its clay around a central point becomes a very serious defect in treating a plastic clay. With a gritty, rough, coarse grained clay this tendency is much reduced, as the clay does not readily form the slips or smooth spots from contact with the auger.

This tendency of all auger machines to build the bar of clay out of concentric layers is of course most strongly developed in the end cut machines for there the propelling force is greatest and the molding forces of the die are greatest. Side cut bars while still formed around a center are much less laminated.

This characteristic fault of the product of the auger mill is something which is inherent in the nature of the machine; it is not like the fault of the plunger machine which can be partly overcome by the proper appliances. All that can be done is to see that the conditions which tend to produce laminations are obviated just as much as possible.

The clays which laminate most in auger machninery are rich, fat, aluminous clays, clays whose natural plasticity is great. Clays of this kind cannot be worked in an auger machine with the production of ware which is structurally sound. If the clays are gritty, not naturally plastic and only made workable by the aid of efficient machinery, and the dies are well arranged to promote an easy flow with as little friction or holding back of the surface as is possible, then the defects can be almost obviated. Instances are not uncommon of where the very best structure has been attained in this way, but it could not be maintained continuously. Sometimes it is attained by sacrificing the outside appearance of the bar by using clay which is too short and tender and devoid of enough plasticity to make it hold together well.

The adaptation of auger machinery to paving material has been very greatly assisted by the use of the shale deposits of the state. These shale clays are really the only class of clays which will give wide success to the auger machine for this purpose. As a maker of building brick the auger machine is without an equal, for the structure of the bar has but very little to do with the value of the product. But with the paving brick the structure is all important.

The method of handling the bar when made, is a subject scarcely less important to the brick maker than the structure is to those who use the brick, as the cost of the product and its surface finish are largely influenced by this part of the work.

The usual method of handling the output of the side cut machine is by an ingenious mechanism known as the side cutting table.

The bar of clay is received on a smooth plate which is kept well greased to assist the clay in slipping over it freely. When the bar has advanced along the plate to a sufficient length, the operator by use of a powerful lever draws a set of parallel wires, strung on a metal frame, through the clay, cutting it into parallel sections of equal length: These are side cut brick. At the conclusion of the cut, the brick are lying close to each other, merely separated by the thickness of the cut which the wires have made. On the return motion of the lever the cut of brick, usually ten or twelve in number, are slipped adroitly to one side on a wooden pallet, to make room for the continuously advancing bar of clay. When thus removed, the bricks are taken to the dryers or to the repressing machinery.

This process of cutting brick by hand and removing them on a pallet, limits the production which can be attained on a side cut machine very greatly. The amount of clay which a good side cut machine is capable of putting out into a well formed bar is enormous, but the amount of this bar which can be cut on any common side cut table is limited to about 30,000 bricks in ten hours. By working the hands by relays, and driving everything to the utmost, more can be managed, but 30,000 constitutes the economical limit of the table.

One great impediment to the speed of the operation of cutting brick by the common side cut table, is the constant use of dexterity and strength which is called for in disengaging the block of freshly cut bricks, and moving them out from in front of the constantly approaching bar.

A new side cut table has recently been devised which does away with this trouble; the bar of clay is received on a greased metal plate as before, but the cutting yoke is so arranged that the cut is made on both the forward and back motion. Instead of separating each cut off to one side, the advancing bar is permitted to shove the block of cut bricks ahead of it until they are each in turn caught on the surface of a belt which moves at a slightly faster rate than the bar of clay moves. Hence each brick is moved off a little distance before the next one gets in motion. This device is called a separating belt. From the surface of this belt each brick can be picked up separately and set on the carriage to the dryer or on the feed table of the repress machines.

This table, while still actuated by hand power, is a long step ahead of the pallet delivery and it is said to be as easy to handle 40,000 per day on this table as 30,000 on the old form. The cutting of a bar of clay into side cut brick automatically has not yet been successfully accomplished. The problem is one which is causing general interest. Many people believe in the advantages of a side cut brick over the end cut for any purpose and to these people the production of side cut brick as cheaply as end cut brick are produced is a vital matter. There are three or more automatic side cutting tables under construction but none in the market. The problem is certain to be solved in the near future.

There are a large number of side cut brick machines on the market. There are two of special merit.

The E. M. Freese Company of Galion, Ohio has probably the best all-round side cut brick machine in use. There are more Freese machines in Ohio than any other kind of side cut machine. The cutting table is the old style side cut, pallet delivery but of its class, it is the best made.

The Frey Sheckler Co. of Bucyrus are the manufacturers of the Wellsville side cut table, just described. It deserves the credit of being called the most successful modern device for handling side cut brick. Their auger machines are also excellent in every way.

The handling of the end cut bar has attained far greater perfection than the side cut. In end cut machinery the problems of cutting and removing the brick have been solved and there is no limit to the work which may be done, except the limit of the machine itself. It becomes a question of size, speed, power and clay supply rather than ability to handle the output.

End cut bricks when made in double and triple stream dies on a side cut machine, are cut off and handled by hand tables, something similar to the side cut apparatus or by reel cutters also operated by hand. But in all of the successful, steam, end cut machines, the cutting is done automatically without the intervention of any labor.

In all of the automatic cut off tables in use, the bar of clay, as it issues from the machine, is received on a belt, and the friction of the clay on the belt forms the motive power which actuates the cutter. By this means the speed of the cutter is proportioned to the flow of the clay; if it were otherwise, the brick would be of unequal length. The cutter is driven in the different types by either a cam motion, or by gearing, or by link belting and sprocket wheels. The cutter consists of a reel with cross wires which are made to cut down through the clay as it runs under the axis of the reel.

The bricks as fast as they are cut off, are separated by a belt running at slightly higher speed; by increasing the speed of the separating belt and increasing its length, any out put whatever can be removed and taken care of. In some of the recent trials, the enormous quality of 250 brick per minute were produced and handled perfectly. This is at the rate of 150,000 brick per day.

There are machines now in operation which have made an average run for many days at a time of 75,000.

Among the automatic end cut brick machines now in successful operation the most prominent are the following:

1. The Chambers machine of Philadelphia.
2. The Penfield machine of Willoughby, Ohio.
3. The Frey Sheckler machine of Bucyrus, Ohio.
4. The Wallace machine.

Among the third class of stiff mud, brick making machines, there are two of more prominence than the rest.

The first of these, made by the Brewer Machine Co. of Tecumseh, Mich., is a complicated affair. The principle of its action may be described by saying that a vertical pug mill is used to force the clay downward and a large "mud wing" or revolving arm is used to give the final propulsion to the clay. This mud wing forces the clay down into a set of molds, arranged around the periphery of a horizontal table. Each mold box is filled with clay and when full, comes under a pair of plungers, acting vertically, one working up under the clay and one down on it. The clay is thus compressed to a solid block, which is subsequently removed, when the movable bottom of the mold box is elevated to the surface level of the table.

The main point about this machine is that the clay is forced into the molds by a power so obscure in its application that no structure, or arrangement of particles is imparted to it, and the plunger pressure, merely operating to compress a portion of clay already introduced into a confined space, cannot possibly do it any harm in this way. Therefore this machine should be an especially valuable one to apply to clays which are naturaly too plastic for use in Auger mills or Plunger mills. The capacity of the machine is about 25,000 per day.

The second machine of the combination type is called the Grant machine or the Grant & Murrey. It consists of a vertical pug-mill, crowding the clay downward and forward something like the plunger motion of the Penfield plunger machine. A large mud-wing at the bottom of the pug mill forces the clay into a space in front of the plunger, which then forces the wad or ball of clay out into a mold; here it is stamped by a vertical plunger and consolidated into the brick form and again forced out on a carrier belt, which takes it away. The action of this machine is not as clean-cut and desirable as the Tecumseh, the clay beiug subjected to movement 3 times, in getting it into the mold box where it is made into a brick. However, it at no time passes through a die under pressure, or is acted on by an auger, so that the field of usefulness of the machine in working plastic clays may be quite important. Its capacity is about 2500 per day. The structure of the brick made on it from plastic clays is very fair, free from the defects which would surely present themselves in working the same clays by auger or plunger machinery.

A third type of machine, the invention of Mr. H. Camp of Cuyahoga Falls has been built and tested at Greentown, Ohio. It is not properly a combination machine as the clay is formed by a distinct plunger action. But the novel feature of the machine is, that it combines the manufacture of the brick, with the repressing of them, and the automatic delivery on a dryer car so that one man in general charge of the machine can produce 25,000 repressed bricks per day on the cars ready for drying, with no assistance. While this machine has been subjected to the practical test of manufacturing 600,000 brick, in which it gives satisfaction, the company that controls it has not made a success of the plant as a whole and its use was not continued. The machine is a marvel of ingenuity, and without question has the elements in it of a very great success; it is likely that some alterations would be needed to adjust its action if it were being introduced widely.

Repressing. After the bricks are made and cut to length, they are finished as far as their form is concerned and with no further work except drying and burning. They are a marketable product. But paving brick manufacturers have many of them gone farther and submitted their bricks to a second mechanical operation, for producing the finished shape. This operation is called re-pressing, though in most kinds of brick it is not properly *Re-pressing*, as it is the *first* application of pressure in a confined space.

The purposes which makers have in view in the repressing are as follows:

1st. To give their ware new and ornate shapes and marks which are not attainable by use of any die where flow of the clay is produced.

2nd. To obliterate the rough sides or ends caused by the passage of the cutting wire through the clay, and give the brick a smooth, dense skin which shall assist in preventing the absorption of water.

3rd. To produce a stronger, denser, better wearing material than can be abtained by the formation of a bar of clay by passing through a die.

The claims of the value of repressing have been very much overstated at times and the prices of paving materials have been raised and kept up, on the strength of the improved quality and additional cost of manufacture of repressed bricks.

Recently however, a distinct counter current of opinion has set in. Opposition to repressing has heretofore been confined to those who had not provided themselves with the necessary plant for doing the work; the recent movement is coming from those who make both plain and repressed brick and are therefore in a position to know the facts in the case.

The claims of this faction are that the structure of the bar of clay is determined in the auger machine and die and that to take the bricks fresh from the machine, and inclose them in a fixed space, and there subject them to heavy pressure causes a breaking up of the original structure, and that the new arrangement of the brick, particles is not as good as the old. They allege that the new material is not denser than the old and that it will not wear as well, and chips easier. Some few even say that the pressure in the repress die does not permeate the entire brick, but only affects it to a slight depth and that the change in shape which the brick undergoes in the repress die is effected by a surface flow of the clay and not by a rearrangement of the whole structure of the brick, and that this surface flow of the clay produces laminations between the unaffected interior and the exterior.

This last claim is an absurd one, and one which ought not to find credence with any intelligent man. The clay in the brick machine acts like a fluid; it is still able to respond to the same influences when it is put into the repress die. One of the laws controlling fluids is that pressure applied anywhere on it, is transmitted throughout the mass equally.

The repress die must be larger than the brick in two dimensions, in order to admit of the brick being easily and automatically dropped into the die before pressure; hence the dimensions of the plain brick are appreciably changed in all directions and the theory of surface flow being sufficient to account for this readjustment of the mass is absurd. The mass is altered by just such a flow and response to pressure as occurred when it was made in the auger machine die.

The question as to the benefits of repressing hinges on this point. No one can doubt that the appearance of the brick is improved by repressing and that new and desirable shapes can be imparted which could not be obtained in any other way. Also, it is apparent that the ragged surfaces of a side-cut or end-cut brick offer facilities for absorption of water, which a smooth surface does not. But whether the new structure obtained in the repress die is as good as the one first obtained in the machine die, is a matter still open for debate.

In the paving brick tests, conducted by the Survey on Ohio material, (and of which extended notice will be given further on) the twenty-six varieties of repressed material tested, showed a loss in rattling of 17.92 per cent. while the plain bricks, (nineteen varieties) showed a loss of 17.42 per cent. Also the tests of the various brands of brick manufactured at Canton, Ohio, (which were all furnished both repressed and plain, and which are included in the general average given above) show in the rattling test as follows:

Repressed—Loss, 16.43 per cent.
Plain side-cut—Loss, 16.68 per cent.

A special test was made on material submitted by the Holloway Paving Brick Co., and seven repressed brick and eight plain brick were given 1,000 revolutions together in the rattler with a loss of

Repressed, 15.02 per cent.
Plain, 19.56 per cent.

Also, in the same test, one repressed brick each from Canton, Royal, and Williams factories at Canton, were rattled with two each of the same factories, plain. The results here showed,

Repressed, 11.45 per cent.
Plain, 10.12 per cent.

The total average loss of all four brands of paving brick in this special test of 1,000 revolutions showed:

Repressed, 13.23 per cent.
Plain, 14. 84 per cent.

This difference is not great, and the fact that the plain bricks would lose their square corners and edges very rapidly, while the rounded edges of the repressed brick would last some time before the skin would break, indicates that in the average there is little to choose between the two in point of toughness and resistance to abrasion.

This test, however, is a very hasty and inconclusive one: it is merely an indication, not a proof; to make the results conclusive, two kinds of brick should be made so that every other condition except the pressing should be exactly the same. They should be made of the same clay, at the same time, dried alike, burnt in the same course of the same kiln Such material was not procurable however, and the tests as made simply represent the run of the yard when they were selected.

The test which is recommended is a very easy one to make, and is within the reach of any paving brickmaker without expense. The truth of the matter could in this way be easily ascertained.

The method of repressing is much the same everywhere. The bricks are taken as directly as possible from the separating belts, cars or pallets, and fed to a repress machine by a feeder—and the machines now in use are arranged to automatically receive, press and deliver the finished block. Two machines at present are in use in the state.

1. The Raymond Repress, of Dayton. 2. The Eagle Repress, by the Frey Sheckler Co., of Bucyrus.

The Raymond press has by far the most extended use of any machinery of its kind. Other types of represses are in process of construction by other manufacturers, but nothing of any importance is yet on the market, except the Eagle.

The capacity of the single Raymond repress is about 12,000 brick per day of ten hours. It can be run at a speed sufficient to make 15,000 per day, but this speed results in loss of perfection in the work, and rapid wear. Two men are required to run the machine. The latest styles of Raymond press are adopted to press large blocks, like furnace tiles, etc., or to press two bricks of the paving block size together. The construction and action are exactly the same, but the expense of repressing is much reduced, as one man can feed both dies and two boys can receive and pile up the pressed blocks. The best records yet made on the new double press show 26,400 brick in ten hours.

The Eagle repress is also fitted with two dies and makes two bricks at each pressure.

The labor of feeding it and disposing of the brick is just the same as in the Raymond. The machine is guaranteed to produce 22,000 bricks per then ours and it can just as easily produce more as any other machine, since the results are mainly dependent on the work of feeding and taking away the bricks.

The mere fact of repressing is not a good reason for any great increase in price over plain material, but if the qualities of a brick are much improved by repressing, the public should demand that it should be done, and the maker should be glad to do it at a fair profit on the cost.

The labor of three men, estimated at $3.75, is sufficient to press an average of 20,000 per day which is less than two cents per thousand.

Drying. The bricks are ready for drying either when they come from the auger machine, or when they come from the repress.

The work of driving out the water which has been added to secure plasticity in the clay is no light affair. In the course of a day's run in a factory making 30,000 nine-pound blocks, the amount of water used in tempering is not far from fifteen tons. To remove fifteen tons of water from bricks by evaporation once in twenty-four hours is a more serious problem than would appear at first sight.

Paving brick pla ts are in a state of growth or evolution in this country and their mechanical processes, and chemical ones as well, are accomplished in a great variety of ways which a few more years' experience will considerably simplify.

Many firebrick and sewerpipe plants have been converted into paving brick plants of late—hence, we find the methods of drying which characterize the other industries, applied to paving brick merely because the facilities are there. There are also several processes of drying especially designed for the rapid and economical production of brick which have not yet fully demonstrated their value to the public.

The systems of drying, excluding open-air racks, may be classified as follows :

1st. Dry floors.

2d. Sewerpipe floors.

3d. Compartment dryers.

4th. Progressive dryers.

Dry floors are the oldest means of drying used in the regular daily production of a considerable quantity of bricks. The dry floor system has grown up with the fire brick business in which it is almost universally used.

The dry floor system uses a large fire proof floor, heated by a system of flues underneath. The fires are maintained in fireplaces at one side of the floor, and the heated products of combustion pass through the flues, keeping the floor above hot, and unite in a draft stack, at the opposite side of the floor. The bricks are put down in the floor on their edge, or end, and sometimes are hacked up in open piles two or four or six deep: usually, however, the floor is expected to hold the day's run and must be emptied and filled once a day. The longer the floor is made, the cooler the products of combustion will become, and the greater number of bricks can be dried with the same quantity of coal. Dry floors are naturally of all sizes according to the manufacturer's requirements: the best ones are often made one hundred and fifty or one hundred and sixty feet from fireplace to stack, Two hundred feet would not be too long to get the best economy in the use of fuel. The roof over the dry floor ought to be provided with ventilation, to allow of air currents through the room. If other stories are added above the dry floor, the amount of drying which can be done with the same fuel can be greatly increased, as the heat arising from the floor is enough to give very good drying power above. The material is placed on the floor by hand, and is taken off again by hand. Sometimes it is necessary to move the bricks on edge or alter their position during the drying which calls for another handling.

The cost of this system of drying is variable: where slack coal is accessible for little or nothing, it is a cheap plan. Where coal has to be delivered by rail, it is not cheap. The moisture in this method is literally evaporated or driven out by heat. The effect of air currents assists somewhat, but the air is given no adequate chance to do any work.

There are objections to the use of this plan. The unequal heat of the two ends of the floors causes the brick to dry under different conditions and to very different extent, in the same time. When a brick is put down moist from the machine on a floor heated about 212°, the rapid and unequal drying cannot help but do harm to the structure of the brick. There is often a loss by bricks cracking and falling in two from this cause, but the greatest damage comes from bricks whose structure is weakened but not broken, and whose failure after being burnt and transported away for use causes more loss.

The cost of the additional labor and handling required by this method of drying must be included as a part of the expense. In fact, all of the systems of drying in use, are so connected with the means of getting the brick into and out of the drying plant, that the mere cost in fuel and attendance cannot be given as a fair statement of the cost of the method.

Sewer Pipe Floors. Sewer pipe is an article which it is very difficult to dry safely and fire proofing is still more troublesome and hence those engaged in this line of work have perfected a system of drying which, when applied to bricks, forms the safest and least objectionable plan that can be used. However, it entails the use of a very expensive plant, especially if the quantity to be dried daily is large.

The plan of operation is to expose the wares, piled in open order two or four deep on slatted or open floors, to the gentle heat and soft air currents caused by steam pipes placed in open order underneath the floors. The piping is generally applied under the two lower floors, and the warm air from below is sure to rise and assist in drying the wares above. The steam is supplied during the day time by the exhaust of the steam engines and steam presses if they are used. During the night, the use of a small amount of live steam is necessary especially in cold weather.

The principle of this process is the absorption of the moisture o the bricks by simple exposure to warm air. No effort is made to produce air currents and the heat used is usually quite small and cannot be made high without great cost for extra piping and use of live steam. The cost of the process is most manifest in considering the expense of fitting up to use it.

The ordinary period of exposure is about seven days for paving blocks. It can be managed with less time, but seven days is the least time to do the work with the attainment of great economy.

To get floor room capable of holding an output of 30,000 per day and allowing seven days for drying, requires a large, tall and strong building, as aside from the weight of the machinery, the weight on the floors will run from 600 to 1,000 tons.

The labor involved in the use of this process is just the same as in the dry floor; the material all has to be put down and taken up by hand and in addition, the large area of floors occupied by bricks and the number of stones generally used, cause extra expense in getting the material down to the kiln yard after it is dry.

The character of the drying done in this way is the safest, best and most wholesome that can be obtained; there are no violent changes in temperature, or forcing of natural conditions at any point.

The cost of drying by this process after the building and piping are once in operation is very little. Many brickmakers dry during 9 months of the year at absolutely no expense whatever for fuel, which would not be spent in any event, in the production of power. During the balance of time they expect to use a little live steam to supplement the exhaust provided by the power plant.

If the floors are smaller and the time which can be allotted to the bricks to dry is limited, then the use of live steam becomes necessary all the time, and while the drying that is secured is still of a good quality, the use of the heat is not an economical one Many more feet of pipe are required to accomplish a given amount of drying by this way than will be required by other plans; hence the only economy of the process consists in the possession of ample space and equipment, so that by the use of the waste steam and time, the work can be done without extra fuel.

Chamber Dryers. The plan of action of the chamber dryer consist in exposing the brick piled in open bulk to the drying influences of heat and air currents continuously until they are dry and then emptying and refilling the dryer for another change. The dryers are usually built on what is know as the Tunnel System; the compartments are long, low rooms, arranged in parallel order, each compartment being provided with its own heat supply, air supply, and draft arrangement, to carry off the steam and vapor and each compartment being equipped with its own doors, and means of control of all the necessary conditions. In some places, the output is such, that two chambers can do all the work, one being filled and emptied every day while the other is drying its charge. Elsewhere, three compartments are needed, one being filled, another drying and another emptying. Again there may be a large number of compartments operated in rotation as indicated. The methods of generating heat and air currents and draft are essentially the same in these dryers as in the next class and will be described later.

The principle of their action, that of drying a charge by itself and under conditions that it is some one's business to keep right, is a good one. It connot be assailed on any theoretical grounds. But in practice, the dryer is emptied and filled with its air currents and heating arrangements inoperative, and when it is full of a given number of bricks, the heat and air flow is usually put into operation at once. There is great danger of cracking the brick at this stage and only the most skillful manipulation will prevent it.

Progressive Dryers, are those which are being constantly filled with greensware at one end, and emptied of dry ware at the other.

The use of this principle depends on some means of advancing the position of the bricks along the dryer at will. The means adopted in almost all cases, is by use of iron or wooden cars, each capable of carrying a good load of brick without great use of power in moving it.

The use of the car system is not at all confined to progressive dryers, but of the progressive dryer it is an integral part.

The operation of the progressive dryer offers us the best example of the highest type of the art of artificial drying at the present time. The bricks are brought to the rear end of the dryer on their car and passing through double doors are placed in the rear of a line of similiar cars. The heat and air are being introduced at the opposite end of the dryer. By the time the air currents reach the rear end they have absorbed in passing through the great volumes of brick ahead, about all the vapor which they are capable of retaining, consequently, the temperature is low, generally 80 to 100 degrees, and the air is filled with humidity, almost to the dew-point. The new carload of bricks in an atmosphere like this, does not begin to dry at all, but it begins to warm through, till the individual bricks are as hot as the surrounding atmosphere. After a time, the cars are shoved down the tunnel to make room for other cars in the rear. The first car now begins to find itself in an atmosphere a little warmer and not quite saturated with moisture. The water now begins to dry on the surface of the bricks, and as they have been previously brought to a warm steamy condition, the surface evaporation is constantly replaced by moisture from the inside. Hence, there is no tendency for the outside of the brick to contract faster than the inside and therefore no tendency to cracking or breaking. As the bricks proceed onward they yield up successive portions of their moisture and finally emerge from the hot end of the dryer, ready for the kiln. There are a few instances of clays which will not yield to this system of drying as it is ordinarily carried on. These clays are of such a nature that they are almost sure to crack even on exposure to the open air for a half hour after they are made. Such clays as these can only be treated in any form of dryer by the use of special conditions, and the special conditions necessary, are a prolonged exposure to a wet steamy warm atmosphere, so that the clay has an opportunity to become not only hot through and through, but can also have an opportunity to absorb moisture rather than lose it during this heating up.

The theory of this plan of drying is as near perfection as it is possible to attain at the same time with rapid and effective work. Where these styles of dryers are used, it is usually the intention to dry every day the entire quantity manufactured in the day's run. It is usually posible to do so with no harm to the bricks, and therefore to make the investment as small as possible in proportion to the work accomplished, the drying is always estimated on the basis of the shortest possible exposure to the conditions.

It is the preliminary exposure to the steamy atmosphere of the rear end of the dryer which makes the rapid and effectual drying without loss by cracking and checking a "possibility." In the beginning of the tunnel dryer system, the arrangements in rear comprised only one door to keep out the outside air and make the draft arrangements do their work. But great trouble was experienced from cracking of brick, and the draft was found to be taking the lighter part of the atmosphere and the steam out of the top part of the tunnel and the bricks below were in an atmosphere where they were warmed or dried very slowly. Hence the top part of each car was often cracked and the bottom part sound, having been raised to the dryer heat before meeting the dry current of air. Sometimes the reverse of this was found, and was due to the lower parts of the cars going down into the lower parts of the dryer before they have been properly prepared for it.

A vertical sliding door was then arranged inside of the outer door and in front of the stack, so that the entire flow of heated air and steam had to go down nearly to the floor of the tunnel before it would escape into the draft. Thus the whole car was subjected to the steamy atmosphere and the drying was equally good at the bottom and top.

The importance of the preliminary heating up of the bricks in a steamy atmosphere, or one so moist that no drying can take place, cannot be overstated. In any form of dryer where the operations of nature are sensibly hastened, or rather where air currents other than natural circulation are used, it is the key to the success of the operation.

In the chamber dryer, this condition is best produced by shutting off all air flow and producing the moist atmosphere by gentle heat alone until the steaming is sufficiently performed; then the heat and air may be both increased. In the progressive dryer, the effort must be directed to continuously maintaining the atmosphere of the rear end of the dryer in this condition.

The action of air in drying brick has been indicated briefly. The mere use of heat, as is done on the dry floor, is the crudest and most expensive plan; water is literally baked out or *driven* out of the clay.

The atmosphere does its drying by absorption or evaporation of the water from the surface of the wet clay. The ability of the air to absorb the moisture of the clay depends on its temperature and its previous condition of humidity. Dry air absorbs water at all temperatures, but the amount which it will absorb increases enormously as its heat arises. So that in drying a large quantity of brick, in a small space, in a short time, the use of the air as a vehicle for the moisture in the bricks is most important. A strong current of air will of itself dry the clay quite rapidly, even at a low temperature, and in tunnel dryers the production and control of the air currents is of equal importance with the production of heat. The methods by which air currents are produced in tunnel or compartment dryers are two:

First by stacks and second by fans.

The stacks employed are usually tall wooden chimneys, of large internal area, in order to secure the movement of a large volume of air with a comparatively small difference in temperature between the inside and outside of the stack.

The use of fans to produce the air current in brick dryers is increasing rapidly. The advantage lies in the fact that the fan's action is a positive force; that so many revolutions per minute mean so many thousand cubic feet of air per minute; and that the action of the dryer is not made to depend on the natural conditions of the atmosphere, which greatly influence the draft of a stack, especially where the available head is so small.

The stack has the advantage of operating without power or the expenditure of fuel for the purpose, while the fan has the advantage of a positive supply against a variable one.

The means employed to heat the air supply in these dryers are four:

"A." By the Radiation of Hot Floors and Brick work, which is heated by the direct combustion of fuel. The products of combustion pass off in the stack at the rear, without having been in direct contact with the ware in the tunnel. This is the principle adopted by the Sherer Dryer of Philadelphia. A number of dryers of similar design, but each constructed on its own plans, are in operation. One at Middleport, Ohio, is using producer gas as a means of getting the initial heat. The following points can be raised against this class of dryers.

1st. They consume fuel expressly for drying brick while more heat than is needed to do the work is thrown away from the plant unused each day.

2d. They consume more fuel than ought to be necessary, because all the heat they impart to the atmosphere is by the radiation of the heated brickwork.

3d. They involve an extra heavy expense for original outlay, as the structure of the dryer and the brick cars have to be fireproof.

4th. The losses in drying brick are almost universally greater where direct combustion is used, than where steam heat is the supply, as the range of temperature is greater, and the radiating surfaces go clear to the rear end of the tunnel. The brick when newly put into the dryer are therefore subjected to heat underneath them at once, which is not the case where steam heat is applied.

"B" By the combustion of fuel and the direct use of the heated gases, diluted with air as the means of drying. This plan was in operation at one point. A large flat hearth furnace with grate bars was used to burn the fuel and the heat, smoke and gases were drawn away by a fan, and, mingled with the proper quantity of outside air to cool them down to the proper point, were blown into the tunnel.

The operation at the point where it was used was very crude, though successful and cheap. But the plan is capable of modification to give good results. It has some inherent faults, however:

1st. The method of generating the heat is sure to produce inequality of temperature. It is impossible to always get the proportion of outside air mixed with the right proportion of gases from the fire to keep mixture at any given temperature.

2d. It requires a fireproof structure to make its use safe.

3d. The smoke, unless it can be prevented by use of gas fuel, or coke, is a serious draw back to the cleanliness of the place.

In favor of the plan, it may be said that the total heat generated is used, except a very small amount for the radiation of the furnace, and the cost of fuel can be thus kept very low; and also that the plan has the advantage of using the fans or positive blowers without the expense of installation attaching to the usual methods of heating the air supply.

"C." By the radiation of steam pipes placed under the floor of the dryer at its hot end, and extending part way back toward the cold end. This is the plan adopted by the Ironclad Dryer Co. of Chicago who have one of the best and most popular dryers in the market. The pipes are filled with live steam which is kept in the heating coils at boiler pressure. The water of condensation is trapped out and returned to the boiler for use again, so that really all the expense in generating the heat, is the cost of the fuel used in vaporizing the water.

The advantage of the use of steam as a means of generatng the heat required are: 1st. That there is no possibility of getting the dryer very much hotter than is intended; indeed the general mode of operation is to use all the heat that can be obtained. 2nd. The cheapness of construction which is thus possible, using wood and sawdust partitions and no brickwork, or iron work except the running parts of the dryer cars. 3d: The comparatively even efficiency of the heating apparatus even under careless management. If there is any steam in a boiler the temperature of the dryer pipes is over 212°. If the steam pressure is 60 lbs. the temperature of the dryer pipes is 307°. Thus the steam may vary in pressure considerably without materially injuring the work of the dryer. But if a fireman is careless or negligent in tending the fires of direct combustion dryer, it cannot fail to produce bad results by excess or defiency at once.

"D." By the use of a compact coil of steam piping arranged to secure the largest possible heating surface in the smallest convenient bulk. By blowing or exhausting air through such a heater by a fan and conveying the heated air in underground brick flues to the dryer, the amount of heating surface may be greatly reduced over the plan of direct radiation on the dryer.

This is the plan adopted in the Benedict dryer, the Sturtevant dryer and various others. The heaters are all so arranged that exhaust steam can be used during the day, while it is being made, and then be replaced by live steam at night. Also in the Buffalo Forge Company's heater the latest arrangement allows of simultaneous use of exhaust steam, and live steam, in any variable proportion which is desired.

This plan probably presents the greatest perfection yet attained in the art of drying bricks. The use of a fan has many advantages over a stack, and the use of a compact heater, in which the heat of the exhaust can be used wherever it is available and in whatever quantity it is available, enables the manufacturer to do the maximum amount of drying in the minimum amount of space with the minimum amount of fuel, and attention. The efficiency to which these dryers actuated both by stack or fan are now brought is shown by the fact that there are several firms willing to make guarantee contracts to dry a daily output of any size, in twenty-four hours with not over one per cent. loss by cracking in any kind of clay, at a final cost of about $1,000.00 for every 5,000 brick per day to be dried. This cost includes the dryer complete with tracks, turntables, iron cars and transfer cars—in fact everything necessary to the operation of a progressive dryer with the car system. The cost per thousand after the dryer is in operation depends on the fuel, on whether live or exhaust steam be used, and in the arrangements of filling and emptying the dryer. Under good conditions the cost can be reduced below twenty cents per 1,000.

In most brick plants the exhaust steam of the engine if applied in a condensed space and used to impart a low heat to a large body of air under constant motion, is sufficient to do three-fourths of the drying. Economy demands that either the waste heat of burning or the waste heat of manufacturing should be used.

Two plans are open to the manufacturer who wishes to get the maximum economy in running expense, rather than the minimum first cost of investment.

Either the exhaust steam of his engine should be made to do all that it is able to do toward drying the daily product, in which case he is justified in using a common engine not especially economical of steam, or he must dry his bricks by the waste heat of the burning processes, and get the utmost efficiency out of the boiler fuel by use of compound condensing engines.

The waste of fuel now going on in most of the brick factories in the drying process seems almost as criminal as the fearful waste in mining the coal from its underground resting place.

Many factories are employing low grade steam engines, whose best economy of steam consumption is very poor, and are over-burdening them so that not over one-half of the possible economy is attained, and then are throwing away into the air the heat which would more than suffice to dry their whole output. In addition, they calmly proceed to draw on their already over-taxed boilers for live steam for their dryers or else use the still worse plan of burning up fuel direct for this purp se. And to all these wastes the burning and cooling kilns of brick are every day throwing out waste heat enough to dry all the daily product twenty times over.

There have been several attempts made by manufacturers to use this absolutely wasted heat from the kilns. No method worthy of general adoption has yet been devised. In one place the kilns are located in a leanto building alongside the main shop. The kiln shed is made tight and has an iron roof. The heat arising is accumulated under this iron roof and directed into the upper stories of the main building, through a row of openings. There being no outlet above in the main building the claim is made that the hot air is forced as it cools to descend by displacement and as it goes downward it dries the wares exposed on the floors. The air current is finally allowed free exit at the bottom. The operators and inventors of this system, which they call "Down draft drying" lay great stress on its benefits. In addition to the heat of kilns, however, the boilers are in the center of the factory on the lower floor and the heat radiated from this source is in itself no small factor in keeping the drying conditions up to the mark. In addition to this economy of drying, the generation of power is accomplished by use of a high grade Corliss engine, so that the best economy of steam consumption possible with the use of non-condensing engines is attained.

In another place, the kilns themselves are located in the basement of the building, which when completed will contain several stories of slatted floors above. The heated air rises in this case directly through the wares and escapes at the roof in ventilators.

In still another place the wares are placed in the kiln in a semi-dry condition and by use of a fan system connecting all the kilns in the place, the heat is abstracted from a cooling kiln and, mixed with the proper quantity of cool air from outside, is blown into the newly set kiln; by this means the temperature is slowly increased until 230° or 250° or even 300° is attained, when the burning proper is commenced. Though this is a drying process, it is attained in the kiln, and not in the dryers, and it is conducted on material in which the moisture is not to exceed five per cent at most. It would be hardly applicable to the proces of paving material made from stiff mud, which must be approximately dry before being set in the kilns.

Though there are grave objections to the use of any of these three plans, yet they are all based on the proper line of action; the improvements which will come to the drying process are sure to be in this line, for in the burning and cooling of clay wares of any kind there is more heat wasted than will dry twenty times the output, and the recovery of the necessary portion of it is only a question of time. With this economy would come the less important but much needed use of high grade power generation, by which the full value of the fuel in the boiler room can be secured.

The Burning of Paving Material. The delicacy and importa ce of this part of the process have been previously alluded to in various connections in this article. Much of the trouble heretofore has lain in the fact that the pioneers in this business have had to build their own roads and find their own way, for while there is very much in common in the burning of sewer pipe and paving brick and in fact any vitrified clay ware, still the difficulties involved have not only been those of vitrifying larger masses of clay than was ever before attempted, but in also satisfying a market that did not yet know what it wanted.

What is really desired or needed to produce a perfect paving material is now beginning to be better understood, and as it is in the burning process, where these qualities are largely made or lost, it is best to discuss the subject in this connection.

The qualities which a city street must have, to make it a good investment for the tax payers who build it are:

1st. Durability under heavy traffic.

2d. Sufficient smoothness to make traction easy and comparatively noiseless, and yet not such smoothness as to make it slippery for horses' feet.

3d. Reasonable cost.

4th. Good sanitary qualities; that is, that the street as a whole or the material of which it is composed shall not be absorbent of the filth which always finds its way there, and thus becomes a receptacle for disease.

Without entering into a general discussion, it is safe to say that vitrified clay is undoubtedly the most satisfactory material now in use in regard to the 2d, 3d, and 4th specifications and that the position of brick pavements yet remain to be proved in regard to the first point. Sufficient time has not yet elapsed since the laying of any street with what we *now* call good brick paving material, to enable us to make a deduction as to its relative wear and cost compared with granite or other natural stone.

The qualities then, which must be possessed by bricks to fill these various requirements are:

1st. Vitrification—by which the ma'erial becomes indestructible to weather or any natural influence it will have to endure.

2d. Toughness, which enables it to stand friction and blows without undue wear.

3d. Uniformity—which prevents the early failure of the material in spots, which very soon extend to the ruin of the whole.

Vitrification, as we have already shown is wholly a matter of burning. Toughness is a quality which depends on three conditions;

1st. The natural quality of the clays, some of which produce tough ware, and some which do not.

2d. The burning, which may be so managed as to destroy this quality wholly.

3d. The cooling or annealing process, which, more than anything else, makes a brick tough or brittle.

Uniformity is a quality affected by two forces; 1st. The process of manufacture, which ought to secure by its machinery material of very great homogeneity; 2d. The burning, which can be managed so as to make but little variation in the different parts of one kiln, and also between the product of different kilns.

So that in the burning more than in anything else, the value of the material for paving purposes depends.

The chemical processes of burning are those which have been previously set forth. The only point of variation consists in the large size and area of the clay body which is to be vitrified and the greatly increased danger of bloating in driving off the combined water.

The custom of glazing paving material has been much discussed and agitated. A popular impression, carefully fostered by the manufacturers who do not glaze, is to the effect that the glaze is a surface veneer which merely adorns the surface of an otherwise unprepossessing material, and that, as a rule, it is used to allow bricks which are too soft in the center to pass inspection. There is no foundation for this belief. As a matter of fact, the glaze of a paving brick is harder than the substance of the brick; and in addition to this it is a fact that very few clays can be successfully and handsomely glazed which have not been thoroughly burnt. Instead of casting suspicion on the quality of the ware, it is more often a proof of its quality. Salt glazing cannot be made to take effect on clay ware at any low temperature; and the presence of any salt glaze is presumptive evidence, though not a positive proof, not only that the brick has been at the vitrifying point, but has been held at that temperature until thoroughly soaked with heat; for practical experience of those who have used salt glaze invariably goes to show that their glazing is only satisfactory when a kiln is thoroughly burnt. Thus the salt glaze in paving material is a source of benefit to the public and makers on the following accounts: First it delays the wear of the surface for a time, and assists in preventing absorption. Second, it is an indication but not a sure proof of satisfactory vitrification, and thereby assists in culling out soft material.

The attention of the maker or public is always directed to that portion of the product which is "off color" and different from the rest; in salt glazed goods this portion included most of the soft material. All the unglazed portions of a kiln are not necessarily soft, because many clays will not readily glaze, owing to the presence of lime salts. So that it is not fair to count glazed material as good, or all unglazed as bad. Nevertheless on a yard where salt glazed goods are made, the good material is largely found among the glazed, and the bad is largely found in that devoid of glaze.

No intelligent objection can be raised against salt glaze, except from those makers who are trying to make paving blocks and building brick in the same kiln at the same time. In this case, the glazing of a few courses of the building bricks is likely to happen and is undesirable, for in building material a certain amount of porosity is essential and a glaze interferes with it.

The Kilns in which the burning of vitrified clay wares is accomplished, do not vary much in reference to the kind of the ware to be burnt, consequently the kilns in use are most of them used indiscriminately by the makers of vitrified wares.

The conditions which the satisfactory drying of clay wares demand have been seen to be definite and concise. Any radical departure from these conditions is fatal to the success of the operation, and that form of dryer in which these conditions can be most easily brought about, or has the most power to vary these conditions slightly to suit the peculiarities of the clay under treatment, is the one which meets the surest and widest success.

In burning vitrified clay wares, also, the conditions under which success can be obtained are comparatively sharply marked; to produce and obey these natural conditions must be the aim of any successful kiln constructor or operator.

The first condition of success in a kiln for burning paving material is the use of fireplaces which not only admit of regulation and control, but enable the burner to consume large amounts of fuel without making poor combustion, and which will allow the cleaning of the fires without the loss of great heat or time in the operation.

In burning paving material the heat, after being carefully and gradually raised to the vitrifying point must be held there for some time, to allow it to "soak in" or permeate the entire body of ware, also the various parts of the kiln are not likely to obtain the proper heat just at the same time and the production of heat must therefore be under accurate control. The vitrifying action takes place over quite a range of temperature and it is the aim of the burner to hold the heat at a point where the vitrifying action will take place slowly and without failure of the shape of the ware. Also, the burner must be able to produce and maintain high temperatures for long periods.

If the fireplace be of a type that is difficult to clean when under full fire, the loss of fuel and time in clearing fires becomes a serious item in the success and cost of the operation.

There are a number of types of fireplaces in use:—The most important ones will be described.

1st. The outside furnace is used in a few kilns. It consists usually of a square brick structure with flat arched roof provided with firedoor and ashdoor in front and with a flue leading into the lower part of the kiln in rear. The fire is maintained on grate bars similar to the furnace of a steam boiler.

There are many objections to this style of fireplace. 1. The production of heat is too far away from the scene of its usefulness. 2. It is hard to clean the fires thoroughly. 3. The fire is not under good control, as, on flat grate bars, the air is apt to burn through the fuel in holes and thus allow the heat to be lowered without the burners' knowledge. The radiation of the furnace is great and causes a loss of fuel on this head. One very serious objection lies in the fact that the outside furnace invariably causes heavy smoke during firing and for sometime afterwards. This is due to the fact that when fresh coal is thrown into a furnace full of incandescent coals, the evolution of gasses is sudden and strong. These gases cannot get enough air in the furnace for complete combustion and are "fixed" or "cracked" by the high heat of the walls and brickwork around them. In this condition they go into the kiln and though they meet plenty of free oxygen there to burn them completely, the temperature is seldom high enough to cause ignition. It is a general rule among fuel and combustion experts, that "smoke once formed, remains smoke." The only way to prevent it, is to cause complete combustion of the gases at the point of their formation, and before they escape from contact with the incandescent objects around them.

The objections urged against the economy and success of the outside furnace, are of a sweeping character; indeed, but little can be said in favor of this method of heat generation which does not apply with greater force to every other kind of fireplace.

Careful examination of the fireplace as seen in operation in many points has demonstrated the essential truth of all of the theoretical considerations advanced.

2d. The inside furnace, is a flat hearth, grate bar furnace similar to the first described,except that it is buiit in the walls of the kiln and foot of the bags, instead of the outside of the kiln. Its firedoor and ash-door open flush with the outside of the kiln wall. The same faults as to regulation control and ease of cleaning, can be urged against this kind of fire. But as to loss by radiation, and opportnnity of complete combustion of gases, no fault can be found. The objections to this fire are confined to points of ease and expediency in manipulation rather than in radical defects of the combustion itself.

3d. "The open front, incline grate bar fireplace," is perhaps the commonest style in use. Without the bars the fireplace merely consists of an opening into the kiln wall about eighteen or twenty inches wide, three feet high and extending from the bagwall in the inside to six inches or a foot outside the line of the kiln's circumference. The grate bars are hooked at the upper end over a cross bar near the top of the projecting side walls of the fireplace and the bottom ends rest on the ground or over a second cross bar lower down. In this fire the flames proceed directly through the bag which acts as a combustion chamber up into the kiln. The incline grate allows the air to play freely beneath the fire, but also allows the burner to see that no air holes are allowed to form through the coals to the interior. The bars being loose are easily moved about in cleaning the fires. The loss of heat by radiation is large; the fuel is piled up level with top of the fireplace when freshly replenished, but as soon as it burns a few moments, it settles down allowing a constant stream of outside air to flow into the fireplace *over* the surface of the fire. This air is often needed to promote good combustion but in this type of fireplace it is not under control and frequently much more than needed is allowed to enter.

4th. "The closed front, inclined grate bar fireplace" in use on the Akron stoneware and sewer-pipe kilns, is one of the best fire places in use. It is fired from the end as in the preceding, but the front is arranged to be closed tight by a door or tile and the only influx of air into the kiln except that which works through the mass of hot coals on the incline grate, is admitted from small holes in rear of the firedoor and which are under control of the burner.

The character of the work of this fireplace is of the highest type; it is practically a gas producer, applied to the needs of the brick kiln; no better control of the work of the fire can be had by any means, but in cleaning the clinkers out from the grates some inconvenience is felt, especially when burning the fireplace for six or eight day campaigns; in its original work it was never necessary to clean the fire thoroughly during the progress of the short burn.

5th. The last important type of fireplace is hard to describe by a name. It is fired from above, not from the end as before and no grate bars are used. The fireplace consists of a space eighteen inches wide by th ee feet deep and extending from the bag wall inside to about eighteen inches beyond the kiln in the outside.

The front is closed by a permanent or movable brick wall, leaving an aperture about 18x18 below it to serve for an ashdoor; on top, the aperture is 18x18 and is provided with a tile or metal cover. Across the fireplace close to the circumference of the kiln, a 12x24 tile is placed vertically on its edge, its top flush with the top of the fireplace. This serves to make a false front for the fire and to hold it back from dropping down into the foot of the bag too far. Between the tile and the kiln wall a small space is left which on being opened or closed acts as a damper in controlling the fireplace and perfecting the combustion.

It is impossible for any air supply to get into the kiln except what passes up through the fire from the ash door and down through the fire from above. Hence all the air is converted into combustible gases which continue in combustion through the bags and into the kiln.

The advantages of this fire are: 1st. There are no grate bars to burn out. 2d. It can be cleaned from clinkers with the greastest possible facility and the least loss of heat. 3rd. The character and amount of the combustion is entirely within the burner's control, for by admitting air in front of the fire the draft in the fire is diminished. 4th. The radiation is at a minimum. 5th. The comsumption of coal is at a minimum. 6th. The quality of the coal used may be very inferior with no further trouble than increased frequency of clinkering, for the fire acts like a gas producer and will consume any kind of inflammable material with a production of hot flame.

The two last fireplaces are the best in use and are easily adapted to any form of kiln. Between the two there is little to choose in point of efficiency; the latter, especially, when provided with the movable front wall is the easiest to clean and manipulate. Comparing these two and any of the other types, there is a distinct economy in coal, in their favor. The saving is slight in the case of the second and third forms described, and considerable in the case of the first.

The second condition in the arrangement of a successful kiln is the use of means to produce a strong draft and yet one wholly under control.

In burning material in down draft kilns, the course of the heated gases is directly contrary to nature. They must go *downward*, through the wares, before they can escape *up* through the stack. The advantage of the use of this downdraft is in the greater regularity of the distribution of the heat. In updraft kilns, the gases establish certain channels which offer the easiest passage upwards. The burning is thus apt and, in fact, is nearly sure to be irregular or uneven. In the downdraft kiln, the heat progresses downward inch by inch as the draft maintains a constant flow from above to below, and this distribution is nearly even in every part of the kiln.

To produce this draft, a stack has to be provided which will have sufficient "head" or power to cause this temporary defection of the heated gases from their upward passage.

The best form of stack for producing this draft is a matter which has furnished ground for much discussion and disagreement among clay workers. There are several plans in use:

1. Single stacks—or one separate stack to each separate kiln.

2. Compound stacks—or stacks which have two or more kilns dependent on them. The stack may be divided at the bottom into compartments looking upwards so as to prevent the different currents of gases from baffling each other, but the stack-pipe is one chamber for the greatest part of its height above ground.

3. Multiple stacks—or the use of two or more small stacks, all working on one kiln space.

Single stacks for a round kiln are preferable to any other arrangement, on account of the following reasons:

1st. The draft on the kiln in question, being always actuated by one and the same stack is always approximately uniform; or rather it varies through approximately the same cycle, each burn; the only sources of variations would be in the state of the atmosphere and the closeness of the setting of the ware in the kiln. In a compound stack, the draft varies greatly according to the number of kilns on full fire at once, and the burner, unless he is a man of intelligence and good judgment, is likely to have constant trouble from this cause, and no matter how good judgment he may possess, the more judgment required, the more frequent will the failures be.

2d. One stack permits of more easy regulation than two or more. One damper affects all parts alike, while in multiple stacks the number of conflicting currents prevents the burners from securing very accurate regulation.

On the other hand, it may be urged in favor of the compound stack, that the heat of one kiln, just finishing or cooling off, gives powerful assistance to the draft of another which is just starting and whose draft is therefore in the weakest condition. This assistance is of great benefit in getting through the drying out and heating up stages of the burn, but as previously shown, it becomes a source of danger when the vitrifying stage is attained. Also in favor of multiple stacks it may be urged that they are cheaper to construct than one stack of any pretensions, and also they have the great advantage of using no yard room, being built in the circumference of the kiln walls, and thus affording greater economy of space and convenience of arrangement than can be attained with either single or compound stacks.

In producing the draft of square kilns, the conditions vary somewhat from those of round kilns. By a square kiln is meant a rectangular one; not one of equal length and breadth. In fact the square kilns in use, are usually eighteen feet wide, by seventy or eighty feet long. In kilns of this size, it is impossible to devise any plan which shall enable one stack to reach the various parts of the kiln with equal efficiency. Therefore, a multiplicity of stacks is a necessity in this type of kiln. But they may still be arranged so as to be under as much control as the single stack on the round kiln or they may be arranged at such frequent intervals along the sides as to produce entirely different effects.

The most excellent burning that was seen in the state in a rectangular kiln was accomplished in one which was about thirteen feet wide by thirty feet long. The stacks were arranged at both ends of the kiln and the main central flue connected each stack. This flue was divided by a horizontal partition into a top and bottom compartment. The bottom compartment, opened only into the central third of the kiln's length, the top parts drained the two end thirds of the kiln, each to its own stack; by dampers the whole draft or any part of it could be directed to either end or the center. By such an arrangement, where control is possible, two or more stacks are an advantage; in fact, in long kilns they are almost a necessity to secure anything like the best work. By the use of a large number of small stacks built in the kiln walls the problem is somewhat complicated, and control is more difficult in proportion to the number of vents and number of currents to regulate.

Whatever the method of production of draft and there is certainly room for honest difference of opinion as to what is best, especially in the two main types of down draft kilns, the functions which that draft has to perform are always alike. It must carry the hot products of combustion down through the kiln; it is the vehicle which transfers the heat from the fireplace to the wares.

The amount of the draft, or rather the rapidity of the flow of the gases is a matter which each burner must regulate for himself. If the flow is too rapid, the heat will not have time to soak or penetrate the substance of the clay wares, but it is whisked down through them and out at such a speed that only a surface heat is imparted to the wares. Every crack and opening is supplying outside air to nullify the effects of the combustion of the fuel in the fireplace, and while the consumption of fuel will be enormous, the progress made in the burning will be very slow.

The other extreme, that of having too little draft is nearly as bad; the consumption of fuel is also heavy in this case for the burning process is prolonged day after day in a vain attempt to draw the heat downward to the lower portions of the kiln. In this case the upper portions become overburnt and cindered and the lower portions are still soft and unfinished. No skill in manipulation can help a kiln out of trouble from this cause. It is a *sine qua non* that there must be draft enough; too much is easily regulated by a damper, but too little cannot be remedied in any such way.

The proper amount cannot be laid down in any fixed rule. Every kiln and every clay has its own character. The best way of determining the correctness of the draft pressure is by a study of the results of the kiln. If the top is always overburnt and the bottom soft, an increase is needed. If the bricks are hard on the surface and soft in the center, decrease the draft. When it is right, the vitrifying temperature ought to be produced first on top and then downwards, course by course, until the bottom of the kiln is reached. A complete burn in any good round kiln, set with dry bricks of moderate heat-resisting power, ought not to occupy more than seven days, in burning clean to the bottom course, and allowing three days for the preliminary heating up and raising of fires, and four days to the finish. If it takes more than this, the draft is in need of regulation, either more or less is required, except in clays of more than the usual difficulty of vitrification, which demand from one to two more days to attain their best properties.

3rd. The next essential condition in the burning of vitrified materials, is the uniformity of distribution of the heat over the area of the kiln. The control of this distribution is obtained by the construction of the hollow bottom of the kiln; in all down draft kilns, the floor, or level in which the bricks are set, is merely a false structure designed to hold the weight of the material to be burnt, while the gases find ready circulation through and beneath this floor, and from this lower level they make their escape to the outside.

On the arrangement of this lower flue area or "bottom", the efficiency of the kiln largely depends.

There are very few, if any, kiln bottoms in which an adjustable control of the gases is attempted. The only feasible plan seems to adjust the arrangement from burn to burn according as the results indicate a need of more or less draft in certain areas.

In rounds kilns the different kinds of bottoms employed are very numerous. It is impossible to describe all the types, and the variations among these types are innumerable. A few of the most important will be mentioned.

1st. The main flue from the foot of the draft stack runs to the center of the kiln and is there crossed at right angles by a flue of equal area, running across the entire width of the kiln. The stack flue is covered over; the cross flue is open to the top; the pier walls which support the floor run at right angle to the cross flue and they are usually built of "pigeon work" or checker work to allow free movement of the gases back and forth as well as toward the point of draft outlet.

The tendency of this bottom is to produce a zone of good burning for a short distance on either side of the cross flue, and best in the center of the kiln, leaving the opposite sides furthest from the center, soft.

2d. The main flue from the floor of the stack runs into and straight across the kiln. A circular flue or ring flue runs around the inside circumference of the bag walls and communicates with the main flue at the point of entrance, nearest to the stacks. The portions of the straight flue and ring flues nearest to the stack are covered over, wholly or partially; the pier walls run at right angles to the main flue. This bottom is the main feature of the socalled New Discovery Kiln, which is sold under yard rights and "protected by patents." (?) The trouble with this arrangement is that the draft tends to take the shortest course to the stack and though the front is more or less blockaded to prevent this tendency, still the draft will take the shortest course accessible, to the neglect of the more distant parts of the kiln. The principle of this bottom is therefore less rational than the first described.

3d. The flue from the foot of the stack goes to the center of the kiln, being open on the top from the circumference to the center. The pier walls are built in a series of concentric circles, each circle being cut by the main flue at one point. The floor bricks are arranged as nearly as possible at right angles to the pier walls and therefore radiate from the center like the spokes of a wheel.

This bottom besides being very hard to clean and repair, still allows the front half of the kiln to rob the rear half of its fair share of the draft.

4th. The main flue runs from the stack under cover to a central well hole which is open to the top. From this wall, radiating pier walls run to the circumference.

By this arrangement, the draft of any one part of the circumference is as good as any other, but the tendency is for the draft to take the shortest cut to the center of the kiln leaving soft bricks all around the circumference.

5th. The main flue runs under cover to a center well-hole, which is partly covered with impediments to the draft. From the well-hole a number of flues radiate under cover to points around the the circumference of the kiln, where they come to the surface with an open top. By this arrangement the draft is equal in all parts of the circumference, and in addition, the excess of the draft which cannot get through the apertures above the well-hole is diverted to the circumference of the kiln, by which the most even distribution of the heat can be effected.

6th. The flue runs under cover to a center well hole which also is nearly covered up by tiles. From the well hole, 8 or 10 flues radiate under cover, to a ring flue which runs with open top around the kiln in front of the bag walls. By this arrangement, practically all the draft is made to escape from the kiln from this ring flue. No section can possibly have any advantage over another. And the heat of the kiln being brought to the floor in a zone around the center and near the outside is bound to travel to the center by induction.

This arrangement is often varied by making the only points for the draft to leave the kiln to be a set of holes between each bag. There is danger in this plan, especially when burning brick, that the outsides will become hot too far in advance of the center and accordingly a little heat is usually allowed to find its way into the well hole direct, without going to the circumference of the kiln and then traveling back to the center under cover.

7th. The flue system is sometimes arranged as in 5 and 6, under a solid floor; the ends of the flues being marked merely by holes of small size. The small flues are then made of the material to be burnt, by setting it with this point in veiw. This kiln has one great advantage. It can be cleaned every burn with no expense, while the others are some of them very expensive to clean from the sand and ashes and brick dust and chippings. The distribution of the heat in this style of bottom is not apt to be as good as in a permanent checker floor.

There are two principal points which ought to be always provided for in the construction of any round kiln bottom.

1st. Make all the draft accumulate in the center of the kiln, before conducting by a covered flue to the stack. By this plan only is it possible to give every point of the kiln an equal chance for draft.

2d. Arrange that the largest part of the draft shall only get to the center, after having passed through the floor of the kiln and then travelled through covered radial flues from the circumference to the central well hole. By this forcing of the draft to the circumference, only, is it possible to get the outside portions as hard burnt as the center, for the circumference is constantly cooled off by radiation and cold air leaking into the kiln and perhaps water, etc., while the center is surrounded by heat on all sides and is bound to become equally hot with the outsides by conduction alone if it is furnished no draft at all.

If these two principles are adopted in reference to the arrangement of the bottom, and good economical fireplaces are used and a single stack of sufficient size with proper dampers for controlling it are provided, the round down draft kiln cannot fail to be a good and satisfactory means of producing vitrified clay ware. There is another point of importance, which directly influences the economy of fuel and time, etc., but it is subsidiary to these essentials without which the highest grade of results are impossible. This point, which has great influence in assisting the draft to bring the vitrifying temperature down to the floor of the kiln, is the relative height of the kiln floors and the fireplace floors. The fireplace floor or gratebars ought to be placed 36 inches lower than the kiln floor or as near this as the conformation of the kiln yard and surroundings will admit. The reason is twofold; 1st. The lower part of the fireholes and bags become choked with clinkers during the progress of a burn and therefore cease to radiate heat to any extent. If the floor of the kiln and the foot of the bag are on the same level, the bricks around the foot of the bag will not be heated by radiation and the draft will pass them by in a more direct course to the escape points, and a constant percentage of soft material around the bags and walls at the floor may be expected. If however the floor be 18 or 24 or 36 inches up above, the bag wall is always hot at that point and by its radiation powerfully assists in drawing the draft away from the center and other favored spots to those which are naturally cold.

2d. The deeper the kiln bottom, with its network of flues is set in the ground, the more trouble from dampness and water from outside and the more time and more fuel are expended in getting the heated currents of gases to penetrate it and the higher will the stack have to be built, in order to obtain the necessary head to overcome this natural reluctance to go down.

By raising the floor, the bottom can be made very shallow, and not only is the extra expense of a higher stack saved, but the draft of the kilns begins earlier in the burn thus heating up faster and saving in this way both time and fuel.

In some situations, the establishing of a different level for the kiln floor and the firing floor, is a decided inconvenience—but wherever it can be obtained it is well worth all the inconvenience it costs, in the increased and regular percentage of hard burnt wares.

Among all the various types of Round Kilns in the state it is hard to select one which unites the greatest number of favorable points. The kilns of the Hocking Clay Company at Logan and the Haydenville Company at Haydenville are probably as uniformly successful as any kilns in the state. Their bottoms are of the best type possible; their fireholes, using inclined grate bars, are not as economical in fuel or labor as the kind fired from above and without grate bars. The stacks are four to a kiln in one case, but merely divide the draft of the well hole into four parts so that no irregularity in the division of the draft is possible. In the other case a single stack is used, on one side of the kiln. The floors are flush with the bottoms of the fire holes.

Another most successful kiln is that devised and used by H. B. Camp at Cuyahoga Falls. In this case, the floor is raised about twenty or twenty-four inches above the firehole. The latter use no bars, are fed from on top and have their front wall made of a cast iron plate or clamp lined with firebrick—the removal of this clamp allows great saving of time in cleaning out the fireholes after a burn is over.

The stacks are in all cases separate and outside the kiln.

At the works of the Cincinnati Sewer Pipe Company at Cincinnati are four kilns built from English designs which have been in operation for some years. Their novel feature is the use of a central stack running up through the arch roof of the kiln.

The use of this central stack has some great advantages:

1st. It enables the greatest economy of construction possible in any form of round kiln.

2d. It becomes hot as soon as the kiln is lit, and affords a draft at once which makes it the quickest acting kiln in use.

3d. The central stack, becoming highly heated, radiates its heat powerfully, and assists in bringing the center of the kiln to its final heat as early as the sides are ready.

4th. The central stack renders a very shallow kiln bottom easy to arrange, so that little or no difference of level of the floor and fire holes is necessary.

As a means of burning, it is the nearest perfection of any kiln in use. Against it however the following points can be raised.

1st. The cubic contents of the stack kiln room is lost each burn. This area in a twenty-six foot kiln with a three foot stack is only about 1.5 per cent. of its cubic working space, so this loss is not serious.

2d. The center stack is in the way of drawing and setting, especially when using cars—for bulky articles like sewerpipes th s interference is more serious than in bricks, where less lost space is necessary.

3rd. There is the possibility of frequent repairs to the central stack, if the bricks used in its construction are not of the best and the work carefully put up.

The disadvantages do not counter-balance the advantages and it is strange that the virtues of the kiln should have been so long unnoticed

In square kilns the arrangement of the flues or bottoms is much less thorougly worked out than in the round.

There are several types in use however. 1st. A solid floor with a deep flue from end to end of the kiln down the center. In the Hallwood Kiln the flue communicates with a stack at one end. In the Thomas Kiln a stack at both ends is provided. In the Griswold Kiln a stack at one end is used with a horizontal partition in the flue, dividing it into an upper and lower half in the two-thirds of its length nearest the stack. By the use of a damper the heat can be made to escape all from the front end of the kiln or all from the back, or in any ratio between, that is desired.

This principle has been applied to the other kinds mentioned, though in different ways of manipulation.

In the Eudaly kiln, which is nearly always built in the rectangular form, the floor is a checker bottom which is divided up into sections by dead walls from end to end and crossways. Each section is drained by a small stack, built up in the sidewalls of the kilns. The claim is that by the regulation of the draft of these stacks the most perfect uniformity can be obtained. This theory certainly looks plausible, but in practice it is nearly always found that the heat takes the shortest course toward the outlet and that the portions of the bottom near the dead walls and partitions suffer from lack of draft.

The Excelsior kiln is practically the same as the Eudaly in form, but its bottom is made of pigeon work partitions so that the currents freely circulate from one part of the kiln to another in response to movements of the dampers in the stacks. In addition the furnaces of the Eudaly are replaced by incline grate bar fireholes, which make no smoke when firing. The kiln is a great step ahead of the Eudaly in its operation while embodying all of the structural advantages and shape of the latter.

The Yates Kiln is another kiln very much like the last two; the stacks, instead of issuing from the sidewalls of the kiln, run up the outside of the crown in pairs and meet in a line of low stacks along the centers of the crown. The fireholes are of good type; the dimensions and shape and structural points are almost identical with the former two. The patentee claims great advantage from the use of one stack in the center of his kiln instead of two on each side. The reason for any great superiority by virtue of this point is not apparent, but the use of the improved fireholes is certainly commendable. Nearly all of the patented kilns in the market are of the square form—only one or two round kilns being in use which are operated under patents.

The value and utility of any of these patented kilns have received a severe check in the last few years in the fact that the results attained in several forms of the common round down draft and two forms of the square downdraft have been continuously and steadily of a very much higher grade than any of the patented kilns have been able to attain; under these circumstances, the advantage of paying a large royalty or yard right is not apparent and it is now chiefly confined to those who are entering the business for the first time and are not familiar with the results of modern practice.

The statistics of the kilns actually in use in the state will prove of interest in this connection.

A—Paving Material.	
1. Round down drafts—	
Common unpatented	252
New discovery	20
Eudaly	4
	276
2. Rectangular down drafts—	
Unpatented	20
Eudaly	41
Yates	3
Hallwood	3
	72
3. Updraft clamps used in burning paving material—	
Updraft	16
Total kilns	364
B.—In the sewer pipe business the kilns employed are:	
1. Round down draft	369
2. Rectangular Akron downdraft	79
	448

The total number of kilns in the two industries is 812—of which 621 or 76.4 per cent. are round and 191 or 23.6 per cent. are all other kinds together.

Of these round kilns, those used in the manufacture of brick have an average diameter of twenty-five and one-tenth feet, and an average capacity when set 25 courses high, of 30,000 bricks.

If set full, the capacity would be about 40,000. The maximum diameter is thirty feet and the minimum seventeen feet. Of the sewerpipe round kilns, the average diameter is twenty-seven and three tenths feet with maximum and minimum diameters of thirty-three and twenty-two feet.

The production of paving material has now been as fully discussed as the space will allow. The clays, their preparation, their manufacture, their drying, and their burning have been treated. Much remains to be said about the methods of handling the output, arrangement of plants and similar questions which would be useful and interesting to those engaged in this line of work, but their remains available space for the discussion of only one more topic in this connection, which is the testing of paving materials and the results of the Ohio materials which have been subjected to official test.

The Testing of Paving Material. The testing of paving material has been subjected to more inquiry and discussion perhaps than any part of its production.

What constitutes the best means of testing? As previously described, the qualities which paving material must possess must be vitrification, toughness and uniformity. Of the latter point, inspection is the only test of the ability of the manufacturer to deliver bricks by the thousand and hundred thousand of one uniform hardness, toughness and solidity.

Of the vitrification, the ability to absorb water has been constituted the official test. As usually carried out, two whole bricks and one broken in halves are dried carefully at a low heat, as over a register or in a radiator or on top of a boiler setting. This drying should be continued not less than forty-eight hours. This drying is necessary to expel water accidentally introduced into the samples, or introduced for purposes of fraud. When dry, the bricks should be weighed separately, and in the aggregate,in scales fit to distinguish the influence of one fourth of an ounce. The bricks shonld then be soaked forty-eight or seventy-two hours in clean water and then removed, wiped dry and weighed again. The increase should be reduced to a percentage of the dry weight, and reported as such. The average of the three is to be taken as the correct figure, provided none of the samples fall conspicuously below the required standard.

Under such treatment as this, vitrified material ought not to show a gain of over two per cent. In Cincinnati and Louisville, the specifications of the city engineers make two per cent the maximum limit which will be received. This practice is gaining ground in other cities where brick pavements are being adopted. Certainly there is no safety in allowiug the limit to be raised much over this point. There is some material which might stand very creditably in actual use which would show an absorption higher than this amount, but it is only where extreme toughness is combined with high refractory qualities that these conditions are met, and such material while possibly good in some cases, is apt to prove dangerous in the long run.

On the other hand, it is not politic to insist on too high a degree of non-absorption, as manufacturers are likely to burn their material past its best physical strength and toughness, in their endeavors to produce a thoroughly vitrified ware.

It should be the aim of the paving brick maker to use a clay which vitrifies early in its burning; that is one which vitrifies easily; such clays often show their best physical strength, coupled with their best vitrification. Refractory clays like sandy fireclays, while they are capable of being made into paving material of very great excellence, require to be burned relatively much harder to come inside the two per cent limit, and are constantly liable to show themselves above it if the samples are taken at ramdom.

The value of the absorption test is unquestionable. It is, more than anything else, a measure of the fitness of the material for the street.

To test the physical quality of toughness, or ability to withstand abrasion and wear, various tests have been devised.

The commonest and perhaps the fairest test of this nature is the "tumbling" test or "rattling" test as variously called. The value of this test however, lies wholly in the way in which it is carried out. The best brick ever made can be reduced to a powder in an hour or two and the poorest bricks can be made to come out of the test unscathed, if the operator so desires.

The process when carried out honestly and to the best advantage is as follows: A rattler, such as is used for cleaning castings in a foundry is procured. It should be thirty-six inches in diameter and forty-two to forty-eight inches long. It should be supported from the ends without the use of a continuous shaft and its cross section should be an octagon. This machine should be equipped to run by power and be started and stopped quickly at the will of the operator. The speed of revolution should not exceed twenty-six or be less than twenty-two times per minute to secure the maximum grinding effect of the charge.

The bricks to be tested should first be weighed accurately and marked with white lead paint in several places each. It is also a useful precaution to break off a small chip of each brick and number it so as to use it as a guide, if all marks are worn off from the samples. The bricks are then thrown into the rattler, which should not be more than a third filled. A rattler of the dimensions given will only handle about forty bricks at a time. For every three bricks, a billet of wood about eighteen inches long by two and a half inches square should be thrown into the rattler and the lid bolted tight. The machine should be started and run for 1,000, 1,500or 2,000 revolutions according to the severity of the test desired. The bricks are now weighed again individually and collectively and the percentage loss of each sample determined.

In conducting a rattler test on these lines, the friction and blows given and received are wholly by the bricks themselves. The billets of wood prevent the too great violence of the falls and blows and the general result is that of frictional wear of brick on brick, in which the fittest survives.

If the amount of brick be increased the efficiency rapidly diminishes as the space left for falling and jostling is diminished. In the same way if the bricks do not fill the rattler third full, so also the violence of the test increases.

The utility of putting the bricks into a rattler half full of angular scrap iron is very much doubted—it is undoubtedly a comparative test, but the conditions in this case find no parallel in the actual conditions of wear. We have no interest in testing bricks for their fitness to do work which they will never be called on to do. Rather, the conditions of street wear should be duplicated in the application of force as nearly as is possible in this form of test.

Under such a test as has been described brick will lose from five per cent to thirty-five per cent in an hours run.

Another method of testing the abrasive strength of bricks is the grinding table. A horizontal iron disc of six or eight feet in diameter is covered with the brick to be tested and each brick is weighed down with forty or fifty pounds of iron. When the table, which is covered with sharp sand and water, is rotated, the under side of the brick will be worn away to an extent strictly proportional to its hardness. This test is valuable in measuring the hardness only; it gives us no true indication of what may be expected from the same material under the combined blow and rolling friction of actual wear.

The crushing strength is often obtained as a test of the value of the material. At one time it was considered the best that could be applied. The facts wrought out by a comparatively short series of tests in the crushing strength go to show, however, that this factor is of very little real value in determining the quality of the paving material.

Progressive tests in the same kind of material at different stages of hardness generally show that the highest crushing strength is attained sometime before the best vitrification, and that the best crushing strength is at a point where the absorption is much too high. Also, no condition of actual wear in any way approximates the stress of the testing machine, and as has been stated before, there is no benefit from applying tests which only give the relative endurance of materials under conditions they will never be called on to meet.

In classifying the various Ohio bricks on the results of the test, the absorption and rattling tests alone were considered; the crushing tests were made with great care and are recorded with the other tests, but enough was seen in making these tests to decide that crushing strength is not a quality worthy of notice in getting the comparative excellence of brick paving materials.

A test was made in one of the western cities not long ago, by laying a circular track and paving it with bricks of the various kinds to be tested. They were put down with all the care that a city street would receive as to bedding and cement, etc. A heavy, broad tread, wheel, carrying a heavy load of iron was now pivoted from the center of the circle and run round the track for hours at a time; after the proper duration of the test the bricks were taken up and their loss determined. This test, while it is too cumbersome to be of much public benefit, approximates more closely to an exact determination of the relative value of the material than anything but actual trial can do.

The probabilities are that an absorption test and a rattling test, in which the conditions of the test are made absolutely uniform everywhere, will soon become recognized as the best modes of making the preliminary tests of paving material.

The manufacturers of the state were requested by the Survey to furnish each a sample of five (5) of their paving brick for a test, and with the exception of a few factories, the samples were received and tested, The tables of the actual figures obtained in each kind of test will be found in an appendix to this chapter, where those interested can trace the exact behavior of their material; the summary of the results, however, is included in the following table:

TABLE VIII.

TESTS OF OHIO PAVING MATERIALS.

Number.	Name of the firm furnishing sample.	Kind of material furnished.	Kind of machinery used in its manufacture.	Kind of clay used in its manufacture.	Per cent. absorption, gain.	Per cent rattling, loss.	Cr'sh'ng str'ngth sq. inch.	Cr'sh'ng st'rngth cub. inch.	Rank in absorption, test.	Rank in rattling, test.	Average rank of sample.
1	Wassall Fire Clay Co., Columbus, Ohio......	Hallwood Block....... 3x4x9.	Sewer Pipe Press. Raymond Repress...	Zanesville shales, with some local plastic clays..................	.60	8.92	5,260	1,315	14	2	8.0
2	Ohio Paving Co., Columbus, Ohio......	Hallwood Block....... 3x4x9.	Penfield Plunger Machine. Raymond Repress..................	Zanesville shales, from Kittanning horizon..................	1.08	32.77	4,465	1,138	24	44	34.0
3	Logan Fire Clay Co., Logan, Ohio...........	Hallwood Block....... 3x4x9.	Frey-Sheckler Auger Machine. Side-cut Raymond Repress...	Shales and fire-clay from vicinity. Small am't surface clays...	1.32	10.68	5,462	1,342	28	3	15.5
4	Nelsonville Sewer Pipe Company, Nelsonvile, Ohio.....	Hallwood Block....... 3x4x9.	Sewer Pipe Press and Raymond Repress...	Fire-clay from Kittanning horizon.....	1.75	7.12	7,499	1,888	33	1	17.0
5	Athens Paving Brick Company, Athens, Ohio..........	Hallwood Block....... 3x4x9.	Frey-Sheckler Auger Machine. End-cut Raymond Repress...	Shales from above the Freeport horizon	.47	12.80	5,208	1,277	10	8	9.0

6	Portsmouth Paving Brick Company, Portsmouth, Ohio...	Hallwood Block....... 3 x 4 x 9.	Penfield Auger Machine, End-cut, Raymond Represses.....	Sub-carboniferous shales of vicinity...	.24	20.27	6,632	1,694	2	32	17.0
7	Cincinnati Brick Co., Addyston, Ohio.......	Hallwood Block....... 3 x 4 x 9.	Penfield Auger Machine, End-cut, Raymond Represses.....	Sedimentary clays from Ohio River Valley..................	1.28	21.30	4,836	1,249	27	37	32.0
8	W. B. Harris & Bros., Zanesville, Ohio......	H llwood Block....... $2\frac{1}{2}$ x 4 x 9.	Penfield Auger Machine, End-cut, Raymond Represses.....	Shales from Kittanning horizon, with surface plastic clays	.33	21.38	4,628	1,131	7	40	23.5
9	T. B. Townsend & Co., Zanesville, Ohio......	Hallwood Block....... 3 x 4 x 9.	Penfield Auger Machine, End-cut, Raymond Repress.......	Shales from Freeport horizon and Fireclay from Kittanning horizon....	1.34	15.51	5,286	1,262	29	15	22.0
10	Middleport Granite Brick Company, Middleport, Ohio....	Hallwood Block....... 3 x 4 x 9.	Grant-Murray Brick Machine, Raymond Repress................	Sedimentary clays from Ohio River Valley..................	1.77	14.39	4,592	1,160	34	12	23.0
11	Hocking Clay Co., Logan, Ohio..........	Hayden Patent Sidewalk Brick............ $2\frac{1}{4}$ x 4 x $8\frac{1}{4}$.	Sewerpipe Press and Hayden Repress.....	Fireclays and sha'es from vicinity.........	.66	22.94	6,125	1,491	16	43	29.5
12	Haydenville Mining & M'fg Company, Haydenville, Ohio...	Hayden Patent Paving Block for Sidewalk use................ 10 x $5\frac{3}{4}$ x $2\frac{1}{2}$.	Sewerpipe Press and Hayden Repress......	Fireclays with little shale from Mercer and Kittanning horizons................	.84	17.49	No cr'shg	tests made.	18	24	27.0
13	East Clayton Manufacturing Company, Lick Run, Ohio......	East Clayton Block... $2\frac{3}{4}$ x 4 x 9.	Sewerpipe Press and Raymond Repress...	Fireclay with little shale from Kittanning horizon..........	1.19	17.37	4,952	1,238	26	23	24.5

TABLE VIII.—TESTS OF OHIO PAVING MATERIALS—Continued.

Number.	Name of the firm furnishing sample.	Kind of material furnished.	Kind of machinery used in its manufacture.	Kind of clay used in its manufacture.	Per cent. absorption, gain.	Per cent. rattling, loss.	Cr'sh'ng str'ngth sq. inch.	Cr'sh'ng str'ngth cub. inch.	Rank in absorption, test.	Rank in rattling, test.	Average rank of sample.
14	Scioto Star Firebrick Company, Sciotoville, Ohio.....	Grant Star Block...... 3 x 4 x 9.	Freese Auger Machine, Side-cut, Raymond Repress...	Sub-carboniferous shales, with little fire-clay added........	.55	11.73	6,733	1,656	12	5	9.5
15	Standard Brick & Terra-cotta Co., New Straitsville, O..	Parto Block............ 3 x 4 x 9.	Freese Auger Machine, Side-cut, Raymond Repress........	Fire-clay and shales from Kittanning horizon.................	.51	22.25	5,390	1,308	11	41	26.0
16	Roseville Brick and Terra-cotta Co., Roseville, Ohio	Roseville Block........ 3 x 4 x 9.	Frey-Sheckler Auger Machine, Side-cut, Eagle Repress........	Shales from Putnam Hill horizon...........	1.47	10.74	7,749	1,781	31	4	17.5
17	The A. O. Jones Brick & Terra-cotta Co., Zanesville, Ohio......	Jones Block............. 3 x 4 x 9.	Freese Auger Machine, Side-cut, Raymond Repress.........	Mixture of fire-clay and shales from Kittanning horizon......	.95	20.66	7,207	1,802	20	34	27.0

18	The Imperial Brick Company, Canton, O	Metropolitan Block... 3 x 4 x 9.	Freese Auger Machine, Side-cut, Raymond Repress and Eagle Repress........	Shales from the Putnam Hill horizon...	.64	16.82	5,653	1,362	15	21	18.0
19	Logan Granite Clay Company, Logan, O.	Logan Granite Paver $2\frac{3}{4}$ x 4 x 9.	Brewer Brick Machine, Raymond Repress	Shales and fire-clays from vicinity..........	.96	19.18	8,727	2,093	21	27	24.0
20	The Ironton Firebrick Company, Ironton, Ohio.........	Ironton F. B. Paver... $2\frac{3}{4}$ x $4\frac{1}{2}$ x 9.	Freese Auger Machine, Side-cut, Raymond Repress........	Shales from vicinity, Kittanning horizon	.25	20.21	5,996	1,342	3	31	17.0
21	The Ironton Firebrick Company, Ironton, Ohio.........	Ironton F. B. Paver... $2\frac{3}{4}$ x $4\frac{1}{2}$ x 9.	Freese Auger Machine, Side-cut, Raymond Repress.........	Fire-clays from same horizons in vicinity	.0	34.40	3,542	807	1	45	23.0
22	The Riverside Brick Company, Middleport, Ohio....	Riverside Paver........ $2\frac{1}{2}$ x 4 x $8\frac{1}{2}$.	Grant Brick Machine, Eagle Repress........	Sedimentary clays from Ohio River Valley..................	1.03	21.36	4,386	1,119	23	39	31.0
23	Canton Brick Co., Canton, Ohio..........	Red Granite Paver... $2\frac{1}{2}$ x 4 x $8\frac{1}{2}$.	Frey-Sheckler Auger Machine, Side-cut Raymond Repress...	Shales from Putnam Hill horizon..........	.45	13.26	10,822	2,604	9	9	9
24	Royal Brick Co., Canton, Ohio.........	Repressed Paver...... $2\frac{1}{2}$ x 4 x $8\frac{1}{2}$.	Freese Auger Machine, Side-cut, Raymond Repress........	Shales from Putnam Hill horizon..........	.30	16.79	8,754	2,116	6	20	13.0
25	W. S. Williams, Canton, Ohio..........	C. W. Williams' Paver $2\frac{1}{2}$ x 4 x $8\frac{1}{2}$.	Frey-Sheckler Auger Machine, Side-cut Raymond Repress...	Shales from Lower Mercer horizon......	.43	15.80	7,741	1,795	8	16	12.0

TABLE VIII.—TESTS OF OHIO PAVING MATERIALS—Continued.

Number.	Name of the firm furnishing sample.	Kind of material furnished.	Kind of machinery used in its manufacture.	Kind of clay used in its manufacture.	Per cent. absorption, gain.	Per cent. rattling, loss.	Cr'sh'ng str'ngth sq. inch.	Cr'sh'ng str'ngth cub. inch.	Rank in absorption, test.	Rank in rattling, test.	Average rank of sample.
26	Holloway Paving Brick Company, North Industry......	Holloway Paver....... 2½ x 4 x 8½.	Frey-Sheckler Auger Machine, Side-cut, Raymond Repress...	Shales from the Lower Mercer Horizon..............	1.82	19.79	8,074	1,882	35	30	32.5
27	Canton Brick Co., Canton, Ohio..........	Plain Side-cut Brick Paver... .... 2½ x 4 x 8½.	Frey-Sheckler Auger Machine	Shales from Putnam Hill Horizon..........	.75	16.89	7,701	1,897	17	22	19.5
28	Royal Brick Co., Canton, Ohio..........	Plain Side-cut Brick Paver..................... 2½ x 4 x 8½.	Freese Auger Machine................. ...	Shales from Putnam Hill Horizon..........	.57	12.41	8,833	2,208	13	6	9.5
29	W. S. Williams, Canton, Ohio..........	Plain Side-cut Brick Paver... .... 2½ x 4 x 8½.	Frey-Sheckler Auger Machine................	Shales from Lower Mercer Horizon......	1.57	16.27	7,341	1,752	32	18	25.0
30	Holloway Paving Brick Company, North Industry, O...	Plain Side-cut Brick Paver..................... 2½ x 4 x 8½.	Frey-Sheckler Auger Machine................	Shales from Lower Mercer Horizon.....	2.54	21.15	7,255	1,732	39	36	37.5

31	Standard Paving Brick Company, North Industry, O...	Plain Side-cut Brick Paver..................... $2\frac{1}{2} \times 4 \times 8\frac{1}{2}$.	Frey-Sheckler Augur Machine................	Shales from Lower Mercer Horizon......	1.37	18.27	8,928	2,024	30	25	27.5
32	Waynesburg Brick & Clay Company, Waynesburg, Ohio...	Plain Side-cut Brick Paver .... $2\frac{1}{2} \times 4 \times 8\frac{1}{2}$.	Freese Auger Machine.....................	Shales from Middle Kittanning horizon	.28	21.35	8,754	2,092	4	38	21.0
33	Waynesburg Brick & Clay Company, Waynesburg, Ohio...	Plain Side-cut Brick Paver .... $2\frac{1}{2} \times 4 \times 8\frac{1}{2}$.	Freese Auger Machine.....................	Fireclay from Middle Kittanning horizon	.88	19.77	6,807	1,668	19	29	24.0
34	Malvern Clay Co., Malvern, Ohio	Plain Side-cut Brick Paver..................... $2\frac{1}{2} \times 4 \times 8\frac{1}{2}$.	Frey-Sheckler Auger Machine................	Fireclay from Middle Kittanning horizon	1.92	15.95	6,806	1,638	37	17	27.0
35	Canton and Malvern Brick & Paving Co., Malvern, Ohio........	Plain Side-cut Pavers $2\frac{1}{2} \times 4 \times 8\frac{1}{2}$.	Frey-Sheckler Auger Machine................	Fireclay from Middle Kittanning horizon	.96	18.73	5,612	1,430	22	26	24
36	Massillon Stone & Fire-brick Co., Massillon, Ohio......	Plain Side-cut Pavers $2\frac{1}{2} \times 4 \times 8\frac{1}{2}$.	Frey-Sheckler Auger Machine............ ...	Fireclay and shales from Quakertown horizon	1.89	13.99	9,513	2,254	36	11	23.5
37	State Line Fire Brick Company, E. Palestine, Ohio...	Plain Side-cut Pavers $2\frac{1}{2} \times 4 \times 8\frac{1}{2}$.	Frey-Sheckler Auger Machine................	Fireclay from Upper Freeport horizon...	1.09	15.26	8,936	2,111	25	14	19.5
38	Salem Garfield Mining & Mf'g Co.,	Plain Side-cut Pavers $2\frac{1}{2} \times 4 \times 8\frac{1}{2}$.	Freese Auger Machine.....................	Shales from vicinity with little fireclay added....................	3.56	19.76	6,355	1,528	43	28	35.5

TABLE VIII.—TESTS OF OHIO PAVING MATERIALS—Concluded.

Number.	Name of the firm furnishing sample.	Kind of material furnished.	Kind of machinery used in its manufacture.	Kind of clay used in in its manufacture.	Per cent. absorption, gain.	Per cent. rattling, loss.	Cr'sh'ng str'ngth sq. incn.	Cr'sh'ng str'ngth cub. inch.	Rank in absorption, test.	Rank in rattling, test.	Average rank of sample.
39	Congo Fire-clay Co., Empire, Ohio.........	Plain Side-cut Pavers $2\frac{1}{2} \times 4 \times 8\frac{1}{2}$.	Freese Auger Machine......................	Fire-clay from Kittanning horizon....	4.47	12.50	7,827	1,995	44	7	25.5
40	Vulcan Fire-clay Co., Wellsville, Ohio......	Plain Side-cut Pavers $2\frac{1}{2} \times 4 \times 8\frac{1}{2}$.	Frey-Sheckler Auger Machine................	Fire-clay from Kittanning horizon....	3.14	13.66	7,581	1,830	41	10	25.5
41	Buckeye Brick Co., Wellsville, Ohio......	Plain Side-cut Pavers $2\frac{1}{2} \times 4 \times 8\frac{1}{2}$.	Freese Aug. Machine, Raymond Repress...	Fire-clay from Kittanning horizon.....	3.32	20.79	None made.	....	42	35	38.5
42	DeHaven Brick Co., Akron, Ohio...........	Plain Side-cut Pavers $2\frac{1}{2} \times 4 \times 8\frac{1}{2}$.		Shales from horizon of lowest coal vein...	5.11	20.34	7,627	1,877	45	33	39.0
43	Bucyrus Brick & Terra-cotta Company, Bucyrus, Ohio.........	Plain Side-cut Pavers $2\frac{1}{2} \times 4 \times 8\frac{1}{2}$.	Frey-Sheckler Auger Machine................	Shales from Glouster, O., mix'd $\frac{1}{4}$ drift clay	.28	14.56	9,942	2,485	5	13	9.0
44	S. Zanesville Brick & Paving Company, S. Zanesville, Ohio...	Side-cut Blocks........ $3 \times 4 \times 9$. Not repressed.	Freese Auger Machine.....................	Shale and fire-clay from Putnam Hill horizon..................	2.97	16.47	5,271	1,230	40	19	29.5
45	Trimble Brick Manufacturing Company, Trimble, Ohio........	Plain Side-cut Pavers $2\frac{1}{2} \times 4 \times 8\frac{1}{2}$.	Frey-Sheckler Auger Machine................	Shales from horizon of Cambridge Limestone	2.26	22.89	7,617	1,890	38	42	40.0
	Averages...........	....	....	....	1.36	17.71	6,847	1,662	....	....	....

COMPARATIVE STANDING.

Based on the Average Rank obtained on the Absorption and Rattling Tests—and excluding the Crushing Tests.

Name of firm.	Kind of material.	Per cent.	Rank.
Wassall Fire Clay Company	Hallwood Block	8	1
Athens Paving Brick Company	Hallwood Block	9	2
Canton Brick Company	Red Granite Paver	9	
Bucyrus Brick and Terra-cotta Co	Side-cut Brick	9	
Scioto Star Fire Brick Company	Grant Star Block	9.5	3
Royal Brick Company	Side-cut Brick	9.5	
W. S. Williams	Repressed Pavers	12.0	4
Royal Brick Company	Repressed Paver	13.0	5
Logan Fire Clay Company	Hallwood Block	15.5	6
Nelsonville Sewer Pipe Company	Hallwood Block	14.0	7
Portsmouth Paving Brick Company	Hallwood Block	17.0	
Ironton Fire Brick Company	Shale Paver	17.0	
Roseville Brick and Terra-Cotta Co	Roseville Block	17.5	8
Imperial Brick Company	Metropolitan Block	18.0	9
Canton Brick Company	Side-cut Brick	19.5	10
State Line Fire Brick Company	Side-cut Brick	19.5	

Paving Brick Tests.

The results of this test, which is by all means the largest and most complete investigation of its kind yet made, are of great interest in many ways. Not only is it interesting to brickmakers, who are competing for standing, but it is interesting to the public at large, to see that material of such excellence, and such high average excellence can be produced by our Ohio manufacturers.

By a careful study of these tabulated results, the following deductions have been made:

1. *Fire clays vs. Shales.* Twenty-three varieties of shale brick, or bricks whose largest constituent is shale, and whose color is red or dark were grouped together.

Fifteen varieties of fire-clay brick, or bricks whose largest constituent is fire-clay, and whose color is light (gray bluish, or buff), were grouped together.

Four varieties, composed of a shale fire-clay mixture in about equal proportions, and whose color is speckled white and red, were grouped together.

Three varieties, composed of Ohio river sedimentary clays exclusively, and whose color is dark red brown were grouped together.

The average results of these four classes are:

	Absorption.	Rattling.	Crushing, sq. inch.	Crushing, cub. in.	Rank.
Shales	1.17	17.61	7,307	1,764	1
Fire-clay	1.62	17.32	6,876	1,678	2
Mixture	1.44	18.72	5,788	1,400	3
River clay	1.36	19.02	4,605	1,176	4

The shales are seen to be distinctly ahead in this table; while they show slightly more loss than fire-brick in rattling, they also show much better vitrification and much better total strength.

Also, in examining the composition of the bricks holding the ten highest numbers in the general table, there are seen to be thirteen shale bricks, against three fire-clay bricks, showing that the best material of the state is eighty per cent of it made of shale clay.

2. *Side Cut Material vs. End Cut Material:*

Taking nine samples of repressed bricks made on end cut machinery, whether plunger or auger, and comparing them with twelve side cut repressed bricks, the following figures were obtained:

	Absorption.	Rattling.	Crushing sq. in.	Crushing cu. in.	Rank.
Side cut	72	17.78	6,925	1,649	1
End cut	92	17.49	5,418	1,354	2

Showing a distinct advantage in general average for side cut material; however, the end cut material in this test was made in many different kinds of machinery and of very different clay. Separating the various kinds more closely the following figures are obtained:

End cut material, plunger machines;

Three samples made in sewer pipe press and then repressed;

One sample made in Penfield plunger machine and then repressed;

	Absorption.	Rattling.	Crushing sq. in.	Crushing cu. in.	Rank.
Sewer pipe press	1.18	11.13	5,903	1,480	1
Penfield machine	1.08	32.77	4,465	1,138	2
Avg. for plunger mach's.	1.15	16.54	5,544	1,395	......

(*a*) *End Cut Material, Auger Machines.* Five samples, all made on the Penfield automatic cut off, end cut, auger machine, and then repressed.

	Absorption.	Rattling.	Crushing sq. in.	Crushing cu. in.	Rank.
End cut auger brick	.73	18.25	5,318	1,322	2
Side cut auger brick......	.72	17.78	6,925	1,649	1

By still further eliminating the causes of variation in these samples, aside from the effect of the mode of manufacture, the following figures are deduced.

Four samples of end cut repressed auger brick made of shale clays, against eight samples of side cut repressed auger brick, also made from shales.

	Absorption.	Rattling.	Crushing sq. in.	Crushing cu. in.	Rank.
End cut shale................	.58	18.94	5,326	1,338	2
Side cut shale................	.74	15.64	7,690	1,187	1

In this last comparison, the sources of variation have been largely eliminated and the results are therefore much more valuable; as will be seen, they point strictly to the general superiority of the side cut brick over the end cut.

In order to test the matter still more fully, five side cut common bricks made from a sedimentary river clay and five end cut bricks from the same clay and same factory, were burned side by side in a kiln of sewer pipe. When burnt and glazed, they were put into a rattler with some other material for special test and were given 1,000 revolutions.

The bricks were fortunately much too soft to develop the qualities of the clay, the heat having been too low and not continued long enough to vitrify them.

The results showed more abrasion of the side cut bricks than of the end cut, but with this important difference; that the five side cut bricks were represented at the finish by four pieces representing each a brick, and two pieces which could be fitted together, representing one brick. The abrasion had stripped off all edges and corners, but had left the main core or section of the stream of clay as it came through the die, intact and recognizable.

In the end cut bricks, however, the fragments were, one brick, four half bricks, representing two whole ones and seven fragments representing two other bricks, showing that while the fragments left, showed more actual collective weight, yet the side cut bricks had far the best of the test in the condition of the bricks coming from the rattler. Only one of the end cut bricks was in as good condition as four out of five of the side cut.

It is much to be regretted that the samples were not burnt hard enough to develop the qualities of the clay; in this case the results would be very valuable.

3. *Plain vs. Re-pressed Bricks.* Has been discussed in connection with that subject; the general averages of the repressed and plain materials are of interest however in another connection.

	Absorption.	Rattling.	Crushing sq. in.	Crushing cu. in.
Repressed	.85	17.92	6,228	1,514
Plain	2.05	17.42	7,705	1,869

While the plain material shows the better abrasion test of the two, the balance between the absorption and crushing strength is beautifully shown. The repressed bricks were better burnt, and took much less water, but their crushing strength was lower. The plain bricks, while not as well vitrified as they should be, several of these going up to 4.5 and even to six per cent absorption, still showed a very distinct improvement in their crushing strength.

4. *Effect of size on the strength and testing qualities.*

Fifteen samples of material, including the best known materials in the state, such as the Hallwood Block, Hayden Block, Jones Block, Metropolitan Block, Parto Block, Roseville Block and several others, all of which were three by four by nine inches in dimensions or larger, were compared against eleven samples of smaller repressed paving bricks, including the Canton and other standard brands.

The results are:

	Absorption.	Rattling.	Crushing sq. in.	Crushing cu. in.	Rank.
Large	.89	16.69	5,857	1,443	1
Small	.80	19.59	6,701	1,604	2

In this table, grading the bricks by absorption and rattling tests, the large blocks have the very distinct advantage over the small ones.

In crushing strength, they are at a distinct disadvantage; their larger surface is not backed up by proportionate strength of structure, and while they usually stand fully as much actual pressure per brick as the small sizes do, they do not stand as much per inch of surface or bulk.

As has been previously remarked, there seems little ground to attach much value to the crushing test, and it seems probable that the strength of the largest sizes is ample to ensure their bearing any load they will ever have to stand.

The actual loss in ounces was perhaps the same in the large bricks as in small ones in the rattling test, but the percentage loss is much less.

This same difference extends to the use of the brick in the streets; the large material may lose as much in five years as the small, but there are twenty to thirty per cent less brick used in paving any given area and twenty to thirty per cent less joints and points at which failure is probable. Also while the strength to resist a breaking strain is not as high per inch of surface or bulk, it is as high per brick as the smaller ones.

A prejudice has existed in some quarters against the large blocks in the alleged difficulty of vitrifying them. By the test it will be seen that there is practictically no difference in the vitrification of large and small blocks; as a matter of fact, the difficulty of burning large blocks comes in avoiding the bloating tendency when expelling the combined water. A very few hours of time and a very few pounds of coal are all that is required to vitrify the extra half inch in thickness which makes the brick classed as a "block."

The manufacture and sale of vitrified material for paving purposes is a new business, and one which is still in the early stages of evolution.

Five years ago, there was not a brick company in the state of Ohio which had any comprehension of the needs and necessities of the contractors, whom they so cheerfully agreed to furnish with vitrified brick. The manufacturers have been learning in the hard school of experience these five years.

One of the great temptations of the manufacturer has been to grade his product leniently. Especially has this been true of all manufacturers who have been making paving blocks, or bricks of special shape and size, designed for street use only. To the maker of this class of wares, the merciless system of rejecting anything in any way deficient has been almost an impossibility. It has meant in many cases a balance on the wrong side of the ledger at the end of the year. And above all the cheerful ignorance of those who have been inspecting and laying this material has made the moral strain on the manufacture still more severe.

The soft brick, or those which do not receive sufficient heat to vitrify them, and the culls or those, which, while hard enough, are cracked, twisted, or chipped, constitute a regular percentage of every kiln's contents. The best burning in the state produces some. The average burning produces twenty-five per cent. to thirty per cent. of material which has no business in the street.

Many companies in starting out have not made fifty per cent. of merchantable material in the first six months. The culls must be disposed of for some secondary purpose. The soft brick can now be burnt over again and made merchantable, at an increased cost of ten or twelve dollars per thousand.

The advantage of paving blocks over brick are being recognized on all sides. In Ohio, the Hallwood block was put into the market in 1888; now there are not less than ten different brands of blocks all of which are essentially the same size, shape and weight although manufactured by twenty different companies. This growth of the block manufacture would have been much more marked, except for one thing, that is, the disposition of the culls.

Block culls are not a merchantable article and are disposed of at a sacrifice. The culls of the common brick size and shape, while not profitable to the maker, are not usually a source of loss to him, for they are a desirable building material when soft and when hard are in good demand for foundations, vaults, sewers and side-wall use, and in fact any place where exposed service is demanded.

In consequence of this fact, block-makers have had an uphill fight, and they deserve far greater credit than they receive, on account of what they have done to raise the standard of the material.

The future of this great industry largely depends on the concentrated efforts of paving brick makers to keep up the high grade of their wares. To sell a soft and imperfect article, merely because the purchrser is ignorant of what he wants, or because the contractor who is putting the pavement down, hopes to hoodwink the citizens who pay for the street by putting in an inferior material because he makes more out of it, is not only an act of dishonesty on the part of the manufacturer but is short-sighted policy, as well.

If brick are put in at one-half the cost of granite or asphalt and last only one-quarter as long, the market will be largely reduced after the first crop of streets begins to fail. On account of this fact, the manufacture of blocks rather than brick, and the use of every means to prevent the sale of soft or imperfect material for paving purposes ought to be the policy of the manufacturer. By making paving blocks popular, the market for brick will be damaged; brick of the proper kind are constantly liable to be mixed with low grade brick, which are difficult to recognize or cull out. It is the constant temptation of the maker who is selling two kinds of brick of the same size and shape, to sell just as many as he can for the highest price. Paving brick are worth about twice as much as building brick, and when both are manufactured at the same yard it is a moral impossibility to get a shipment of uniformly high quality.

On the other hand, the public is entitled to the advantage to be derived from large blocks and at the lowest cost which will enable the manufacturer to make a fair profit on his business. It is unfair that the makers of large blocks should be compelled to charge the public a price sufficient to pay for the loss of his culls. What is recommended in the joint production of vitrified blocks and bricks at the same time. In down draft kilns set twenty-five courses high, the average paving brick burn will not include over seventy-five per cent. of thoroughly first class paving brick. Of the twenty-five per cent. culls, the twenty per cent. is soft material in the bottom and around the sides of the kiln out of the direct line of the draft and, five per cent. is likely to be hard bricks, twisted or cracked in burning. If the bottom of the kiln had been set with five or six courses of plain side cut or end cut brick, and on top of these nineteen or twenty courses of paving material of special design the loss of the material in the kiln would have been confined to the five per cent. of damaged ware.

This simultaneous production of two grades of ware has been tried in many places; it is a much more sensible plan than by trying by the expenditure of large amounts of coal and extra pains in the construction of the kilns, and setting, to force the heat to every part of the kiln. Especially desirable is this plan in the beginning of the business; in this case fifty per cent of common material is better than twenty per cent, and more profitable. There is no trouble in reducing the courses of common brick at any time that the success in burning paving brick seems to justify it.

The cost of production of paving material is various; the location of the factory; its natural advantages as to crude supplies and the equipment of machinery have everything to do with it. In many old factories, which have taken up the manufacture of paving material as a new lease of life, the cost is much too high and they will find themselves overtaken again in the race of competition.

In a modern, new factory, provided with the best appliances in every department, and situated where coal, clay and shale and water supply can all be obtained at the first cost of production, the actual cost of manufacture and burning and putting the ware in cars, wagons or yards, can be reduced to about $4.00 per thousand; $5.00 per thousand is still a low price; $6.00 is too much for the manufacturing cost. To these prices must be added the losses by inferior grades of goods produced; cost of extra handling of product in the times of dull trade; interest on the investment; insurance; taxes; cost of maintaining the office and salesman; and all other items of general expense which are common to all business interests.

Where blocks are produced, the increased amount of coal and clay used, with a slight increase on the labor, will cause an additional cost of fifty cents or seventy cents per thousand. The total expense per thousand, then, on a modern plant, located and equipped as described, ought not to exceed $7.00 per thousand at the factory.

The price which material has been bringing has been much higher than this. It began, for all points in central Ohio where the freight would not exceed $2.00 or $3.00 per thousand; at about $20.00. The price has dropped every year as the confidence of the manufacturers to produce the required article grew stronger. The sales of 1892 were largely on a scale of $14.00 per thousand; and $10.00 per thousand for repressed common brick sizes. Every indication points to a still large cut in prices this year. A number of new factories are now ready to market their output, which have in the past season merely been getting ready for operation and "learning the trade".

The public are certainly entitled to a considerable reduction in prices; $10.00 per thousand ought to buy good vitrified blocks in any town in central Ohio.

One reason for this elevation of prices which has been mantained so far, has been in the fact that municipal corporations have been the principal buyers of the wares. It is a shameful fact, attested to by many of the most prominent makers of paving material, that the venality of those who have conducted the public business has hitherto greatly increased the cost of brick pavements to the public. It is certainly a misfortune to the industry that its product is bound to be marketed principally to municipal corporations, if not directly, at least indirectly, through the contractors who agree to furnish material and build the streets. One great source of expense to the manufacturers and therefore to the public has been the unskillful and prejudiced inspection, to which the paving material awaiting use in city streets has been subjected. Large lots have been condemned by reason of the failure of small samples; or have been rejected on account of trivial surface defects or color.

The present development of the paving brick industry in Ohio has been put in shape in the following table as far as the data have been available.

TABLE IX.

LIST OF PAVING BRICK FACTORIES OF OHIO.

	Name of firm.	Location.	Product.	Kilns.	Kiln capacity.	Annual product, millions.
1	W. B. Harris & Bros	Zanesville	Hallwood Block	12	480,000	6.0
2	T. B. Townsend & Co	"	"	11	480,000	7.5
3	The A. O. Jones Brick & Terracotta Co	"	Jones Block	10	420,000	6 6
4	The South Zanesville Brick & Paving Co	S. Zanesville	Side cut block	5	200,000	3.6
5	The Roseville Brick & Terracotta Co	Roseville	Roseville block	3	105,000	3.6
6	The Standard Brick & Terracotta Co	New Straitsville	Parto block	8	256,000	6.0
7	The Trimble Brick Manufacturing Co	Trimble	Side cut paver	....	....	6.0
8	The Logan Granite Clay Co	Logan	Logan granite paver	8	280,000	6.0
9	The Logan Fire Clay Co	"	Hallwood block	12	420,000	7.0
10	The Hocking Clay Co	"	Hayden block	14	168,000	3.0
11	The Haydenville Mining & Manufacturing Co	Haydenville	"	14	140,000	3.0
12	East Clayton Manufacturing Co	Lick Run	Clayton block	12	324,000	6.9
13	The Nelsonville Sewer Pipe Co	Nelsonville	Hallwood block	20	700,000	12.0
14	The Athens Paving Brick Co	Athens	"	18	630,000	12.0
15	The Middleport Granite Brick Co	Middleport	"	6	310,000	6.6
16	The Riverside Brick Co	"	Riverside Paver	4	200,000	6.0
17	Barnard Brick & Tile Co	Bellaire	Side cut paver	8	640,000	6.0
18	Nonesuch Brick Co	Empire	"	4	300,000	3.0
19	Congo Fire Brick Co	"	"	6	450,000	6.0
20	The Vulcan Clay Co	Wellsville	"	5	300,000	5.0
21	The Buckeye Brick Co	"	"	3	525,000	6.0
22	The Furnace Fire Clay Co	Salineville	"	4	200,000	3.5
23	The Royal Brick Manufacturing Co	Canton	Repressed paver	7	840,000	12.0
24	C. W. Williams	"	"	6	300,000	3.0
25	The Canton Brick Co	"	Red granite paver	9	750,000	12.0
26	The Imperial Brick Co	"	Metropolitan block	10	1,800,000	20.0
27	The Holloway Paving Brick Co	N. Industry	Holloway paver	7	400,000	6.3
28	The Standard Paving Brick Co	"	Side cut paver	8	400,000	6.0

TABLE IX. LIST OF PAVING BRICK FACTORIES OF OHIO—Concluded.

	Name of firm.	Location.	Product.	Kilns.	Kiln capacity.	Annual product, millions.
29	Salem Garfield Mining & Manufacturing Co.	Garfield	Side cut paver	2	280,000	3.0
30	The Canton & Malvern Fire Brick Paving Co.	Malvern	"	13	650,000	9.0
31	The Malvern Clay Co.	"	"	10	550,000	7.5
32	The Waynesburg Brick & Clay Co.	Waynesburg	"	4	410,000	7.5
33	The Massillon Stone & Fire Brick Co.	Massilon	"	9	435,000	7.5
34	The State Line Fire Brick Co.	East palestine	"	12	630,000	10 5
35	The Akron Brick & Tile Co.	Akron	"	6	800,000	3.0
36	The Cooper Brick Co.	"	"	5	1,000,000	3.0
37	The Bucyrus Brick & T. C. Co.	Bucyrus	"	12	440,000	7.5
38	The Cincinnati Brick Co.	Addyston	Hallwood block	8	800,000	12.0
39	The Ironton Fire Brick Co.	Ironton	Ironton paver	5	150,000	3.6
40	The Scioto Star Fire Brick Co.	Sciotoville	Grant Star block	6	200,000	3.6
41	The Portsmouth Paving Brick Co.	Portsmouth	Hallwood block	7	230,000	3.9
42	The Wassall Fire Clay Co.	Columbus	"	10	210,000	6.0
43	The Ohio Paving Co.	"	"	8	240,000	9.0
44	The Buckeye Fire Clay Co.	Urichsville	Side cut paver	6	240,000	6.0
	Totals			357		292.3

III. THE MANUFACTURE OF PIPE AND HOLLOW GOODS.

The manufacture of pipe and hollow goods is made to include the following general divisions:

1. Sewer pipe.
2. Fire proofing.
3. Terra cotta chimneys and flue linings.
4. Building tiles.
5. Drain tiles.

Of these, the first four are frequently worked all together in the same factory. The fireproofing and terra cotta work is managed entirely in connection with sewer pipe plants. The manufacture of building tiles or hollow foundation blocks of heavy cross section is now carried on in a few factories as a separate business, entirely apart from the sewer pipe manufacture. Great expansion is sure to take place in this direction in the future; the use of vitrified clay products in this class of work has scarcely begun and it cannot fail to become a constantly increasing source of wealth to the state.

The manufacture of sewer pipe and building material demands the use of vitrifying clays; terra cotta and fireproofing, though not vitrified, are as a fact produced from the same clays; the difference in their appearance is due to the comparatively low temperatures used in burning.

The clays used in the manufacture of the first four kinds of hollow ware have already received general notice under the description of clays suited to the manufacture of vitrified wares.

The processes of preparation of these clays has also been described in connection with paving material; there is nothing about the preparation which is characteristic of this particular use except that the tempering has to be much more prolonged and thorough, on account of the difficult shapes and sections of ware which are produced. The shapes required in fireproofing are especially difficult and troublesome to manufacture, and they require very thorough tempering of the clays.

The manufacture of the various kinds of pipe and hollow goods is almost wholly accomplished on one machine, the sewer pipe press; this machine has had brief description in connection with brickmaking machinery. It consists of two vertical cylinders separated by a heavy, cast iron frame to which the cylinder heads are bolted; the upper or steam cylinder is usually forty inches in diameter. The piston rod is made either single or triple and connects the steam and clay pistons. The clay piston is a cast iron head, which can be renewed easily and it is not usually provided with any means of taking up wear. It is rapidly cut away around its edges by the flow of the clay past it when under great pressure. It is sometimes bushed with a wrought iron ring shrunk on, which can be replaced easily as it wears out. The clay cylinder should be a casting of good strength and thickness to allow for frequent boring out. The walls are worn by the escape of clay under pressure, the wear being usually greatest about one-third of the way down the cylinder where the clay first begins to feel the effect of the pressure.

The cylinders can be bored out by hand without moving from the piston by use of appropriate devices, but the usual plan is to send the cylinder and piston to the shop for refitting.

The area of the steam and clay cylinders is usually in the ratio of four to one. The tendency in the newer shops however is towards the use of a larger ratio. Clay cylinders of twenty inches are now frequently equipped with steam cylinders of forty-four inches, and eighteen by forty is another common combination. Smaller sizes are made down to twenty-four by eleven.

In response to the growing demand for large pipe, larger presses have been constructed; one in use is forty-eight inch steam, by twenty-four inch clay, by five feet stroke. This press will make thirty inch pipe in one stroke without refilling the clay cylinder.

Another press not yet in operation but in process of construction is sixty-four inch steam cylinder by thirty-six inch clay cylinder by five feet, eight inch, stroke.

This will be the largest press ever made for this purpose; the utility of these large presses will be in the ease with which they can get out a large run of large pipe. They will make twenty-four and thirty inch pipe with the same ease and speed that a forty by twenty press will make fifteen and eighteen inch pipe. The sewer pipe business is conducted on very close margins and consequently any possible source of economy in production is eagerly taken up, and the tendency now is towards using presses capable of making large pipe with a speed and economy commensurate with the production of the smaller sizes.

The steam which is used in the work of the sewer pipe press is regulated by a rotary steam valve, controlled by a lever from the level of the working platform; the piston is moved up by the steam as well as down, and is kept at the top of its stroke while the clay cylinder is being filled by the expansive force of the steam used to lift it up; when the clay cylinder is filled, the steam is liberated from under the piston which by its weight compacts the clay beneath it and expels most of the air. The steam pressure is now used above the piston and is cut off when the stroke is nearly completed, leaving only a short portion of the stroke to be accomplished by expansion. The use of steam in the sewer pipe press is excessively wasteful and if its lost efficiency were not largely recovered by use in drying the pipe and heating the building, the loss would be still more grievous. The loss of economy in the steam is greatest when cutting rings or making small sizes of pipe by which the steam cylinder is successively filled and emptied of steam a number of times in each cylinder full of clay.

The lower end of the clay cylinder has a set of rings bolted to it in the form of an extension. In this extension a tripod casting called the "spider" is secured; from the center of the "spider" a short, stout bolt depends, to the lower end of which is fastened the "bell" which is the core which regulates the interior size of the sewer pipe. The outside of the pipe is formed by a die ring which bolts onto the extension ring carrying the "spider." The sockets of the pipe are made by securing a core or "socket former" onto the end of the die ring and forcing the clay to fill the vacancy till it appears at a number of small issue holes around the circumference. The "socket former" is then unclamped and the further stroke of the clay piston only forces out a stream the size of the straight part of the pipe.

The manipulation of the socket former which is a movable counterpoised piston bearing the former on its upper end, takes the active work of one man; the manipulation of the steam valve and cutting off gear, which severs the pipe from the press, and the counterpoise of the socket former, takes the time of another man. Two men are required to remove the pipes, up end them, and turn them to a standard length. Three men are usually sufficient to take them away and deposit them on the drying floors. If the distance is great, or the use of two or more floors is needed, another man is required; seven men or eight men thus constitute a "press gang." The amount of work which any average "press gang" gets out in a day's continuous run is about as follows, for each size of pipe:

24-inch pipe		350	pieces	per	day.
20 "	"	450	"	"	"
18 "	"	550	"	"	"
15 "	"	800	"	"	"
12 "	"	1000	"	"	"
10 "	"	1200	"	"	"
9 "	"	1400	"	"	"
8 "	"	1800	"	"	"
6 "	"	2200	"	"	"
5 "	"	2800	"	"	"
4 "	"	3500	"	"	"

These figures hav often been exceeded. In large pipes, twenty-four inch have been turned out at the rate of five hundred or six hundred per day, and in six inch pipes, the best Ohio record is four thousand, one hundred and six (4,106) pipes in ten hours.

The causes of limitation in the work of a sewer pipe press lie partly in the expert gang work required to finish and remove the pipes as fast as made, and partly in the necessity of frequent loss of time in refilling the clay cylinders. The most modern presses are being fitted out now with a number of labor saving devices for simplying the gang work as much as possible. The additions are largely in the way of applying power to each operation of the crew where it is possible to do so. The large 48 x 24 press at the Calumet works has been equipped with power, 1st, for moving the socket former and platform up and down; 2d, for cutting off the pipe and throwing the knife out of gear; and 3d, with a small steam cylinder, called the "doctor," for throwing the latch of the socket former in and out of gear.

These various power appliances are controlled by a set of levers in front of one man, who in the course of time becomes wonderfully expert in handling them; so much so that an outsider cannot follow his motions with any show of intelligence.

The use of the "doctor" and the power cutting off gear are now common. A movement toward improving the work of the press by using better means to fill it with clay has been inaugurated at the National Sewer Pipe Co. at Barberton. A press is in course of construction for them which will use a horizontal steam cylinder with a long slot in its upper side, through which the clay will be introduced. This horizontal cylinder bolts onto the main vertical clay cylinder, close to its upper end; in operation, the clay is to be filled into the horizontal cylinder loose, and compacted in the course of the five foot stroke into a solid plug of the same dimension as the clay cylinder. When the vertical cylinder is empty, and its piston drawn up above the level of the horizontal cylinder's entrance, the movement of the horizontal piston will fill the vertical cylinder with a solid compact charge of clay which will enable the work of pressing to begin instantly when the piston touches it and will enable a cylinder full of clay to furnish material for two or three pieces of each of the smaller sizes, in excess of the number obtained by the common method of filling. By the use of this device, which is well secured by letters patent, it is expected to increase the out put to five thousand or six thousand pieces of six inch pipe in ten hours.

A similar idea has already been used in the horizontal press and has long been giving satisfaction. The mechanical appliances in use in feeding the clay to the steam press have been considerably improved. There are two plans using mechanical skill, the Smith Feeder and Anderson Feeder. Both of these work with great dispatch; the Smith Feeder is very easily arranged so that one man can distribute the clay to two presses; indeed in the National Works, one man feeds three presses on three different floors at the same time. He is located on the middle floor and has the lower and middle feeders in plain sight, and uses mirrors to reflect the appearance of the upper one down to him. The Smith Feeder consists of two belts, one running at high speed all the time, and the other which carries the clay to be fed is stationary except when clay is needed. The big belt by a motion of a foot or so throws enough clay into the little one to fill the cylinder; it can be done with very great celerity.

In some old works the press is still fed by hand power with a shovel, but this method has nearly disappeared.

The pipes as fast as they are made are cut to length and deposited on wooden pallets of appropriate size; if the pipes are small they are then set on end on a platform truck until it is loaded and are then wheeled away and set on the dry floors.

Large pipes are transported to their destination on pronged trucks which enable the workmen to raise the pipe and pallet an inch or two off from the floor and run with it at a good speed.

After the pipes have been stiffened in the warm air for a few hours, they are trimmed and sponged and finished up smooth and any incipient cracks are mended.

The drying of sewer pipe has been explained and discussed in connection with brick drying, as many brickworks use this plan of drying. There is no question as to the great benefits of this plan of drying, as to economy and safety, but even with the use of all the room that is needed, sewer pipe men frequently have great trouble from cracking of the pipes. This is likely to be due to faults of the structure of the pipe or using clay fresh from the mines as much as to any thing else. However, any hollow ware is more difficult to dry safely than any kind of solid ware, and as a rule, the use of only the slowest and most natural processes will suffice to dry without considerable loss.

The burning of sewer pipe is accomplished in all respects like the burning of paving brick except that much less time is required owing to the thin section of clay to be vitrified. When burning a kiln of fireclay pipe in which there are many large pipe or double strength pipe, the burning is much slower, often lasting five, six or even seven days.

For kilns containing no double strength pipe and mostly small sizes, four days is usually sufficient. Shale pipes require somewhat less time than fireclay and are never made in double strength; for a long time it was asserted that they could not be made more than the usual thickness, but it is now admitted to be possible to make them, while it is not done.

The kilns for this class of work have been described in connection with paving brick; the round down draft kiln is the standard everywhere. The contents of a kiln of pipe is estimated by its list value; for instance, the average size of the round kilns used for this work is 27.3 feet. A kiln of this size would hold an average of pipe about $1,600 to $1,800 list value; if a large number of handmade fittings were put in, the value of the contents might easily be made much larger, but the aim is to burn a regular proportion of fittings to every kiln, so as to make the loss as small as possible in event of too much or too little heat.

The surface finish of sewer pipe is a matter of much importance to the manufacturer; the requirements of the market are very severe and even unjust. Sewer pipe seems to find a very small and unprofitable market, and yet the slightest defect, even of color, is frequently enough to condemn the pipe.

The glaze which is imparted to the surface of the pipe is a matter of much importance; it not only beautifies the color and appearance, but it fills up the pores, smoothes over minute cracks and renders the surface of the pipe little liable to offer obstruction to floating solids in the sewage which the pipe is designed to carry.

The glaze is uniformly obtained by using salt vapors; no instance of any slip glazing has come to notice. The salt glaze is obtained by one or two applications of the coarse salt in the fire holes, the operation lasting from one to two hours.

Great care has to be observed in setting the pipe to avoid bringing any two pieces too close together, for it frequently happens that the salt vapors are carried through the kiln, only attacking the exposed parts of the ware and two pipe leaning together would both be devoid of glaze from the point of contact downwards.

The inability to secure a good dark glaze is a source of much loss to the manufacturers; if their clay is difficult to glaze or takes a light clear glaze,the use of oxide of manganese is sometimes resorted to. It is mixed with the salt and burnt in the fire and its effect when vaporized as chloride of manganese is to form a dark, black colored glaze. This is an unsightly color to one who knows what it is, but it has been of great assistance to many manufacturers in getting rid of pipes which would be otherwise rejected on account of their color.

In fact the system of grading sewer pipe is unnecessarily severe. For any ordinary use, the seconds are as good as the firsts; it is not the consumer who profits by this severity of selection; it is the middle men or retailers who buy the seconds at low rates, and work them off on the public as first class goods, which, for any matter of service and utility, they are.

The position of Ohio as a sewer pipe producing state has long been foremost. We not only make by all odds the greatest amount of ware, but we have the three largest factories of this kind in the world.

The National Sewer Pipe Company at Barberton, Ohio, enjoys the proud distinction of being the finest plant of its kind in the world; it is in reality four complete plants in one.

It has introduced a number of labor saving economies in its construction which are worthy of notice. The clay which is a fairly hard shale is loaded in dumping railroad cars by a steam shovel and hauled by the company's engine to the factory, two miles distant.

The clay in being dumped is fed to the dry pans by long, steel lined conveyors which are fed by men stationed along its line in the stock house.

The grinding and tempering offer no special novelties except the great excellence of their mechanical arrangements.

Six presses, two on each of the three lower floors are run by four crews, who are changed about somewhat, in order to produce the materials where they can be put on the floor to dry with the least cost.

The drying is novel; it is accomplished by use of the Sturtevant System of heating buildings, using steam coils and a fan for producing a large flow of hot air which is conducted to the building in underground flues and distributed by large galvanized iron pipes. The system, while new to the sewer pipe business, has the elements of success in it. The distribution of air should be around the circumference of the building, and the fan house ought to be placed in communication with the top of the building so that the air could be worked over and over without the useless expense of heating up a fresh supply of air all the time. Some difficulties are likely to occur in this system in regard to cracking the wares nearest the vents of the hot air supply, which can be remedied by providing more and smaller vents so as to make no decided currents.

The kilns are fifty-two in number and operated by four crews setting, and four crews drawing; the kilns are round down drafts 28 ft. 6 in. in diameter with one of the best kind of fire places and a good arrangement of "bottom:" The burning is all under the control and supervision of one man.

The generation of power is accomplished in a magnificently equipped power plant; one engineer and one foreman do all the work for the daily production and maintenance of seven hundred and fifty horse-power. The Brightman mechanical stoker and a system of conveyors and elevators do all the handling of coal, which is only shoveled once, from the railroad car to the coal bin.

The following table gives the only statistical inform.tion of the sewer pipe business which was attainable.

TABLE X.

LIST OF SEWER-PIPE FACTORIES OF OHIO.

1	Haydenville Mining & Mfg. Co	Haydenville	Fire c ays...	2	15
2	Jefferson Sewer Pipe Co	Toronto	" ...	2	10
3	John Francy's Son's & Co	"	" ...	2	16
4	The Great West'n Fire Clay Co.	"	" ...	2	17
5	Ohio Valley Fire Clay Co	"	" ...	2	10
6	Calumet Fire Clay Co	El iottsville	" ...	5	21
7	Excelsior Sewer Pipe Co's	"	" ...	1	8
8	Freeman Fire Clay Co	Freeman's Station	" ...	3	15
9	Empire Sewer Pipe Co	Empire	" ...	2	8
10	N. U. Walker & Co	Walker's Station	" ...	4	23
11	Jos. Lythe & Sons	Wellsville	" ...	2	14
12	Knowles Taylor & Anderson	East Liverpool	" ...	2	15
13	Royal Clay Manufacturing Co.	Midvale	" ...	5	36
14	Diamond Fire Clay Co	Uhrichsville	" ...	2	10
15	Uhrichsville Fire Clay Co	"	" ...	2	10
16	State Line Sewer Pipe Co	East Palestine	" ...	1	12
17	United States Fire Clay Co	New Lisbon	" ...	1	12
18	Ohio Sewer Pipe Co	"	" ...	1	12
19	Camp & Thompson	Greentown	" ...	1	9
20	Crown Fire Clay Co	Dover	*	2	21
21	Hill Sewer Pipe Co	Akron	Shales	1	11
22	Akron Sewer Pipe Co	"	"	2	20
23	Buckeye Sewer Pipe Co.	"	"	2	13
24	Summit Sewer Pipe Co	"	"	2	12
25	Robinson Bros. & Co	"	"	2	16
26	George P. Sperry	Talmadge	"	1	9
27	Camp & Thompson	Cuyahoga Falls	"	2	16
28	National Sewer Pipe Co	Barberton	"	6	52
29	Columbus Sewer Pipe Co	Columbus	"	2	12
30	Cincinnati Sewer Pipe Co	Cincinnati	Fire Clay...	1	4

SEWER PIPE PLANTS RUNNING ON PAVING BRICK.

31	Nelsonville Sewer Pipe Co.....	Nelsonville..............	Fire Clay...	2	20
32	East Clayton Mfg. Co...........	Lick Run................	" ...	1	12
33	Haydenville Mining & Mfg. Co	Haydenville............	" ...	1	14
34	Hocking Clay Co......	Logan......................	" ...	1	14
35	The A. O. Jones & Co............	Zanesville..............	" ...	1	10
	Total................................	....	....	41	529

* One-half fire clay and one-half shale.

The manufacture of building blocks has been alluded to before as being a very promising business, and one which is sure to grow; it offers two special features for consideration. The first point is, that the use of Auger machines is possible and indeed profitable, the building blocks being plain sections of a square hollow bar; the production of such a bar is more economical by Auger mill than by the vertical steam press. The Double Ended Horizontal Steam Press is specially adapted to this class of work and enables the simultaneous production of two different kinds of ware.

The second point is the introduction of the car and tunnel system of drying; the ware having comparatively little variation in size and like fireproofing, electrical subway conduits, building blocks, etc. enables the dryers to furnish a steady supply of one kind of ware to the kiln setters. In the regular sewer pipe process the drying floors not only serve as means of drying the pipe, but as storage rooms from which the various kinds of ware needed in setting the kilns most economically can be drawn as needed. On this account the drying system for sewer pipe is not likely to undergo material change from existing plan.

But in building blocks this is a great step in advance, as it reduces the cost of the plant so much that the business is likely to be pushed by many men who could not otherwise touch it.

The first tunnel and car dryer for hollow wares originated with Mr. H. B. Camp of Cuyahoga Falls; he worked this plan successfully for nearly ten years before any one else saw fit to try it; it is now in use in six or eight plants. The present experience indicates that drying hollow wares of small and medium size is not only possible, but profitable in a chamber dryer, and that by rigidly watching the conditions of the air, larger wares still could be profitably handled in this way. The use of progressive dryers has not been attempted in this connection and it is not likely that it will be.

The manufacture of drain tiles for agricultural purposes is to the art of pipe making, what common brick making is to the paving brick business.

It not being either desirable or advantageous to have the product vitrified, the clays used can be of a very low grade. The bulk of the material used is red plastic clay from the drift, or sedimentary clays from the river valleys. The preparation of this class of clays ranges from nothing at all to crushing between rollers and pugging. The Auger mill is almost the universal machine used in manufacturing; the drying is usually in racks protected from sun and rain but unassisted by artificial heat. The burning is usually managed in small round down draft kilns, though some tilemakers retain the old updraft kilns.

The business is not a large or important one, or one which bids fair to add much wealth to the state for the manufactures are almost wholly for the home consumption of their district. The low values and fragile character of the wares stand in the way of any extensive shipments.

There is one tile works, that of Messrs. Dennison Bros. at Delaware, Ohio, which has taken a new departure in the business. They have built an entirely new plant, suitable for sewer pipe manufacture, including dry and wet pans, sewerpipe press, elevators, etc. and devote their special attention to the manufacture of the largest sizes of tiles suitable for county ditches and railroad work.

The product is not vitrified, but is hard burnt, and will stand shipment. They make common drain tile up to twenty four inches in diameter.

Their clays are derived from a stratum of the Huron Shales, which is of a very high grade clay here, except for the presence of considerable iron pyrites in little nodules.

The field of operation in this line is not large however, and a long experience in the drain tile business has been the only way to get a trade in this line sufficient to ensure success.

IV. THE MANUFACTURE OF REFRACTORY MATERIAL.

The art of manufactuing refractory material calls into play a knowledge of the higher qualities of clay; we have considered in the discussion of crude pottery and vitrified wares the kinds of clay suited to each, and have seen that in these cases, a certain degree of fusibility is required. In making refractory material the whole study is to secure the utmost resistance to the fusing and fluxing action of fire, consistent with a certain physical structure of the material.

The importance of this form of clay working is hard to justly represent. It does not now occupy the important stand it once did in the business industries of the state or the world; other forms of clay working have easily outstripped it, as far as capital invested and value of output go. Perhaps, however, the best way to picture its importance is to try and imagine what we should do without it. Every ton of iron in the country is smelted inside of firebrick walls; every boiler setting and household grate uses a small quanity of it. No metallurgical industry is possible without the use of fire resisting brick, and no other form of clay working would be possible if it were not for fire proof kilns.

In a word, while making refractory materials has not had the expansion and development of some of the cruder forms of clay working, it is *par excellence* the most important use to which clay can be put.

Taken as a whole, this industry in Ohio is not in as healthy a condition as could be wished; many of the fire brick factories have deserted their original business to enter into the temporarily more profitable manufacture of paving materials, and but few new factories for the manufacture of fire brick have been built in the last decade.

The reason for this is probably due to the over expansion which prevailed some ten years ago. The iron business, on which, above others, the firebrick business depends, has been constantly improving in its metallurgical work, so that while less furnaces are in operation year by year, and that while for one new furnace built about five old ones are dismantled, the production of iron increases nevertheless as the demand justifies it. Also, the introduction of new processes and new refractory materials in both iron and steel making are combining to cut down the demand or the product of former years.

Notwithstanding these facts many of the well located firebrick plants of the state show a gratifying advance in prosperity in the last decade.

The Clays.—The native clays, suitable to manufacture of refractory materials, are of two classes:

1st. The Flint Clays.

2d. The Plastic Fireclays.

Flint clays are the ma n standby of the refractory material trade of Ohio and Pennsylvania. As has been mentioned in the preliminary discussion of the general properties of clay, flint clays are a *lusus naturæ* which scientific men find it very hard to explain. In composition, the best of them are practically pure kaolins but other flint clays are found which are the counterpart of the common plastic fire clays of the state in chemical analysis, and still show the typical flint clay structure to its best advantage. And furthermore, flint clays have now been encountered which retain the flinty structure in connection with the most impure chemical character and an absence of any high refractory qualities.

The main and essential feature which distinguishes the flint clays from others is their almost complete lack of plasticity. Flint clays do exist which are apparently a connecting link between the strictly non-plastic and the common hard plastic clays, and such clays by use of severe physical treatment become somewhat plastic.

But, it is claimed by those who use the best grade of flint clays that no amount of grinding and kneading with water will make a true flint clay any more plastic than a sand rock would become under similar conditions. One or two dealers in flint clays have asserted their ability to make any flint clay plastic, but have failed to prove their assertions or show any basis for their statements. The effect of weather, including frost and heat, will undoubtedly crumble a flint clay to a fine sharp sand, but personal examination of the surface of piles of flint clay which had been exposed for several years failed to show any indication of plasticity.

Also, the fine dust of flint clays which have been ground dry, which has settled out of the air, has been collected and wet and kneaded without any indication of plasticity.

The composition of the flint clays of the state is illustrated by the following table of analysis:

TABLE XI.

	1	2	3	4	5	6	7	8	9	10
Silica, combined	35.39	35.72	46.75	48.56	44.34	45.30	46.04	43.19	59.92	39.90
Alumina	31.84	29.62	38.17	37.47	40.05	39.96	39.35	41.60	27.56	30.08
Water, combined	11.68	8.71	14.03	13.03	14.23	13.75	14.00	13.48	9.70	7.00
Clay base	78.91	74.05	98.95	99.06	98.72	99.01	99.39	98.27	97.18	77.58
Silica, free	17.13	20.65	......	......	.26	.35	.16	......	......	16.90
Titanic acid	1.68	......	......	Phosphoric acid, 25	......	......	......	Sulphuric acid, .26	......	1.15
Sandy impurities	18.81	20.65	......	.25	.26	.35	.16	.26	......	18.05
Sesquioxide of iron	.67	1.14	.29	tr.	.80	.14	.10	with the Alumina,	1.03	1.67
Lime	.50	.45	.57	.11	.27	.21	.15	.15	tr.	......
Magnesia	.19	.14	.12	tr.	tr.	.12	.09	.06	tr.	......
Potash	.59	.79	.07	.28	tr.	.18	.22	.95	.67	2.30
Soda	......	.29	......	.28	tr.	......	......	......	......	......
Fluxing impurities	1.95	2.81	1.05	.67	1.07	.65	.56	1.16	1.70	3.97
Moisture	.69	1.92	......	......	......	......	......	......	1.12	.90
Total	100.36	99.43	100.00	99.73	99.79	99.66	99.95	99.43	100.00	100.50

No. 1. Flint Clay from C. E. Holden, Mineral Point, Ohio, Lower Kittanning, Horizon, used for high grade refractory material sampled in 1883—analysis by Lord.

No. 2. Same clay, finely ground and averaged, sampled 1892, analysis by Orton.

No. 3. Flint Clay from Carter County, Kentucky, furnished by Portsmouth Fire Brick Co., analysis by Otto Wuth.

No. 4. Same clay, sampled and analyzed by Kentucky Geological Survey.

No. 5. Gaylord Clay, Scioto Co., Ohio, from Portsmouth Firebrick Co.—by Kremer & DeDeken.

No. 6. Eifert Clay, Carter Co., Kentucky, from Portsmouth Fire Brick Co., by Kremer & DeDeken.

No. 7. Tiplan Clay, Carter Co., Kentucky, from Portsmouth Fire Brick Co., by Kremer & DeDeken.

No. 8. Stone City Flint Clay, Stone City, Kentucky.

No. 9. Salineville Flint Clay, Furnace Fire Brick Co., Salineville, Ohio.

No. 10. Mount Savage Clay; New Jersey Report.

These clays are seen to be of great purity, the average contents of fluxing materials being only 1.54 per cent.

The oxygen ratio of the average of these clays is:

Oxygen in acid, 1.36; oxygen in base, 1.
Oxygen in alumina, 51; oxygen in flux, 1.

indicating a compound between a protosilicate and a sesquisilicate with very low proportion of fluxing bases.

Silicates of most of the bases are most fusible between the subsilicates and bi-silicates with pure compounds of silica and alumina; however, the point of greatest fusibility seem to be above the bi-silicate ratio and below the trisilicate ratio.

These flint clays constitute the body mixture of all of the refractory materials of the state, but on account of their non-plasticity, it is necessary to use plastic fireclays to act as a bond material.

The aim in selecting the plastic clays for a refractory mixture. is to get as sandy a clay as can be had which will develop plasticity well; the more sandy the clay is, the less it shrinks, except by vitrification. A clay free from any impurity but sand will stand a high heat and shrink but little and it is a clay of the nature that is sought.

In the following table, No. XII, the analysis of five Ohio plastic fireclays, which are actually used as bond clays for the flint clays of the state arecompared.

Also the analysis of a very superior high grade plastic clay which is imported from Germany for use as bond to flint clays in glass pot manufacture is given.

This clay is far superior to anything which we find in this state in the way of a plastic clay.

TABLE XII.

Number.	1	2	3	4	5	6
Silica combined	31.07	29.22	60.77	53.84	63.12	72.33
Alumina	26.47	24.97	25.74	24.93	26.20	19.06
Water combined	9.96	8.90	9.46	11.50	10.72	5.52
Clay base	67.50	63.09	95.97	90.27	100.05	96.91
Silica, free	27.71	31.34	....	....	....	....
Titunic acid	.94	1.30	....	....	....	....
Sandy impurities	28.65	32.64	....	....	....	....
Sesquioxide of iron	1.22	1.66	1.61	2.79	....	.71
Lime	.59	.63	.89	.40	....	.28
Magnesia	.32	.40	.63	1.50	....	.18
Potash	.99	.28	1.20	2.18	....	.45
Soda	tr. Li_2O	tr.	....	.51	....	.14
Fluxing impurities	3.12	2.97	4.33	7.38	....	1.76
Moisture	1.04	1.69	....	....	....	1.33
Total	100.31	100.39	100.30	97.65	100.05	100.00

No. 1. Ballou fire-clay; Muskingum Co., Ohio, analysis by Lord.

No. 2. Island siding fire-clay, Jefferson Co., Bolivar clay, analysis by Lord.

No. 3. Phelps clay from Hocking Co., used by Wassall fireclay Co., analysis by McDowell.

No. 4. Hanging rock fire-clay, from Kittanning Horizon, from Portsmouth Firebrick Co.

No. 5. Oak Hill plastic clay; partial analysis by D. O'Brien.

No. 6. Plastic fire-clay from Gros Almerode, Germany.

The average analysis of these clays indicates about the following structure:

Clay base	61.50
Sand	32.00
Fluxes	4.25

with an oxygen ratio as follows:

Oxygen in acid, 2.60; oxygen in base 1. Oxygen in alumina, 10.3; oxygen in flux 1.

This ratio indicates a clay very close to those used in yellow ware manufacture and less sandy than those used in stone ware manufacture and more refractory than the sewer pipe clays.

Very much depends on the quality of these bond clays, for the action of the bond under heat is very similar to its action when wet, even though there be but little of it, it is the envelope which holds the other particles in shape; if it softens and flows, the particles of good clay flow with it while not affected much by the heat or water themselves.

The supply of clays that are fit to make the highest grade bonds is actually more scarce and difficult to obtain than good, fire resisting, flint clay.

The compound of the mixture for producing refractory brick depends on the following considerations:

1st. The source of fire resisting power is mainly in the flint clay.

2d. The source of physical strength when ready for use depends on the plastic bond; when the bricks are in position and under a high heat, the flint clay becomes softened and cohesive and it then furnishes the real strength of the brick, but at these high temperatures there is no danger of friction from material as highly heated as the bricks themselves.

3d. To allow of rapid change or alternations of high and low temperatures, the bricks must be of a loose, open grained structure, so as to admit of rapid absorption or radiation of heat.

4th. To produce a sound and strong brick composed of non-plastic material which has a very high shrinkage and a plastic bond, it is necessary, first, that the bond clay should be of very low shrinkage and second, that part of the flint clay should be calcined previous to mixture, so as to take out the shrinkage and allow the union of the particles to remain unbroken when burned. It is impossible to make a strong and good fire-brick from a mixture of dissimilar clays of high shrinkage, for one kind invariably tends to separate from the other when under heat, and the bond is therefore destroyed. It is to this fact that the failure of all attempts to make a good refractory material out of pure quartz and pure kaolin is due. Both are infusible, but when mixed and burned together, the kaolin bond shrinks away from the grains of quartz, and the whole structure becomes perfectly worthless and rotten. No satisfactory refractory material was made from quartz until the use of clay as a bond was given up, and milk of lime in small quantities was substituted.

On these four conditions, the mixtures for refractory clay bricks depends.

It will readily be seen that these conditions are to some extent inimical to each other, and to secure a brick of the highest fire qualities, it is necessary to sacrifice its physical strength to a large degree.

A common mixture for this purpose consists of 45 per cent. calcined flint clay, 45 per cent. raw flint clay and 10 per cent plastic bond. A brick made of such a mixture is very loose and porous in structure, very friable and easily worn away by friction, even when hard burned. To use such a brick to advantage it must be placed where the heat is so intense that the flint clays become slightly soft and cohesive and the substance of the brick becomes plastic by the influence of heat. Therefore to use such a brick where the heat is only moderate and where it would be subjected to abrasion of stock or tools, would be a waste of money, for a brick of lower fire qualities would stand the heat equally well and the friction very much better.

The charge used to produce a brick of good physical strength and moderate fire properties is often about 50 per cent. plastic fire clay and 50 per cent. of calcined and raw flint clay.

Often mixtures, based on these same considerations and compounded with reference to the kind of work they have to do, are also made; some, between the two just quoted and some, composed of still larger proportions of plastic clays.

There is a class of brick called mill brick which are used almost wholly in lining puddling furnaces and like structures and these brick have to stand quite severe abrasion from the tools of the puddler and firemen and the scorifying influence of the iron slags. These bricks are generally composed of all plastic fire clay which makes a brick of great toughness though of rather low heat resisting power. In some few places, paving brick and mill brick are made from the same clay in the same factory. This is a mistake, for it is a certain fact that a clay which will make good paving brick cannot make good fire brick and vice versa.

The compounding of the charge of these various clays is accomplished in most cases by use of a shovel. The clay is loaded into wheelbarrows, so many shovelsful of each kind. In only a very few cases is the compounding done by weight.

The preparation of the clays. The makers of firebrick usually lay considerable stress on the weathering of the clays, some urging that a great purification ensues from so doing.

The experiments and experience of potters have shown pretty clearly just what purification may be hoped for by the exposure of clays to weather.

Weather acts in two ways, one physical and one mechanical. Physically it breaks the hard clays up into fine grains which greatly reduces the labor of grinding. The soft clays are rendered tough and plastic by their exposure to weather. Chemically, the atmosphere oxydizes sulphide of iron to sulphate which the rain water dissolves and carries away. In addition to sulphate of iron, sulphates of lime and magnesia, existing as such or formed by metathesis from the sulphate of iron and carbonates of lime and magnesia, are soluble in water and are removed by rain. Any changes in the other iron constituents or the potash and soda compounds must not be expected, as it has been shown that washings clays in the pottery processes does not diminish these constituents by solution.

These oxydizing and washing effects are very gradual indeed; the conditions under which they proceed most rapidly are very seldom present in the stock piles of clay companies and as a matter of fact, the benefits of weathering are almost wholly confined to the improved mechanical condition of the clay for the machinery.

The accumulation of clay in stock, however, is a necessity with most works, whose winter supply has to be dug and hauled to market in the favorable seasons of the year.

The washing of the charge of hard clays is a practice resorted to at the best works; it is much scoffed at by those who do not use it as being an utterly useless expense. Its utility depends altogether on the conditions under which hard clay is obtained; if from a mine under ground, it is not likely to be in need of washing; if from open cut benchings, it is sure to have more or less mud in it which ought to be removed.

Even drenching with a hose pipe over a sink is beneficial, but the use of a mechanical device is necessary to do the work thoroughly.

The log washer, or a crude form of pug mill, used in washing iron ores from adhesive clay would answer this purpose satisfactorily.

The processes of grinding the clay and tempering it ready for use is accomplished in three principal methods:

1st. The wet pan.

2d. The dry pan and pug mill.

3d. The dry pan and wet pan.

The wet pan is the characteristic implement of the fire brick makers of the state; it is in all respects comparable to the machinery already described under the preparation of brick clays, except that the wheels are usually very broad and of much smaller diameter. The common dimensions are twelve to fourteen inch face by twenty-four to thirty inches diameter; the wheels weigh from three to six thousand pounds each.

The charge of clay is dumped in altogether and wet down as often as necessary; the soft clay speedily becomes very plastic, especially as the amount of water used is often considerable and as the wheels reduce the hard clay and calcine finer and finer, the plastic clays are distributed in a thinner and thinner enveloping layer over each particle. The grinding usually occupies from ten to fifteen minutes, occasionally much more time is allowed.

Such treatment as this will develop the very best plasticity that any clay is capable of; the only thing which can be urged against its efficiency is the fact that there is no absolute means of regulating the sizes of the particles of hard clay, which may survive the grinding without being crushed.

The use of a dry pan proves itself of great value to the makers of high grade refractories. It permits the accurate sizing of the flint and calcined clays and it permits their reduction to a size with far greater economy of power and time than can be attained in the wet pan. The further tempering after grinding by dry pan may be accomplished by pug mill or wet pan.

The use of a wet pan is by all means to be recommended. It is of more importance in making refractory material than sewer pipe and paving brick manufacture, for in refractory material the main value of the product depends on the proper mixing and blending of the qualities of the various ingredients.

Clay prepared by dry pan and tempered by wet pan is in the most satisfactory shape for use that modern experience is able to suggest.

In some cases as in the manufacture of mill brick from all plastic clays, the use of a pug mill is permissible, because the natural plasticity of the clay and the fact that it is all one kind, render a mere mixing with water sufficient.

The tempering of the clay being completed, the moulding process begins.

Fire brick of good quality are still made largely by hand; the aim of the maker is to produce in each brick, an absolutely structureless piece of clay, which can have no tendency to failure of strength by the influence of any machinery in its formation.

No machinery has yet been devised which enables the production of such an article. The auger and plunging machines are wholly unsuited to the needs of the fire brick maker, each brick is with them but a section of a bar of clay of very objectionable structure.

The nearest approximation to good structure is obtained in the soft mud machines and these are sometimes brought into requisition.

The best fire brick, however, are still hand moulded; by the human hand each brick becomes a unit by itself and no structural defects are obtained.

The labor of hand moulding is severe and costly; 4,000 per day is the standard day's work for each moulder and his off bearers, whose work is to take the product to its place on the dry floor, sand the monlds, and bring in the supply of tempered clay.

Where hand moulding is the only means of manufacture, the moulders tables are arranged along one side of the dry floor, a certain space of which is allotted to the product of each table. The work of the day is usually finished by noon and is put on the dry floor as fast as made. Early in the afternoon, the pressing of the brick begins. This is so managed as to allow each portion of the day's product about an equal portion of the day to dry before pressing. The press crew consists of four men, who, by use of a portable press, do a similar stint to the moulders, 4,000 per day's work.

This pressing when partly dried is made necessary by the softness of the temper for hand moulding; it would remove some expense if the pressing and moulding could be performed in one continuous operation.

By this system, bricks are dried in just twenty-four hours; the work of each crew being so timed as to keep always a sufficient space for work between dry brick on their way to the kilns and the new crop being deposited on the floor.

The manufacture of fire brick on soft mud machinery can not be specially objected to as far as the structure of the product is concerned, but in shape and finish it is not nearly the equal of hand made brick. The moulds all have to be stroked or cut off level with a large metal plate; this leaves one side of the brick rough and unpresentable. Also to operate the brick machine to an advantage it is necessary to run it something near its capacity, which is 25,000 to 30,000 per day. The drying of such a large quantity by hot floor is not usually possible, and the use of racks and pallets become necessary as the brick are much too soft when first made to stand handling of any kind. This fact makes their repressing a source of considerable expense, as they have to be brought out of the racks and pressed and then put back again or placed on a hot floor or other drying apparatus.

Hence, the limitations of the soft mud process; it makes a good brick, strong and of good structure, but of bad appearance, and to remedy its appearance by repressing is out of the question at the common prices. On very high grade material it might be possible. In this connection, the use of the iron clad dryer on the product of the soft mud machine is interesting to note. The drying was effected without trouble or cracking, and was carried on in connection with stiff mud bricks at the same time.

The use of auger or plunger brick machinery in the manufacture of high grade brick is a constant temptation to the brick makers by reason of the lessened cost of production.

Aside from the structural defects of the bar from which the brick are cut, the brick are too dense and compact for the best results, and it is impossible to get the proper bond with the small quantity of plastic clay which is used, unless the temper of the mixture be made softer than the Auger machine will work to an advantage. The methods of burning refractory bricks are beginning to experience some change; for many years past, almost the only process of burning was in the old up draft clamp kilns, A great many works still retain them. But the progressive members of the business have been introducing the down draft kilns. The down draft kilns employed are mainly of the common round type. A few square Newcastle kilns, built in blocks or batteries are in use. No Eudalys or other patent kilns are in use in the fire brick business of this state. The Thomas kiln, a down draft kiln, of great excellence, which originated from an effort to convert the old up draft kilns into down draft is in use in the Scioto and Lawrence county districts. The up draft kiln which furnished the main points of this Thomas kiln was constructed as follows:

The width of the kiln was twelve to thirteen feet inside; the length, though immaterial, was usually about thirty feet; the walls which were about thirty inches thick, were pierced at intervals of every twenty-seven inches by narrow fire holes, twelve or thirteen inches wide. These fire holes deliver into the kiln at a point just about level with the floor, the height of the floor level above the bottom of the fire holes, being about twenty-four inches. The kiln is entered through a narrow wicket at each end, just wide enough to let a man come in with a brick barrow.

In setting these kilns. they adjust the arches carefully in front of the fire holes, so that each arch is filled with the heat from the fire holes at each side of the kiln. The bricks were burned very satisfactorily in these kilns but at a rather high expenditure of fuel; the top course of fire brick were commonly left on edge and in open order, to promote a strong draft of air through the kiln while drying it off. When the red heat had worked its way upwards to this course, so that it could be seen red at night through the cracks, then men were sent out to tighten the platting. This they did by putting the top cour e down flat and as close together as possible and sprinkling sand or ashes or slack coal on the surface. This acts as a seal to the rising draft and prevents the waste of fuel and the formation of uneven drafts up through the bricks. The heat being compressed under the tight course is carried by conduction to every part of the kiln equally.

With a well equipped up draft of this description, the burning can be managed with great precision and excellence though it is undoubtedly somewhat more extravagant in fuel.

In making this kiln into a down draft kiln, but few alterations were necessary. The crown was sprung from wall to wall at a height of nine or ten feet from its centre to the floor. The heat was carried to the top of the kiln by a fire wall on either side of the kiln, tied to the main wall by distance brick at frequent intervals to keep it from falling into the kiln. The draft was provided by a small stack at each end of the kiln and a continuous flue from end to end down the centre connected the two stacks.

This flue was divided into an upper and lower section which was made to draw from separate portions of the kilns' length so as to get an equal draft at all points.

Simple and cheap as such a kiln is, it meets as many of the essential constituents of success as any square kiln in use. The burning which was exhibited from this kiln cannot be surpassed by any appliance now in use.

The burning of fire bricks is not in any way as delicate or skillful an operat on as the burning of almost all other clay wares is, for the reason that the material, being made to endure high heats, cannot easily be over burned and if burned less strongly than is desirable there exists no difficulty in disposing of the product without sacrifice of the price. In short, the customers of the fire brick trade are about divided in their preference for hard and soft bricks, so whatever the kind of burn, the product will be acceptable to one or the other class of customers.

In theory, it is much better to use fire brick which have already passed through severe heat in burning, for most purposes, because their shrinkage is thus brought to a very small amount, and shrinkage of the brick of large pieces of brickwork is a frequent cause of very expensive repai s.

The shrinkage to clay bricks of all kinds is the main reason for their abandonment for use in steel furnace roofs which are now built almost entirely of silica brick which expand when heated.

The use of soft burned fire bricks is sometimes justified by the theory that clay ware will stand just so much heat, that each time bricks are brought to that heat their life is so much shortened, etc.

Another reason why soft brick in a certain proportion are useful is found in the case of cutting and trimming them to fiit in odd shaped work. Fire brick laying has a great deal of fitting and adjusting to do and hard bricks offer great trouble and delay to the operations of the bricklayers.

The effect of high heat in burning fire brick ought never to produce any signs of vitrification in its particles; if it does, the clays are not of high grade. Bricks like the Benizette, Woodland, Mount Savage, Solid Crown, etc., cannot be made to show the effects of heat in any such temperature as is developed in the burning kiln.

The temperatures actually employed in burning fire brick are very much the same that are used in burning other clay wares, but the range of temperatures is greater for the obvious reason that the excess temperatures will do no harm other than the waste of a little coal.

The heat which fire brick receives in burning, however, is sufficient to effect some changes in the impurities. Iron, for instance, in any hard burned fire brick is apt to indicate its presence by a black blotch of cinder or silicate of iron. The ends and exposed portions of the bricks often show a black or brown incrustation, commonly ascribed to the "sulphur" in the coal, which is in reality a fused layer of fine coal ashes drawn into the kiln by the draft and attached to the surface of the brick while sticky by heat.

The regular manner of fire brick manufacture has been briefly set forth. One important addition to this statement has now to be made.

This is the application of the dry press machinery to fire brick making. The origin of this departure from the old customs of the fire brick business probably came about through the use of dry press machinery by several firms who are engaged in making fine buff and other light shades of building brick from fire clays.

However, this may be, the process is in operation at the works of the Dover Fire Brick Co. near Strasburg. The clays used are a very hard flint clay from the lower Kittanning horizon and various plastic fire clays found associated with the flint clay and in other horizons.

The mixture is ground in a dry pan and screened to a rather fine powder and is then run through a "Steamer" which is a tempering device patented by Mr. C. Arnold, the manager of the works.

The "Steamer" consists of a tight wooden box, provided with two small parallel pug mill shafts in the bottom. The clay is fed into it in a stream, which is broken up into a shower by a high speed rotary wire brush. The shower of clay falls through a zone where it passes between jets of steam blowing in contrary directions, and falls to the bottom of the box where the pug shafts keep it agitated in the steamy atmosphere until it is ejected.

Mr. Arnold claims great advantage for this arrangement in tempering clay for a dry press machine; he asserts that the strength of the brick are very materially increased, and the general quality of the ware greatly improved.

As a means of introducing *evenly* a small quantity of moisture into the clay to be pressed, this machine is probably a valuable contribution to the already existing forms of tempering machinery.

The same effect is to some extent realized by wetting slightly the clays as they are grinding in the dry pan. This is the wrong place to add the water however, for it interferes both with grinding and screening

The importance of this addition to the mechanical part of fire brick manufacture cannot be properly defined. The quality of the material has hardly been sufficiently demonstrated as yet, though in this one instance the promises of permanent success are flattering.

Dry pressed brick have certain advantages over all other kinds in the particular field of usefulness which they are able to fill. They are first, perfect in form and size, which is of great importance to the brick layers in their work. Second, they are dense and strong, resisting more pres sure under a crushing test than any other kind of brick. Third, they cost less to manufacture than any other kind of brick. On the other hand they will not resist severe abrasion, no matter how hard they are burned, as they never develop any cohesive bond at all comparable with that attained by the use of water.

The structure of good fire brick has always been purposely made very open and porous. The dry pressed brick cannot be called open in any sense. It is an aggregation of particles brought into their relative position by pressure and nothing else, and it is more dense and weighs more to the cubic inch than any wet brick can be made to do. Nevertheless it is easily permeable to water and possibly to air and heat as well, for it is impossible by pressure alone to force any particles into any close union like that attained by water.

The question of the value of the process hinges on this point. Is the fine and minute porosity of a dry pressed brick a fair equivalent for the coarser and more apparent porosity of the hand moulded article. If it is, an intelligent and careful trial of the two kinds of material will prove it to be so, and in that case, the use of dry press machinery in fire brick manufacture is the most important and valuable addition to the resources of the trade that has been made in the last twenty years.

The use of dry press machinery does away with the necessity of the use of any dryer, though as a matter of expediency a tunnel dryer is generally used, and the cost of production is very greatly decreased over the old plan.

The manufacture of other refractory materials than fire brick is represented at present mainly by the glass pot and glass works supply trade. Retorts for gas making were formerly manufactured at three or four points in the state. The extensive use of iron retorts and the perfection of other gas processes have very seriously crippled this trade in the United States however, and clay retorts are only manufactured at a few points in the county.

The manufacture of steel work specialities, like nozzles, stoppers, stopper sleeves, ladle brick, Bessemer tuyeres, etc., is carried on in a limited way in one or two factories.

Glass pot manufacture is probably the highest and the most technical work in the refractory material business. The service which is exacted from a glass pot has probably no equal for severity, unless the work of a steel crucible be considered.

The pots are of various types and sizes, but a large pot of the covered style weighs thirty-five hundred to four thousand pounds. It not only has to stand up in a furnace filled with flames at a high temperature and sustain its own weight, but must retain a fluid charge of a ton or more of molten glass whose ingredients comprise the most powerful fluxes like soda ash and oxide of lead. It is a wonder how a pot can be made to last at all, but cases are not infrequent where they are made to last a number of months. They are never allowed to cool when once heated on account of the danger of cracking but are kept continuously in service until worn out.

The material used in glass pot construction comprises only the finest refractory clays. Ohio furnishes only one or two clays used in this business.

The Mineral Point clay, which occurs on the Lower Kittanning horizon has been used for this purpose for a number of years. Its quality has been greatly improved by a system of rigorous hand picking and chipping.

The majority of glass-pot clays come from Germany and Missouri. Every clay now used is subjected to a most rigorous inspection at the mines and at the factory. At the factory this work is performed by women, who break open every lump and by chipping free it from every speck of impurity. No piece larger than a walnut is permitted to enter the mixtures. The mixtures employed are made on the same principal as those compounding in fire brick. The calcine is supplied in part by calcined flint clays, but more largely by old pot shells returned from service. These old shells have to be chipped with the most scrupulous care from the adhering layer of glass inside and the scorified and incrusted outside portion. Strange things are often found imbedded in the bottom of old glass pots; bolts, nails, lumps of metallic lead, and all kinds of iron objects, added with the charge through carelessness or spite.

These old shells come from pots previously made and numbered and of whose number a record is kept, and can be thus identified as to composition and graded accordingly so that no uncertainty of composition is encountered by their use.

The charge when mixed is ground in a dry pan, and tempered in a pug mill, by repeated passages through, When tempered, the clay is piled in large masses and compacted by hammering till solid, and blanketed to undergo a process of sweating or steeping.

By common opinion among glass pot men, this steeping is a very important part of the work. It is hard to see from a theoretical standpoint where the value of this process comes in. The only reason that can be suggested, is that the grinding of the clays, especially hard clays, exposes more surfaces to the action of the water than would be exposed by a natural process of cleavage by weather and that a long process of soaking may induce a softening of its nature not otherwise attainable. It is claimed that the quality developed by long standing is toughness; that clay newly mixed is short grained, while old clay is cohesive, like rubber.

Whatever may be the truth of this claim, the universal practice is to allow as long a period to elapse as possible between the mixing of the clay and the using of it. In some cases as long a period as two years is allowed to pass before the clay is used.

The various parts of the glass pot are constructed of different mixtures of clay. The top of the pot has only to stand the heat and bear up its own weight. The bottom has to stand the weight and the scorifying action of the glass. The sides have the severest work of all, having to maintain the weight of the roof and the inside pressure of the molten charge. The usual point of failure is eighteen to twenty four inches above the bottom of the pot.

The actual process of manufacture is one of slow building. A pot is built up in sections of a few inches every day. Each days work is welded onto the last, and the new work is kept from becoming too dry by wet cloths. Thus the process continues until completion, which occupies from one month to six weeks. A pot maker will have twenty or thirty pots in treatment at once, in various stages of progression. As fast as one crop comes off, a new one is blocked out. The drying it most carefully managed in perfectly tight rooms; no heat is used except to prevent freezing and no draughts of air, above all things. A month or six weeks of air drying is allowed, followed by a few days of heating in a hot room, preliminary to shipment.

The pots are never burned, except in the place where they are to do their work. They are put in position and heated very gradually up to the full heat of the furnace and never cool until the furnace is shut down for repairs.

The manufacture of glass in tank furnaces has turned a part of the energy of the glass pot men into a new channel. Glass tanks are large iron tanks lined with special shaped blocks of the finest refractory materials and are covered by an arched brick roof, under which the flames from the furnace circulate. Very few tank furnaces are built alike and consequently each one necessitates a complete set of moulds, for every block and brick required.

A tank is usually constructed by contract, the manufacturer agreeing to make the blocks and erect the brick work. Great stress is laid on a perfect fit of the blocks, as the glass is sure to search out any cracks or fissures in the retaining walls.

Blocks for tank furnaces are of various sizes. Some of them weigh eight or ten hundred pounds. To dry and burn such enormous lumps of clay, is a matter of great difficulty. Time is the main feature and must be used without stint.

The refractory material trade of Ohio is now situated in two districts. The Scioto district, including the factories at Portsmouth, Sciotoville, Webster, Ironton and Oak Hill forms the principal center of production. This district depends mainly on the fine flint clays of Scioto county, Ohio, and Carter county, Kentucky, just across the Ohio river.

The Ohio Valley from Steubenville to Wellsville is the source of a large brick and sewer-pipe industry. The bricks however are sold indiscriminately as fire brick and pavers. The factories on the Ohio side of the river are mainly in the fire brick business. The factories on the West Virginia side of the river are in the paving brick business, and only make fire brick incidentally. These works all use one stratum of hard fire clay which however, readily becomes plastic when ground and tempered. The balance of the fire-brick manufacture in the state is conducted in isolated shops at Youngstown, Niles, Cleveland, Dover, Mineral Point, Zanesville, Logan and a few other towns. No statistics were collected or are available from other sources.

V. THE MANUFACTURE OF BUILDING MATERIAL.

The manufacture of building material made from clay really includes the following lines of production:

Bricks.
1. Common hand made brick.
2. Soft mud brick.
3. Stiff mud brick.
4. Stock brick.
5. Pressed brick.
6. Enameled brick.

Terra cotta.—Building ornaments.

Hollow goods.
1. Fire proofing.
2. Chimney and flue linings.
3. Building and foundation blocks.

Tiles.
1. Roofing tiles.
2. Glazed panel tiles.
3. Encaustic floor tiles.

The manufacture of hollow goods has been fully considered under the former heads. The brick industries of the state have also been largely discussed and described in dealing with the more important and technical subjects of paving bricks and fire bricks. However, there remain several interesting forms of clay working which could not justly be passed by at this point.

The manufacture of low grade brick for the common purposes of life has become a business of the very greatest importance as a commercial matter, but is becoming less a matter of technical skill or of scientific interest as the years pass by.

The larger cities, which are the main consumers of brick, now demand two distinct kinds of brick materials. One class of comparatively small quantity is needed for the fronts and exposed parts of buildings. In this grade, the demand is gradually stimulating the manufacturers to fresh trials of skill and taste, regardless of cost.

The second class includes the inferior grades which constitute the bulk of all the walls, and of the sides and the rear portions, the whole. Bricks for this purpose are certainly not becoming any better as the years pass by, and many contend that the grading is becoming more and more lenient. In Chicago and other large markets almost anything made of clay, regardless of its shape, finish or color, is readily accepted, if it is only fairly hard. Soft material, especially for tall buildings, is strictly ruled out, but in proportion as attention is turned to the beauty of the fronts and architectural shapes, the demands as to the finish of the remaining portions are reduced.

The contractors of these large buildings regard the common brick as so many cubic inches of hard burnt clay and nothing else about the brick interests them. This influence has led in many centers of production to a distinct lowering of the grade of the common brick, and the whole attention of the maker is turned to the improvement of his mechanical facilities, and lowering the cost of his product, rather than to improve the grade which he is able to produce.

It is the history in every city where this spirit extends, that the hand moulding process is rapidly being pushed to the wall. In fact the hand moulding process is in full and healthy development only around some of the smaller cities and in country districts. Toledo and Cleveland have began to depend wholly on the product of yards in which the soft mud machinery is used. Thirty thousand per day is the usual output of these machine; yards are therefore classed according to the number of crews they run, as thirty thousand, sixty thousand or ninety thousand yards.

In Columbus, the machine brick trade is represented by two factories making dry pressed shale brick for backing up purposes. No front brick are made in this vicinity. In Cincinnati, the rushing methods of Chicago are finding rapid acceptance. Stiff mud brick are crowding the old time hand moulding yards more sorely each year.

The hand moulding process, while using less machinery and power than any other, produces a brick free from structural faults. Manufacture by this process is largely a matter of labor, and the cost is now regulated by the price of union labor. Everything is reduced to a system, and one standard price for an alloted quantity of brick per day is the rule in all centers of production. The actual production of the various manufacturers thus costs about the same. Their only chance to economize, is by management of the details, and the skill of burning; one burner may produce a larger percentage of good brick than another.

The soft mud machine makes a brick of good structural quality, but every brick has one rough side where the mold is stroked off. The main advantage of the machine over the hand moulding is the increased output. The cost of the plant is much higher, however, a large part of the expense being for racks and pallets for outside drying.

The auger machine process for building brick is mainly confined to the production of end cut brick. It is in this business that the automatic end cutting machines originated.

The formation of the bar of clay has nothing to do with the value of the product for building purposes, and color or smoothness has about as little, in the large markets.

For building brick, the clays selected are usually plastic drift and sedimentary clays.

The preparation consists usually in passing through rollers to separate large stones, and to crush smaller ones, and a pug mill to temper the clay. For the soft mud and hand moulding process no machinery except a crude pug mill for preparation is used. The drying is accomplished by the most elaborate dryers in the large factories, and by racks and open yards in the smaller yards. Burning is altogether accomplished by the use of clamp up-draft kilns. The use of oil fuel, and natural gas, has been a temporary advantage to some few brickmakers, but has been of no permanant profit to the industry. The firing of the kilns is done in the arches, in the fire-holes or in outside furnaces.

Stock brick are a grade between pressed front brick and the best grades of common brick. The grade is dying out as the introduction and perfection of the dry press process goes on. At one time stock brick were the best that could be obtained. The method of manufacture is much the same as that of common brick, except that they are subjected to a pressing process after they have been allowed to partly dry, and become of a stiff, cheesy consistency. At this temper the clay takes a beautiful sharp edge, and if handled carefully the results are very fine. The clays are selected to make a fine colored brick; no other will sell at the advanced figures charged, and the burning is done generally in clamp kilns, in which the arches, benches, sides, ends and top are made of common brick, and the stock brick are put in a compact mass in the center, where they are all sure to be burnt hard and informally. The grading of the colors produced is managed just the same as the grading of pressed brick and ten or twelve shades are recognized.

In actual quality, fine stock brick are apt to be of a higher character than press bricks which sell for more, on the principle that any clay-ware that has been tempered in water is more cohesive and less absorbent than dry press brick of equal hardness.

Pressed Brick. The manufacture of high grade pressed bricks for city buildings and artistic architectural construction, has been slowly developing for some years. It has received much stimulus in the last few years and the industry is rapidly coming forward. Indeed the younger generation of architects, and these same progressive manufacturers, are rapidly making a new industry out of the old one. While there are a number of pressed brick manufacturers, in Ohio, there are a comparatively few who are representatives of the new departure. The Columbus Brick and Terra-Cotta Co., The North Baltimore Pressed Brick Co., The Akron Vitrified Pressed Brick Co., The Oakland Pressed Brick Co., of Zanesville, and The Findlay Hydraulic Pressed Brick Co., are types of the most progressive ones. Of these the last three named firms produce nothing but fine red front bricks. The clays they use are different in each case. The Akron Vitrified Pressed Brick Co., whose factory is at Independence, is the only factory using the red Bedford shales, so far as is known. These shales constitute a persistent but comparatively thin stratum, which crosses the state in a line taking in Cleveland and Columbus. The shales are always red in color. At Independence they form the top of the hills and cover the surface down to the top courses of the Berea Grit which is quarried extensively near by.

Exposures as fortunate as this one, are likely to be rare, as the soft shales are too easily eroded to form the surface deposit over any large area. Hard rocks are usually found on the surface. The high grade of this deposit is undoubtedly due in part to the mellowness which has been imparted by centuries of exposure.

The Oakland plant at Zanesville began operations on the famous red loam which has made Zanesville stock brick famous in past years. After some months of successful work they introduced a change in the composition by using one-half of the shales which cover the middle Kittanning coal with the red loam. The change gave them no less choice a color, together with far greater toughness and strength. The loam clay was very sandy, and while it made a very beautiful brick it was a very tender one and the edges were likely to be rubbed off and broken. The shale is a fine paving brick material, and one which vitrifies easily; by mixing it with the sandy clay, a bond by partial vitrification was produced.

The Findlay Pressed Brick Co., use a surface drift clay of a very sandy character, which they gather and shed during the summer season with great care and by methods which insure thorough mixing and averaging of the composition.

The preparation of the clays where the shales are used, is by dry pan and screens. When the drift clay is used, such thorough methods are not required. Brick are made at Independence, by the Boyd Press; by the Whittacre at Oakland; and by the Hydraulic at Findlay.

The brick at both Independence and Zanesville are dried in steam heated dryers, using cars as a means of transportation. At Findlay the brick are set directly in the kiln and are dried by the heat of one of the cooling kilns which is blown in to the green kiln by a fan. This method was alluded to more fully in the remarks on drying of paving brick. The burning is accomplished by down draft kilns of rectangular form. Each factory uses a different kiln, one the Eudaly, one the Griswold and one the Graves.

The two factories located one at Union Furnace, and one at North Baltimore, are entitled to special credit as being the pioneers in the line of new architectural work alluded to before. The Union Furnace plant is located in the edge of the Coal Measures, and has in the hills surrounding it a series of strata, comprising three or four veins of fire-clay, besides several shales and surface clays of value. The colors produced are a line of buff brick, comprising ten or twelve shades; a line of so called terra-cotta shades, which are a mixture of buff and dull red; and a line of grays, which are very light buff with pure black. Other lines of colors have been experimented on and produced on a small scale.

The North Baltimore Plant produces a similar line of buff brick, and also a fine red color. They have also gone into the manufacture of enameled brick.

In these two works, the efforts of the manufacturers have been to meet the architects half way in the production by accurate and scientific means, of whatever colors, shades and shapes may be needed for artistic work in construction.

The mixtures are controlled by weights and thorough care is taken, to keep the stock always uniform, so that the production of the shades of any one color will fall inside the regular classified grades. In these works the process of manufacture is distinctly less important than the accurate control and grading of the product.

It is found necessary for each line of colors to establish not less than ten or twelve shades of that color due to the variations of the burning, and position in the kiln. The accurate grading of the brick into shades is a matter of great delicacy and expense, and yet on this stage of the work the artistic value of the product depends.

The process of manufacture is by use of the dry-pan and screen and Boyd brick press at Union furnace, and by Steadman disintegrator and Simpson brick press at North Baltimore. The burning is accomplished by down draft kilns at both plants. At Union Furnace, there are two large continuous kilns of the Guthrie patent. The principle of these kilns is undoubtedly correct as it involves the use of the waste heat of cooling in pre-heating the air to be used for combustion in the chamber which is burning, and the use of the heat from the burning chamber in drying off and heating up the chambers in advance.

The method of accomplishing this result however is defective, in every style of continuous kiln which has yet been erected in the state. The failure usually is in the waste of heat in the rear of the fuel chamber. One chamber in the rear of the fire is ample to pre-heat all the air required for combustion, and it has been determined by practical tests that no drying takes place further than three chambers ahead of the fire.

If the maximum speed and the minimum consumption of fuel is to be reached, it must be through some plan by which the surplus heat of the cooling chambers can be made to assist in the drying off and heating up of the chambers which are too far ahead of the fire to benefit by the waste heat of combustion.

The faults of the continuous kiln as it stands are mainly against the speed of its operation. Only three chambers ahead of the fire can be benefitte i by the heat of combustion, and from six to seven days are required to the kiln. Hence a chamber can only be burned off every two days. If, by transfer of heat from rear of the fire to the fourth, fifth, or sixth chambers ahead of the fire, it could be managed to bring these chambers up to three or four hundred degrees before their time came for direct heat, then the burning could progress with nearly twice the speed, without any more fuel being used. However, the economy in fuel which is attained by use of even the most imperfect of the continuous kilns, is so very great compared with that obtained by down-draft or up-draft kilns that it cannot but prove attractive to any brick maker who sees it. The obstacles in the way of its general adoption are, 1st, the great cost of the kiln; 2d, the comparatively limited out-put; 3d, the skill required in the proper management of the kiln. These three reasons stand in the way of any rapid changes to this plan from the older methods, though the economy in fuel cannot be questioned or doubted by anyone familiar with its work.

Enameled Bricks, have been produced in Ohio for eleven or twelve years to a limited extent. At one time the industry seemed to be likely to go forward rapidly to a substantial development. Comparatively little headway has been made however in the last ten years. There are three factories which produce enameled brick in Ohio—W. B. Harris & Co., of Zanesville, T. B. Townsend & Co., of Zanesville, and The North Baltimore Pressed Brick Co., of North Baltimore. Possibly there are others who have taken up this line recently, but none others are known to the Survey. The enamels, which are thick, opaque, colored glazes, are laid on the burnt bricks, which are then put into saggers and burned, just as any pottery ware would be.

The white colors are the most difficult to produce, as the glaze has to be sufficiently thick and opaque to conceal the dark red color of the body of the brick; blues, browns and other strong colors are less troublesome. •

The use of enameled brick places at the architect's disposal a range of beautiful effects which he can obtain in no other way. They are more suitable for inside decoration of public buildings, halls, waiting rooms etc., than for the decoration of outside work.

Terra cotta. The manufacture of high grade building ornaments is not carried on to any extent in Ohio. The process of manufacture is an elaborate one. The clays for each color are prepared with great care and are often compounded with other clays and chemicals to obtain the desired effects. The process is dry press machinery on all sizes and shapes which can be produced in this way; the larger pieces are made in molds from tempered clays and the highest grades are even moulded and carved by hand.

Ti.es. The manufacture of roofing tile has been in progress for some ten or twelve years in the state, though the industry is still confined to comparative by small dimensions. There are three factories represented viz: The J. C. Ewart Roofing Tile Co., of Akron, The Repp Roofing Tile Co., of New Philadelphia, and the Barnard Tile Co., of Bellaire. The latter company has only recently completed and perfected its process and is just begining the manufacture of tile.

The advocates of roofing tile are mainly architects who like it for artistic reasons. Some forms of it certainly produce very fine effects on roofs which are designed for its use. The shapes used are diamond or lozenge shaped, plain flat shingle tiles, scalloped shingles, and a new design like a modified letter S in section.

The qualities which a roofing tile must have in order to compete with the other well established forms of roofing are: 1st, vitrification, so as to stand frost and rain without any sign of failure. 2d, strength and toughness, by which it will stand transportation and handling during its application. 3d, thinness of section, by which its weight can be brought within reasonable limits. Tile makers contend that a tile roof is lighter than a slate roof, owing to the great overlap of the slate and practically no overlap of the tile. A popular prejudice to the contrary effect, has a strong hold on the public. 4th, the tile must be true and not easily warped in order to make its attachment easy and secure.

A line now being introduced, in which the tiles are glazed with the cheapest lead glaze on the exposed portions of the outside. The purpose of this is to avoid the necessity of such hard burning, the strength and toughness of the tile being at its best stage before the proper vitrification is attained. This action is in the proper line as it will allow lighter, thinner tiles, with equal strength and increased impenetrability.

The manufacture of the tile is by process which the makers wish to keep secret. The main principle of the process is the production of thin flat bars of clay about six by three-eights inches in section, which are then pressed or stamped into the requisite shape.

The strips may be made by forming a single or multiple bar of clay of this kind, or cutting up a common sized bar into ribbons by wires across the die.

The manufacture of panel and flooring tiles is a business which calls in play the highest skill of the potters art, coupled with mechanical attainments of a superior grade. Panel tiles, which are intended for purely decorative use in fine buildings, are usually made of a white composition, similar to the white body employed by white ware makers. The decoration is largely by glazes which are made to produce effects of light and shade by the thickness of the layer which they form in the elevations and depressions of the surface. The use of colored glazes and decoration by them becomes a distinct branch of pottery decoration. The designs which are produced on the surface are mechanical in the cheap goods, and on the most expensive, artistic skill of high grade is demanded.

The manufacture of encaustic flooring tile is a matter of far more skill than the production and ornamentation of white ware panel tiles. The process in brief involves the compounding of a separate body-mixture for each color which appears in the finished tiles. The body is produced by uniting the clays, flint spar, and metallic oxides, which are to produce the color in a washing plant and the thoroughly mixed ingredients are separated out by the filter press as in common pottery. The cakes from the press are dried in tunnels like brick and are then ground up to a fine powder by high speed disintegrators, and the powder is removed by air blast as fast as it is reduced to the proper fineness. This powder is then put away in brick cemented bins, where it retains just the proper dampness for use. Each powder mixture is used in making a tile by just such means as the ground clay is used in making a pressed brick, except that where tile are made showing two or more colors, a separate operation has to be made for each color employed. The presses used are of special construction. The burning of the ware is done in saggers in regular pottery kilns.

There are three works in Ohio which are engaged in the manufacture of artistic panel and encaustic tiles. The American Encaustic Tiling Co., of Zanesville is the oldest, largest and best concern of its kind in the United States. It has recently occupied its new factory which has been equipped at a cost of over a half million of dollars. It has mechanical arrangements for the simultaneous production of eight different colors of body mixtures. It uses electricity as a means of transmitting power from the engine house to the various parts of its enormous plant where power is required. Thirty kilns are in user.

TABLE XIII.

DETAILS OF ABSORPTION TESTS.

Sample number.	Brick number.	Name of manufacturer.	Location.	Weight of bricks, dry.	Weight of bricks, wet.	Increase of weight.	Per cent. increase.	Average per cent.
1	1	Wassall Fire-clay Company	Columbus	137.5	138.5	....	....	.60
	2	" "	"	134.0	134.0	1.5	1.09	
	3	" "	"	136.5	138.0	1.0	.72	
2	1	Ohio Paving Company	"	138.5	139.5	2.0	1.43	1.08
	2	" "	"	137.0	139.0	1.5	1.09	
	3	" "	"	136.5	138.0	0.5	.34	
3	1	Logan Fire-clay Company	Logan	141.0	141.5	3.5	2.52	1.32
	2	" "	"	138.5	142.0	1.5	1.09	
	3	" "	"	136.5	138.0	2.5	1.73	
4	1	Nelsonville Sewer-pipe Company	Nelsonville	144.0	146.5	2.0	1.41	1.75
	2	" "	"	141.5	143.5	3.0	2.11	
	3	" "	"	142.0	145.0	1.0	.70	
5	1	Athens Paving-brick Company	Athens	142.5	143.5	1.0	.70	.47
	2	" "	"	137.0	138.0	....	....	
	3	" "	"	136.5	136.5	0.5	.36	
6	1	Portsmouth Paving-brick Company	Portsmouth	136.0	136.5	0.5	.37	.24
	2	" "	"	133.5	134.0	×	×	
	3	" "	"	136.5	136.5	0.5	.38	
7	1	Cincinnati Brick Company	Addyston	129.0	129.5	0.5	.38	1.28
	2	" "	"	129.0	129.5	4.0	3.10	
	3	" "	"	129.0	133.0	0.5	.33	

TABLE XII.—Continued.

Sample number.	Brick number.	Name of manufacturer.	Location.	Weight of bricks, dry.	Weight of bricks, wet.	Increase of weight.	Per cent. increase.	Average per cent.
8	1	W. B. Harris & Brothers	Zanesville	148.5	149.0	1.0	.72	
	2	" "	"	151.0	151.0	×	×	.33
	3	" "	"	148.0	149.0	1.0	.67	
9	1	T. B. Townsend & Company	"	151.5	154.0	2.5	1.65	
	2	" "	"	144.0	145.0	1.0	.69	1.34
	3	" "	"	146.5	149.0	2.5	1.70	
10	1	Middleport Granite Brick Company	Middleport	115.0	117.0	2.0	1.73	
	2	" "	"	111.0	113.0	2.0	1.80	1.77
	3	" "	"	112.0	114.0	2.0	1.78	
11	1	Hocking Clay Company	Logan	99.5	100.0	0.5	.50	
	2	" "	"	100.5	101.5	1.0	1.00	.66
	3	" "	"	101.0	101.5	0.5	.49	
12	1	Haydenville Mining & M'fg. Company	Haydenville	178.0	179.5	1.5	.84	
	2	" "	"	176.0	177.0	1.0	.56	.84
	3	" "	"	179.0	181.0	2.0	1.11	
13	1	East Clayton Manufacturing Company	Lick Run	125.0	125.5	0.5	.40	
	2	" "	"	126.0	127.5	1.5	1.19	1.19
	3	" "	"	124.5	127.0	2.5	2.00	
14	1	Scioto Star Fire-brick Company	Sciotoville	146.0	146.5	0.5	.34	
	2	" "	"	150.0	151.0	1.0	.66	.55
	3	" "	"	149.0	150.0	1.0	.67	
15	1	Standard Brick & Terra Cotta Co.	New Straitsville	128.5	129.5	1.0	.77	
	2	" "	"	127.0	117.5	0.5	.39	.51
	3	" "	"	129.0	129.5	0.5	.38	

TABLE XIII—Continued.

Sample number.	Brick number.	Name of manufacturer.	Location.	Weight of bricks, dry.	Weight of bricks, wet.	Increase of weight.	Per cent. increase.	Average per cent.
16	1	Roseville Brick & Terra Cotta Co.	Roseville	157.5	159.0	1.5	.95	
	2	" "	"	161.0	162.0	1.0	.62	1.47
	3	" "	"	158.5	163.0	4.5	2.83	
17	1	A. O. Jones Brick & Terra Cotta Co.	Zanesville	140.0	142.5	2.5	1.78	
	2	" "	"	138.5	139.0	0.5	.36	.95
	3	" "	"	141.0	142.0	1.0	.70	
18	1	The Imperial Brick Company	Canton	155.0	155.5	0.5	.32	
	2	" "	"	156.5	157.5	1.0	.64	.64
	3	" "	"	155.0	156.5	1.5	.96	
19	1	The Logan Granite Clay Company	Logan	121.0	122.0	1.0	.82	
	2	" "	"	121.5	122.5	1.0	.82	.96
	3	" "	"	121.5	123.0	1.5	1.23	
20	1	The Ironton Fire Brick Company	Ironton	127.0	127.0	×	×	
	2	Shale Pavers	"	131.5	132.0	0.5	.38	.25
	3	The Ironton Fire Brick Company	"	130.0	130.5	0.5	.38	
21	1	" "	"	125.5	125.5	×	×	
	2	Fire-clay Pavers	"	131.5	131.5	×	×	×
	3	The Ironton Fire Brick Company	"	131.5	131.5	×	×	
22	1	The Riverside Brick Company	Middleport	101.0	102.0	1.0	.99	
	2	" "	"	99.0	100.0	1.0	1.11	1.03
	3	" "	"	92.0	93.0	1.0	1.08	
23	1	The Canton Brick Company	Canton	109.5	110.0	0.5	.45	
	2	" "	"	107.5	108.0	0.5	.46	.45
	3	" "	"	109.5	110.0	0.5	.45	

TABLE XIII—Continued.

Sample number.	Brick number.	Name of manufacturer.	Location.	Weight of bricks, dry.	Weight of bricks, wet.	Increase of weight.	Per cent. increase.	Average per cent.
24	1	The Royal Brick Company	Canton	110.0	110.0	×	×	
	2	" "	"	115.0	115.0	×	×	.30
	3	" "	"	110.5	111.5	1.0	.90	
25	1	W. S. Williams	"	119.5	120.5	1.0	.83	
	2	"	"	116.0	116.0	×	×	.43
	3	"	"	111.0	111.5	0.5	.45	
26	1	The Holloway Paving Brick Company	N. Industry	110.0	110.5	0.5	.45	
	2	" "	"	109.5	114.0	4.5	4.11	1.82
	3	" "	"	110.5	111.5	1.0	.90	
27	1	The Canton Brick Company	Canton	113.0	113.5	0.5	.44	
	2	Plain Side-cut	"	108.5	109.0	0.5	.46	.75
	3	The Canton Brick Company	"	110.5	112.0	1.5	1.35	
28	1	The Royal Brick Company	"	116.0	117.5	1.5	1.29	
	2	Plain Side-cut	"	110.0	110.0	×	×	.57
	3	The Royal Brick Compa y	"	114.5	115.0	0.5	.43	
29	1	The W. S. Williams	"	116.5	118.5	2.0	1.72	
	2	Plain Side-cut	"	116.5	118.0	1.5	1.29	1.57
	3	The W. S. Williams	"	118.0	120.0	2.0	16.90	
30	1	The Holloway Paving Brick Company	N. Industry	109.0	114.0	5.0	4.58	
	2	Plain Side-cut	"	114.0	115.5	1.5	1.31	2.54
	3	The Holloway Paving Brick Company	"	116.0	118.0	2.0	1.72	
31	1	The Standard Paving Brick Company	"	116.5	117.0	0.5	.42	
	2	" "	"	121.5	125.5	4.0	3.29	1.37
	3	" "	"	115.5	116.0	0.5	.42	

TABLE XIII—Continued.

Sample number.	Brick number.	Name of manufa. turer.	Location.	Weight of bricks, dry.	Weight of bricks, wet	Increase of weight.	Per cent. increase.	Average per cent.
32	1	The Waynesburg Brick & Clay Co......	Waynesburg........................	114.5	119.5	×	×	
	2	Shale Brick........................	"	114.5	115.0	0.5	.43	.28
	3	The Waynesburg Brick & Clay Co......	"	121.0	121.5	0.5	.42	
33	1	" "	"	114.5	116.0	1.5	1.31	
	2	Fire-clay Brick........................	"	111.5	112.5	1.0	.89	.88
	3	The Waynesburg Brick & Clay Co......	"	115.0	115.5	0.5	.43	
34	1	The Malvern Fire-clay Company........	Malvern........................	116.0	119.5	1.5	1.29	
	2	" "	"	107.5	110.5	3.0	2.79	1.92
	3	" "	"	118.0	120.0	2.0	1.69	
35	1	Canton & Malvern Brick & Paving Co.	"	105.0	101.0	1.0	.95	
	2	" "	"	103.5	104.5	1.0	.96	.96
	3	" "	"	103.5	104.5	1.0	.96	
36	1	The Massilon Stone & FireBrick Co....	Massillon	102.0	105.0	2.0	1.98	
	2	" "	"	108.0	110.0	2.0	1.85	1.89
	3	" "	"	108.5	110.5	2.0	1.85	
37	1	The State Line Fire Brick Company...	E. Palestine........................	121.0	122.0	1.0	.82	
	2	" "	"	120.5	122.0	1.5	1.24	.109
	3	" "	"	121.5	123.0	1.4	1.23	
38	1	Salem—Garfield Mining & M'fg. Co.	Garfield	108.0	112.0	4.0	3.70	
	2	" "	"	107.5	111.0	3.5	3.25	3.56
	3	" "	"	107.0	111.0	4.0	3.73	
39	1	The Congo Fire-clay Company..........	Empire	96.0	101.0	5.0	5.27	
	2	" "	"	95.5	98.0	2.5	2.61	4.47
	3	" "	"	99.5	105.0	5.5	5.52	

TABLE XIII—Concluded.

Sample number.	Brick number.	Name of manufacturer.	Location.	Weight of bricks, dry.	Weight of bricks, wet.	Increase of weight.	Per cent. increase.	Average per cent.
40	1	The Vulcan Fire-clay Company	Wellsville	110.0	112.5	2.5	2.27	
	2	" "	"	111.5	114.5	3.0	2.69	3.14
	3	" "	"	112.0	117.0	5.0	4.47	
41	1	The Buckeye Brick Company	"	110.5	112.5	2.0	1.81	
	2	" "	"	108.5	113.0	4.5	4.14	3.32
	3	" "	"	112.0	116.5	4.5	4.01	
42	1		Akron	110.0	115.0	5.0	4.54	
	2		"	112.0	116.5	4.5	4.01	5.11
	3		"	110.5	117.5	7.5	6.78	
43	1	Bucyrus Brick & Terra Cotta Co.	Bucyrus	117.5	118.0	0.5	.42	
	2	" "	"	110.5	110.5	×	×	.28
	3	" "	"	114.5	115.0	0.5	.43	
44	1	The South Zanesville Brick Company	S. Zanesville	137.0	138.0	1.0	.73	
	2	" "	"	142.5	147.5	5.0	3.50	2.97
	3	" "	"	139.0	145.5	6.5	4.67	
45	1	The Trimble Brick Manufacturing Co.	Trimble	111.5	115.5	4.0	3.58	
	2	" "	"	112.5	114.5	2.0	1.77	2 26
	3	" "	"	111.5	113.0	1.5	1.34	

TABLE XIV

DETAILS OF RATTLING TESTS.

1	Wassall Fire Clay Co.	549.0	500.0	49.0	8.92	Kept shape very well.
2	Ohio Paving Co.	416.5	280.0	136.5	32.77	Disintegrated in layers around the cores.
3	Logan Fire Clay Co.	421.5	376.5	45.0	10.68	One brick broken, not much worn.
4	Nelsonville Sewer Pipe Co.	435.0	404.0	31.0	7.12	Kept shape very well.
5	Athens Paving Brick Co.	418.0	364.5	53.5	12.80	Good condition.
6	Porthsmouth Paving Brick Co.	407.0	324.5	82.5	20.27	Chipped considerably, fair condition.
7	Cincinnati Brick Co.	392.0	308.5	83.5	21.30	Disintegrated like No. 2.
8	W. B. Harris & Bros.	449.0	353.0	96.0	21.38	Fair condition, chipped.
9	T. B. Townsend & Co	448.0	378.5	69.5	15.51	Fair condition, worn, not chipped.
10	Middleport Granite Brick Co.	344.0	294.5	49.5	14.39	Stood fairly well.
11	Hocking Ware Co.	303.0	233.5	69.5	22.94	Broke into small fragments.
12	Haydenville M. & M. Co.	537.5	443.5	94.0	17.49	Broken somewhat.
13	East Clayton Manufacturing Co.	380.0	314.0	66.0	17.37	Fair condition.
14	Scioto Star Fire Brick Co.	447.5	395.0	52.5	11.73	Good.
15	Standard Brick & T. C. Co.	386.5	300.5	86.0	22.25	Broken considerably.
16	Roseville Brick & Terra Cotta Co.	484.0	432.0	52.0	10.74	Good, not chipped much.
17	The A. O. Jones B. & Tile Co.	423.5	336.0	87.5	20.66	Broken somewhat.
18	The Imperial Brick Co.	469.5	395.0	79.0	16.82	Fair condition.
19	The Logan Granite Clay Co.	367.5	297.0	70.5	19.18	Wore well, not chipped.
20	The Ironton Fire B. Co., shale	388.5	310.0	78.5	20.21	Chipped badly, not much worn.
21	The Ironton F. B. Co., fire clay	389.5	255.5	134.0	34.40	Broken into pieces, very brittle but hard.
22	The Riverside Brick Co.	295.0	232.0	63.0	21.36	Not broken much, fair shape.
23	The Canton Brick Co., repressed	328.0	284.5	43.5	13.26	Good
24	The Royal Brick Co., repressed	336.5	280.0	56.5	16.79	Good condition.
25	W. S. Williams, repressed	348.0	293.0	55.0	15.80	Good condition.
26	The Holloway P. Brick Co., repressed	336.0	269.5	66.5	19.79	Wore well, not chipped much.
27	The Canton Brick, plain	334.5	278.0	56.5	16.89	Fair condition.
28	The Royal Brick, plain	342.5	300.0	42.5	12.41	Good condition.
29	The W. S. Williams, plain	356.5	298.5	58.0	16.27	Fair condition.
30	The Holloway P. B. Co., plain	347.5	274.0	73.5	21.15	Fair condition, not chipped much.
31	The Standard P. B. Co.	358.5	293.0	65.5	18.27	Stood fairly well.
32	The Waynesburg B. Co., shale	356.0	280.0	76.0	21.35	Somewhat shattered, rather tender.
33	The Waynesburg B. Co., fire clay	344.0	276.0	68.0	19.77	Broken up somewhat.
34	The Malvern Fire Clay Co	348.0	292.5	55.5	15.95	One brick broken badly, others good.
35	The Canton & Malvern B. Co.	315.0	256.0	59.0	18.73	Good condition.

TABLE XIV—Concluded.

36	The Massillon Stone & F. B. Co.	325.5	280.0	45.5	13.98	Wore well.
37	The State Line F. B. Co.	367.0	311.0	56.0	15.26	Each brick broken, but fragments not much worn.
38	The Salem Garfield Co.	334.0	268.0	66.0	19.76	Stood well, not chipped.
39	The Congo Fire Clay Co.	304.0	266.0	38.0	12.50	Wore well.
40	The Vulcan Fire Clay Co.	344.0	297.0	47.0	13.66	One brick broken badly, wore well.
41	The Buckeye Brick Co	342.0	272.5	69.5	20.79	One brick and four bats left, wore rounded.
42	Unidentified, Akron	349.0	278.0	71.0	20.34	Much worn but not broken.
43	Bucyrus Brick & F. C. Co.	343.5	293.5	50.0	14.56	Good.
44	The Zanesville B. Co.	431.0	360.0	71.0	16.47	Stood well.
45	The Trimble Brick Manufacturing Co.	343.0	264.5	78.5	22.89	Broken up somewhat.
	Average	....	....	....	17.71	....

TABLE XV.

DETAILS OF CRUSHING TESTS.

Sample number.	Brick number.	Name of firm.	Average length.	Average width.	Average thickness.	Tons pressure.	Pressure sq. inch.	Average for sample.	Pressure cu. inch.	Average for sample.
1	1	Wassall Fire-clay Company	9.12	2.94	3.97	80	5,967			
	2	" " "	9.12	2.91	4.00	55	4,145	5,260	1,503	1,315
	3	" " "	9.06	2.92	4.03	75	5,670		1,036	
2	1	Ohio Paving Company	9.00	3.01	3.97	65	4,791		1,407	
	2	" " "	9.06	2.98	3.94	55	4,074	4,455	1,207	1,138
	3	" " "	9.00	2.94	3.84	60	4,535		1,034	
3	1	Logan Fire-clay Company	9.12	2.97	4.06	85	6,276		1,181	
	2	" " "	9.06	2.94	4.03	80	6,007	5,462	1,546	1,342
	3	" " "	9.12	2.94	4.15	55	4,102		1,491	
4	1	Nelsonville Sewer-pipe Company	9.00	2.94	3.97	90	6,803	7,499	988	1,888
	2	" " "	9.06	2.97	4.00	110	8,176		1,714	
5	1	Athens Paving Brick Company	9.00	2.88	4.09	75	5,787	5,208	2,044	1,277
	2	" " " "	9.00	2.88	4.06	60	4,630		1,415	
6	1	Portsmouth Paving Brick Company	9.00	2.88	3.91	80	6,173		1,140	
	2	" " " "	9.00	2.91	3.85	78	5,956	6,632	1,579	1,694
	4	" " " "	8.94	2.88	3.97	100	7,768		1,547	
7	1	Cincinnati Brick Company	8.75	2.97	3.88	62	4,772	4,836	1,957	1,249
	2	" " "	8.75	2.94	3.88	63	4,898		1,230	
8	1	W. B. Harris & Bros.	9.06	2.91	4.12	58	4,400	4,628	1,262	1,131
	2	"	9.12	2.94	4.06	65	4,849		1,068	
9	1	T. B. Townsend & Co.	9.12	3.00	4.09	55	4,020	5,286	1,194	1,262
	2	"	9.25	2.97	4.25	90	6,552		983	
10	1	Middleport Granite Brick Company	8.75	2.57	3.94	60	5,336		1,542	
	2	" " " "	8.75	2.54	4.00	40	3,599	4,592	1,354	1,160
10	3	" " " "	8.62	2.53	3.85	52	4,983	1,229	899	

TABLE XV—DETAILS OF CRUSHING TESTS—Continued.

Sample number.	Brick number.	Name of firm.	Average length.	Average width.	Average thickness.	Tons pressure.	Pressure per sq. inch.	Average for sample.	Pressure per cu. inch.	Average for sample.
11	3	Hocking Clay Company	8.75	2.54	3.94	53	4,841		1,126	
	1	" " "	8.62	2.25	4.06	45	4,571	6,125	1,452	1,491
	2	" " "	8.75	2.25	4.12	58	5,981		1,899	
12	2	Haydenville M. &. M. Company	No	2.25	4.12	77	7,822			
	1	" " "		crushing	test	made.				
13	2	East Clayton Mfg. Company	8.94					4,952	1,238	1,238
14	1	Scioto Star Fire-brick Company	9.06	2.62	4.00	58	4,952	6,733	1,382	1,656
	1	" " " "	9.00	2.95	4.06	75	5,612		1,930	
15	2	Standard Brick and Terra-cotta Company	9.12	2.97	4.07	105	7,056		1,253	
	1	" " " "	9.19	2.91	4.09	68	5,125	5,390	1,239.	1,308
	2	" " " "	9.12	2.75	4.15	65	5,144		1,425	
16	3	Roseville Brick and T. C. Company	9.06	2.69	4.12	72	5,870		1,844	
	1	" " " "	9.00	3.31	4.35	120	8,003	7,749	1,750	1,781
	2	" " " "	9.09	3.19	4.38	110	7,663		1,743	
17	3	The A. O. Jones Company	9.25	3.25	4.35	112	7,582	7,207	1,802	1,802
18	1	The Imperial Brick Company	9.25	3.00	4.00	100	7,207	5,653	1,362	1,362
19	1	Logan Granite Clay Company	8.87	3.06	4.15	80	5,653	8,727	2,228	2,093
	1	" " " "	8.94	2.56	4.15	105	9,248		1,958	
20	2	The Ironton Fire-brick Company, shale	9.25	2.59	4.19	95	8,206	5,996	1,427	1,342
	1	" " " "	9.19	2.56	4.44	75	6,334		1,257	
21	2	The Ironton Fire-brick Company, fire-clay	9.00	2.50	4.50	65	5,658	3,542	804	807
	1	" " " "	9.19	2.53	4.37	40	3,513		809	
22	2	The Riverside Brick Company	8.12	2.56	4.41	42	3,571		747	
	1	" " "	8.12	2.47	4.00	30	2,992	4,386	1,316	1,119
	2	" " "	8.25	2.47	3.94	52	5,185		1,294	

TABLE XV—DETAILS OF CRUSHING TESTS—Continued.

Sample number.	Brick number.	Name of firm.	Average length.	Average width.	Average thickness.	Tons pressure.	Pressure per sq. inch.	Average for sample.	Pressure per cu. inch	Average for samp'e.
23	1	The Canton Brick Company, repressed	8.25	2.31	4.12	102	10,704	10,822	2,598	2,604
	2	" " " "	8.31	2.31	4.19	105	10,940		2,611	
24	1	The Royal Brick "	8.44	2.44	4.12	80	9,769	8,754	1,886	2,116
	2	" " " "	8.37	2.38	4.15	97	9,739		2,347	
25	1	W. S. Williams, "	8.50	2.38	4.31	75	7,415	7,741	1,920	1,795
	2	" "	8.44	2.35	4.31	80	8,067		1,872	
26	1	The Holloway Paving Brick Company, repressed	8.37	2.25	4.25	85	8,908	8,074	2,096	1,882
	2	" " " " "	8.37	2.31	4.34	70	7,241		1,668	
27	1	The Canton Brick Company, plain	8.71	2.50	4.06	80	7,701	7,701	1,897	1,897
28	1	The Royal " " "	8.25	2.47	4.00	90	8,833	8,833	2,208	2,208
29	1	W. S. Williams "	8.50	2.50	4.19	78	9,341	7,341	1,752	1,752
30	1	The Holloway P. B. Company "	8.37	2.47	4.19	75	7,256	7,256	1,731	1,731
31	1	The Standard Paving Brick Company	8.75	2.56	4.41	100	8,928	8,928	2,024	2,024
32	1	The Waynesburg Brick Company, shale	8.50	2.50	4.19	100	9,412		2,246	
	2	" " " "	8.50	2.50	4.15	97	9,130	8,754	2,199	2,092
	3	" " " "	8.50	2.53	4.22	83	7,719		1,829	
33	1	" " " " fire-clay	8.44	2.56	4.12	70	6,479		1,573	
	2	" " " " "	8.32	2,53	4.00	40	3,801	6,807	950	1,698
	3	" " " " "	8.44	2.50	4.09	107	10,142		2,479	
34	1	The Malvern Fire-clay Company	8.50	2.56	4.12	75	6,895	6,806	1,673	1,638
	2	" " "	8.62	2.59	4.19	75	6,719		1,603	
35	1	Canton & Malvern Brick and Paving Company	8.37	2.47	3.91	60	5,804	5,612	1,484	1,430
	2	" " " " "	8.56	2.50	3.94	58	5,421		1,376	
86	1	The Massillon Stone and Fire Brick "	8.62	2.50	4.22	110	10,209	9,513	2,419	2,254
	2	" " " "	8.62	2.50	4.22	95	8,817		2,089	

TABLE XV—DETAILS OF CRUSHING TESTS—Concluded.

Sample number.	Brick number.	Name of firm.	Average length.	Average width.	Average thickness.	Tons pressure.	Pressure per sq. inch.	Average for sample.	Pressure per cu. inch.	Average for sample.
37	1	The State Line Fire Brick Company	8.62	2.56	4.25	100	9,063		2,132	
	2	" " "	8. 5	2.56	4.25	107	9,554	8,936	2,248	2,111
	3	" " "	8.62	2.55	4.19	90	8,189		1,954	
38	1	The Salem-Garfield M. Company	8.62	2.37	4 19	70	6,853	6,355	1,635	1,528
	2	" " "	8.50	2.41	4.12	60	5,858		1,422	
39	1	The Congo Fire-clay Company	8.25	2.44	3.94	70	6,955	7,827	1,765	1,995
	2	" " "	8.19	2.47	3.91	88	8,700		2,225	
40	1	The Vulcan Fire-clay "	8.50	2.52	4.19	92	8,590		2,050	
	2	" " "	8.37	2.59	4.07	75	6,919	7,581	1,698	1,830
	3	" " "	8.44	2.62	4.15	80	7,235		1,744	
41	1	The Buckeye Brick Company	No	crushing	test	made.				
42	1	Akron—Unidentified	8.50	2.56	4.06	85	7,812		1,924	
	2	" "	8.50	2.59	4.03	90	8,176	7,627	2,029	1,877
	3	" "	8.50	2.56	4.05	75	6,893		1,679	
43	1	The Bucyrus Brick and T. C. Company	8.56	2.44	4.00	112	10,725	9,942	2,681	2,455
	2	" " " "	8.56	2.50	4.00	98	9,159		2,289	
44	1	South Zanesville P. B. Company	9.06	2.88	4.31	80	6,132	5,271	1,421	1,230
	2	" " "	8.94	2.79	4 25	55	4,412		1,038	
45	1	The Trimble Brick Company	8.56	2.50	4.06	80	[illegible],477	7,616	1,842	1,890
	2	" " "	8.56	2.47	4.00	82	7,756		1,839	
		Averages						6,847		1,662

TABLE XVI.

TEMPERATURES, MEASURED BY LUNETTE PYROMETRIQUE ON CLAY-WORKING AND IRON-WORKING INDUSTRIES.

Clay-working Temperatures.

Test					Temperature in degrees Fahrenh't
Test 1	Delaware Clay Co	Shales	Drain tile	Bottom of kiln, nearly finished	1,600
2	S. A. Weller's Pottery	Mixture	Earthenware	Hottest part of kiln at best heat	1,860
3	Bagley and Roberts	Fire-clay	Stoneware	Heat measured after kiln had begun to cool.	1,922
4	Muskingum Stoneware Co	"	"	" " " " " " "	1,900
5	Zanesville " "	"	"	Hottest part of kiln, at best heat	2,922
6	Pittsburg Clay Co., N. Brighton, Pa.	"	"	" " " " "	2,010
7	" " " " "	"	"	Bottom " " " "	1,950
8	Gelhart & Goodman	"	"	Hottest " " " "	1,892
9	United States Stoneware Co	"	"	" " " just after best heat	2,045
10	A. T. Weeks, Akron	"	"	" " " " " " "	2,045
11	S. & W. Baggott	"	Yellow ware	" " " at its " "	1,710
12	Cartwright Bros	Composition	C. C. ware	" " " " " "	1,950
13	Toronto Pottery Co	"	White granite.	" " " " " "	2,160
14	Forest City Sewer Pipe Co	Fire-clay	Sewer pipe	" " " " " "	1,920
15	Crown " " "	Fire-clay and shales	"	" " " after " "	1,840
16	Ohio " " "	Fire-clay	"	Kiln not up to highest heat	1,800
17	Hill " " "	Shales	"	" at best heat	1,920
18	Akron " " "	"	"	" " "	1,900
19	Buckeye " " "	"	"	" past best heat	1,875
20	A. O. Jones Co	Fire-clay	Paving brick	" at best heat	1,862
21	W. B. Harris & Bros	Shales	"	" " "	1,800
22	Logan Fire-clay Co	Fire-clay mixture	"	" past best heat	1,702
23	Nelsonville Sewer Pipe Co	Fire-clay	"	" at highest heat	1,920
24	Canton Brick Co	Shales	"	" " "	1,800
25	" " "	"	"	Another kiln at highest heat	1,840
26	Canton & Malvern Co	Fire-clay	"	Kiln at best heat	1,920
27	Massillon Stone and F. B. Co	"	"	" " about best heat	1,8[illegible]0

TABLE XVI—TEMPERATURES, MEASURED BY LUNETTE PYROMETRIQUE ON CLAYWORKING AND IRONWORKING INDUSTRIES—Concluded.

Ironworking Temperatures.

		Temperature in degrees Fahrenh't
Test 28	Otis Steel Works—Inside of boiler firebox, fired by Brightman, stoker	2,175
29	" " " " " another boiler firebox fired by Murphy, stoker	2,295
30	" " " Ingot on plate mill table, being rolled into steel plate	1,950
31	" " " " in heating furnace, ready for rolling	2,120
32	" " " Bessemer steel, being poured into ingot moulds	2,560
33	" " " Open hearth steel " " " "	2,620
34	" " " Same steel in furnace, before being tapped out for pouring	2,660
35	Central Blast Furnace—Mill iron, as it ran from furnace to casting bed	2,225
36	" ', " Bessemer iron, as it ran from furnace to casting bed	2,295

CHAPTER IV.

THE COAL FIELDS OF OHIO.

By Prof. Edward Orton.

Areas.—The rocks of the Carboniferous system, in which all our coal seams are embraced, constitute the surface rocks of about ten thousand square miles in the southeastern quarter of the state. The counties in which these rocks are found in whole or in part, are the following:

Trumbull, Mahoning, Columbiana, Carroll, Jefferson, Harrison, Belmont, Guernsey, Noble, Monroe, Washington, Morgan, Athens, Meigs, Gallia, Lawrence, Scioto, Jackson, Vinton, Hocking, Perry, Muskingum, Coshocton, Holmes, Tuscarawas, Stark, Wayne, Medina, Summit and Portage. A few insignificant outliers are found in other counties. But what has been said is by no means the same as saying that there are 10,000 squares miles in Ohio, under any one of which square miles, one or more coal seams exists. There are large areas within the general boundary named above in which, although the rocks are included in the Carboniferous age, coal seams were never formed. There are other considerable areas from which the coal seams that once existed have been entirely removed by the processes of denudation that have been at work during the millions of years, in which this part of the continent has stood above the level of the sea. There are still other considerable areas in which coal seams are found in their regular places in the series, but too thin, or too impure, or too much broken by the accidents of their early history, to possess any economic value. Finally, there are considerable sections in which, while half a dozen coal seams are represented, but one or two are found in volume large enough to justify mining, at least, under present conditions.

The general statement, therefore, that the Ohio coal field embraces ten thousand square miles of territory, is calculated to give an erroneous and misleading impression. In any case, the assumption that the value of a coal territory can be properly estimated by measuring the surface which it occupies, is altogether inadmissible. One district may have but a single seam that is worth mining, while another may have two, three or four seams. Neither can the value of a coal field be determined by the aggregate thickness of its several seams. In one district, there may be a single seam, five feet in thickness, for example; and in another district, there may be five seams, aggregating ten feet in thickness. The chances are that in this case the first named field will be the more valuable; the second may not justify mining at all. To determine the relative values of coal lands, a number of consideration must be taken into account.

The maps that accompany this volume render it, for the first time, possible to determine approximately the coal resources of the state. They show the separate areas of the principal seams, above drainage. To these areas there must be added the extensions of the several seams under cover so far as they have been determined by test borings in advance of development. In default of such tests, the additional areas required in carrying the seam to some arbitrary depth below drainage, as 300 or 500 feet, may be computed. Nothing but the vaguest estimates of the amount of Ohio coals has heretofore been possible, but it is probable that the amount is always exaggerated in our speculations on the subject. A study of these maps will reveal the fact that our coal resources are by no means co-extensive with the ten thousand square miles of our Carboniferous rocks. Some important deductions from this study will appear in a later section of this report.

Origin of Coal.—For the last fifty years, there has been no reasonable ground for doubt as to the real nature and ultimate source of coal. Coal is more or less metamorphosed vegetable structure, and consequently the materials composing it were, in the main, derived from the atmosphere, by the cells of growing plants, under the agency of sunlight, at some earlier stage of the earth's history. These conclusions are questioned by no one who has earned a right to an opinion. Occasionally, it is true, some belated denizen of the seventeenth century still attacks the problem of the origin of coal in the *a priori* way, and evolves a theory of its formation from his own consciousness. Such theories do not deserve or require refutation. Like the seed sown in stony places, they speedily wither because they have no root. They are inventions, and not discoveries, and in our day at least, they are quite sure to go to their own place and to be buried with their inventors.

Again, for the last fifty years, there has been no reasonable ground for doubt, or at least, ever-lessening reasonable ground for doubt, that the vegetation which formed the coal grew where it is now found. It is not drifted vegetation, but it was accumulated *in situ,* by the slow processes of plant growth. This position received powerful support from a famous paper of the late Sir William Logan, which was read before the Geological Society of London, in 1841. It was entitled "On the Character of the Beds of Clay lying immediately below the coal seams of South Wales." In it, Sir William announced the significant fact, which had long been known by the miners and used by them as a guide in their practical explorations, and from whom he had received it, that all the coal seams of the South Wales field are underlaid by beds of clay, and that these beds always contain the well known vegetable fossils, *stigmaria*. The statement of the fact we owe to him. Its modern significance escaped him for the time. The proof was forthwith furnished by Binney, that the stigmaria are the roots or underground stems of lepidodendroid and sigillaria trees. At about the same time came the discovery, in a railway cutting near Manchester, of a number of sigillaria trees, standing unmistakably where they grew and immediately connected with an overlying coal seam. These were the initial and epoch-marking facts of the subject, but they have been repeated and supplemented and extended in every region of the world in which coal is mined, from that day to this, until they have become, to the last degree, familiar and commonplace.

As we advance beyond this position and inquire as o the conditions and modes of growth of this land vegetation, we find ourselves at once among unsettled questions. Most of the well matured and more elaborate theories that have been advanced in recent times, however, agree still further, and, in regard to a very important factor in the discussion. Almost all of them hold that this vegetation grew on lowlands, and not only near the sea level but near the sea itself. The obvious facts of almost every section of Carboniferous rocks, in which a seam of coal is included, allow, indeed, no escape from this conclusion, but the particular modes of growth of these great sheets of vegetation are variously conceived and represented.

(*a*) Forests growing on swampy tracts, finally submerged and buried under sheets of sand or clay, the forest trees themselves, and chiefly their bark, constituting the bulk of the coal; this is one of the earlier and cruder theories which it is somewhat surprising to find still surviving. It has recently found new expression through Carruthers, the distinguished paleo-botanist, who seems to adopt it without reserve. Several elements of it also enter into the extravagant theory of Grand-Eury which has recently appeared.

(*b*) An accumulation of vegetation quite after the manner of the mangrove swamps of sub-tropical lands at the present time makes another theory. Sir Archibald Geikie adopts this as the best picture of the conditions of coal formation that we can find in the existing order of things.

(*c*) By Sir Charles Lyell, the cypress swamps of the lower Mississippi were made to do like service. Sir William Dawson seems to agree with Lyell that the conditions of coal formation are most adequately represented by these great accumulations.

(*d*) Fifty years ago Brogniart made the suggestion in an almost incidental way that we should find in the peat bogs of today the analogue and representative of the coals seams of Carboniferous time. It is not necessary to claim that a suggestion of this sort had never been made before, for such a claim could not be maintained, but the time had come at last for it to strike root. It has been living and growing ever since.

A young Swiss naturalist, Leo Lesquereux, was perhaps the first to expand the suggestion into a theory of definite shape and proportions. Called by the government of his own canton to report upon its peat beds as a source of fuel, he took up the study of the bog and made himself thoroughly master of its botany, its physics, its chemistry, its geology. He extended his observations and studies, still under government patronage, to the peat bogs of northern Europe until he knew better than any one had known before, the laws of their formation and growth. From peat bogs he came to the study of coal. His field now lay on this side of the Atlantic. He saw, or thought he saw, that the laws of the peat bog could be applied to the coal seam; that the key, the only key, to the history of the latter was to be found in the knowledge that he had already acquired among the beds of fuel that are growing now but whose roots go back into past millenniums.

In its development, this theory appears to be almost an American theory. It has found far wider acceptance here than elsewhere, and the best statements of it all come from this side of the Atlantic.

It was expounded very ably in the main by Henry D. Rogers in the reports of the First Pennsylvania Geological Survey, but his statement was marred by the introduction of some dynamic features that are quite foreign to our present thought and in which he has no followers.

Dr. Newberry made one of the most compact and symmetrical statements of it that has yet appeared, and he came to the subject with large and fresh and independent knowledge from every part of the field. Prof. E. B. Andrews repeatedly presented the theory in excellent shape, basing his statements in the main on his own observations.

But it still remains true that in view of the central and far-reaching claims of the theory, no thoroughly worthy or adequate presentation of it has ever yet been made. We can go further and say that no near approach has yet been made to such a presentation. All the statements that we have are limited to a few pages each, designed for popular use and falling far below the demands of scientific completeness and exactness.

While, therefore, there are considerable differences of view as to the modes in which vegetation was accumulated in the Carboniferous swamps, these differences concern points of minor value. All of the leading theories have a great deal in common.

As to the kinds of vegetation that make the chief contributions to the formation of coal, a few words must suffice.

The vegetable kingdom is divided into two principal sub-divisions, viz., the *Phanerogamia*, or flowering plants, and the *Cryptogamia*, or flowerless plants. These divisions are further sub-divided as follows:

Phanerogamia (Flowering plants.)	Exogens, *common forest and fruit trees.*	
	Endogens, *palms, grasses, grains, etc.*	
	Gymnosperms, *pines, cedars, etc.*	
Cryptogamia (Flowerless plants.)	Acrogens	Club mosses. Ferns. Scouring rushes, etc.
	Anogens	Mosses, etc.
	Thallogens	Algæ or seaweeds. Lichens.

The coals of the Carboniferous age are principally derived from groups of plants that belong near the middle of the series, viz., from the Acrogens and the Gymnosperms, or, in other words, from the lowest of the flowering and from the highest of the flowerless. The contributions of the Gymnosperms are relatively unimportant and the families of plants from which the coal is almost entirely derived are the *lycopods*, or club mosses and the *ferns*. These families were expanded far beyond their present condition of development. They have left such abundant materials for our study in the coal seams and the associated strata that we are able to restore them, with a good degree of confidence as to the faithfulness of our results. We know their roots, their stems, their bark, their wood, their pith, their leaves, their spores, their fruits.

It is to the microscope that we owe the final demonstration of the vegetable origin of coal. An addition to our knowledge of its composition, made within the last twenty years, may be stated in this connection. It has been proved by means of thin sections of coal that considerable portions of some seams are made up of the spores and spore cases of lycopodiaceous plants. Professor Huxley went so far, in a paper published in 1870, as to claim that coal of the Carboniferous age is mainly derived from this particular source. While this extreme claim cannot be allowed, it is doubtless true that the spores of the ancient club-mosses, took a large part in the up-building of many seams.

The spores of modern club-mosses are produced in great abundance. They constitute an article of commerce under the name of *lycopodium*, which is found in all drug stores. When it is remembered that the club-mosses of our day are generally less than one foot in height, it is easy to understand how the gigantic representatives of the order in Carboniferous time, which attained a height of fifty to seventy-five feet, could make so important a contribution to our fossil fuel, as has been claimed for them in the preceding paragraph. The composition of lycopodium is excellently adapted to preservation, under the conditions which must have prevailed in the coal-forming swamps.

It seems probable that the division of our coals into coking and open-burning will be found to be based on the particular sources of plant growth from which they are respectively derived.

Coal seams are generally found combined in great systems, interstratified with sand stones, conglomerates, shales, limestones and beds of iron ore, the whole series measuring hundreds and sometimes thousands of feet in thickness. We bring to our interpretation of a *coal field*, thus constituted, the points already made, viz., that every seam was accumulated by vegetable growth in swamp, or marsh, or bog near the sea level.

It goes without saying that in the explanation of a coal field, subsidence of the coal forming area must be invoked. The swamps are successively buried under sediments brought in from the adjacent sea, or more infrequently, by sheets of limestone that grew in the invading water.

The northern extension of the Appalachian coal field, as it is found in Ohio, is by far the most orderly field that has ever been described. There is a regularity and simplicity of structure in it that makes it the type and standard for this whole class of formations. The questions connected with coal fields are found here in their simplest form. There are no folds in its strata, and very few arches, and these few are low and gentle. There is not, within the limits of the field, a fault that deserves the name. Its reliefs are almost wholly due to erosion. The dip is remarkably steady and uniform, and inasmuch as it very rarely rises as high as one degree, it can be determined only by triangulation. The series that is found on one side of a hill can be depended on with like intervals and relations on the other. The general order of its most important coal beds has long been known, the great economic interests involved leading to their early and continuous exploitation on a large scale.

What, then, do we find in this, the simplest and most symmetrical, the least disturbed and complicated of all known coal fields?

We find a maximum of two thousand feet of strata covering ten thousand square miles of surface.

Of what does this series consist? Irregularly distributed through it, but most largely in the lower portion, are found six or eight strata of sandstone that can be followed with a good degree of steadiness throughout the field. They have their names and places in the scale. Part of them are conglomerates, characterized by the presence of quartz pebbles, which sometimes are of large size and form the bulk of the stratum. These sandstones and conglomerates constitute the largest single element of the series.

Next to them in aggregate thickness are beds of shale, frequently replaced with sandstone layers, the shales being gray, blue, black or red in color, and gathered in the largest quantity, in the upper half of the Coal Measures.

There are a dozen sheets of limestone distributed irregularly through the entire series. All of them are thin. They are often to be measured by inches instead of by feet, but they hold their places in the scale with wonderful tenacity. Half of them are of marine origin, as is clearly shown by the abundant fossils which they contain, and, on the same grounds, the rest are found to be of fresh or brackish water origin. Part of them are underlaid by seams of coal and others of the series have coal seams directly above them. In addition to the persistent sheets of limestone, there are many sporadic deposits of calcareous character.

Always associated with the limestones, and often replacing them, are ten or twelve deposits of iron ore, some of which have been of large economic value.

Distributed throughout the entire series, and giving name and character to the whole, are fifteen or more seams of coal, ranging from a black mark to a dozen feet in thickness. The valuable phases of the seam are uncertain and unsteady, but the horizons are persistent and distinct, to a wonderful degree. Each, as we know, stands for a land surface. With the seams of coal and far more extensive and steady than they, are beds of fire clay, of varying degrees of purity. Almost every coal seam is underlaid by clay, and the limestone and ores are also covered or supported by them in many cases.

How are these elements distributed? By no means at hap-hazard throughout the scale, as it might appear at first sight. A well-marked order of arrangment comes into veiw when the series is properly studied. The three elements of those already named that stand for life, that represent the agencies and forces of life, are always found in close proximity to one another. Coal, standing for the life of the land, limestone, for the life of the sea, iron ore, equally dependent on life for its separation and concentration, but blended with both limestone and coal, these form vital nodes in the series, relatively of small amount but containing most of its economic interest and value. The intervals between the nodes are occupied by the sandstones and shales already named as forming the bulk of the series. They are, for the most part, barren of life, and owe their accumulation to inorganic forces. Measured against the products of life, these sandstone intervals have a thickness of five or ten feet to one. But these intervals are approximately equal. In every part of the field, some normal measure will be found that will occur again and again in the sections we shall meet, as we rise with stair-like regularity from coal to coal, or from one limestone to another.

The eastern, northern and western boundaries of the Ohio coal field are well defined and well known. Were the lowest coal seams formed over this entire area? Have we a right to expect their presence within the central portions of the basin if we descend deep enough? Were the earlier seams progressively covered with the swamps of all the latest coals, and were the last the widest in extent? These questions, and others of like import, have been variously answered, but the affirmative replies are so irreconcilable with the facts o the field, and with the first principles and established laws of coal geology that they must ultimately be abandoned and discarded. A few propositions embracing these points that could be abundantly expanded and supported if time and space allowed, will be stated here.

1. The present coal field of Ohio, at the beginning of the Carboniferous Age, was occupied by an arm of the sea, the slowly-growing Cincinnati Arch making its western boundary.

2. Around the shores of this ancient gulf, marginal swamps of varying width existed, which, by their long-continued growths and subsequent fossilization, became the earliest coal seams.

3. While the swamps were successively submerged and covered by shales, sandstone and limestone, derived from or formed in the adjacent sea, and were finally covered by other swamps, the continental nucleus was slowly growing to the southward, as it had been growing from the earliest records, and with it the Cincinnati Arch united, by a like advance to the eastward, the combined movements gradually expelling the waters of the gulf and converting the earlier formed portions of the coal field into dry land.

4. Every successive coal-forming swamp, thus had a narrower area than its predecessor.

5. As all the coal seams were formed at sea level, so all were raised by the continental growth to an approximate equality which their outermost outliers still retain.

6. To look for the earlier formed seams in the center of the basin, would be to look for the living among the dead.

7. In the formation of one seam, in particular, the floor of this gulf around which the coal swamps were growing, appears to have been raised nearly to the sea level at many points, and coal appears to have formed in island-like masses over much wider areas than any single marginal swamp could account for.

The importance of the facts that are here considered cannot well be overstated. The resources of the Ohio coal field, as can easily be seen, are intimately connected with and dependent upon the mode of growth of the entire field. The affirmative answers to the questions proposed in a preceding paragraph, would give us a hundred fold more coal within the boundaries of the field than the answers that the facts oblige us to make. It does not now appear that Ohio has any great stock of deeply buried coal. At no point in the state have coal seams been brought to our knowledge in the repeated tests for gas and oil that have been carried forward in the last few years, at a greater depth than six or eight hundred feet. It seems quite likely that these figures will make the general limit of the extent of our coal seams as they descend towards the center of the gulf around which they were formed. Such a depth would be consistent with a breadth of seam of twenty to thirty miles, the breadth being measured at right angles to the axis of the gulf.

Value of coal.—One of the most striking generalizations of modern science is to this effect: all the force that is in the world, available for man's use, is derived from the sun.

To this statement there is but a single exception, and that an insignificant one. When the tide rises highest upon the land, some little portion of it can be arrested, and detained by dams and gates suitably located. By opening the gates when the tide turns, the head of water which has been secured can for a few hours turn wheels, grind grain, saw lumber and execute other like offices. This force is, however, limited to a very small portion of the earth's surface and is of small account at the best.

But every other form of force that men utilize, is directly or indirectly referable to the sun.

The wind is one of the natural forces that men learned to use long ago in their migrations and their mechanical work, but it is the heat of the sun that is the cause of every movement in the atmosphere. The entire power of the winds is borrowed directly from the sun.

The force of running water, applied also to transportation and mechanical work, has been of larger service than the force of the wind. What gives the running water its force? It is gravitation, as the water descends the mountain side or the continental slope to the sea. But how came the water upon the mountain side or the continental slope? Every drop that we find above the ocean level was lifted from the great reservoir by the heat of the sun and borne to its destination by winds that had the same origin.

But the earliest force that man learned to use in the improvement of his condition was the power of muscle. To the power of his own muscle he soon added the patient strength of the animals that he was able to subdue.

From what source is muscular power derived? The animal world is, in the last analysis, wholly dependent on the vegetable world and the vegetable world is, in warp and woof, the direct product of the sun's rays. All vital or living force can therefore be traced directly back to the sun.

But what of the great powers that are making over the world in our time, viz., steam and electricity? Do not these forces of the modern world come from a new source? By no means. It is the sun's power that works in and originates both. The changing of water into steam is the work of fuel, and as fuel is always organic in its origin, it must be accounted for by the sun's rays as shown in the preceding paragraph. For electricity, every current that we can utilize takes its rise either in motion produced by steam or in the chemical changes of certain elements and compounds, all of which are based ultimately on some form of carbon derived from the vegetable world and therefore from the sun.

How does this power of the sun become available to us? By what process is the solar energy transformed into the power of muscle, steam and electricity?

The vegetable kingdom is the agent of transfer. The all important office of absorbing, appropriating and storing the power of the sun has been assigned to the plant. The plant accomplishes the all important work of storing the sun's power through the agency of the cells of which it is composed. The vegetable cell has the surprising property of being able to live and multiply itself on air alone, through the agency of the sunlight.

One of the constant constituents of the atmosphere is carbonic acid, a gas that consists of one atom of carbon combined with two atoms of oxygen. The bond that holds these elements united is a powerful one. We are able to break it in our laboratories, it is true, but only by employing the full resources of chemical skill. But in the vegetable cell, under the sun's light, this bond melts away, like a thread of flax in the flame of a furnace. The carbon is fixed in the forming tissues of the plant, while the oxygen is restored to the atmosphere to maintain its vitality.

To effect this decomposition a certain measure of the sun's force is required. All the force that was employed in breaking this bond, the heat, the light, the chemical power, is now held in these products of growth, in a potential state. But it is readily given back to all appropriate demands and the self-same light and heat by which the vegetable substance grew, we obtain again when we burn this substance in furnace or grate. This is the sole source of the power of fuel, and all fuel, or in other words, whatever will burn, has borrowed its power, to burn from the sun.

Taken within the animal system, the products of plant growth give to it, also, the force that they hold imprisoned. On this account and in this way, they become the food, the support, of animal life, the sole source of its heat, its activity, in a word, of its vital force. All animal movements, muscular or molecular, that we can see or that we are obliged to infer, result alike from, or at least are alike conditioned by, this transformed power of the sun.

The remarkable office of the vegetable cell is thus brought to light. It is a storer of power, a reservoir of force. It mediates between the sun, the great fountain of energy, and the animal life of the world. The animal can use no power that has not been directly or indirectly stored in the vegetable cell. This storage is forever going on. Of the vast floods of energy that stream forth from the great center of our system, an insignificant fraction is caught by the earth as it revolves in its orbit. Of the little fraction that the earth arrests, an equally insignificant part is used directly in plant growth. But the entire productive force of the living world turns on this insignificant fraction of an insignificant fraction.

Is there any way in which this sun power can be permanently stored on the large scale? Nature has devised various ways of retaining and preserving the power which the vegetable cell has accumulated in the past years or centuries or ages. Some of these forms of stored power, men have long known and valued, but with the really great accumulations, they have but comparatively recently become acquainted.

These accumulations are found in *soils*, which, originally composed of the disintegrated portions of the earth's rocky crust, have been gradually enriched by the remains of vegetable and animal life. Centuries have been spent in storing a fertile soil with this transformed sun power.

A second example of stored sun power is to be found in *forest growths*. They always stand for centuries of accumulation. A forest consists of air, moulded and subdued temporarily by the sun's rays, but ready to pass back into the atmosphere again, and bound to restore, as it either burns or decays, all the heat by which it grew.

Peat bogs, in the third place, furnish a similar example of stored sun power. Built up of humbler forms than forests, they still represent in all respects the same great laws of accumulation. They stand for the separation of large amounts of carbon from the air through the agency of the solar ray.

But the accumulations of power that have been already noted shrink into insignificance when compared with the coal seams of the geological scale, which represent the forests and the peat bogs of earlier ages in the earth's history. These are the *great* accumulations of power. Taking their place as they do, in orderly fashion, among the stratified deposits of the earth's crust, and going back in many instances to a high antiquity, we rightly name them *fossil power*.

Sir William Dawson estimates that a foot of coal requires for its origin the patient growth and slow decay of a hundred of the forests out of which it was formed, for of this vegetable growth only a remnant was saved. For many thousands of years for every foot of coal, we can be sure, the sun must have poured down its floods of light and heat upon these Carboniferous swamps. The light and heat were absorbed there in the processes of plant growth, were locked up in leaf and stem and spore, were buried beneath the sediments of an advancing sea, were converted at last into stone, became a part of the earth's crust, but still retaining their original nature, still containing, literally and truly, the light and heat, the *power* of the ages of the early world in which they had their birth.

The fossil power stored in coal began to be turned to some small account in England several years hundred years ago, but there were only a few districts in the kingdom that could readily avail themselves of th new found supplies. The impossiblity of transporting coal on the large scale forbade any general development of it. All the great applications of the stored power of the world belong to the nineteenth century and the most important of them belong to the last fifty years. What has been done within this century constitutes by far the most important chapter in the economic history of the race. Fossil power lies at the root and center of an unparalleled advance. It is connected in a most intimate and important way with a single invention, viz., the steam engine. But the steam engine in all its formsis conditioned by and dependent on the fossil fuels, which are now under consideration.

The forests of any country would, under its exorbitant demands, melt away like dew before the sun. In large portions of the world, and even in those as England, where steam power has worked its greatest triumphs, it would be simply impossible to use it in any large way, were it not for the vast stocks of power that were stored in the strata during the earlier ages of the earth's history.

There are, in particular, two great lines of service rendered by coal through the steam engine. They are found in manufactures and in transportation.

In manufactures, the steam engine supplies power wherever it is wanted and just as much as is wanted. Before its advent men were sharply restricted in their use of power. They were limited to winds, to streams, to tides and to the power of muscle. The restriction applied, not only to the amount, but also to the location of the available power. But the steam engine has changed all this. It brings to any desired point the energy that is required for the most gigantic and the most varied tasks.

At the bottom of all this wonderful and, on the whole, beneficent activity, lies coal, the great representative of the fossil power of the world. It is coal that turns every wheel, lifts every lever, strikes every blow. In Great Britain alone, coal does the work of more than a hundred million men. It adds to the wealth of these fortunate islands on this basis. In transportation, steam has brought about a still more wonderful change. The civilized world, with all its belongings, has been mobilized by means of its application to locomotion.

The sun power that in reality does all this work has been buried in the earth's crust for many millions of years. While coal is rendering these several lines of service it gives value at the same time to every other form of power and every other source of wealth, as soils, forests, mines.

The most striking characteristics of our day center around this one element. There is no more distinctive feature of the nineteenth century than (*a*) the remarkable growth of cities throughout the civilized world, and (*b*) the unparalleled increase of wealth among men. Both take their rise in coal. Both are conditioned in its use in all their phases and stages. In no century of the past has there ever been any close approximation to these features of our own time. The problem of food and fuel supply has heretofore held the growth of cities in close check, but coal in the steam engine removes this check. Since the year 1800, the total wealth of Great Britain has been more than doubled. Similar facts obtain in all progressive nations, in proportion to their utilization of fossil power. The increase of wealth in the United States during the present century is vast beyond all expression or conception. It is easy to show how vital a factor in it all, transportation through the stored power of coal has always been.

Never before has such extreme inequality prevailed in the distribution of wealth, as in this century. The individual fortunes of our day, mainly gathered in the last forty years, exceed all that have been known before, and render the standards of comparison that the world has used for the last two thousand years, ridiculously inadequate.

The secret of this amazing increase of wealth, is to be found in the steam engine or rather in the coal which feeds it. A pound of good coal used in a good engine stands for the work of six horses for an hour; a ton of coal, for the work of 1300 horses, for a day of ten hours. There are lines of railroads under a single management, whose locomotives comsume 10,000 tons of coal in a day. But 10,000 tons of coal stand for the work of 13,000,000 horses, working ten hours a day.

It is considerations like these that set coal before us in its proper light. It is because we find in it the chief representative and the main accumulation of the stored power of the sun that we are bound to set so high an estimate upon it. We are unable to see how the world can maintain the astonishing rate of progress which has been established within the last fifty years, if our coal resources are cut off or materially reduced. But coal is not a mineral of indefinite amount, like limestone or sandstone or clay. On the contrary, its stocks are sharply limited. This fact, taken in connection with those already named, lays upon us the imperative obligation to make every pound of it go as far as it can, do all the work of which it is capable. Our practice cannot, however, bear examination from this point of view. We are guilty of the grossest and most reckless waste in all our dealings with coal, in mining, in marketing, and in utilization. The treatment that this precious form of wealth is receiving at our hands is a disgrace to our civilization. A few examples will set the facts before us, as they are found in our own State.

In one Ohio coal field a seam of coal is found that expands for a limited area, from four or five feet, to ten or twelve feet in thickness, but the upper or added portion of the expanded seam, though excellent coal, is somewhat inferior to the lower portion. If all of the thicker seam is sent out, the product of the mine is discredited to some extent, in comparison with the output of mines in which the thinner phase only is mined. The result is that the upper portion of the thick seam is often left in the mines, hopelessly lost to human use. The rejected portion is in reality better coal than the best that is produced in the entire coal fields of some of our western States. This lamentable result is due to the conditions of marketing coal that prevail.

In the same field, two seams of coal are found within the same acreage, fifty to seventy feet apart. The lower seam is the thicker and stronger coal and on this account is somewhat the more marketable. But if the lower seam is mined first, the upper seam is rendered valueless, through the disintegration affected by the unwatering of the coal and by the irregularities that result from the subsidence of the strata over the worked-out spaces. If the upper seam, which is also a valuable bed of coal, is to be saved at all, it must be mined first. But there are considerable areas in which the lower seam is taken and the upper thereby sacrificed. The fault in this case, is due to the demand for immediate returns on the part of the coal operator.

Another lamentable source of loss occurs in the districts in which the coal is of the open-burning variety. The slack of this open-burning coal, which results from undermining and handling, is mainly wasted; but the portions of the coal from which the greater part of it is derived, constitutes the best and purest portion of the entire seam. This waste accumulates to the extent of millions of tons in our great coal fields. Only a brief exposure of it to the air is necessary to rob it of all value. Still another important source of loss is to be found in the work of unskillful miners, especially in the districts in which the open-burning coals occur. The unskillful miner reduces a much larger portion of the coal to slack than the properly trained miner and as already stated this product of the mines is mainly lost to service.

But the greatest loss of all results from the failure to take out all the available coal in the operation of mining. This failure has several roots, as the demand for immediate returns; improper system of mining, reckless or ignorant administration of whatever system it employed. The chief cause is, however, the low prices at which coal is sold. No proper incentive to intelligent and thorough work is found in the value of the coal thus wantonly wasted.

The unnecessary losses thus far entailed and now in process of infliction on our most important coal-fields are estimated by those best calculated to judge as ranging from 5 to 25 per cent. The latter figure includes losses of the first sort named in this review.

In a civilized state it ought to be impossible for barbaric waste of the kinds above named to go on. But there is no power that can be invoked to arrest it. Our whole system of laws forbid interference with the land owner or the coal producer in the question involved. Each can do "what he will with his own".

At no distant day, the State will be obliged to take a radically new departure in putting an end to this reckless and unnecessary sacrifice of its stored power, which while it does not enrich us, makes the future poor indeed. The sooner the State assumes the necessary supervisory and restrictive power, the better. Along with this increased exercise of power on the part of the State, there should follow an increased price of coal. Our coal will never be properly mined or properly burned so long as it costs at the mines less than $1.00 per ton. This question of waste demands immediate and serious consideration. The present status of coal mining in Ohio is a reproach to the commonwealth, but like conditions prevail in all the other portions of our coal fields, and a reform cannot be accomplished in one State or district without the co-operation of the rest.

Divisions of the Ohio Coal Field.

The number of fairly persistent coal seams that justify mining in the large or small way in this State at the present time is not less than 15. By the most liberal construction, 18 such seams might be counted. Of the really important seams there are not more than 10.

Before making out the list, the principles on which our coal seams are named, will be indicated. The laws of geological nomenclaturs require that any regular element of the scale shall be known, wherever it is found, by the name by which it was first adequately described. The Pennsylvania coal fields were developed considerably in advance of those in Ohio, and consequently all the principal seams were found to be provided with names when first recognized within our territory. These names we were obliged to adopt, even though the Ohio representatives of particular seams might be more valuable than those found in Pennsylvania. There are a few seams found in Ohio, the equivalence of which with Pennsylvania coals has not been fully demonstrated. For such seams we must use names derived from the Ohio localities in which they occur. In the lists which follow hereafter both the Pennsylvania names and the Ohio equivalents, so far as they have been determined will be presented.

In his original classification of the Pennsylvania coal seams, Professor Lesley adopted the letters of the alphabet for the designations, *A* being applied to the lowest seam of the lower coal measures; in like manner, Professor Newberry, in his classification of the Ohio coals, applied numbers to the seams, using *1* for the lowest seam of the conglomerate coal measure, but supposing it to be the same as coal *A* of Lesley. It so happened that the numbers were fixed to the coals of the Ohio scale before the facts as to the series were adequately collected and consequently their use has brought great confusion and trouble into our system. Valuable seams were left without a number and again the same number was given to different seams and one and the same seam received different numbers in different localities. Numbers are easily remembered and prove very popular with the practical part of our population that is chiefly concerned with the coal fields, and it cannot be denied that if the facts were all in hand, there would be comparatively little objection to the application of such designations. But even in such a case, confusion would sometimes result from the failure of one or more seams to put in an appearance in a particular section, thus bringing, in apparently consecutive order, elements that are separated in nature by well marked intervals.

COAL SEAMS OF OHIO.

Washington coal.		
Waynesburgh "		
Sewickley "		Macksburgh or Meigs Creek.
Pittsburgh "		
Crinoidal Limestone coal.		
Patriot coal.		
Cambridge Limestone coal.		
Mahoning	"	
Upper Freeport	"	
Lower Freeport	"	
Middle Kittaning	"	
Lower Kittaning	"	
Clarion	"	
Brookville	"	
Tionesta	"	
Upper Mercer	"	
Lower Mercer	"	
Quakertown	"	
Sharon	"	

Coals above the Pittsburgh as named by Prof. I. C. White, Bulletin 65, U. S. Geol. Survey are as follows:

Nineveh coal.		
Jollytown "		
Washington "	with several splits.	
Wayensburgh"	"	"
Uniontown "		
Sewickley "		
Redstone "		

We are obliged also, by the requirements of geology, to adopt the divisions of the Carboniferous System that were established in Pennsylvania. It is certain that the column would have been somewhat differently dealt with if its subdivisions had been first established in Ohio. But all the boundary lines of the Pennsylvania system can be plainly enough followed here when our attention is directed to them. Against one division only, have we even any apparent ground of complaint. Moreover, the entire system is much more fully expanded in Pennsylvania than in Ohio and on this account, the former state furnishes the best grounds for making out the true order. The main divisions, which were established by Rogers and his assistants, in the First Geological Survey of Pennsylvania, have been universally adopted by the geologists of the Appalachian coal fields. They are as follows: all of the divisions being represented in Ohio.

Carboniferous System.	Upper Barren Measures. Upper Coal Measures. Lower Barren Measures. Lower Coal Measures. Seral Conglomerate.

It is the lowest of these divisions, for the establishment of which we find no suitable justification in the facts as they occur in Ohio, considered by themselves alone. With us, this part of the scale would certainly be merged in the next higher division, viz., the Lower Coal Measures, if we were to consult our own geology solely. It has, in fact, always been so treated, in the discussion of our series in the state reports. But this treatment isolates our coal field and breaks up a scientific arrangement that has a wide spread application and ought to be abandoned.

These several divisions will be considered separately.

SECTION I.

The Coal Seams of the Conglomerate Coal Measures.

(*Seral Conglomerate, Pottsville Conglomerate, No. XII.*)

This series was originally described as an enormous mass of conglomerate, mainly white, interbedded with gray sandstones, with a maximum thickness of eleven hundred feet in the Pottsville coal field of eastern Pennsylvania. It was noted at an early date however, that several coal seams were found, included in the conglomerate. As the formation is followed westward, across Pennsylvania, as has been fully demonstrated by the Second Geological Survey, it is reduced in volume and its conglomeritic features are less pronounced and sometimes wholly lost, and certain intercalated elements acquire greater development and importance. When the series was at last traced into Ohio in Trumbull and Mahoning counties, the pebble rock, though present in a thin stratum was no longer its most striking feature, but it was found to consist of coal seams, fire clays, limestones, iron ores, shales and ordinary sandstones. In other words, it had become a considerable and integral part of our productive coal measures. The conglomerates are, however, still recognizable, and while we should never have thought of making them the normal and characteristic elements of the section, we are still able to recognize all the divisions of the Pennsylvania system within our limits. There are three main divisions of the Seral Conglomerate, in western Pennsylvania, viz., the Homewood sandstone, the Conoquenessing sandstones, upper and lower, and the Sharon conglomerate. The Sharon conglomerate is fairly well developed in northeastern Ohio. The Conoquenessing sandstones are also in some localities, well represented. They are known by us as the Massillon sandstone, while the Homewood sandstone is much reduced in thickness, supports no quarries and has consequently taken no distinctive name, but it can be recognized in a coarse and uneven-bedded sandstone, containing many coal plants, in a thousand sections. From point to point, around the margin of our coal field, these elements can be traced, and they thus constitute an identifiable framework, which has its bodily extension to the eastward into Pennsylvania, and to the southward into Kentucky and West Virginia. The Seral conglomerate in Ohio can be counted as 250 feet in thickness.

The coal seams included in this series, are the following:

Tionesta.
Upper Mercer.
Lower Mercer.
Quakertown.
Sharon.

The Sharon Coal.—This, the lowest coal seam of Ohio, was for twenty-five years, in the early days of our mining interests, our most valuable deposit of fossil fuel, but the seam has been almost exhausted and it no longer holds an important place in the enumeration of our coal resources.

The peculiarities of its occurrence have been well described in previous reports of the Geological Survey. Dr. Newberry, in particular, made a special study of this seam in its economic and geological features. His descriptions of the seam and its mode of occurrence leave little to be desired. (Volume I, page 214; volume II, page 126.) He showed that the Sharon coal in Ohio was formed in basins, excavated in the subcarboniferous rocks and that consequently, continuity of the seam on a large scale does not exist. In volume V, much additional information is given as to this coal deposit. (Volume V, pages 156, 169, 773, 1011.)

No mapping of the areas of the Sharon coal has been attempted in connection with the present report, because of the rapidly approaching exhaustion of the seam in all its known areas. In Trumbull and Mahoning counties, the work of mining coal in the large way has almost come to an end. There is at present but a single large mine left in this once prolific field. A few small areas remain, mainly in connection with the older mines, but no considerable body of untouched coal of good thickness is now known, although explorations have been carried on in a very thorough and extensive manner through the entire region in which the coal could reasonably be looked for.

In Portage county, there is still some activity in the mines of this seam. The Palmyra district supports four or five mines, and explorations to the eastward show some areas of coal which will probably prove thick enough for mining.

In Summit county, mining has practically ceased, though it was the center of an important production for 25 or 30 years.

In Medina county, a small amount of coal is mined in the Wadsworth district and several new areas have recently been brought to light.

The most important mines of the Sharon coal in northern Ohio are now confined to the Massillon field of Stark county. Mining is here carried on with a fair measure of vigor in several bodies of coal. All of these deposits are reached by shafts of greater depth than was required in any of the early mines, but there is no considerable body of the coal known that has not been already attacked. The end of the field cannot be removed more than a few years at furthest from the present time.

A few spurs of the Massillon field extend into Wayne county, but they are of small extent and value.

From this point southward to Jackson county, the Sharon coal is not mined except in an occasional drift bank, opened for the supply of one or more households of the immediate neighborhood.

In Jackson county, the Sharon seam has long been worked on a moderate scale under the name of the Jackson Shaft coal. The mines in this seam are still in operation, but the boundaries of the known areas are all in sight and not far distant. A full account of this field is to be found in volume V, Geol. of Ohio.

From this review is seen that the Sharon coal belongs mainly to the past, and is no longer an important feature in the supply of Ohio coals. As explained above, this is the reason why no mapping of the Sharon field has been attempted, in connection with the present volume. The areas of the coal now known, if delineated, would be insignificant, while if the old boundaries were represented as coal lands, the representation would prove misleading.

The Quakertown Coal.—The second coal of the Pennsylvania series, counting upwards, is named the Quakertown coal, from a locality in the Mahoning Valley. It is here a thin seam, lying about fifty feet above the Sharon coal. It was once mined at Quakertown, Pa., on the small scale. The Quakertown seam can be plainly followed into Ohio through all the counties in which the Sharon coal is or has been mined. Its place in the series is well marked, being between the two division of the Conoquenessing or Massillon Sandstone and it is not likely to be either missed or confounded with any other seam in the explorations by the drill which are carried forward in the field. It is familiarly known in the districts in which the Sharon coal occurs as the rider seam. It seldom reaches a thickness of more than eighteen inches in northern Ohio and is often reduced to a black mark. At many points to the southward a thin coal is found within one hundred feet of the base of the Conglomerate group which may represent the Quakertown coal, but the facts do not warrant anything more than the probable reference of these occurrences to this horizon.

The Wellston or Jackson Hill Coal.—In Jackson and Vinton counties, one hundred or more feet above the horizon of the Jackson Shaft coal, a valuable coal seam is found. It is locally known as the Jackson Hill coal, and also as the Wellston seam. The latter designation is decidedly to be preferred, and will be used in this chapter. The coal has been extensively worked at a few points during the last twenty years and its boundaries have been constantly widening through all this time, and a much larger area of it is now known than was suspected when the seam was first opened. This area is indicated on map No. 2, by a boundary subordinate to that of the upper coals. Tests have developed the existence of this seam to the northward and eastward, and the boundary upon the map is made to include all of the territory that lies within a line connecting the most distant points in which the coal is known to exist. It is, therefore, to be expected that large "wants" in the seam will be found to exist within the field as thus indicated. The Madeira shaft sunk on the line of the Baltimore and Ohio Southwestern Railway, near McArthur Junction, has found the seam in good condition. This is the northermost mine in the seam.

As was shown by Professor Andrews, in 1869 and 1870, the Wellston seam is one of unusual excellence. It is in some respects distinguished from every other coal in our entire field. In its best phases, it runs exceedingly low in ash, and what ash there is falls through the grate bars like wood ashes. It also is low in sulphur and therefore makes no clinker. It is easily kindled and for steam production, where careful stoking can be provided, it is unsurpassed. The worst charge that can be maintained against it is, that it is "flashy," i. e. that it burns up rapidly and consequently requires much care in keeping up the fire. Wherever introduced, the Wellston coal holds its place against all competition. The coal is soft and tends to mine small; but on account of its purity, the nut coal commands a ready market, at a price but little below the price of theh ighest grade or lump coal. The additions that have been made to the Wellston field during the last ten years, may be counted the most important extension of our fuel supply from the Coal Measures of southern Ohio within the period named above. It is altogether likely that the boundaries of this seam will be still further extended by explorations that are now in progress. From the statements now made, it is evident that favorable conditions for coal making prevailed over a considerable area in southern Ohio during the epoch of the Quakertown Coal. These conditions were also extended to the southward. We find in northern Kentucky several important bodies of coal on the level of the Wellston seam.

The Lower Mercer Coal.—Not much more is known of the Lower Mercer coal than was known in 1888, the date of the last report of the Survey on the Ohio coal fields. The statements then made would apply in unchanged and unqualified terms to the facts of today. The seam is found around the entire margin of the Ohio Coal Measures. Its place which is approximately at least, one hundred and fifty feet (100–200) above the Sharon seam, is distinctly marked in every township in which it is due, but there are only a few points at which it offers suitable encouragement to mining, even in neighborhood banks. The only work done in it is confined to Mahoning, Holmes, Licking, Muskingum, Hocking and

Vinton counties. A few thousand tons, perhaps less than twenty thousand, will cover its annual output. Nor is the prospect for the future better than the experience of the present. Where thick enough to justify mining as far as this factor is concerned, the seam is so mixed with slate, as to be a most unsatisfactory fuel. It is safe to say that the Lower Mercer coal will stay in the ground until fuel of all sorts becomes more scarce and more valuable than it is at the present time. The best phases of the Lower Mercer coal now known are found in the first two counties named above, Mahoning and Holmes. To this list we may add the Flint Ridge cannal of Licking county, but this bed seems to have been maimly worked out.

The Upper Mercer Coal.—A somewhat more favorable account can be given of the next higher seam in the scale, namely, the Upper Mercer Coal; and yet little that is new has been learned in regard to it since 1888. Its position is so well marked, that wherever the seam is developed to any considerable extent, it is sure to be noted. The Upper Mercer limestone is frequently replaced on a large scale by flint. This phase of it is especially conspicuous in its outcrops, which are commonly known as flint ridges. The coal belongs directly below the limestone or flint, or at most is separated from it by only a short interval. Wherever the limestone or flint is exposed, the coal, if present, is sure to be seen. The interval between the two Mercer coals generally exceeds 30 feet, and is rarely more than 40 feet. The approximate measure most frequently repeated in experience, and which therefore can be counted the best general figure, is 35 feet. This interval helps to determine the name and place of the seam in the cases in which the limestone or flint is found wanting.

This coal is mined in a small way in Mahoning, Holmes, Coshocton and Vinton counties, possibly, also, in a few county banks in Hocking and Jackson counties. It has no constant or established character. In Mahoning county, in the neighborhood of Canfield, several banks are opened in the seam, where it is known as the Bruce coal. It is here an open burning coal of ordinary grade. In Holmes county, near Millersburg, the seam shows large volume at a few points, but the quality is so low that it is hard to say whether the seam is best described as an impure cannel, or a rich bituminous slate. But in Bedford township, Coshocton county, it occurs as a valuable body of cannel coal. This field was described in some detail in Volume V, and nothing remains to be added at this time except the statement of the fact that railroad facilities have recently been brought to it and practical development has since gone forward on a larger scale than was ever before possible.

In Vinton county, the seam attains, on the whole, its best development. It is found in the neighborhood of McArthur, where it is known as the Newland coal. The seam has good volume throughout portions of Hocking, Vinton and Jackson counties, but its quality is unreliable where the thickness is greatest. It tends to become impure and slaty. Occasionally part of it becomes cannel coal of indifferent grade.

While there is a large body of fuel to be found on this horizon, it does not seem probable that it can compete in the markets of our day with the seams that are now being mined. It does not, however, follow that it will remain without value for all the future. When the time comes, as it must come at no distant day, in which different grades of coal can be offered in market at prices corresponding to their intrinsic value, the Upper Mercer coal will then find its proper recognition.

The Tionesta Coal.—Some doubt has been expressed as to the existence of a coal seam sufficiently persistent to deserve to be included in our list between the Upper Mercer and the Brookville coals. It must be acknowledged that the question as to these lower coals can be studied further with profit. There are, however, a few sections in Ohio, as shown in Volume V, in which a coal seam of thickness sufficient to justify mining, at least in a small way, is found about equidistant between the Upper Mercer coal and the seam which underlies the Putnam Hill limestone. The latter is counted in Volume V as the Brookville coal, or the representative of the first seam of the Lower Coal measures proper. The question of identification, hower, extends to this last named seam, as well as to the one below it. There is more stratigraphical than economic importance, in the questions so far as Ohio is concerned, and since no new facts have recently been brought to light upon the section involved, the question must be left here unsettled, as it was left in Volume V.

SECTION II.

The Coal Seams of the Lower Coal Measures.

The division which we now reach in our review, is by all means the most important division of the Carboniferous system in Ohio. We find here not only a larger number of coal seams that justify mining, than in any other division, but we find associated with these coal seams the most valuable beds of fire clay of our entire series. The only limestone formation of the Coal Measures that is found reliable in a large way for lime-burning and for furnace flux is also included in the same division, viz., the Ferriferous limestone. To this list there should be added numerous beds of iron ore that were counted of considerable value a few years since, but which have lost their economic importance, in great part, since the development of the iron ore fields of Michigan, Wisconsin and Minnesota.

The coal seams of the Lower Coal Measures in Ohio are six in number. They are named below in decending order:

6. Upper Freeport coal.
5. Lower Freeport coal.
4. Middle Kittanning coal.

3. Lower Kittanning coal.
2. Upper Clarion coal.
1. Lower Clarion coal (Brookville).

The only change made in this enumeration from the order named in Volume V is in the replacement of the term "Brookville" by "Lower Clarion."

Professor Lesley, in his final review of the Pennsylvaina coal fields has found it necessary to recognize a tri-partite arrangement of the coal seams of the Lower Coal Measures as follows:

Freeport Group.	Upper. Middle. Lower.
Kittanning Group.	Upper. Middle. Lower.
Clarion Group.	Upper. Middle. Lower.

The Ohio coal seams can be well enough provided for by a bi-partite system, as indicated above; though it cannot be denied that occasional representatives of the extra Pennsylvania seams are found within our limits. The questions in regard to the exact correlation of these extra seams are, of course, open ones. The leading seams named above will be briefly reviewed in the order of their formation, but for a more extended account of the facts pertaining to them, the reader is referred to Geology of Ohio, Volume V.

The Clarion Group.

1. *Lower Clarion or Brookville Coal.* This seam underlies the Putnam Hill limestone. It is best developed in Stark county, where it is mined under the name of the Limestone coal. A full account is given of it in Volume V, p. 230, to which the reader is referred. The same seam is mined in a very small way at Zanesville within the city limits. It has acquired no new importance since the date of the last review. It adds so little to our fuel resources, that it would scarcely be missed if it were dropped from the scale.

2. *Upper Clarion Coal.* The coal seam which directly underlies the Ferriferous limestone is confined to the southwestern extension of the Ohio coal field for the reason that the limestone itself is limited to this district, so far as a generous development of it is concerned. The limestone makes its first appearance as a thin and inconstant bed in Perry county. It gains strength and steadiness through Hocking county and comes to itself in Vinton county, extending thence in full force through Jackson, western Gallia and Lawrence county, to the Ohio river. In Vinton, Jackson and Gallia counties, the limestone coal, as this seam is universally called, is an important local source of fuel. It is beginning to be appreciated as a possible basis for mining in the large way, and the lands containing it are now being gathered in considerable

bodies with reference to future mining enterprises. One or two mines for the general market have been added to tnose named in Volume V, which are still extensively worked.

None of the coal seams thus far named have been included in the maps of Volume VII. But the map of Jackson and Vinton counties, accompanying Volume V, gives the main boundary and also the outliers of the Ferriferous limestone. This map would answer almost equally well for the "Limestone coal."

The Kittanning Group.

3. *The Lower Kittanning Coal.* This is a fairly wide-spread seam and is accordingly known by many local names. It is Coal No. 5 of Newberry, from the Tuscarawas Valley, westward and southward. It is Coal No. 3 of the same author in the Ohio Valley, where it is also known as the Clay Vein coal. It is the Lower Zanesville and the Lower New Lexington coal of Andrews, and the Newcastle coal of Lawrence county. It is also the Washingtonville or Letonia coking coal.

The Lower Kittanning coal may be said to be included in the first main boundary of the maps that accompany this volume. The boundary is referred to the Middle Kittanning seam only, in the legend of the maps; but as the two seams are only twenty to thirty feet apart in the region of their best development, their outcrops, where both seams are present, are practically identical. There are a few localities, in which outliers of the Lower Kittanning coal maintain themselves beyond the margin of the Middle Kittanning coal seam for a mile or two. But even in such cases nothing is really sacrificed of economic value in counting the boundaries of the two seams identical, because the coal of the outliers is generally under so thin cover as to be worthless. The frequent absence of the lower coal forbids us to introduce its name in the description upon the map.

The practical developement of the Lower Kittanning coal remains about the same as the date of the issue of Volume V. There is less rather than more mining done in this seam at present than there was ten years ago.

4. *The Middle Kittanning Coal.* The seam now reached is, on every account, one of the three most valuable seams of our entire coal measures. The only two with which it can be fairly compared in economic importance are the Upper Freeport and the Pittsburgh coals. So far as Ohio is concerned, the seam now to be considered is, in reality, the Upper Kittanning seam; but in the Pennsylvania scale the present seam is identified as the first seam above the Lower Kittanning coal, while a distinct seam is found in some counties at a somewhat higher place in the scale. It must thus be known, therefore, as the Middle Kittanning coal, though at Kittanning itself, the locality from which the name is derived, it is the upper of the two seams that are found there. The case is the same in Ohio.

Of its numerous synonyms no list need be made at this point. By outcrops that no geologist could be pardoned for losing for a single mile, if allowed to connect his series step by step, the seam can be followed from the Pennsylvania state line in the Ohio valley, where it is known as the block coal, through the Yellow Creek valley, where it is called, the Hammondsville strip vein, under the divide that separates Tuscarawas water from Yellow Creek, to the Little Sandy, where it is universally known as number 6. Eastward from this point, it is extensively worked in Stark county, and is also present everywhere, though thin, in northern Columbiana county. It can also be directly connected, with the Pennsylvania series through the Mahoning valley, as was first shown by Professor I. C. White.

Westward and southward from the Sandy Creek valley, the seam is the most reliable and the best known element, as well, of the entire geological scale of the district traversed. No question is possible as to its extension and continuity from the Tuscarawas valley to the Ohio River.

This is the lowest of the coal seams, the outcrops of which have been laid down on the series of maps that accompany this volume. As explained under the previous head, the outline of the Middle Kittanning seam answers for the Lower Kittanning seam nearly as well, the two seams being separated by so small an interval.

A study of these maps reveals large areas of the Middle Kittanning seam in many counties of our Coal Measures. These facts will be treated under a subsequent head.

The Middle Kittanning seam does not promise to support deep mines to any great extent in Ohio. It is emphatically a marginal deposit, in the order of its formation.

The Freeport Group.

The two coal seams of the group next reached are the counterparts in many ways of the group last passed in review, namely, the Kittanning coals. While three seams are recognized in the Freeport group in Pennsylvania, but two are found in Ohio, viz., the Lower and the Upper. Again, as in the Kittanning group, the principal value belongs to the uppermost of the two seams, so far as Ohio is concerned. The Upper Freeport seam, as has been already stated, is beyond question one of the three leading seams of our coal field. For the present, the Middle Kittanning seam is much more productive than the Upper Freeport, largely through the contributions of the Hocking valley field, but in the course of a generation or two, the table will be completely turned. The facts pertaining to this point will be presented on a later page, in connection with a description of the maps.

5. *The Lower Freeport Coal. Coal No. 6a.* The Lower Freeport seam supports but one important coal field in the state, namely, the Steubenville field. At no other point does it attain importance enough to warrant mining in the large way at the present time. From large areas where it is due, it is altogether wanting, at least in any econom-

ically valuable condition. Even its place is by no means always marked. In numerous sections, distributed through a score of miles at a stretch, its place in the scale will be passed without a blossom of coal, clay, limestone or iron ore to indicate the fact.

Above Steubenville, in the Ohio valley, the Lower Freeport coal is known as the Roger seam. Many small mines are opened in this seam in Jefferson and Columbiana counties.

The next best development of the Lower Freeport coal is found along the western margin of the Ohio coal field, from the Hocking valley southward to the valley of the Ohio River. In the Hocking valley it is occasionally fairly developed, attaining a maximum thickness of three feet. The coal is of fair quality, but capricious in its development to a high degree.

The reference of what is known as the Hamden Furnace coal to the Lower Freeport horizon, which was made in Volume V, has been proved to be erroneous, by the work done in the present report. The seam thus designated has been shown to be the Middle Kittanning coal by means of a better series of sections than was before found. *

In Lawrence county the Lower Freeport coal is known as the Hatcher vein. It is about three feet thick at its best and at present renders a small measure of service in supporting small mines for neighborhood supply.

The Steubenville coal lies entirely below drainage, but an exception has been made for this important field by indicating it on map No. 8, covering the territory in which it is now being mined. As a rule no account has been taken of coal seams when they have fallen below drainage.

In regard to the Steubenville coal a question of identification has always existed. Dr. Newberry referred it confidently to the Upper Freeport horizon, and he had the analogies of this seam in his favor in this reference. More careful work, however, done in the preparation of Volume V, seemed to necessitate its reference to the Lower Freeport horizon. While it has all along been acknowledged that the horizon of this field is not as definitely settled as those of our other coal fields may be said to be, nothing has come to light that tends to really unsettle this conclusion. In the preparation of the present volume, a review of the Steubenville field, with special reference to this question, has been made by Prof. F. W. Sperr, who did the work of determination for Vol. V. but no change has been warranted thereby. The main facts that tend to keep the question open are those derived from the drilling of deep wells in the territory contiguous to western Jefferson county. The Cambridge coal (Upper Freeport) is found running down under deep cover towards the known extension of the Steubenville seam.

The most that can now be said is, that the facts gathered from the

* This new determination is to be credited to Mr. C. E. Sherman, an assistant on the Survey for 1892-3.

surface geology seem to point clearly to the Lower Freeport horizon, while the underground facts lean toward a reference of the seam to the Upper Freeport as the true equivalent. The facts derived from the first source are the more satisfactory and they oblige us therefore to adopt the conclusion already given.

6. *The Upper Freeport Coal. Coal No. 7.* The seam now to be considered has already been repeatedly named in the preceding review as one of the three most important seams of the Ohio Coal Measures. At present time it holds the second place in this list, the Middle Kittanning outranking it in production. But in the course of twenty-five years the Upper Freeport will undoubtedly be in the lead of our coal seams in production, and this relative superiority it will probably maintain for a considerable period. Its only competitor for the first place in production will thenceforth be the Pittsburg coal seam.

The Upper Freeport coal has a fairly distinct character through its entire extent in Ohio. It is always a moderately cementing coal, is well-jointed, does not contain an excessive amount of ash, but is rather high in sulphur. It carries 52 to 55 per cent. of fixed carbon, and less than 40 per cent. of volatile matter. It is somewhat lacking in physical strength, and therefore does not bear transportation as well as most phases of its principal competitor, viz., the Middle Kittanning seam, but as it is largely used in steam production, this fact does not weigh heavily against it. Moreover its slack admits of being coked and can be turned to some account in this way.

The seam has not the continuity that belongs to the Middle Kittanning. The latter, as will be remembered, can be followed in wellnigh unbroken outcrop, around the entire margin of the Lower Coal Measures; but the Upper Freeport seam, although it can be distinctly traced as a horizon by the presence of characteristic black shale, fire clay, limestone, or iron ore, one or all, is found as a valuable seam of coal in limited and distinct basins. Of these basins there are two that are the present centers of important mining operations, viz., the Carroll county field and the Guernsey county field. The Sunday Creek Valley also contains an important development of the Upper Freeport coal. But the two fields first named give promise of important extensions far below drainage. The Guernsey county coal field, in particular, has been proved by thorough exploration to extend for many miles to the southward and southeastward in excellent volume and character. The testimony of the drillers of deep wells in central Harrison county also point to valuable extensions of the Upper Freeport seam in that region, at a depth of approximately five hundred feet below the surface. A like report was also made by the driller of a deep well at Quaker City near the eastern boundary of Guernsey county. In this case the coal brought up was analyzed and was found to agree in composition with the Upper Freeport coal of this district.

This completes the review of the coal seams of the Lower Measures. There is a single seam in the Lower Barren Measures that has been mined in a small way for the general market. It was described in Volume V, under the designation of the Brush Creek coal, but a better name is now proposed for it in the Pennsylvania scale, viz., the Mahoning coal. Its place is about midway between the Upper Freeport coal and the Cambridge limestone. It is in Columbiania county only that the Mahoning coal has been found in volume large enough to justify its being worked in systematic mining operations in Ohio, and even here the seam has lost its former importance. It is here known as the Groff vein.

No account will here be given of the several thin seams belonging to the Barren Measures that are found irregularly developed within our Coal Measure territority. A coal seam that reaches 18 inches in thickness, if of good quality, is never to be despised. The time will come when every such addition to our fuel supply will be carefully counted and utilized.

SECTION III.

The Coal Seams of the Upper Productive Measures.

Two seams, one of them of first class importance, have been mapped in connection with the present volume, viz., the Pittsburgh coal and the Meigs Creek coal, of our scale, which is probably the Sewickley seam of the Pennsylvania reports. Other seams also find place in the Ohio series and one and another may be worked in a small way, but none has importance enough to demand admission to this review.

The Pittsburgh Coal Seam. The Pittsburgh coal is unquestionably, and by all odds, the most valuable single coal seam of the great Appalachian field. It has a far wider area, a greater average thickness, and, on the whole, is of better average quality, than any other seam. At the same time, it is by far the steadiest of all our seams, holding the same general character from town to town, from county to county and even from state to state.

It reaches its highest development in western Pennsylvania. where it furnishes a considerable portion of the gas coal of the United States, and where it is also the center of our greatest coke production. This highest development is attained in Westmoreland and Fayette counties. As the seam is followed northward and westward from the centers named it suffers some reduction in quality, even before it reaches the state line. There is a distinction in all the markets which the Pittsburgh coal reaches between the eastern and western mines of these Pennsylvania counties, and the distinction is to the disadvantage of the latter.

A few words will be given to a description of the character of the Pittsburgh coal in this, its most characteristic field. The description is drawn from the volumes of the Second Pennsylvania Survey. It is everywhere a double seam, consisting of a roof coal and a main bed, between which a clay parting intervenes, ranging in thickness from an inch to three feet, but over wide areas this parting is found about ten to twelve inches in thickness. The roof coal generally consists of several thin sheets separated from each other by layers of shale. The combined layers of coal and shale in the roof stratum have a maximum thickness of eight feet, and an average of three to four feet can be found continuously for hundreds of square miles. The roof coal is never mined, as the fuel is too impure to find any place in the market.

The lower division of the Pittsburgh coal, which in reality constitutes all that we know by this name, ranges in thickness from three and one half feet to nine feet. It shows three persistent shale partings which divide the coal into four benches. These benches are universally known in the Pittsburgh district, as the Upper, or Breast coal, the Bearing-in coal, the Brick coal and the Bottom coal. The Upper Bench, or the Breast coal, is the main reliance of the miner. The Bearing-in bench is from two to four inches thick and is constant in its occurence. Its name indicates the use to which it is put by the miner, and its main contribution to the output of a mine is in the form of slack.

The third bench, or the Brick coal, consists of bright, well-jointed coal, equal, or nearly equal in quality, to the coal of the main bench. It holds a thickness of eight to fourteen inches, through large areas.

The bottom bench is so slaty and sulphurous, or, in a word, so nearly worthless, that it is seldom mined. It generally has a thickness of about four inches.

The roof coal thickens to the northward at the expense of the lower or main division; conversely the latter thickens to the southward and reaches its maximum of nine feet in some of the townships of Fayette county. In the vicinity of Pittsburgh and in Allegheny county generally, it is about five and a half feet thick. In northern Washington, or the Pan Handle district, it falls to its lowest mark, or three and one half feet; and at the same time its quality is less approved than at any other points.

In composition the Pittsburg coal ranges as follows:

Fixed carbon	58 to 64 per cent.
Volatile matter	30 to 35 per cent.
Ash	4 to 14 per cent.
Sulphur	1 to 3 per cent.
Moisture	1 to 4 per cent.

These figures are the result of a very large number of analyses, continued through many years. They show that the best phase of the Pittsburg seam is a coal of great excellence, while in its poorer condition, it may show a large amount of ash and sulphur, and take a comparatively low place among our fossil fuels. There are large districts, however, in western Pennsylvania, in which the better phase predominates.

The Pittsburgh Coal Seam in Ohio.

The statements now given reveal the general structure and character of the Pittsburgh coal in the district from which it takes its name.

As this great seam is followed across the Ohio river into Ohio, two distinct and important areas of it are brought to our view, the first of them, in eastern Ohio, occupying southern Jefferson, eastern Harrison, Belmont and probably the northeastern corner of Monroe county. Its approximate western boundary may be indicated, according to present knowledge, by a line drawn from the southwestern angle of Belmont county, to New Martinsville, West Virginia. The Pittsburgh seam has very little value west of this line as a deposit continued from the east. The second division is found to the south and west of the first. It occupies in valuable condition, all or most of Meigs county, the eastern half of Athens and a very small portion of Morgan county on its southern border, and possibly the southwestern corner of Washington county. The first of these divisions may be called the eastern Ohio field; the second, the southern Ohio field. Between the two, as now appears, a great "want," or break in the continuity of the seam is found. It shows itself in a progressive reduction of the seam, the roof coal disappearing first and the Pittsburg sandstone being let down directly on the coal. The close association of a sandstone with a coal seam shows itself here in the usual way, viz.: the sandstone cuts into the coal, reducing its thickness and lowering its quality. In the center of the want, as for example, in the Duck Creek valley in Noble county, there is nothing but a fire-clay and a black mark to represent the great coal seam. Its absence can be explained either by erosion after its regular formation or by the failure of appropriate conditions for its original growth. Both explanations are doubtless required for different portions of the area in which the Pittsburg coal is due, as far as geological horizon is concerned, but not present. This "want" occupies Muskingum, Guernsey, Morgan, Noble and probably the northeastern half and the southwestern half of Washington and of Monroe counties, respectively. Its axis or central line extends in a southeasternly direction apparently on a line connecting Cambridge and St. Mary, West Virginia, or Newport, Ohio. The breath of the area from which the coal is missing, measured at right angles to the axis, is found to be approximately forty miles. For the southwestern boundry of the "want" a line drawn from McConnelville to Parkersburg, West Virginia, can be taken as agreeing best with the facts now known. At least to the east of this boundary, very little coal of the Pittsburg seam is known to exist until the eastern field is again reached. Each of these subdivisions will be briefly characterized.

(*a*) *The Eastern Ohio Division of the Pittsburgh Coal Seam.* The seam enters Ohio from Hancock and Brooke counties, West Virginia. Its most northerly outcrops in this state are found in the highest river hills of Jefferson county, a few miles above Steubenville. As it is followed southwestward, it takes heavier cover and finally extends in unbroken continuity into the adjacent counties of Harrison and Belmont. Its dip is to the south and east, but the exact direction and the amount of the descent vary in different parts of the field. All the characteristics of the seam as it occurs in Ohio can be found in the western townships of Jefferson county and the eastern townships of Belmont county, where it is mined on a large scale. These characteristics agree closely with those of the seam on the opposite side of the river which have been already described. For an extended account of this field see the chapter of Prof. C. N. Brown in Vol. VI (Chapter X.)

The Pittsburgh coal in eastern Ohio is a bright, well-jointed and well-faced coal. It is of a highly cementing nature, is moderate in ash, but rather high in the proportion of sulphur that it contains. It has a fair measure of physical strength, and consequently is mined in blocks of good average size. It "bears the grief" of transportion fairly well, and the cementing quality of its slack comes in to help it out on every turn. It has the same remarkable steadiness that marks the seam in the Pittsburgh field. Its thickness in the district named ranges from four and a half to six and a half feet.

In its structure it shows the same alternations of conditions of origin which the Pittsburgh coal proper everywhere attests. The seam consists of a roof coal and a main coal, as already described. As in Pennsylvania, so in Ohio, the roof coal is a worthless deposit of blended coal and shale, from one foot to four feet in thickness. When exposed in a fresh cut it is hard to believe that it is destitute of value. It is separated by about one foot of fire clay from the main coal and this fire-clay is known as the "draw-slate" among the miners, as in the Pittsburgh field.

The main coal is in reality a four-benched seam, but in Ohio only two divisions are commonly made of it, viz., an upper and a lower portion which are known respectively, as the top coal and the bottom coal.

The upper bench or top coal, is the "breast coal" of the Pittsburgh district, There is a "bearing-in" slate, occupying exactly the same position and answering the same office, here as there; but the bottom coal is seldom further subdivided, though, in reality, exactly the same divisions could be made of it as in the Pittsburgh field, viz., brick coal, lower slate and bottom bench.

The thickness of the two above named divisions is as follows:

Upper bench, 28 to 40 inches, averaging 30 inches.
Bearing-in slate, ½ to 4 inches.
Lower bench, 24 to 28 inches.

The brick coal, so called, of the Pennsylvania field, ranges in Ohio from 8 to 14 inches; but, as already stated, it is not commonly separated from the coal of the lower bench, proper.

It is difficult to give the average composition of the Pittsburgh coal of eastern Ohio because of the great differences that obtain in the methods of mining it. The seam, as has been shown, carries three dividing bands of slate, and when carelessly mined, the coal is contaminated by more or less of this substance, while careful mining would reduce the amount of foreign material and improve the valuable percentages correspondingly.

The composition of the Pittsburgh coal as it is sent to market from the great mines of Jefferson and Belmont counties is about as follows the figures being the average of a dozen or more analyses:

Fixed carbon	50	per cent.
Volatile matter	40	per cent.
Ash	7.5	per cent.
Sulphur	3.5	per cent.
Moisture	2	per cent.

Careful mining, on the contrary, yields a coal in which the figures run approximately as follows:

Fixed carbon	54 to 55	per cent.
Volatile matter	37 to 38	per cent.
Ash	4.5 to 6	per cent.
Sulphur	.75 to 2	per cent.
Moisture	1 to 3	per cent.

These results, even the best of them, may seem unfavorable to the character of the Pittsburgh seam in Ohio, but the coal is easily kindled, it burns with a hot fire and the utilization of all its slack is possible These facts outweigh any disadvantage which its composition might lead us, on theoretical grounds, to expect. It is a thoroughly approved steam coal and is especially valued for steamboat use because of the readiness with which it is kindled. It also ranks high as a domestic fuel, and taken all in all, is a welcome addition to any market.

At some of the great mines, coking ovens have been built for the better utilization of its slack. While, as has been before stated, the slack possesses the coking property in a high degree, the amount of sulphur in the resulting coke, forbids its employment in most kinds of metallurgical work. It is never an iron making fuel, and can be used but to a limited extent in iron working. This important limitation reduces its market value and the demand for it greatly.

The extension of the Pittsburgh seam below drainage is one of the important questions pertaining to the coal resources of Ohio. Much is to be expected from it on account of its persistency, but the view of twenty-five years ago, that it was reasonable to count on it as stretching entirely across the interval between Pomeroy and Bellaire, can find no intelligent defenders today.

The facts, as at present seen, have been indicated, at least by implication, in the preceding statements. The eastern field gives promise of a noble extension under cover throughout the southwestern portion of Belmont County.

In map No. 10, the coal is represented as occupying this area in a solid body. The ground on which this liberty has been taken has been already set forth. On the same ground we have a right to expect the Pittsburgh coal in good condition in the northeastern half of Monroe county. The facts derived from the recent drilling of oil wells seem to bear out this view, though the unsatisfactory nature of such testimony is fully recognized. Many years must, however, elapse before mines will be worked in Ohio through shafts 500 feet or more in depth. It is probable that the shallow-lying seams will first have been approximately exhausted.

(*b*) *The Southern Ohio Division of the Pittsburgh Coal Seam.* This division has its chief center of development in Meigs County, where under the name of the Pomeroy coal, it has been extensively mined for the last fifty years. This field was treated of at some length in a chapter of a former report prepared by Ellis Lovejoy, E. M., (See Geology of Ohio, Vol. VI. Chap. XI.)

Besides, the great development in Meigs county, the seam is found in good condition in several townships of Athens county, and it also extends in a few unimportant outliers into Morgan county. The general structure of the coal in the Pomeroy field is as follows:

Roof coal	8 to 14 inches.
Horn coal	3 inches.
Main coal	42 to 48 inches.
Clay	4 inches.
Bottom coal	7 inches.

The first two divisions do not furnish marketable coal. The lower bench is also inferior and is not mined. This leaves three and a half to four feet of coal for the general market.

Pomeroy coal has long been an approved fuel throughout the Ohio and Mississippi valleys for domestic use and steam production, and large areas of the original deposit have been exhausted in meeting these demands. Its average composition is as follows:

Fixed carbon	50.00
Volatile matter	38.50
Ash	6.50
Moisture	3.50
Sulphur	1.50

It is interesting to note that the establishment and development of the salt production of Pomeroy and vicinity have been intimately connected with and dependent upon the character of the Pittsburgh coal. As noted above, the uppermost portion of the seam, eleven to seventeen inches in thickness, consists of inferior coal, which the general market will not accept. To find a use for this waste portion of the seam, the salt manufacture of this portion of the Ohio Valley was projected. By deep drilling a fair source of brine was found in the great sandrock, that has since been known as the Logan Conglomerate, and more recently, as the "Big Injun" oil rock of western Pennsylvania and West Virginia. On this supply of fuel and brine, an important business was established, which grew to large proportions between 1865 and 1870. Since that time the industry has languished, being unable to meet, with comfort, the competition forced upon it by the new centers and new sources of salt production.

In the chapter above referred to, the extension of the Pittsburgh or Pomeroy seam, known as the Federal Creek coal, was also described. But an important section of it has had its chief development since the publication of that report and consequently a few additional statements are demanded here. The tract in question is situated in Berne Township, Athens county, and is drained by Federal Creek and its tributaries. Of the latter, the most important is Marietta Run. The seam here reaches a greater volume than at any other point in the state. It yields, at its best, eight feet of clean coal, which occurs in two nearly equal benches that are separated by one or two feet of fire-clay or sandy shale. This phase of the seam is now being worked on a large scale in several mines on an extension of the Toledo and Ohio Central Railway. The output of the mines also finds a way to market by the Baltimore and Ohio Southwestern Railway. The coal is of the ordinary type of the Pomeroy seam, except that it runs higher in sulphur than the best phases of the seam. The latter element thus far stands in the way of the successful production of coke from the slack of the mines. A bright coke of unusual physical strength comes from the ovens, but the sulphur runs so high in it as to forbid its employment in iron making or other metallurgical work of high grade. This defect can no doubt be corrected to a considerable degree by washing the coal. The Federal Creek coal, however, has a full measure of popularity as a steam and domestic fuel.

The seam is at its best volume, as above described, when it descends under final cover on the east side of Federal Creek Valley. The testimony of certain well drillers who have operated in adjacent territory is positive as to its extension in the same condition for several mines to the east and southeast of the valley. If this testimony proves trustworthy, an important addition to our coal resources is to be found in this new field. In any case, the proved and fairly inferrible area of the thick coal constitutes a field of considerable value. There is nothing to render unreasonable or improbable the view that this phase of the seam is the one to be looked for under cover through its remaining extent to the southeastward. It may, therefore, well be that one of the chief remaining coal fields of the state will be found in southeastern Athens and adjoining parts of Washington county.

The seam falls abruptly from its great volume, as it is followed to the northward, the loss occuring, as usual, by failure of its upper member.

The Meigs Creek Coal.

The only remaining seam to be considered here, is that which is known in our reports as the Meigs Creek coal, from its development in the drainage basin of the stream of that name in Morgan county. It is probable that this seam is identical with the Sewickley coal of the Pen-sylvania series. Its place in the series is seventy-five to one hundred feet above the Pittsburgh coal and about 250 to 300 feet above the Crinoidal limestone. The outcrops of this seam have been traced in Muskingum, Morgan, Guernsey and Noble counties, and are represented in Map No. 9. A few outliers occur in Washington and Monroe counties, which were not reached in our work, but these deficiencies are not important.

A good account of the Meigs Creek coal in Ohio was prepared by Prof. C. N. Brown for Volume V, of which volume it constitutes Chapter XI.

In its best condition, in Muskingum and Morgan counties, the seam shows a thickness of four and a half feet of coal fit for the market. It is, however, split by more or less clay and shale partings. From its maximum thickness it falls to four, three and two feet in the surrounding territory, as indicated in the report above referred to.

Its composition as averaged from a sufficient number of samples, is as follows:

Fixed carbon	44.50
Volatile matter	40.50
Ash	11.00
Sulphur	5.00
Moisture	3.00

These figures indicate a coal of comparatively low grade, but it is a welcome fuel, all the same, throughout a large district that is more conveniently supplied by it than by any other seam.

The identification made in Volume V, of the coal formerly mined in the large way at Macksburg, Noble county, with the Meigs Creek, or Sewickley seam, has been called in question by some geologists, who are disposed to place the Macksburg coal higher in the series and to count it the probable equivalent of the Waynesburgh coal of Pennsylvania. But a review of all the available facts made by Professor Brown with reference to the present report, leaves him confident, that his original reference is the correct one. The facts of its occurrence and composition are in harmony with this reference.

In the higher strata of Belmont and Monroe counties, there are occasionally found coal seams thick enough to justify mining in the small way. It is probable that if full knowledge of the stratigraphical facts were in hand, all these cases would fall under one or another of the seams already named in our general list. But in default of such knowledge, no exact reference is possible.

At a little hamlet called Mechanicsburg, twelve miles south of Woodsfield, Monroe county, a four-foot seam of coal has long been known and worked in the deep valley of one of the tributaries of the Little Muskingum. The seam has not been followed in any direction outside of the valley in which its outcrops occur. Some of the facts of its occurrence give it a decidedly sporadic look. But, on the other hand, it may prove to be, on some coal horizon that possesses more or less value for this region. The seam cannot apparently lie lower in the scale than the Meigs Creek horizon, and it may be much higher.

This completes the brief account of the coal fields of the state which was undertaken in the present chapter. A description of the maps to which frequent reference has been made in these pages will be found in the preface of the present volume.

GEOLOGY OF OHIO.

VOLUME VII.

PART II.

ARCHÆOLOGY,

BOTANY,

PALEONTOLOGY.

GEOLOGY OF OHIO.

CHAPTER I.

THE ARCHÆOLOGY OF OHIO.

AN ABSTRACT EMBODYING THE PRINCIPAL RESULTS OF EXPLORATIONS AND DISCOVERIES THUS FAR MADE, DESIGNED FOR THOSE TO WHOM THE HITHERTO PUBLISHED LITERATURE OF THE SUBJECT IS NOT EASILY ACCESSIBLE.

By Gerard Fowke.

From the earliest settlement of Ohio the aboriginal remains of the State have aroused curiosity and stimulated research. The present paper will attempt a *resume* of what has been learned concerning them; but the limited space that can be allowed to it precludes any citations from the many books, pamphlets, and shorter articles, or any extended reference to the various theories, that have been put forth in regard to their uses or the people to whom they are to be attributed. Its only aim will be to present in a compact form conclusions based upon a careful study of the earthworks and the relics associated with them. There is little in the article that has not previously appeared in some form; the publications of zealous workers have been so numerous as to render difficult any originality of statement beyond records of personal discoveries. As it would be invidious to make particular mention of one investigator to the exclusion of others equally meritorious, and is impracticable to give due credit to all who deserve it, this compendium will be made as impersonal as possible.

SECTION I.

PALÆOLITHIC MAN.

The discovery of rude implements of human fabrication in presumably undisturbed gravel beds along the lower portion of the Delaware River, has led western archæologists to believe that similar evidences of man's presence in the valley of the Ohio and its tributaries will reward the patient investigator. The series of gravel beds in the two regions are practically of the same age, belonging to the period immediately following the recession of the ice-sheet after it had reached its southernmost limit, and were deposited by the great floods resulting from the melting ice.

If it can be proven that these implements are scattered promiscuously throughout gravel which has remained as it was originally deposited, the fact of human existence during or at the close of the glacial period is beyond controversy.

Implements have been found in several places in Ohio under such conditions that the time of their manufacture would appear certainly to have preceded that in which the river valleys were filled with the drift; notably the chipped flint found at Madisonville by Dr. Metz twelve feet beneath the surface in a knoll higher than any other ground within several hundred yards. On the other hand, specimens from Piqua, which were reported to occur under conditions essentially similar to the last, and which much resemble some of the European implements from the drift, have been found, as was afterward determined, intermingled with ordinary Indian relics, under flood deposits which may have accumulated within a few decades.

The streams in the glaciated district of Ohio have worn their beds from the level of the highest terraces bordering them, to that at which they are now found; this erosion was more rapid in former time than at present. The shifting of such streams from side to side of the alluvial lands through which they flow is also quite rapid in some cases; it being not unusual for a river or creek to change its course hundreds of yards in a single generation, cutting away the earth on one side and filling it in at a lower level on the other. With a rapid current to carry away the detritus, a stream will in this manner often produce a vertical bank to the top of any terrace against which it may impinge; and when it again makes its way toward the opposite side of the valley, denudation will give to this bank a slope whose inclination will depend upon the character of the material and the length of time given to atmospheric agencies for their action. These alterations have been continually in progress since drainage was established along its present lines. For this reason, a stone implement of any description that was once on top of the ground, or in the soil near the top, may now be found in clean gravel much below the present surface, some distance from a stream or at a considerable elevation above it, or may be covered by a mass of earth nearly equal to the thickness of the highest gravel bank reached by the water;—and yet have come to its present position within a few centuries; for polished grooved axes and well finished spear-heads have been found at a depth of twelve feet or more in river bottoms. The discovery of an implement, no matter how rudely finished, under such circumstances is by no means to be accepted as indubitable evidence that man existed in that locality during glacial floods. To establish such existence it is necessary to prove beyond doubt that the gravel or sand in which the specimen occurs still retains the exact position and condition in which it was laid down at the beginning; this can be determined only by geologists who have made a close and careful study of such deposits in every phase of their complicated structure. The question must remain an open one until the claims of the advocates and the opponents of glacial man in America are more definitely substantiated than at present.

The terraces with a thickness of fifty feet or more along our rivers and creeks owe their formation to precisely the same causes that are daily creating the minor bars along the shores of these streams; the difference is merely in the diminished forces now at work.

It will be apparent, therefore, that great caution is to be exercised by those who are seeking for palæolithic implements; many things, as indicated above, are to be taken into consideration. The most skilled glacialist is liable to be deceived by the arrangement of secondary terraces, and thus countenance an erroneous opinion which more extended observation would correct. All the greater need, then, for one to whom may not have been given the opportunity for a large field of study, to be chary of hasty deductions.

It is probable that discoveries of this character will multiply with the growth of such work as requires excavations on a large scale; those interested will do well to remember that many persons are given to such "practical jokes" as making false statements regarding circumstances under which specimens are obtained, or deftly concealing desirable objects in places where they are being sought. This is particularly the case when a pecuniary reward awaits an interesting discovery.

SECTION II.

ENCLOSURES, ROADWAYS, MOUNDS.

Casual mention had been made concerning earthworks by various travelers, in connection with short descriptions of mounds, but the first comprehensive account of them was given by Squier and Davis in their report on "The Ancient Monuments of the Mississippi Valley." The publication of this volume called general attention to the existence in Ohio and, to a less extent, in the adjoining states, of a class of prehistoric remains differing in character from those belonging to any other part of the country.

In Ohio, works of this kind fall in three separate classes:—the heavy embankments of earth peculiar to the level or low lands of the southern half of the state; the larger hill-top fortifications composed of earth and stone in varying proportions, confined mainly to the same localities as the first; and the far greater number resembling in some respects both of the above, but usually smaller, seldom symmetrical, evincing less care or design in construction, and placed on high or low ground indifferently, sometimes with little regard to topographical features. They are of wider distribution than the others, occurring more or less frequently throughout the area between the Alleghanies and the Mississippi, from Tennessee to Michigan.

(*a*.) LOW-LAND ENCLOSURES.

Coincident with the appearance of the volume above mentioned was the manifestation of public interest and curiosity in the remains placed first in this division. The regularity of curves, the remarkable uniformity in lengths and areas, the complexity and intricacy of structure, the absolute geometrical accuracy of squares, octagons, and circles, as claimed in the text and portrayed in the illustrations by the authors, induced the belief that this region had been occupied by a race which had attained to a high degree of culture; and finally extravagant theories were promulgated, totally unauthorized by the most liberal interpretation of statements which themselves claimed much more than was justified by facts.

The fertile valleys of the Muskingum, Scioto, and Little Miami, seem to have been the favorite homes of the builders of these earthworks, whose magnitude compels the admiration and serious consideration of every intelligent visitor. With the exception of one group on the Kanawha River, and another opposite the mouth of the Scioto, which is really a part of the "Portsmouth Works," all the principal enclosures of this class are confined to the vicinity of these streams. Many speculations have been indulged in concerning the purpose for which such works could have been constructed; but so far without definite result. Every explanation or theory yet advanced is largely conjectural, and in some or many respects inconsistent with facts which soon become apparent to the careful observer. The term "sacred enclosures" was among the first applied to them, from the supposition that they were used only in the performance of religious ceremonies. It is impossible to imagine any condition of life that would lead people to enclose areas so great for no other purpose than to conceal the operations of one portion of the population from the remaining portion; or to conceive of what use the walls would be in case all should take part in the exercises. There is nothing in our knowledge of any barbarous race, extant or extinct, that justifies such a statement. True, the priests of most religious systems in former ages, concealed the preliminaries of their rites from the multitude; but to cite records of the use of caves or groves for this purpose in vindication of the theory that the same object could be attained by means of a comparatively low wall around a twenty-acre field, is a large tax on credulity. Nor is the suggestion more tenable that they were used as "game drives and preserves," or places wherein to decoy and confine wild beasts until such time as it might be convenient or necessary to slaughter them; for such animals as existed here in that period would make scant ceremony of surmounting any walls that could be built of earth. Moreover, such methods are not in accordance with the disposition of people who live even partially by hunting; the love of adventure, the desire to achieve noteworthy exploits, the excitement and emulation of the chase, reacting upon one another, will not be satisfied by so tame a pleasure as may be derived from slaughtering in cold blood a defenceless quarry. At any rate, admitting that our aborigines had become so enervated as to enjoy this form of "sport," they would have accomplished their aim more readily by making palisade traps at the head of some ravine near where the game was to be found, than by the construction of these awkward contrivances, usually placed in a situation as unsuitable as could be found for such a purpose.

The idea has been advanced, also, that the walls served as foundations for houses, the interior space being devoted to cultivation. Calculations have been made showing the exact width of such houses. But the theory takes as its basis that the walls are composed of tough clay which will stand with a very steep slope from top to bottom. None of the embankments are thus constructed, being made of the loam and gravel constituting the soil around them, which will not maintain a greater angle than an ordinary fill made of similar material for a road or railway. To erect on them at their present height a dwelling, except of very contracted width, would require a breadth at the top greater than can be given to any of them with the amount of material used, unless means be taken, as by palisades or a retaining wall of some description, to keep them from crumbling down; there is no evidence that this was ever done.

Somewhat akin to the last, is the suggestion that the enclosed space was used for agricultural purposes by the inhabitants of villages at some place outside the walls, who took this method ot checking the encroachments of animals destructive to their crops; but, as before mentioned, such animals would find earthen walls a trifling obstacle. This objection is overcome by supposing palisades along the top of the embankment; but if such were used only sufficient earth to hold them in place would be needed. There are no indications of such protection; logs or posts of the size to be an effectual barrier would leave their traces in charcoal, ashes, decayed wood, or cavities filled with lighter earth, for an indefinite time, as is fully verified by numerous discoveries of the sort in mounds and village sites.

Another hypothesis is that villages were located within the walls which were erected as a defense against invaders. Some of them may have answered for such purpose; but in most there is one feature that militates against this supposition as it does against all the preceding;—namely, the openings or gateways, which are usually so numerous as to show that ready entrance and exit was to be liberally provided for, and almost invariably so wide that speedy closure would be impossible even with much greater facilities for such work than we have any reason for supposing to have been at the command of the owners. Further, a wall higher than a man's head,—as many of these now are, after the denudation of centuries,—especially one with an interior ditch, would give the defender no advantage over his opponent; for unless a platform were constructed entirely around the inner side, he could not see over the top except by climbing up a slope on which it would be difficult to secure a foothold. With a lower wall and an exterior ditch, the conditions would be different; and if some adequate method of defending the gateways were devised, a successful defense could be made against superior numbers—provided the work was at a sufficient distance from a hill or body of timber overlooking the interior. As an example of this feature, the circle in the works at Hopetown (Ross County) extends for a part of its course along the side of a hill, at some distance above its foot. Also, in the works at Anderson Station in the same county, the larger embankment which encloses considerably more than a hundred acres, is built on the side facing the high land from which an enemy would naturally approach, just on the bank of a terrace in such a way that the inmate would have barely room to stand, while the besieger has an ample space of level ground in h s favor. Again, the usual indications of permanent occupation are lacking; village sites are recognized by the great accumulation of refuse due to the life habits of the people, broken bones, ashes, burned stones, and the like occurring in profusion. These have not been found in sufficient quantities to lend color to the theory.

Still others have assigned to enclosures an office similar to the Roman circus, considering them places where persons inclined or compelled to entertain the populace with games or feats of strength and valor, would have abundant space for the display of their skill and prowess; the spectators meanwhile viewing the performance from seats provided for them along the top of the wall. This is giving prehistoric man credit for more enterprise and public spirit than seems warranted by known facts. If boundaries were needed, they could be marked by lines; and the hills or terrace-banks in the immediate vicinity of any of these works overlook level tracts as well adapted for such purposes as those within the walls.

A few illustrations are here presented that will give a fair idea of the arrangement and appearance of some of the more notable enclosures. Except when otherwise stated, all figures are copied from the work of Squier and Davis.

Plate I is a map of "twelve miles of the Scioto Valley," in the vicinity of Chillicothe.

Plate II, a map of "six miles of Paint Creek Valley," about Bourneville.

There is scarcely a point in either valley, below Circleville or Bainbridge, where one may not be within a few minutes ride of a mound, village site, or other evidence of aboriginal habitation. The same is true of both Miami valleys in the lower half of their course, and of the Cuyahoga and some other small streams tributary to Lake Erie; the only reason for showing the one section in preference to the others is because of the greater extent of its enclosures. The scale upon which the maps are drawn prevents an accurate delineation of the separate works; but their relations to each other and to the topography of the territory containing them is sufficiently well shown.

Plates III and IV give an enlarged representation of two groups according to the surveys and measurements of the authors; the former being named by them "High Banks" works, and the latter "Liberty Township" works, situated respectively four and eight miles south of Chillicothe. At High Banks the river sets against the terrace along the north side, forming a steep bluff from the top to the water's edge, the current carrying away the earth as fast as it caves in; and it would seem that no great length of time has elapsed since the river had its channel along the western bank of the terrace, as there is a depression or thoroughfare at its foot through which the water rushes in time of freshets, while the higher parts of the bottom land are still several feet above overflow.

Plate IV shows similar enclosures, but without the long parallel embankments of earth common to most works of this class. Especial reference will be made in another place to features of these groups.

In Plate V are shown the Newark works, which in extent, variety of structure, and amount of labor involved, probably surpass any similar remains in the world. Mile after mile of embankment—circles and other geometric figures, parallels, lodge-sites, and mounds, covering an area of more than four square miles, amaze the archaeologist and curiosity-seeker alike as they spend hours and days traversing the ground in every direction, constantly finding something worthy of investigation and description. No one who visits this place can fail to be impressed with the thought that he is viewing the results of a vast amount of labor intelligently performed for a definite purpose; and few can avoid the temptation of endeavoring to interpret this purpose, to fathom the motives which would impel men thus to labor, or to frame a theory that will clear away the obscurity impending as a cloud over these mysterious tokens of an unknown people. Many have tried; none has succeeded.

The "Marietta Works" shown in Plate VI comprise a group whose main interest is found in the flat-topped mounds within the lines of embankment. Such mounds are common in the southern states, and several of great size, including the famous Cahokia Mound, stand in the bottom land opposite St. Louis; but with this exception they are of rare occurrence north of the Ohio River and there is no place other than at the mouth of the Muskingum River where they are so large, or are found in connection with the enclosures belonging to the middle Ohio Valley.

The topographical markings in the figure will show that, whatever may have been the design of this particular group, it occupies nearly all the available level ground in the plain on which it is erected. While this fact does not necessarily reinforce any of the theories above set forth, as to the purpose of such works, the adherents to some of them will find difficulty in providing sufficient space for the town or village and cultivable ground necessary for the accommodation of those by whom the structure is supposed to have been reserved for only occasional or temporary use.

Numerous other groups in the state are worthy of separate mention; but as a large volume would be required to contain all that might be properly said regarding them, this sketch must suffice. Some are so complicated in arrangement as to suggest the idea of a labyrinth; others, more simple in form, are in such situations as to render approach to them inconvenient or even difficult. In extent they range from those measured by square miles to those which are contained within an area of two or three acres.

(*b.*) HILL-TOP ENCLOSURES.

The second division is intended to include only the larger enclosures, on high ground, in the same section of the State containing those just described. The difficulties in the way of accounting for the uses of the former do not exist with the latter. To all who examine carefully their locations it is evident they were intended for defensive structures. Whether composed entirely of stone, or of earth, or of both combined; whether confined to a plateau or extending down the hill-side below; whether having a ditch, either interior or exterior, or rising directly from a level surface;—in all, the method of construction and their position relative to the surrounding country, make it obvious they were intended as a place of refuge in time of danger from foes. Many of them command extensive views in every direction, notably the one on Spruce Hill, nearly opposite the village of Bourneville, which overlooks the valley of Paint Creek from the hills along the Scioto to the high land about Hillsboro, as well as the region for many miles north and south. This fortification is indicated at C in Plate II, and is shown in detail in Plate VII. The hill on which it stands is a long, narrow spur projecting from the table-land to the south, with steep, in some places almost precipitous, sides. The wall, composed entirely of boulders and cobblestones, resulting from disintegration of the sandstone strata at and near the surface, closely follows the margin of the level summit at every point except where the lines connecting the ends is carried across. It was only from this direction that danger need be apprehended by the inmates, as no other portion of the enclosure could be reached except by a tedious ascent of the steep hill, over loose rocks in many places, and constantly exposed to the missiles of the besieged. Although nowhere more than two feet in height now, the amount of material scattered along the line where it has stood is abundant for the construction of a barrier sufficient to check the advance of an unorganized or undisciplined foe. The few breaks or openings easily accessible are all in the part crossing the neck of the spur, and are quite narrow, with the wall curving inward at each. Thus every entrance could speedily be closed to form a *cul-de-sac*, making an assault extremely hazardous to a hostile force by exposing them on three sides to those within. This feature, infrequent in ancient works, is indicative of considerable military knowledge and skill on the part of the builders.

Somewhat similar in construction is the stone fort near Glenford, Perry county. It is built on a hill, cut off by deep ravines from the adjacent country except on the southeast side where a narrow isthmus, scarcely wide enough for a wagon road, connects it with the higher land in that direction. The outcrop of the cap-rock of the hill, a heavy stratum of coarse sandstone, forms a vertical cliff of varying height almost entirely around it; on the edge of this cliff have been piled thousands of cubic yards of stones. Where the height of the cliff would obviate the necessity of further obstacles to an enemy, the wall ceases; where it is so low as to afford but little protection, an amount of stone sufficient to answer the purpose is heaped up. There are many crevices in the bed-rock, all of them guarded according to their size and position; one of these opens out on the isthmus, and here was the principal entrance. Possibly this had something to do with the selection of the site. A wall is built along each side, and opposite the end is a wing wall commanding its whole length. At several different points are minor openings, most of them convenient to good springs at the foot of the hill.

Fort Hill in Highland county is another example of this class. It is located on one of the western peaks of the Sunfish Hills, entirely detached by Brush Creek and deep ravines from any other elevated area. The hillsides present a succession of minor cliffs, shale banks, washouts, and loose, broken rock; in only two or three places can a continuous moderate grade be found to the summit. At the top, a sandstone ledge crops out, and the weathered fragments of this are piled up into a rude wall around the hill, conforming in some measure to its irregular outline. The height of the wall was increased by throwing on it a large quantity of earth, excavated along its inner, or upper, side, leaving a considerable ditch.

Differing somewhat in method of construction from the above, but similarly located in a defensible position is the embankment at North Bend, also known as Fort Hill. As this title is due by preemption to the work last described, it would be well to call this one Fort Miami, from its location on the high hill overlooking all the territory about the mouth of the Great Miami River. Although there is some stone in the embankment, by far the greater portion of it is earth, obtained from a ditch along the inner foot of the wall. Perhaps careful measurements would show otherwise, but there appears to be more earth heaped up than could be replaced in the trench; if so, the surplus was gathered up close by. The gateways are comparatively narrow and few in number; from the situation of some of them, it would seem they were little used; others open toward the easiest approaches. The walls are massive; if their cubic contents should be divided by their total length, it is probable the quotient, representing the amount of earth in any given unit of length, would exceed that similarly obtained in any other structure in the state. It is doubtful whether nearly all of those described in the first section would not suffer by the comparison. Unless the embankment has been much reduced in height by atmospheric agencies since its abandonment, with a corresponding increase in breadth and diminution of slope, some of the difficulties in the way of ascribing a military purpose to the large enclosures of the level lands apply with the same force here. Under present conditions there would be small choice in position on either side of the wall at equal distances from it. Possibly there was some additional method of defense or protection of which no trace now remains.

Surpassing all other hill fortifications in magnitude as well as in systematic design is Fort Ancient in Warren county. Built on a spur almost detached by deep hollows from the plateau, somewhat more than two hundred feet above the level of the Little Miami River, which flows close below, its walls follow accurately the tortuous course due to the scores of ravines which give a crenulated outline to the brow of the hill. The numerous openings, almost without exception, lead out on narrow points overlooking ravines on either side, and commanding from two or three directions every possible avenue of approach. The thought at once suggests itself they were completed by bastions closing in the limited outside space, usually only a few square yards in extent. Where facing a slope easily defended, the embankment is quite low; parts most liable to attack, or commanding important points, are greatly strengthened. The portion crossing the level is nearly twenty feet in height; the ditch here is on the outside; elsewhere it is within.

Few modern fortifications equal Fort Ancient as a defensive work. With ordinary care surprise would be impossible. Omitting the few rods of level ground at the east, the walls can be reached only by ascending a steep slope, in plain view of any who may be on the watch; while from the peculiar conformation of the ground nearly every portion of the hill-sides may be placed under cross-fire. Properly garrisoned, the place would withstand a prolonged siege by a well-equipped army; with primitive methods of warfare it would be impregnable.

Shown in Plate VIII.

A perplexing element in the study of all these forts is the question of water supply. No springs exist within them, as they are above drainage;

shallow depressions in some have been called reservoirs, but these would be very precarious as they depend entirely upon rain-fall and are dry most of the summer and autumn; to carry from the base of the hill an amount adequate for the multitude which could find quarters within the enclosure or be necessary for its defense, would be an undertaking arduous always, and hazardous in time of war.

(*c.*) PROTECTIVE ENCLOSURES.

The more elaborate works, having been so often described and figured are somewhat familiar to the public; fully as interesting, though not so impressive, are those which have been less noticed. They vary in design from a straight wall, to a combination of elliptical or nearly circular enclosures, with accompanying wing walls or supplementary structures, covering many acres. Apparently their general purpose was for protection to villages or settlements within them. The point of a high hill with precipitous sides, or a peninsula in a level bottom, is cut off from the adjacent country by an earthen or stone wall, straight, curved, or broken, as may be most suitable; as large a level area as may be desired is enclosed by a crooked embankment, whose ends abut upon a cliff or stream; or, where these plans are not feasible, the entire space required is often artificially enclosed. All these methods may be combined in one series. Generally, but not always, a ditch accompanies the wall; it may be interior or exterior. It is probable the earth in the majority of these embankments upheld palisades. Such barriers were common with the Hurons and Iroquois of the seventeenth century and earlier; logs were placed vertically in a ditch and the excavated earth packed solidly against them. When necessary, greater stability was obtained by piling against the rampart a quantity of earth gathered from the surface close about, or taken from a trench which in its turn gave additional security.

Analogous works are found in the southern states, some where Indian towns are known to have stood, others in natural strong-holds where they have been erected within this century, during war with the whites, by Creeks and other Indians who manifested much tactical skill in their construction and use.

In Ohio, remains of this sort are most numerous in the valleys of the two Miamis and in the two or three tiers of counties south of Lake Erie, though not uncommon in other portions of the State. Many of them closely resemble enclosures and defensive works in other states known to have been occupied or built within the historic period. In a few cases transverse cuttings have shown marks along the center line, due, beyond question, to the decay or burning of posts that stood in them.

The works at Norwalk, Huron county, shown in Plate IX, fairly represent this division; the method of closing the entrance in the ellipse, the manner in which the end of the hill is guarded against forays, the dependence upon the stream and its banks, for security in other directions, and the partially excavated ditch within the ellipse, are well shown and render further illustrations unnecessary.

(*d.*) SMALL ENCLOSURES, LODGE-SITES, ETC.

Besides all these, there are many small, tolerably regular, circular, square, and elliptical enclosures, found in nearly all portions of the State, often on top of the highest hills. They are from fifty to two hundred feet across, some scarcely traceable, others having an elevation of two or three feet, with a breadth of five to ten times the height. There is but one entrance way, on the east side in most, sometimes on the north or south, very seldom on the west. In Plates III and V, they will be seen in connection with the larger enclosures evidently forming a part of the system; they also occur with other groups. With some, mounds are associated; others are miles from the nearest aboriginal structures. The heavier embankments frequently have an interior ditch; occasionally a mound stands on the space thus enclosed, sometimes quite small, again taking up nearly the whole area within the ditch. Skeletons have been exhumed from such mounds. In a few instances a curved bank surrounds a square center, the ditch varying in width to accommodate itself to both.

In erecting council-houses, lodges, or even temporary wigwams, Indians are accustomed to make a bank of earth like a circus ring around the sides, to keep the floor dry and serve as a wind-break. Such may have been the nature of these prehistoric works; they are not larger than would be required for some Indian houses of recent times. The utility of the ditch, however, is not apparent; nor is it a part of the modern Indian's plan. The central mound would certainly exclude a number from this category, unless it were erected after the building was destroyed or abandoned. Some of them sufficiently resemble the large enclosures to induce a belief in their creation for a similar purpose—whatever that was. If the method of constructing dwellings along the top of an artificial ridge was ever in vogue, the low, broad embankments would be much better adapted for such houses than the higher ones which have been attributed to such intention; they would be less subject to damage by erosion, more easily kept in shape, less difficult to reach from the ground, and sufficiently high to protect the floor from dampness by seepage from the adjacent soil. If thus utilized, the ditch might form a reservoir (many of them retain water nearly all the year), while the court would answer for various public purposes.

In the Scioto Valley, mostly at some distance from other remains, are several excavations which have no counterpart elsewhere; they are not properly enclosures, yet cannot be placed with anything else. On the top of a low hill; near the edge of a terrace in bottom land; or in the middle of a level field;—a circular hole has been dug and the earth thrown around the margin. All have been considerably filled in by cultivation, but some are yet from six to eight feet deep and eighty to one hundred and fifty feet in diameter, measuring from the highest part of the wall. The sides now slope uniformly, whatever may have been their original shape, to form an inverted cone; in wet weather they contain some water, which soon disappears. The same end is also effected in a peculiar manner; on a low, depressed ridge connecting two hills, commanded by high ground on every side, a circular embankment has been thrown up to a height of eight feet on so small an area as to leave no level space inside, the inner face of the bank forming a conical basin whose bottom is at the original surface. This form is the last connecting link between the enclosures and the mounds.

The purpose of these pits is beyond conjecture; there is nothing in use among modern tribes with which they can be compared.

(*e.*) ARTIFICIAL ROADWAYS.

The existence of a few gentle inclines from a higher to a lower terrace, or to a stream, has caused a belief that the "Mound Builders" cut such roadways, piling the earth on either side. None were thus made. The few which are actually artificial have escaped notice through their insignificance; they are usually found in connection with larger groups of works situated on a plain with steep banks. To facilitate ascent, steps would be cut or a pathway dug, the removed earth falling toward the bottom. With every heavy rain, more or less dirt would wash down, and from throwing this out of the way, the excavation would widen and deepen; in time a gully of considerable width and easy slope would result.

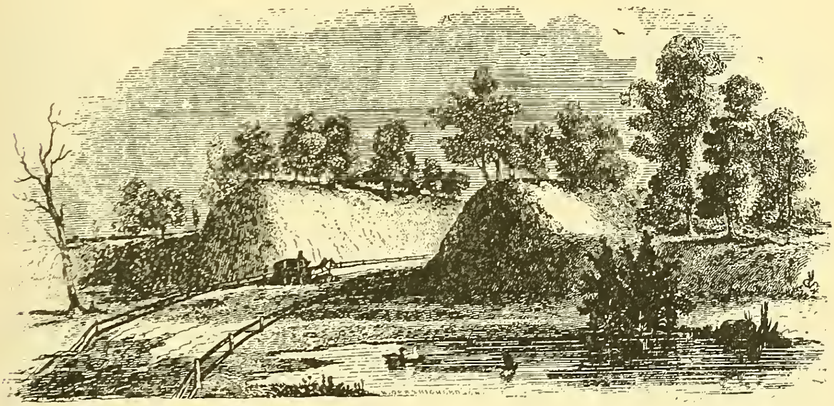


FIG. 1. View of Graded Way, near Piketon.

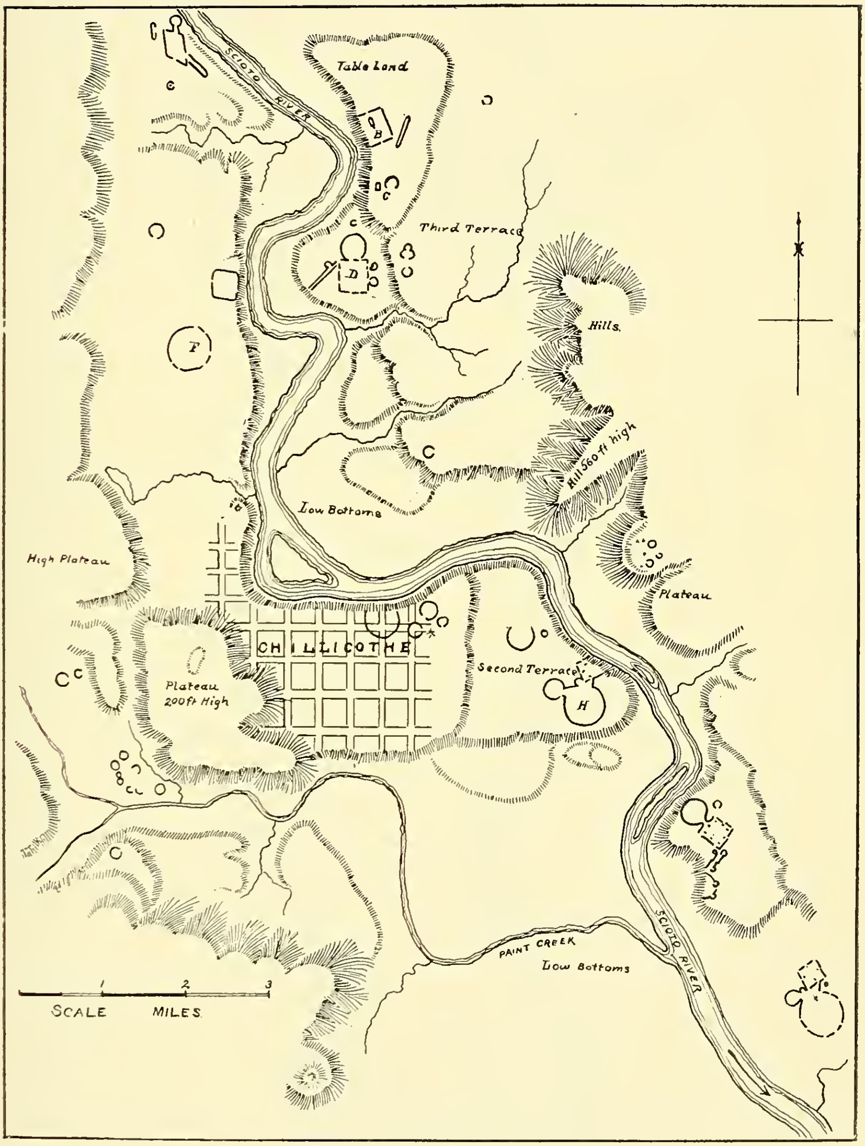
Those usually described or figured are natural depressions, possibly slightly modified, which happened to be where they were needed. The "Graded Way" at Piketon has long been cited as a remarkable example of such industry. Figure 1 from the original drawing reproduced in various archaeological works, has always been taken as a correct representation. In Plate X are given a plan and sections from a recent survey. The error and exaggeration of the figure will be apparent at once. In itself, the work is of no special importance or interest; but the perverted accounts of it have done much toward impressing the reading public with erroneous ideas regarding the people who are credited with its formation.

The depression is not in any degree artificial, but is due entirely to erosion, being a former cut-off or thoroughfare of Beaver Creek. It does not rise to the level of the upper terrace, but continues with a slight grade to the bank of that stream, in a curved line, growing wider as it proceeds. The bottom at the narrowest part measures 120 feet across, whereas the greatest base measure of either wall is sixty-nine feet. Instead of the whole work being 1,080 feet in length, as stated, the depression is 2,225 feet, one wall 636 feet, and the other 761 feet along the top. The elevation of the terrace is twenty feet, not seventeen, while neither wall is more than nine and one half feet at any point and only a few rods of it is over six feet high. Instead of gradually tapering to a point, the west wall when viewed from the south end more resembles an ordinary mound. The earth composing them was not thrown up from below, but was gathered on the surface and deposited along the break of the depression, a portion of it being allowed to fall down the sides to make a steeper slope. Both walls change direction at more than one point, and so far from extending its entire length on the upper terrace, the east wall descends into the depression and terminates near its bottom.

(*f.*) EFFIGY MOUNDS.

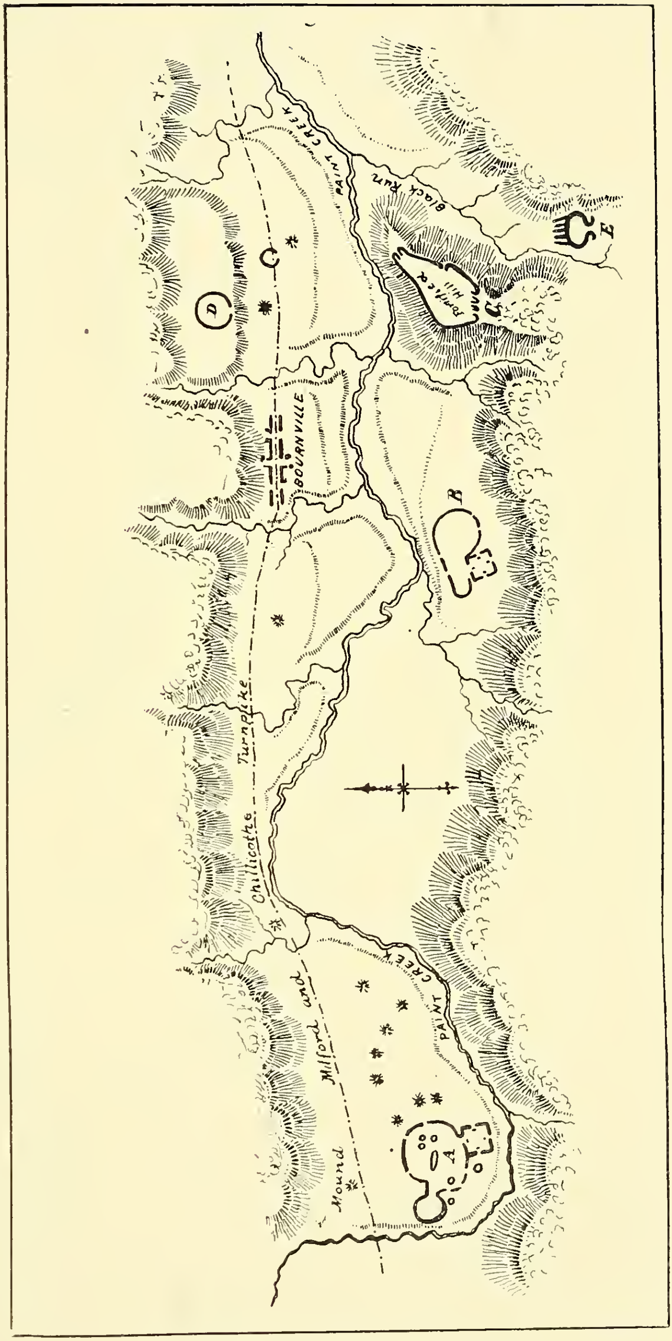
In several states are mounds presenting a rude outline of some animal. They are almost invariably made of earth, though occasionally one is of stone. By far the greater number is found in the north-west, especially in Iowa and Wisconsin, where they exist by thousands. The human figure as well as that of many species of quadrupeds and birds have been recognized, generally by persons who are not expert zoölogists. They are frequently, and it may be correctly, called emblematic or symbolic structures; "effigy" is, perhaps, a safer term.

Ohio possesses several of these figures, only two of which really resemble anything. First, and above all others for its size and striking appearance, is the Great Serpent of Adams county. With its head at the end of a narrow point, jutting out over Brush Creek bottoms, restricted by a perpendicular cliff on one side and a deep ravine on the other, the effigy winds its contorted body along the surface for a quarter of a mile. The front part of the figure, which lies on sloping ground, has been partially effaced by denudation, and was overlooked by earlier visitors, as may be seen in Plate XI, from the original survey. In this the ellipse is greatly

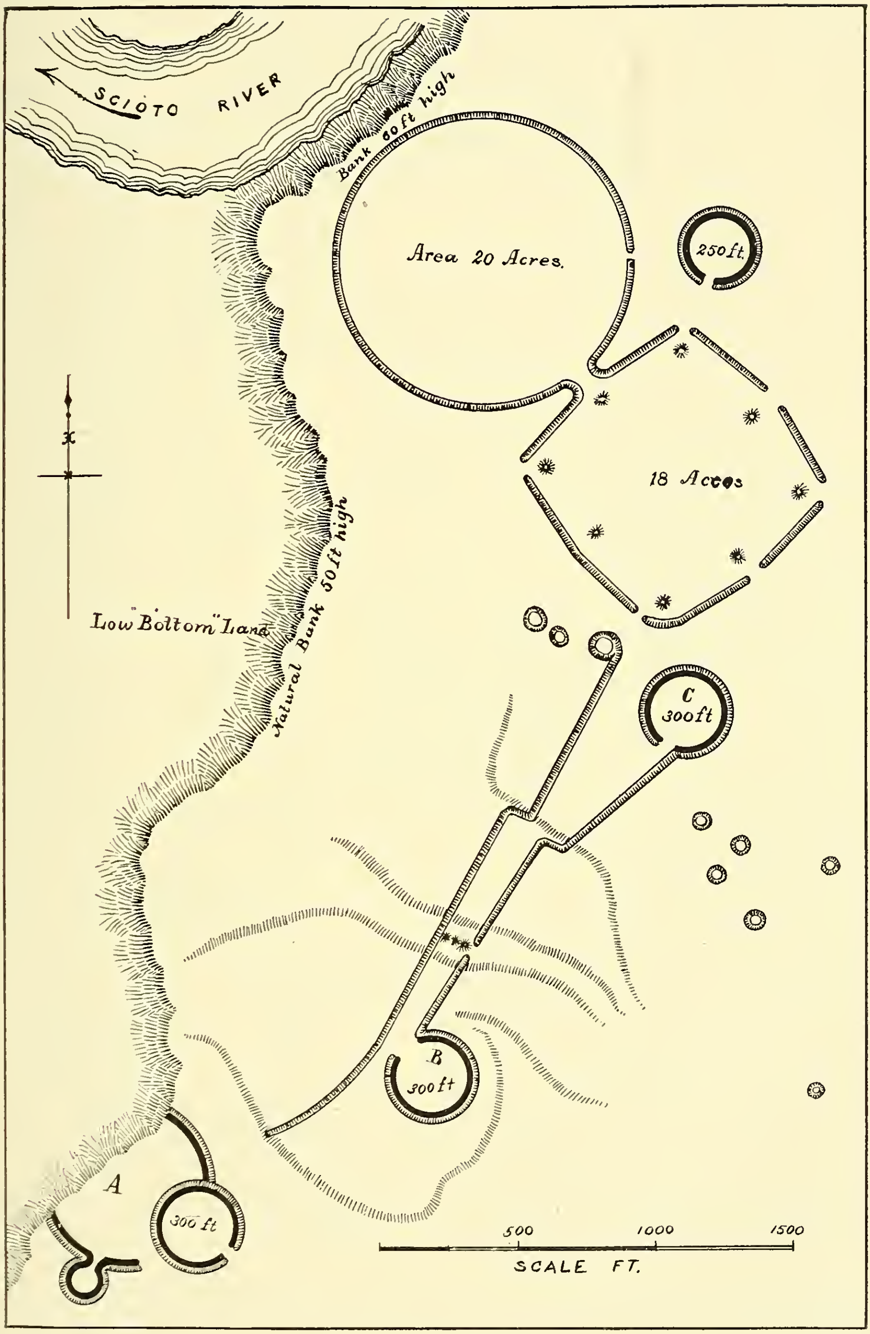


Twelve Miles of the Scioto Valley.

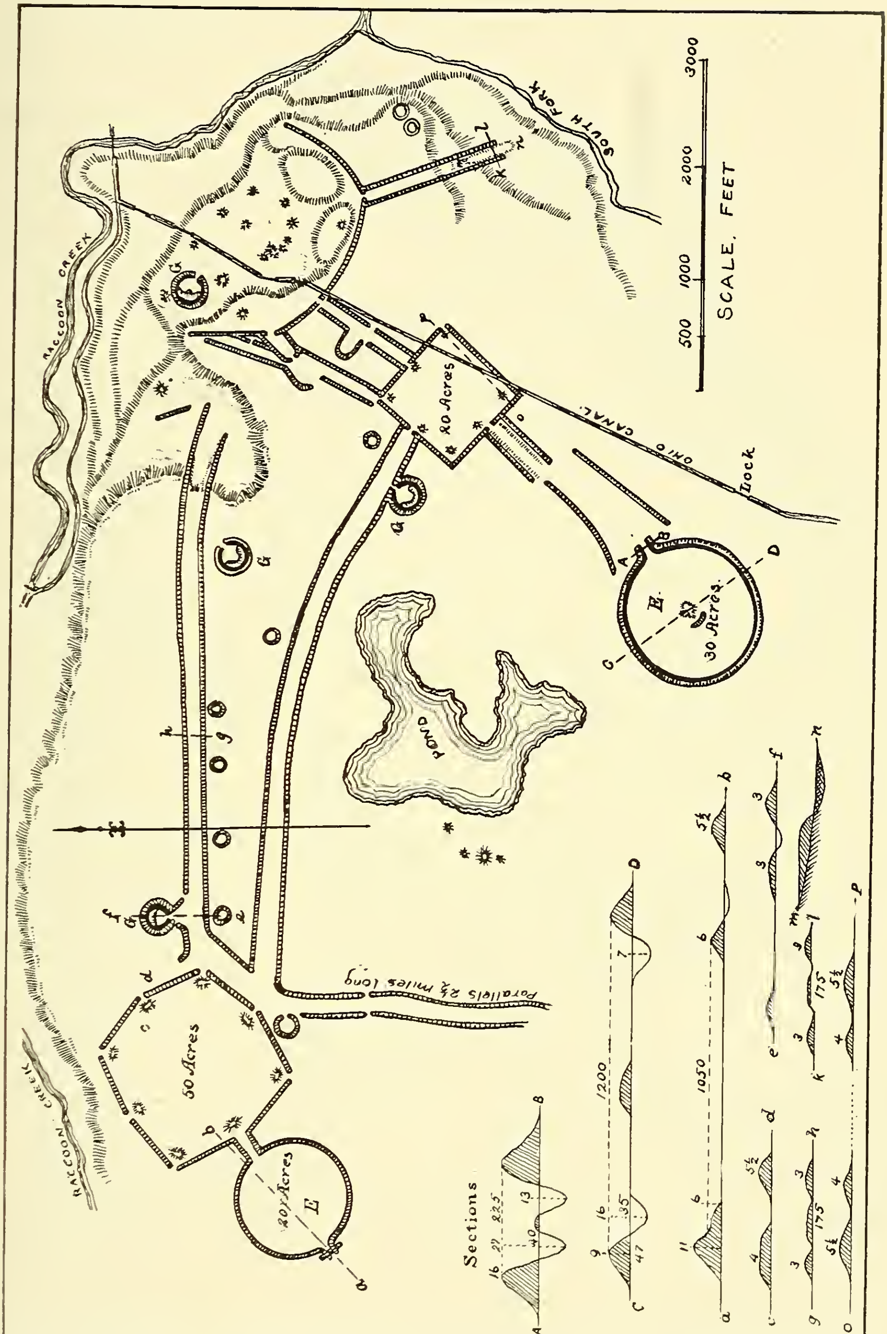
Geol. of Ohio, Vol. VII.



Six Miles of Paint Creek Valley.

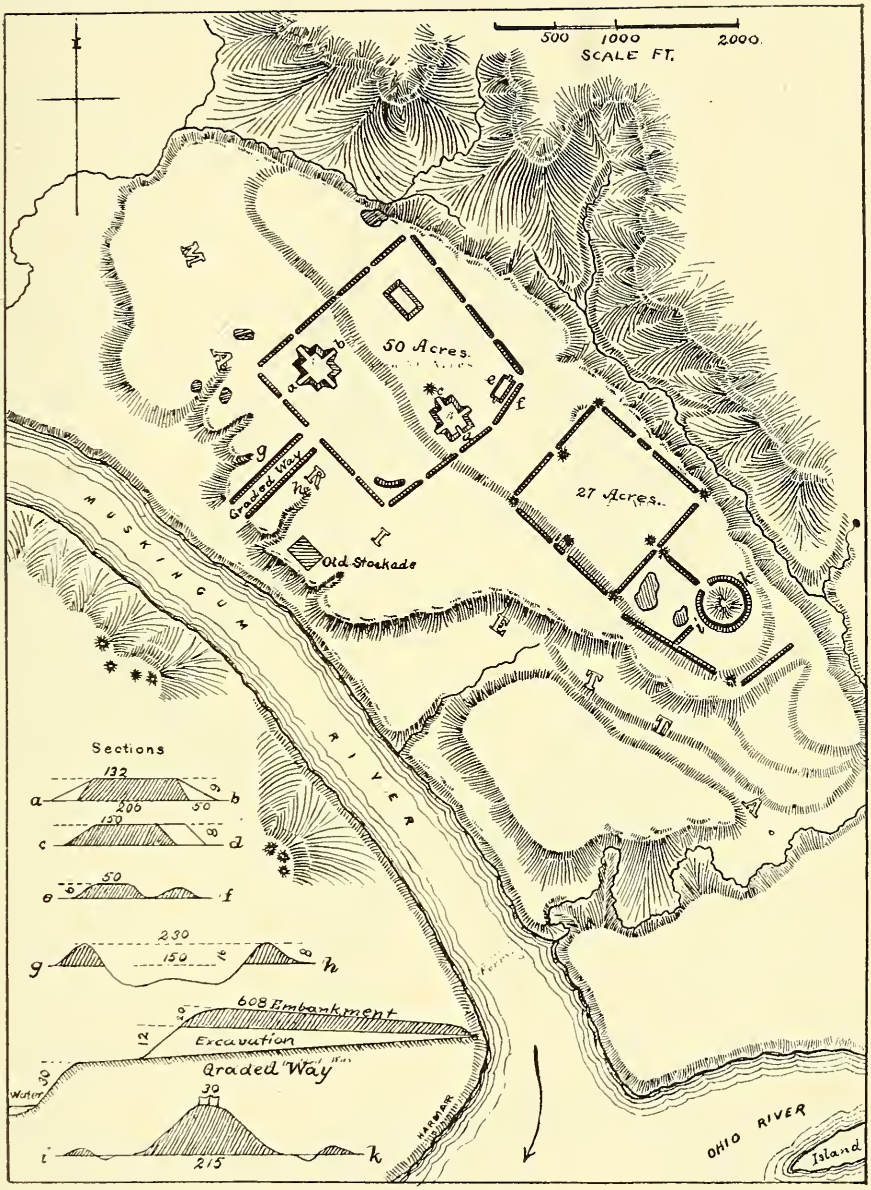


High Bank Works.

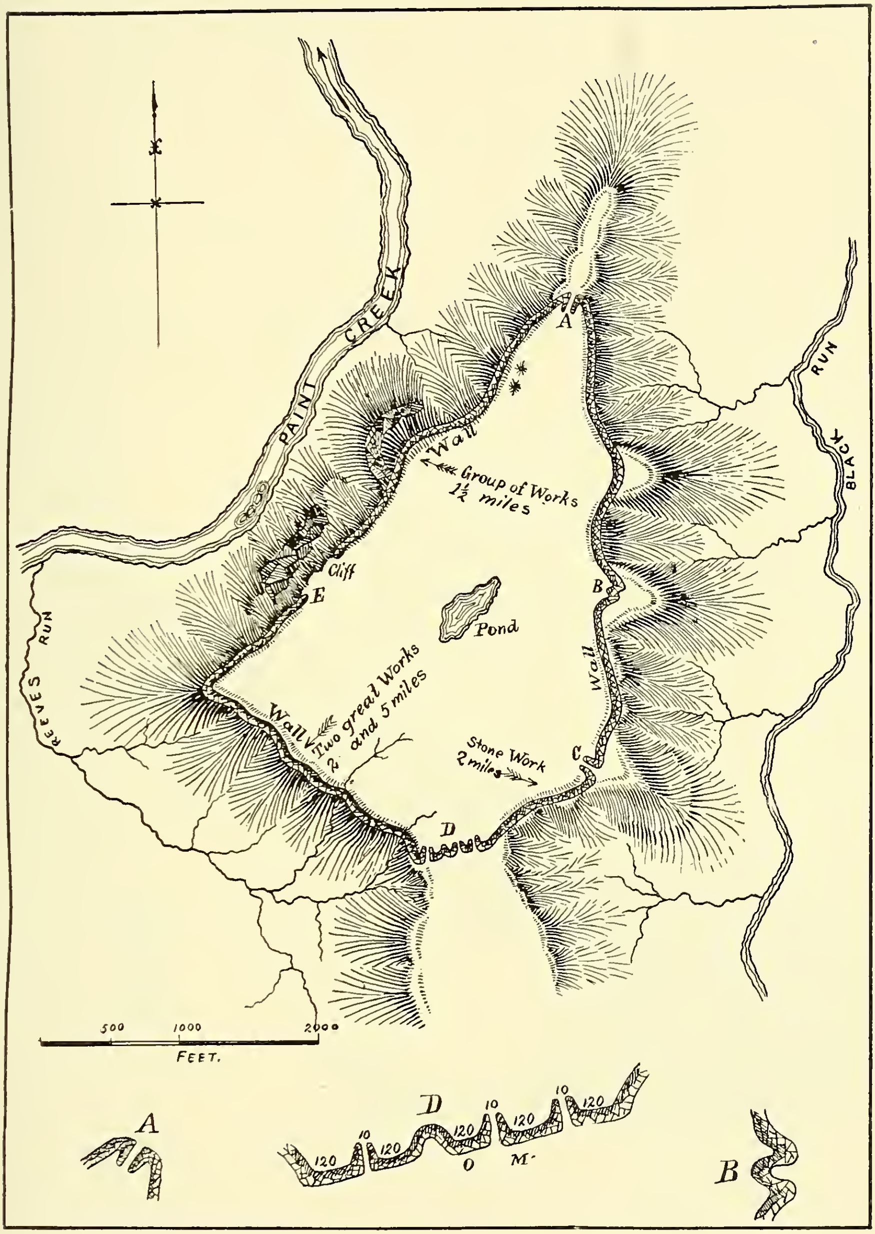


Newark Works.

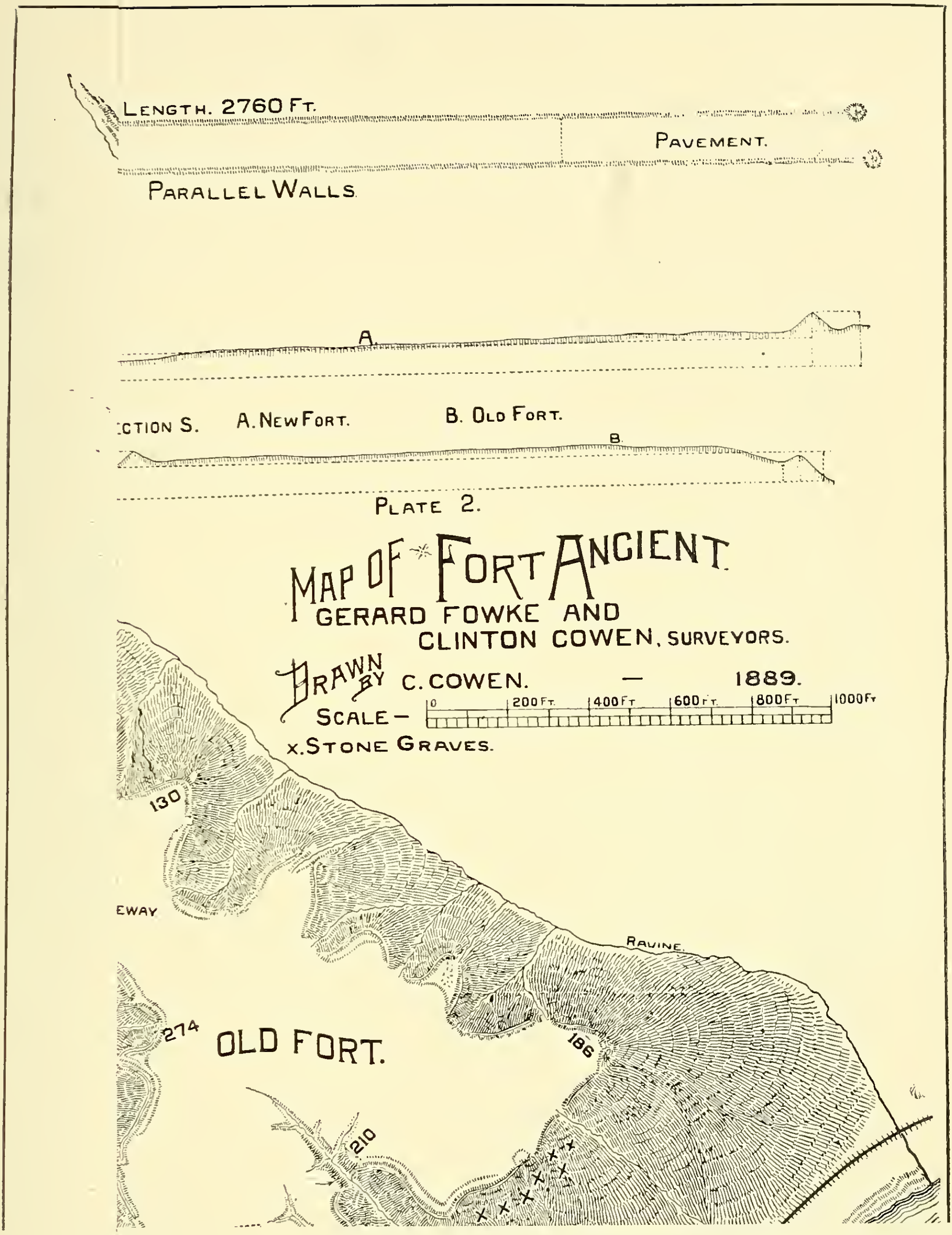
ARCHÆOLOGY VI.

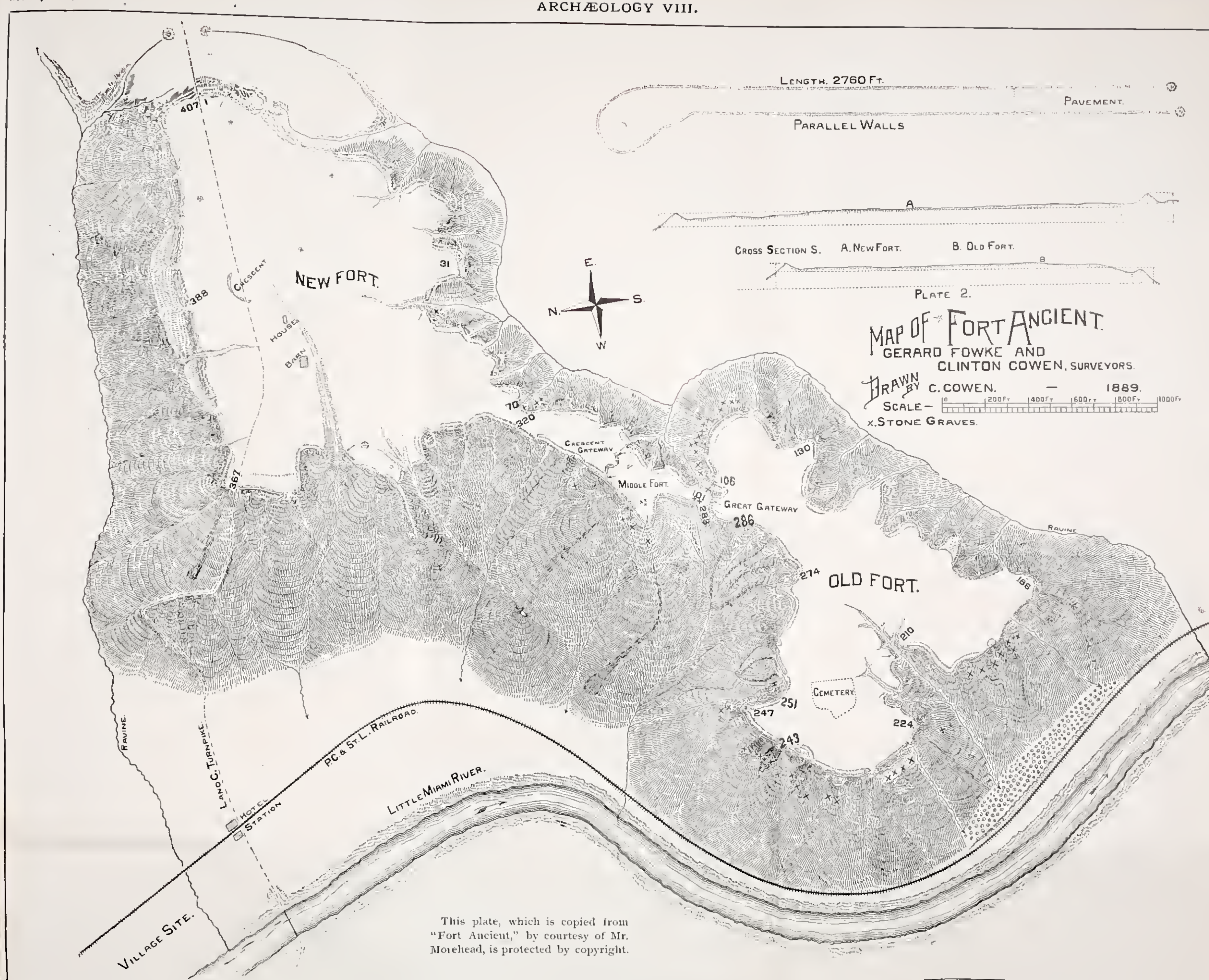


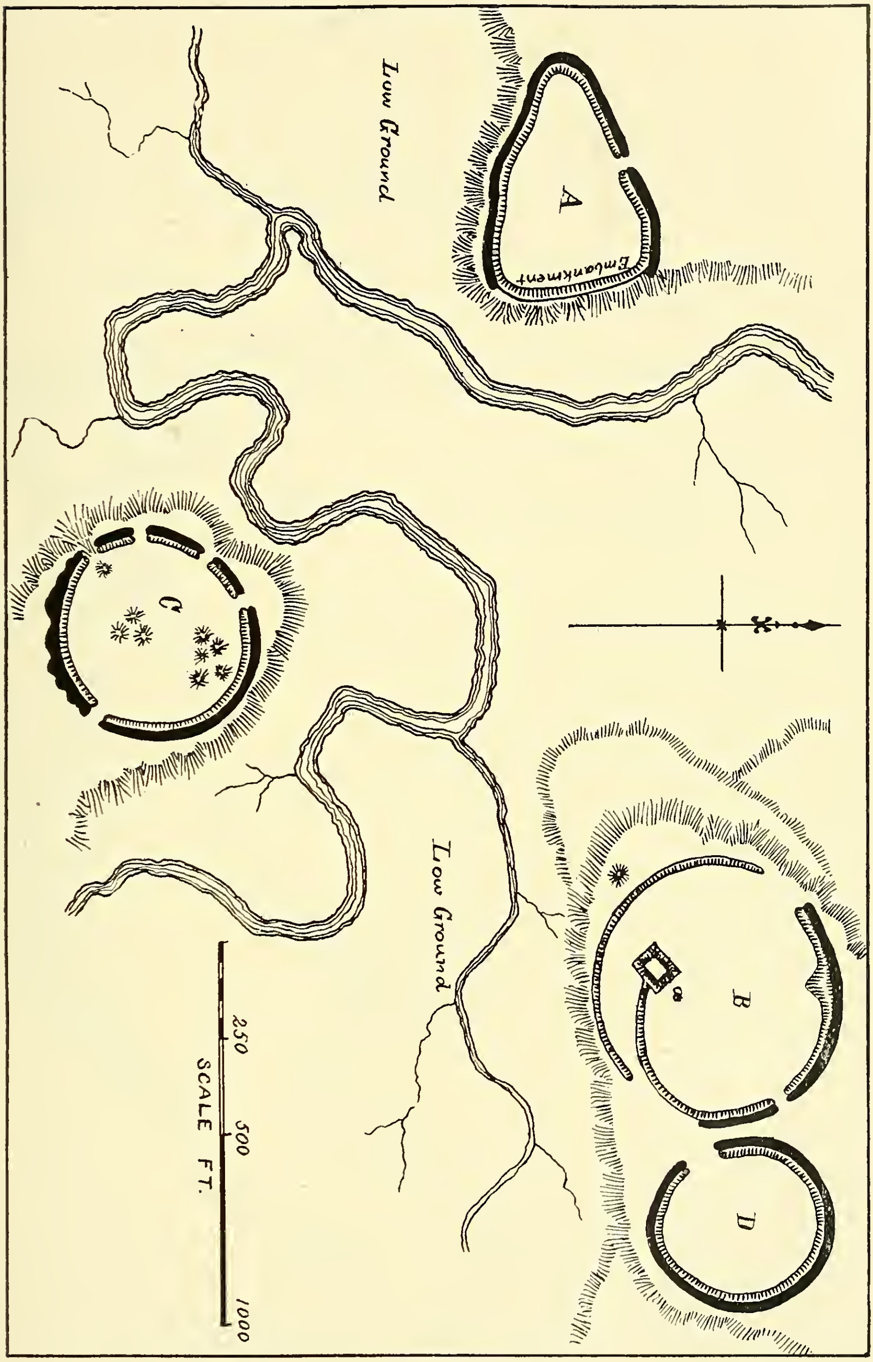
Marietta Works.



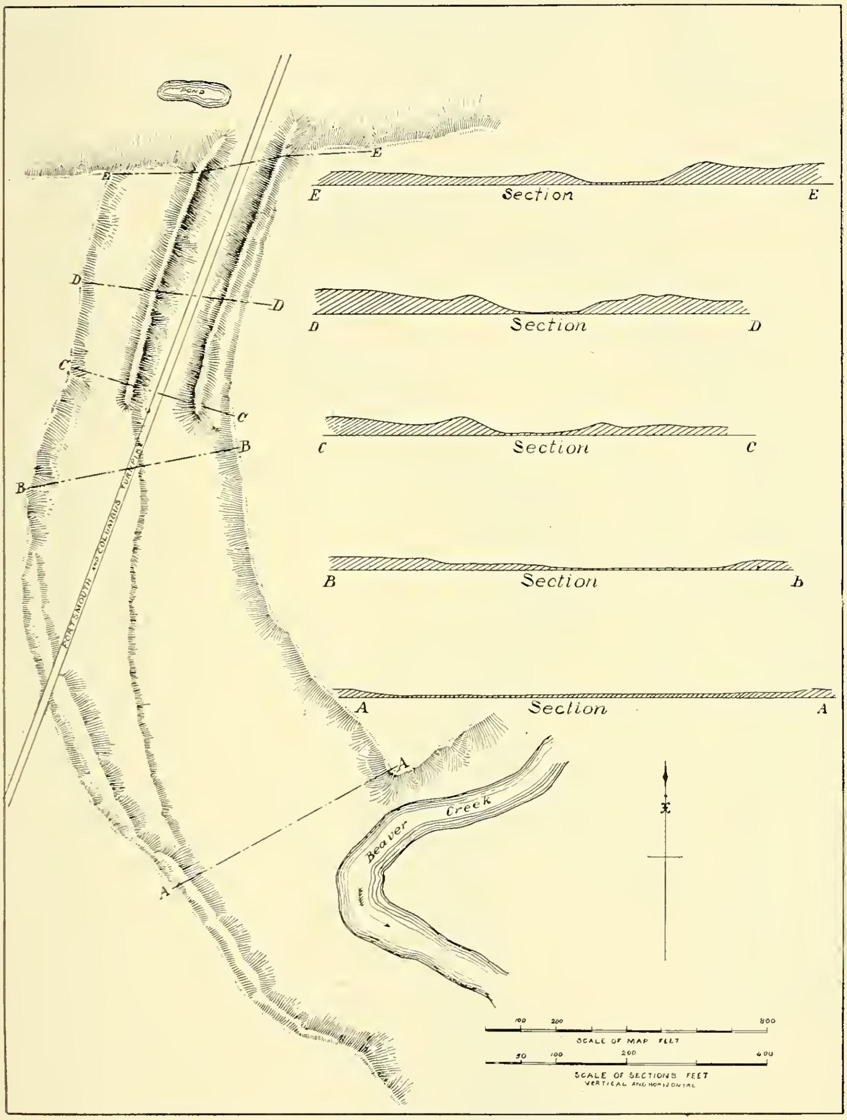
Spruce Hill Fort, near Bourneville.


LENGTH. 2760 FT.
PAVEMENT.
PARALLEL WALLS.
A.
CTION S.
A. NEW FORT.
B. OLD FORT.
B.
PLATE 2.
MAP OF FORT ANCIENT
GERARD FOWKE AND
CLINTON COWEN, SURVEYORS.
DRAWN BY C. COWEN. — 1889.
SCALE —
0
200 FT.
400 FT
600 FT.
800 FT
1000 FT
x. STONE GRAVES.
130
EWAY
RAVINE.
274
OLD FORT.
186
210

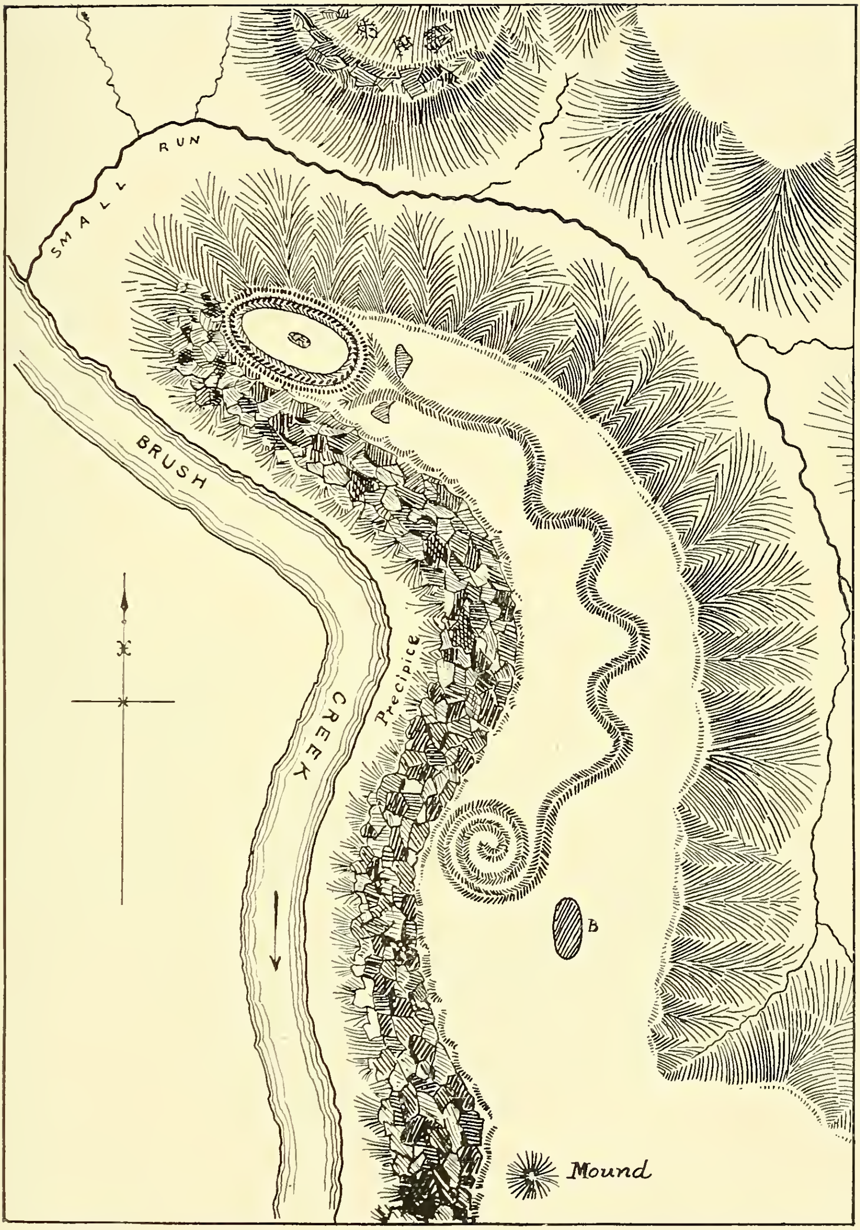

MAP OF FORT ANCIENT.
GERARD FOWKE AND
CLINTON COWEN, SURVEYORS.
DRAWN BY C. COWEN. — 1889.
SCALE — 0 | 200 FT | 400 FT | 600 FT | 800 FT | 1000 FT
x. STONE GRAVES.
PLATE 2.
LENGTH. 2760 FT.
PAVEMENT.
PARALLEL WALLS
A
CROSS SECTION S. A. NEW FORT. B. OLD FORT.
B
E.
S.
N.
W
NEW FORT.
CRESCENT
HOUSE
BARN
407
388
367
31
70
320
CRESCENT GATEWAY
MIDDLE FORT.
106
283
GREAT GATEWAY
286
130
RAVINE
274
OLD FORT.
186
210
CEMETERY.
251
247
243
224
RAVINE.
L AND C. TURNPIKE.
HOTEL
STATION
P.C. & ST. L. RAILROAD.
LITTLE MIAMI RIVER.
VILLAGE SITE.



Norwalk Works



Beaver Creek Valley below Piketon.



Serpent Mound

exaggerated; instead of filling all the space toward the end of the cliff, as represented, it terminates several rods from the point, leaving room for an elevation, plainly artificial, covering several rods. It is believed by many archaeologists that the so-called "body" is only the tail; that the "open mouth" is the expansion of the rear portion of the body; that the "egg" represents the heart or vital principle, as is common in Indian pictographs where animals or birds are portrayed; and that the raised portion beyond the ellipse constitutes the head and beginning of the body, the outlines along either side having been washed away.

So much as is here figured has been rebuilt by the Peabody Museum, which now owns the structure. Should the more recent explanation of the figure be found correct, the restoration will no doubt be completed and the entire work brought to its original condition.

The other effigy, known as the "Alligator Mound," is near Granville, Licking county, on a ridge projecting into the valley of Raccoon Creek. In direction it does not coincide with the trend of the ridge, which term inates with a smooth rounded outline, but is built across the extreme point. A small pile of burnt stone and earth lies to the right of the mound, a slight artificial bank connecting them.

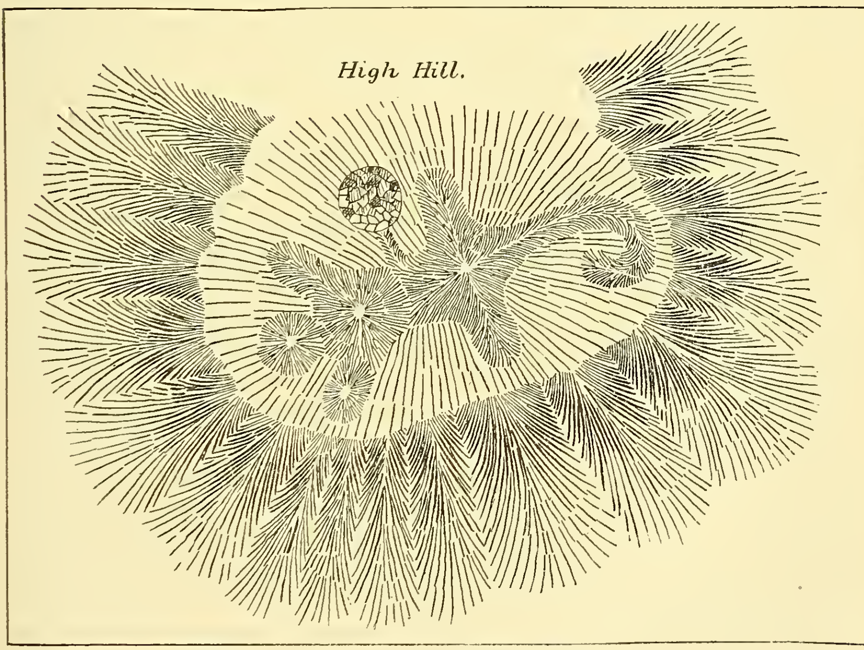


FIG. 2. Opossum or Alligator Mound.

The name does not seem well chosen. The body (see Figure 2) may-be supposed to resemble any short-legged, short-necked animal, while the tail is not tapering but of nearly uniform size and has a more pronounced.

coil at the end than a saurian's tail is capable of assuming. The figure is evidently intended for an opossum—an animal much better known than an alligator to the aborigines of Ohio.

The small figure near the center of the large circle at Newark (Plate V) is generally considered an effigy; but it has not yet been agreed whether it represents a prostrate man with extended arms, a flying eagle, a bended bow with an arrow across it, or a bird's foot. A similar, but smaller mound is near the "Graded Way" at Piketon.

On the right bank of the Scioto, six miles from Portsmouth, in an enclosure, is an irregular mound supposed to be intended for an effigy, which has been compared to a tapir; it resembles that animal about as much—and as little—as it does any other.

(*g.*) MOUNDS.

The great majority of mounds in Ohio are composed entirely of earth, though many are altogether of stone and occasionally one occurs in which both materials are used.

As a rule the earth mounds resemble in shape a medium between a low cone, and a flat dome or segment of a sphere. Some have an elliptical outline; others are flat-topped. All these usually come under the designation of "conical mounds," which is, perhaps, as accurate as any single descriptive word could be, though none are, or ever have been, exactly conical; a mound could not be built in that form, nor, if it could, would it retain such shape after the first storm. A few are truncated pyramids, the base always four-sided, sometimes almost a rectangle. As it was a rather common practice for southern Indians to use structures similar to the last as sites for buildings, it has been supposed the ones found here were utilized in the same way. While this may have been the case with those standing on low or level ground, in connection with additional evidences of occupation, as at Marietta and in two or three other localities, there are some whose situation is contrary to such a supposition. For example, a mile south of the stone fort in Perry county, is a mound of this character about eighteen feet high and covering nearly two acres. It is on top of a hill which slopes away in every direction. The soil in the vicinity is poor, the surface is a succession of hills and ravines, and it is not credible that an aboriginal settlement would have been located amid such surroundings.

The sparseness of such mounds and their occurrence under the same conditions as the commoner forms, are inconsistent with the idea which has been advanced that they owe their origin to a different people or belong to a different age; their erection is undoubtedly due to the same motives which induced the building of nearly all the others. Only two or three have been opened, but their contents and method of construction were practically of the same character as shown in numerous mounds of the usual form, examined in the same localities.

The total number of mounds in Ohio has been estimated at ten thousand. This is probably under the correct figure; for while they are almost totally absent in the northwestern counties forming the "Black Swamp" district, and are comparatively scarce in the rugged hill-lands of some of the southern and southeastern counties, there is scarcely a township in any other portion of the state in which they are not found. In Ross county there were not less than five hundred, probably more, before any had been destroyed by the advances of civilization. Butler and Licking counties were not far behind. In the valley of every tributary of the Ohio, except where it flows through rough country, the surface is so dotted with them that signals could be transmitted from one to another for a hundred miles or more. On the summits of steep hills; in bottom lands subject to overflow; on every terrace bordering a stream; on plateaus and uplands; wherever there is cultivable or naturally drained land, a good point of observation, an ample supply of water, a convenient topography for trails;—the Mound Builder has left his mark. Even in places where it would seem a nomad would not care to go, except as led by the excitement or necessities of the chase, and for as brief a time as possible, such evidence is not lacking of prehistoric residence or, at least, sojourning.

In magnitude they vary from one reduced by farming operations until it is scarcely perceptible and probably never more than three feet in height or twenty feet across, to those fully thirty feet in elevation with a base diameter from one hundred and fifty to two hundred feet. But the latter dimensions are rarely reached; by far the greater number are below twenty feet in altitude and one hundred feet across at the ground. The immense pile at Miamisburg, with an elevation of sixty-eight feet and an estimated volume of more than sixty thousand cubic yards is so far beyond any other in size that it must be excluded in giving figures that shall fairly represent those falling within the ordinary limits.

Various schemes have been proposed for the classification of the mounds into definite groups and systems, but none that will meet all requirements. There is so much similarity in the arrangement and contents of some amid totally different surroundings, and conversely such unlikeness in the structure of others which constitute a single group, that conjectures as to their purpose, based on location or appearance, find as many exceptions as examples. Of the great number of mounds excavated with more or less care and exactness by farmers, collectors, scientists, and others, the results of such explorations as have been reported establish the fact that fully nine-tenths of them, if not more, contained skeletons; and it is a fair assumption that the ratio will hold good for all.

Nor is the absence of human remains to be considered an indication, unless otherwise substantiated, that they were constructed for some other purpose; for conditions are frequent in which, although the character and disposition of relics found are such as invariably mark those deposited with a corpse, all traces of bone have disappeared. There are many, however, which present not the slightest evidence of ever having been used or intended for mortuaries; and no hypothesis yet advanced concerning their purpose is satisfactory. The flat-topped ones have been referred to above. Those on high points are usually called signal mounds from an idea that fires were built on them as semaphores, the ashes often found in them being adduced as proof of such use. But skeletons with relics have been found in such mounds; in situations so exposed wind and rain would prevent the accumulation of ashes due to occasional fires; there could be no reason for piling a quantity of earth over the spot used for this purpose; to increase by a few feet the elevation of a point which already commanded an extensive view, would be of no advantage; ashes are found in as great quantities in many mounds on low land as in those on hill-tops; finally, a pile of damp leaves and trash which would make a column of dense smoke, and leave few traces of their use, would serve better than any quantity of large wood. The mound on Mt. Logan, opposite Chillicothe, so often mentioned as composed nearly altogether of ashes from signal fires, was found on examination to contain only a relatively small amount, being mostly of earth, and containing human remains.

Fires were also maintained for other purposes than as signals. Near Linnville, Licking county, on elevated land, is a group consisting of one stone and three earth mounds. From one of the latter, originally eighteen feet high, eight feet of the upper portion was cut off. Almost from the top the earth was burned to a deep red, small masses being glazed or even vitrified; flint fragments the size of a brick resembled pieces of chalk, the result of intense heat. Numerous holes filled with charcoal and ashes, showed plainly by their regularity, and the marks on the sides, they were casts of upright posts or logs, some of them a foot in diameter. These were first noticed three or four feet above the point at which the explorers ceased to work; several of them were followed as far below that level as the shovels would reach, without coming to the bottom. They must have formed only a small part of the material necessary to convert so great a mass of earth almost into the condition of a brick-kiln; their vertical position shows the earth was piled around and above them before they were burned, somewhat after the manner of a charcoal pit. It was plain that a fire was kept continuously burning here for a considerable period, perhaps several days; but for what reason is not apparent. Certainly it was not as a "signal," although the mound is visible for several miles from different directions.

With reference to all earth mounds except "effigies," it seems best for the present to describe them simply by their situation, shape, and dimensions. A definitive name expressive of one certain purpose, applied to a mound on account of its location or outward appearance, is very apt to be misleading.

Specific descriptive terms, suggested by some peculiarity of internal structure, have also found a place in mound nomenclature; all are open to the same objection, namely, the lack of uniformity in those to which any particular word is applied, and their close resemblance in some respects to many which are arbitrarily placed in another division. It is natural to employ the term "burial mound" for one containing human remains; but the desire to honor the dead may not have been the only motive leading to its construction. So with those erected for any other apparent purpose; while the work may have been undertaken with a definite object in view, subsequent or subordinate ideas may have led to modifications of the original plan. Thus, a mound intended as the burial place of one body may be afterwards made to cover several; one erected to protect a deposit of various articles, possibly as a votive offering on an "altar," perhaps only for concealment, may be extended to include another in which several bodies are interred. Occasionally several small mounds placed near together, some for burial purposes; some apparently to protect property considered valuable; others containing quantities of implements and ornaments injured or almost destroyed by fires made on them after they were deposited; still others which contain nothing to throw light on the reason for their existence;—may all have earth heaped on them until they merge into a single symmetrical structure that seems the result of a continuous effort toward a defined end.

In magnitude and ingenuity the large enclosures and fortifications of Ohio have no equals; but, as a rule, other remains are less impressive than similar works occurring elsewhere. The few representatives of the effigy groups of the northwest are, with the single exception of the Serpent Mound, inferior in size and interest; the same is true in regard to those resembling the great flat-topped pyramids of the south. Externally, the ordinary conical or dome-shaped mounds present no remarkable features, unless it be the great size of some; and even in this respect they are surpassed by many in other states. Explorations in these mounds, however, have resulted in discoveries which render them of the highest interest, not only to the archæologist, who finds in them abundant material for careful study, but also to the general public whose attention is attracted by the novelty of what can be placed on exhibition.

The manner of their construction was long a puzzling question; it was deemed impossible that such piles of earth could be made without the aid of machinery or beasts of burden. But there has never been found the slightest evidence of the use of any mechanical appliances, not even a hand-barrow, nor a bone of any animal susceptible of domestication and of sufficient strength to be serviceable in such work. On the other hand, scores of mounds of various sizes, in different localities, have furnished proof that human toil alone was employed. In many, almost the entire interior is composed of lenticular masses of earth, from a peck to two pecks in volume, or as much as a man will easily carry, such as could result only from loads of this size being flattened out by the weight of the earth above them. They are not apparent in some mounds; sand and certain kinds of clay or loam will often unite so that no division is perceptible between different deposits; their regularity may have been destroyed by the workmen passing over them; the earth scattered as it was thrown down; in shallow mounds or in the upper portion of large ones their outlines may be effaced by the action of percolating water; but as no indications of a different mode of construction have been reported from any source, it is fair to assume this was the ordinary method.

A singular product of aboriginal notions, and one that seems peculiar to Ohio mounds, is found in the so-called "altars." There are masses of clay six to eight feet across,—seldom larger—usually irregular in outline, and up to a foot in thickness. A sufficient space of ground having been cleared off and sometimes burned or pounded until hard, the material was spread out, kneaded or "puddled" to a firm and uniform consistency, the upper surface made smooth and flat, and a basin excavated in it. This is always rectangular, with rounded corners and a level bottom. It varies from three to five feet in length with a width one-half to three-fourths as much, and a depth of four to eight inches; very few fall beyond these limits in either direction. The margin of the clay was either left as it had been deposited, or cut away its entire thickness to form a rim of uniform width around the basin. A fire was then kept burning on it until all the clay remaining was hard as a brick. Sometimes all the ashes and charcoal resulting from the fire were carefully removed; in this case the altar-cavity is usually filled with fine, dark earth, possibly resulting from decayed organic substance, or with clean white ashes. Occasionally it contains human bones which may belong to adults or to children, may be nearly consumed by heat or may show no trace of fire. The name "altar" is derived from the deposits, presumably sacrificial offerings, frequently found on them; though quite often they contain no relics. Some yield only a pipe, a fine spear-head, ornaments, or a few other articles, generally well-finished. In others the contents amaze the most experienced explorer. Ornamental objects of every material which it was possible for a primitive people to obtain or utilize; minerals whose nearest beds are hundreds of miles away; shells from the ocean or gulf; stamped and carved figures in copper whose design points unmistakably to a Mexican origin;—all occur, some in the greatest profusion. From a single altar near Madisonville were taken fully two bushels of specimens; among them alligator and shark teeth curiously carved; thousands of pearl beads, ornaments of copper, shell, bone, quartz, slate, meteoric iron, and many other materials; besides objects whose use is not apparent.

From another in a small mound near Chillicothe were obtained over two hundred pipes made from several varieties of stone and carved into faithful effigies of more than a score of different animals and birds. In a very large mound a few miles from the last, were several altars covered with specimens, many of them different from any previously discovered; for examples, a copper axe weighing thirty-eight pounds; obsidian implements over a foot in length, of exquisite finish; pearl and copper beads so numerous they were measured in cigar-boxes; copper plates stamped and cut into most intricate designs and figures seemingly impossible of accomplishment without steel dies and cutters. Nearly all in the above list—which might be indefinitely multiplied, though not with such remarkable examples—had been injured by fire after they were deposited; some of the copper was partially fused, the pipes and many other stone pieces badly shattered, the shells and pearls almost calcified.

Such specimens, though most abundant on the altars, are by no means confined to them. They are found in other parts of the same mounds, and in mounds without altars. In these cases they most frequently occur with skeletons, or in positions indicating obsequies. Some, however, may be found singly or in small collections, at the bottom or in the body of the mound, having no relation to other deposits or, apparently, to the general purpose of the structure. Usually the latter are less carefully wrought or of inferior material; a part of them may have been dropped by the builders, but others were so placed intentionally. They may be votive offerings or a tribute to the dead, overlooked at the proper time, or added subsequently.

The tumuli usually contain few skeletons; the ossuaries where, at long intervals, were deposited the bones of all who had died since the last general sepulture, or the communal burial mounds in which bodies are piled one over another year after year, such as are frequent in other localities, seem foreign to Ohio, unless in the northern counties. Occasionally a mound fully twenty feet high was erected over one person; often not more than five or six skeletons are found; very seldom more than twenty. In most cases the body was extended on the back, though instances are reported of skeletons sitting up or lying on either side, extended or drawn up till the knees touch the chin. The head may be toward any point of the compass; in many mounds no two skeletons are parallel or in the same posture. Ordinarily the bodies were laid on the surface and a mound built over them; but it is not unusual to find remains at various places within the deposited earth. The spot selected was almost invariably cleaned off before burial, though the sod was not always removed, as shown by a thin, grayish, clayey streak, seldom more than an inch thick, produced by decay of grass and roots covered with earth. Graves, most of them less than two feet deep, have been found in the earth beneath the tumuli; in some, the disposition of the bodies and character of the specimens with them is the same as in the mound; in others, different. As the sod line extends unbroken over some of the latter, they may pertain to a different people.

Although many skeletons are in direct contact with the earth, something was probably always interposed at the time of burial. Poles, puncheons, or bark frequently formed a resting place as well as a covering for a corpse. Sometimes these were placed across two logs, one on either side of the body. Pens were often built of poles or small logs crossing at the corners after the manner of a log cabin; some were barely large enough for one person, others were fully ten feet square. The walls were either vertical, and covered with poles to form a flat top, or drawn in on two sides like the roof of a house. Again, poles were set with one end in the ground, the tops being fastened together to form a conical or bee-hive like structure inside of which the dead were placed; some of the poles were cut or broken to the desired length, others left projecting considerably. Such ligneous remains are found only in exceptionally dry mounds, and are loose as ashes, their arrangement being traceable only by the casts or molds left in the earth. Bark exists only as a very thin layer which appears always to extend somewhat beyond the bones; hence reports of skeletons wrapped in it are questionable, unless it be shown to cover a space but little larger than a body would occupy.

The light, porous, black, earth so often found about skeletons, may result from decay of furs, cloth, feathers, and the like.

Fire was sometimes an important feature in funerals, as shown by large quantities of ashes; these were often brought from elsewhere, skeletons without any marks of burning being partially or entirely covered with them.

If it was customary to deposit with the dead his personal belongings, they must have been largely of a perishable nature; for more than half of the skeletons exhumed are unaccompanied by relics of any description. With some are only a few beads or arrow-heads, a pipe, ornament, or hatchet; others were provided with a considerable variety or large number of articles. No systematic distribution is manifest in relics associated with skeletons. Various ornaments are found in positions denoting attachment to the clothing or person of the deceased; but for the most part funeral offerings seem to have been deposited promiscuously, the mourners having little regard for preciseness in the arrangement of their tributes. Pipes are found near the skull, in either hand, on the breast, or at the feet; clay vessels containing carbonaceous matter, probably remains of food, though of rare occurrence, have no particular place; objects suitable for war, hunting, or adornment are put anywhere. True a considerable degree of uniformity which may signify tribal relationship, has often been observed in different places, in the positions of skeletons and the adjustment of specimens with them; but such coincidences are less remarkable than a distinct fashion of burial would be for each of many thousand individuals.

Marks of violent death, as a fractured skull, broken limb, or bone with imbedded arrow-head, are sometimes met with; but no indications that any tumulus was erected solely to cover those slain in battle. On the contrary, all periods of life are represented in many of them, from the infant of a few days to the man or woman of extreme age.

Below the base line of many mounds, especially the larger ones, are cylindrical holes sometimes by scores, from six to twenty inches in diameter and from twelve to thirty inches deep. Some of them by their position and regular intervals seem to have held posts which formed part of a house or other structure. These contain charcoal, ashes, or traces of wood; and in a few instances portions of the posts themselves, converted into charcoal, extend upward two feet or more into the mound. Other holes are filled to the top with the ordinary refuse of an Indian camp-fire, as clean ashes, fine loose earth apparently from decay of organic substance, mussel and snail shells, broken and burned animal bones, fragments of pottery. Very few of these seem to have had fire in them, the sides rarely showing any evidence of heat. Some were dug considerably anterior to the construction of the mound, as skeletons have been found lying directly across them with a thin intervening layer of accumulated earth.

At least one example is known of a mound being erected above the charred, fragmentary remains of a person who was burned at the stake.

Intrusive burials by modern Indians, or by whites, at the apex of the mounds, are very common; and, rarely, a mound has been opened from the top nearly or quite to the bottom by persons who have placed in the excavation additional bodies and then restored the mound, carrying it to a height several feet greater than its original elevation.

Stone mounds are confined to such parts of the State as have on the surface an abundant supply of stones of convenient size for handling, and to situations where these may be easily collected. Less numerous by far than the earthen tumuli, they compare favorably with them in average size. One which stood eight miles south of Newark had a base diameter of two hundred feet with a height fully one-fourth as great. All the stone in the retaining wall along the north side of the Licking reservoir was taken from this mound, yet several thousand cubic yards remain in place. This one, however, was exceptional; few exceed twenty feet in height, with a base line from three to four times as much. The difficulty of excavation, and a general belief that nothing of interest is to be found in them, have prevented a thorough examination of any of these mounds; in such as have been removed the aim was to utilize the material, and little attention was paid to anything else. Human bones, broken by the pressure of the stones and softened by percolating water, have been found at the original surface; and vague statements are made regarding copper, shell, and stone objects with them; but nothing definite can be learned as to their type or arrangement. Relics sometimes occur alone in such order as to suggest they were deposited with bodies of which no trace now remains. Earth was very seldom used in constructing these mounds, but decaying vegetation and the dust borne by winds have caused a considerable accumulation within them.

In a few mounds the bodies were covered by stones over which earth was piled sometimes to a thickness of several feet. In one of these a space fully fifteen feet in diameter was covered with human bones promiscuously thrown in as if from sacks or baskets. They were between two layers of bark, beneath a stone mound four feet high, over which six feet of earth was heaped. No similar case is reported, bodies usually being interred as in earth mounds.

Through much of the hilly portion of Ohio, particularly along the Ohio River, are numerous stone graves. Almost without exception they are on the summit of a high hill, or the point of a long ridge, commanding an extensive outlook. In their construction the ground was cleared off, sometimes only the humus being removed, at others the earth being dug away to the subsoil. Large flat stones, closely fitted, were then laid down and the body or bodies deposited on them. Similar slabs were set on edge around this base, the tops projecting perhaps a foot above the surface. Most of the graves are circular or elliptical in shape, a few being rectangular. The latter are often only large enough for a single body, though several may be built in a connected group; the former vary from that size to twenty feet across. Narrow ones have a covering of slabs, thus forming a box-like receptacle. The enclosed space of those too wide for such protection is filled with stones which were loosely thrown in, or supported by timbers whose decay has allowed them to fall in confusion. Sometimes the vertical slabs rest on the margin of the pavement instead of around it; occasionally there is more than one row of them. Over some of the graves loose stones were piled, forming a cairn. The bones are generally so decayed and broken it is impossible to ascertain the number of individuals buried; and relics of any kind are very rare.

(*h.*) GRAVES, CEMETERIES, AND VILLAGE-SITES.

As nearly three times the average population of any community will die within a century, it is obvious that, large as may be the aggregate of mound interments, only a small portion of the dead were thus disposed of. The great majority were buried in ordinary graves, whose form is determined by the nature of the ground. In sandy or gravelly earth they are of ample size to receive one, or perhaps several extended bodies, and may be three feet in depth, though usually less; in tough clay soil they are not often over a foot deep and barely large enough for one corpse to be crowded in, either straight or folded to the smallest compass. In most cases the earth seems to have been thrown back directly on the body, though flat stones were sometimes placed over them; there are also faint indications of wood having been interposed. Scarcely a day passes that skeletons are not unearthed somewhere in the State either singly or collectively. They are most frequent in gravel beds and alluvial land, but occur in various other situations, seldom in any definite order. A few, especially on plateaus or hill-tops, are in graves the bottom and sides of which are lined with thin stone slabs. Few artificial objects are with them, principally implements of the chase or simple ornaments. It is quite probable, from the method of burial, and the character of the relics, they are the remains of modern Indians, or at least of a tribe different from the "Mound Builders;" and as they are not numerous in any one place they may represent only a small or temporary camp.

Of a different nature are some extensive aboriginal cemeteries and village-sites, particularly in the Miami valleys, in which explorations have disclosed hundreds of graves and lodge-sites interspersed in the manner common to many known tribes. Removal of the soil that has formed since their abandonment reveals in the latter the characteristic ash-pile of the central fire, in and around which is scattered all the refuse of a primitive dwelling, along with almost every variety of tool, ornament, or whatever property these people had that could resist decay under such circumstances. The graves are somewhat similar in their construction to those above described being shallow and usually containing only a single skeleton, either extended or folded; but a much greater diversity and amount of personal belongings are found in them and more care seems to have been taken in the burial.

Remains of this nature have been found in river-bottoms under several feet of silt that is now subject to frequent overflow.

The discovery of these villages and cemeteries, like that of the graves, has in nearly every case been accidental. The soil above them may be cultivated for generations without a suspicion of what lies beneath until denudation by a freshet, the excavation of a cellar or foundation, or some more trivial cause exposes them. Their present arrangement indicates that wigwams, huts, or whatever form of shelter was in use were placed in any spot convenient to the builders, and interments made almost at random in the spaces between; but a more regular system was probably observed, the apparent lack of order resulting from moving the domicile occasionally; with such methods of living, house moving was easier than house cleaning. In the lapse of time, too, the exact position of graves would be forgotten or disregarded and interments encroach upon those already made. This confusion makes examination tedious and expensive; it is necessary to upturn every square foot of surface to make sure that nothing is missed, consequently, only comparatively small areas have been carefully worked over. None of the principal ones so far discovered, are in the immediate vicinity of large enclosures or mound-groups; but undoubtedly wherever there are extensive surface remains of any prehistoric people, similar evidences of dense or continuous occupation exist under a depth of earth that effectually conceals them. Considering the nature of the soil, the character of their utensils, and the preservation in low, moist mounds, of childrens' skeletons, it is impossible that all vestiges of the ordinary life of the "Mound Builders" should have disappeared. The remains in question are indeed, usually attributed to them; but be this as it may, nothing has been disclosed incompatible with the habits of several tribes of modern Indians.

At present, any attempt to elucidate the principal questions concerning the various earthworks and allied structures of Ohio, must end in failure. Too little is known; in some respects the matter stands almost where it did in the beginning. Nothing can yet be stated positively as to their age or builders, or the purposes of the enclosures. The evidence is mostly negative, confined to showing what is not correct rather than what is; but the emendation of an error is a step toward the truth, and it is a satisfaction to know that as one discovery follows another, and successive earnest investigators gradually develop a systematic method of dealing with the subject, the false impressions due to those who have attempted to generalize upon insufficient knowledge, are being refuted and swept out of the path of scientific research. Theorizing and guesswork are being relegated; recognizing the necessity for immediate action, the tendency now among archæologists is toward closer observation, and the collection of facts to be collated by future students. Each is stimulated by the thought that he is adding his quota to a result demanding the continuous and untiring efforts of many diligent workers.

SECTION III.

THE MOUND BUILDERS.

Racial connection, or even ordinary communication is not to be inferred from a practice common to all times and countries. Mounds are among the earliest and most widely distributed means of honoring the dead or establishing a land-mark. Savages could pile up earth or stones before they could carve a rock or hew a piece of wood; barbarians could show more respect by a memorial in whose erection all might take a part. Nothing is more enduring; when once heavily sodded a heap of earth remains unchanged through vicissitudes which will reduce to ruins any other form of human industry. Oriental cities, now deserted and crumbling, were founded in sight of mounds whose origin was even then lost in the mists of antiquity. The Vikings and sea-kings were thus interred.

Travelers report them in nearly every portion of the globe, among races who are ignorant of their meaning.

In our own country the expression "Mound Builder" has been appropriated as a distinctive term for a people supposed to have preceded the modern Indians, and to have differed from them in almost every respect; and was made to embrace the authors of not only the remains in the Ohio Valley, but all cognate works in the United States. Methodical investigation has broken up this mythical "nation" into separate tribes whose relationship to one another, if, indeed, there be any, is very obscure. Most, if not all, of the southern Indians built and used mounds subsequent to the advent of the French and Spaniards; around the lower lakes are the small mounds and burial pits of the Hurons and Six Nations; east of the Blue Ridge are the ossuaries and communal graves, some of them more than ten feet high, of the Massawomees who were probably consanguineous with the last; in the upper Lake region are similar sepulchres, known to contain the dead of the Iroquois, Sioux, and Chippewas; through Wisconsin and adjacent portions of Minnesota are hundreds of mounds, some intended as tombs, others the covering and banking of huts erected by the "Ground House Indians," who were exterminated by the Sioux a little more than two centuries ago; there are reasons for believing that the numerous effigies of Wisconsin and Iowa, with their attendant tumuli, dome-shaped mounds, and long embankments were constructed by the Saks, Foxes, or Winnebagoes; most of the stone graves of Tennessee, with the mounds belonging to them, are thought to be the work of the Shawnees; in the Shenandoah and parallel valleys are the cairns and burial mounds of the Mingoes, Delawares, and Catawbas; the Cherokees of East Tennessee and North Carolina used mounds for burial and for house-sites; Osages, Blackfeet, and other Indians west of the Missouri and Mississippi Rivers made tumuli. The Mandans, Iroquois, and some southern tribes protected their towns with embankments, ditches, and palisades.

These were all builders of mounds; but none of their remains can be compared with those of Ohio, although many efforts have been made to prove that to the ancestors of some or other of these tribes the latter works are to be ascribed. Various fugitive clews have been followed, but all, have, literally, terminated in the wilderness.

It is very desirable that the name of "Mound Builders", instead of its being used in its present vague and discursive meaning should be restricted solely to the unknown race which constructed the enclosures, hill-top fortifications, and large mounds of the upper Ohio Valley (in which sense it is used in this article); adopting some other appellation for the equally unknown—if different—people whose traces are found lower down in the same valley and in the contiguous territory along the Mississippi—and, for the present, assigning remains in other localities to such stocks as probably made them. These distinctions would be only provisional, and subject to any changes required by new discoveries; but they would at once convey a more definite meaning than the present incoherent generalization which often exacts a lengthy explanation for a simple statement.

Even with the above limited signification, the title "Mound Builders" may be eventually found too general in its application. There is sufficient difference between the symmetrical enclosures of the bottom-lands or the massive hill-forts, and the smaller or irregular embankments found in the same sections, to justify a supposition of different builders. So of the large mounds, whether earth or stone, and some of the smaller mounds of either material alone or of both combined, or the stone graves or cairns. Still further subdivision may be necessary as the work progresses. With the migratory habits of the native Americans, it is not to be supposed that a single stock or tribe held possession of any section for an unlimited time, or that fertile districts would remain unoccupied for a long period. The dissimilarity observed in the various remains which were at first thrown into a single classification denotes that several waves of population swept over this region. Perhaps the resultant entanglement may never be unraveled; but better to be confronted with this difficulty, than to rest content with the partial knowledge that does not recognize its existence.

An argument in favor of the unity of mound-building people and their entire disconnection from the modern Indian, has been the supposed lack of knowledge on the part of the latter concerning these works. The error of this assumption is shown, as specified above, by numerous cases of comparatively recent construction. The Indians found in the Ohio Valley by the whites, having been in the region only three or four generations, no doubt came here long after the departure of the Mound Builders; they could know nothing of them merely from living among their remains, and if any vague record had been handed down from a former age of possible contact, its connection with unaccustomed features in a strange country would probably not have been noticed.

The Delawares have a tradition—translated and committed to writing more than a century ago—that their tribe in migrating from the west toward the east, came to a great river. The country beyond this was occupied by a people called the Allegwi or Tallegwi, who had many towns. They gave the Delawares permission to pass through their territory; but when a part of the tribe had crossed the river, the Allegwi attacked and routed them with great slaughter. Enraged at this treachery, the Delawares formed an alliance with the Iroquois, who had, in the meantime, come to the same river farther up. The combined forces crossed and drove back the Allegwi. For many years warfare continued with varying fortunes, but gradually the allies gained ground. The Allegwi built large and strong forts, which they stubbornly defended but were, sooner or later, compelled to abandon. Finally the superior skill of the invaders triumphed. To escape utter extermination the remnant of the native tribe fled southward of the Ohio. The Delawares passed on to the sea, while the Iroquois remained west of the mountains.

It is said the Iroquois have a similar legend.

The most that can be made of it, however, is that the Delawares at some indefinite time and place in their migrations, expelled a people who made use of some sort of protective works. This is scarcely sufficient to identify them with the Mound Builders. Still less does it justify a recent attempt to show that because they "went south" and because "Tallegwi" can by skillful manipulation be transmuted into "Cherokee," the latter people are therefore lineal descendants of the former. By a similar process the name Alleghany has been derived from "Allegwi."

On the other hand, if it be assumed that, after the Allegwi were driven back from their borders, the struggle reached its maximum in central Ohio, the progressive development of defensive works will be accounted for, from the minor embankments forming a part of the principal groups, through the hill-top enclosures in the same sections, to the strongholds in rugged, broken, country remote from other evidences of a permanent settlement, as exemplified in the forts of Highland and Perry counties.

But allowing the tradition everything that can be claimed for it, the question is merely shifted, not solved; there is nothing to indicate what river may have constituted the boundary, except the statement that it was "full of fish"—a vague description. The transcriber of the legend claims to have identified the Detroit as the proper stream, and to have seen on its banks a great mound under which lay the bones of the slain. But this stream could not have been crossed by immigrants from the west unless they had first made their way into the Georgian Bay district and retraced their route; moreover, the country about the western end of Lake Erie, and particularly the northwest corner of Ohio where they must have come first, is precisely the region in which remains of Mound Builders or any other prehistoric race, are most lacking.

With aboriginal methods, the construction of such works as Fort Ancient or Fort Miami would have required a considerable length of time; yet they must have been completed before an enemy could molest the laborers to any great extent. It does not seem they could be erected to meet an emergency; on the other hand it is improbable that a people with foresight thus to provide for a contingency would make no effort to protect outlying territory in the direction of any river or other natural division they could choose as a boundary.

The resemblance of the flat-topped mounds at Marietta to those of the Cahokia group or analogous structures farther to the south may be merely a coincidence or may indicate a relationship between the builders. It is easier to accept the former alternative than to believe a single group of such size would occur at so great a distance from mounds of the same type and yet be surrounded by embankments belonging solely to the region in which it is found. If they be considered the work of the Mound Builders, as the term is used in this paper, then with Chillicothe, in whose vicinity their principal settlements seem to have been located, as a center, a radius of a little more than one hundred miles will include nearly all the remains which appear to belong to this particular tribe, except those in the vicinity of Charleston, West Virginia, and some mounds on the upper Ohio. Outside of these limits, the size, appearance, interior arrangement, and contents of the different mounds and enclosures compel a belief that they are due to different peoples, or if to the same people then to different periods. A similar statement may be made for almost any portion of the country; namely, that no connected system or definite form of aboriginal work of any nature, prevails over a scope of territory much, if any, exceeding two hundred miles in linear extent. This is a wide departure from the popular view, and may be too radical for ready belief; but unless the general drift of archæological discoveries is very deceptive some such conclusion must be finally accepted. The notion that all prehistoric remains in the eastern United States are the work of a single race, is now thoroughly demolished; but it may be that the reactionary idea which supposes a separate tribe for every observed difference in such remains is equally erroneous. As in all other debatable questions, the truth will probably be found at last somewhere in the middle ground avoided by disputants who seek the extreme in either direction.

(*a*.) SOCIAL ORGANIZATION OF THE MOUND BUILDERS.

A primitive people must conform their habits to their surroundings; with the ability to modify physical conditions to meet enlarged desires, civilization begins. Under analogous circumstances races or tribes of a like degree of culture, though unrelated, will attain similar ends by practically the same methods. It is not to be overlooked, however, that the means must be adapted in large measure to the environment. A resemblance in certain typical forms is not absolute proof of identity or even communication of the people to whom they belonged, but may mean only that the social conditions were essentially alike. The discovery in mounds of objects showing characteristic Indian handiwork does not, therefore, signify that these mounds were built by known tribes, but is only an indication that the Mound Builder had not, in this particular, advanced beyond the Indian. Hence the value of specimens; in the absence of written records or trustworthy traditions, the status of the Mound Builders is to be learned only from a correct interpretation of their tangible remains.

With the notable exception of grooved axes, of which only two or three have been unearthed, all the ordinary forms of so-called Indian relics, whether of a useful, ornamental, or supposed ceremonial character, are common in the mounds, and present no special features. in appearance or material, that may not be observed in similar specimens from the adjacent surface. This statement applies only to articles of stone or other durable material. Objects peculiar to mounds are almost invariably of something that would soon be destroyed if exposed to the weather; as pottery, bone, shell, copper, wood, textile material, or soluble minerals, whose preservation is due to the protection afforded by the earth above them. They are more abundant than mound relics of the more lasting materials, and of greater scientific value, as a careful study of them has revealed much that would otherwise have remained unknown concerning the customs and habits of their makers.

The sole evidence of a mechanical or artistic ability beyond that attained by many tribes independently of contact with a civilized race, found in any mound in Ohio under circumstances precluding the possibility of intrusive deposit, and bearing no similitude to any wares of European manufacture imported for barter with the natives, are some objects of sheet copper from Ross county. They present an intricacy of design, a degree of symmetry and finish, impossible of achievement by the most advanced aborigines who have ever existed within the limits of the United States, so far as there is any historical, traditional, or other knowledge; and could have been made only by a skilled artificer, from accurately drawn patterns, with tools of steel or like metal. A very few similar pieces have been found in other states. Their rarity refutes the idea they were made in the vicinity where found; with the abundance of copper it is unlikely that its use would be confined to rude ornaments and implements to the exclusion of such ornate specimens; and no signs have been fonnd of the tools requisite for their manufacture. The resemblance of human figures among them to characteristic carvings in Mexican antiquities, points to that country for their origin; but it is uncertain whether work of this character was performed there.

Omitting from consideration the few articles so plainly of foreign derivation, a comparison of all the relics collected from mounds with those picked up on the surface and those of known Indian manufacture will show that the former do not surpass the latter in any particular denoting superior skill, knowledge, or discernment of harmonious proportion. It is remarkable that the contrary opinion should be so commonly accepted and so tenaciously adhered to despite the evidence of abundant material widely distributed and readily accessible for examination. Because many specimens, really beautiful in design and execution, are exhumed from tumuli, and many rude or hastily wrought ones are gathered up on the surface or observed in use among Indians at the present day, it seems to be taken for granted that all relics may be brought under this convenient and inclusive system of classification. But the converse is equally true; some modern or surface specimens are more artistic and of better finish than most of those from mounds. The exquisite, gem-like, war and hunting arrow-tips from Oregon and Arizona; the long, slender, delicately chipped knife or spear-like implements of agate and obsidian from the Pacific coast; the smooth, compact, perfectly moulded pottery from the Pueblos of the south-west; the ornaments, masks, and engraved emblematic figures of shell, of the Cherokees, Shawnees, and others; the copper tools, weapons, and ornaments around the upper lakes; the carefully made arrow or spear-heads and knives of flint, the polished celts or hatchets, the symmetrical banner stones and various other forms of decorative or so-called ceremonial pieces found so abundantly throughout the Mississippi Valley;—are fully equal and often superior in every respect to objects of the same class taken from the mounds Pipes must be excepted; while those made of Catlinite by the Sioux are as correct in design and as skillfully made, so far as the work is carried, the others are unequaled in their minute carvings and their faithful representations of the animal life they are intended to portray.

Not everything belonging to the builders of the tumuli was interred with them, for the objects are too few as compared with the skeletons; neither was a selection made of personal belongings with reference to certain types or degrees of imagined excellence, for a great variety is sometimes found in a single deposit; nor do surface specimens pertain altogether to either a later or different race, for this would mean that the Mound Builders never mislaid property about their village-sites, and that by a singular coincidence the presumed different race lost on these sites many implements and other articles corresponding closely in appearance to what their predecessors—or successors according to the point of view —had carefully hidden away.

These facts in themselves suffice to show that the Mound Builders had not reached a stage of culture in advance of some tribes well known to history. But there is ample other evidence to the same effect.

They had no alphabet. They had no domestic animals or beasts of burden. They knew nothing of the economic use of any metal; copper, galena, hematite, they had in plenty, meteoric iron, gold, silver, in small amounts; all were treated as so many stones to be chipped, beaten, or rubbed into desired tools or gew-gaws. Cement or mortar was unknown. They could not build an upright wall with flat stones. They could not dig a well. They did not wall up a spring. They did not facilitate passage up and down the bank of a gravel terrace by constructing a roadway They had no hand mills, not even as rude an implement as a Mexican metate or grinding stone, though corn must have been a staple food. The various objects that have been preserved to the present time, were picked, rubbed, chipped or flaked into shape according to the nature of the material and their intended use. Holes were drilled in pipes and ornaments with a stick, cane-stem, point of antler, horn, or stone, with sand, either dry or wet, as a cutting medium. Mussel-shells, perforated for attachment to a handle, were used as hoes. The principal reliance for agricultural implements was bone, horn, or wood, which would soon decay; few or none of stone are found, but this is no doubt because stone which can be wrought into suitable forms for such usage does not occur within convenient distance.

They brought together, it is true, various substances from widely separated localities; but this is far from conclusive that they dominated the country over so great an area. It is not even evidence they performed the labor necessary to obtain these things. After settlements were made by whites along the coast, trade was carried on among the Indians over a territory requiring journeys of hundreds of miles. Undoubtedly a similar traffic had long been practiced. Extended hunting and war excursions were not uncommon among many tribes, notably the Iroquois, whose raids extended to upper Michigan, the Mississippi River, North Carolina, and Tennessee. Shawnees and other Indians have migrated from place to place over several states. The Chippewas carried copper nuggets for exchange, from Lake Superior to the coast of Virginia. Articles of barter were passed from hand to hand, from tribe to tribe, through long periods of time. In all these ways small objects could wander hundreds or thousands of miles from their starting point.

Of material foreign to Ohio, used by the Mound Builders, obsidian is nowhere nearer than the Rocky Mountains or Yellowstone Park; copper is found in the southern Alleghanies and the Blue Ridge, but chemical analysis shows their supplies came from northern Michigan; mica was obtained east of the Blue Ridge in Virginia, or the mountains of North Carolina; catlinite (it is not definitely determined whether this was known to them) only from the Pipestone quarries of western Minnesota; marine shells, native to warm waters, from the Gulf or southern Atlantic coast; lead ore from central Kentucky, or the vicinity of Galena, Illinois. Artificial objects of all these substances occur more plentifully in the neighborhood of the natural deposits than farther away; so it is probable that the principal work of quarrying, and much of the manufacturing was done by the aborigines living in the vicinity, from whom others obtained their supplies. If outsiders had conducted the necessary mining operations, they would have taken home, to work up at their convenience, most if not all of the raw material which could be utilized; and it is probable this plan was followed with unwrought pieces obtained bv trade. They certainly would not have been at the trouble to complete, and then abandon, the great quantities of specimens found remote from their habitations.

The various positions in which bodies are buried, and the character of the objects placed with them, accord with what is observed among many modern Indians. It is said—the report lacks confirmation—that the Chinooks of the extreme northwest bury their dead in the exact attitude in which they died. This custom, if it ever existed, offers the only reasonable explanation of the extraordinary postures so often noticed, even to the discovery of sitting skeletons. The last, however, are infrequent; the cases reported are usually the skeletons of bodies which were closely folded and laid on the side; when the flesh decayed the bones settled to the bottom of the grave in a promiscuous heap, and the skull, if not broken, apparently rests upon them.

The depositing of food, weapons, or other articles with the dead, is generally supposed to signify belief in a future life where decedent will have occasion for the possessions found useful in this. Conceptions of this nature are necessarily very shadowy in primitive minds. A great many people in the most enlightened communities believe in ghosts, dread to remain alone with a corpse, avoid a cemetery after night-fall, deposit various articles in coffins, array a corpse in the best apparel attainable, decorate graves at intervals for years. They can give no reasons for doing these things; if any notion of immortality is involved it is only a vague feeling too faint for logical expression. It cannot be expected that barbarians or savages should have clearer ideas. Imbued with the same solicitude that animates their more civilized congeners, they may intend only an offering to make amends for any injury or slight that might call for retaliation. When private property is concerned, there may be a feeling that, whether dead or alive, the individual was entitled to keep what belonged to him and no one else had a right to claim it. There is a wide-spread superstition, too, that the use of small personal possessions after the death of their original owner, will entail disaster upon any one so rash as thus to tempt his fate.

Any or all of these motives may have entered into the custom in question; and all of them are equally set at naught by the fact that so many bodies were deposited with absolutely nothing to accompany them.

The opinion that a prehistoric race exercising undisputed jurisdiction over any considerable portion of the territory, or one that attained as near to civilization as the highest stage of barbarism, ever dwelt in the Mississippi Valley, is contradicted by all observed facts. Nor does the assertion of a dense population in any section, even where there is the greatest evidence of it, rest upon a better foundation. The imagination is charmed with the picture of toiling multitudes under the direction of task-masters, engaged year after year in building tumuli, bases for sacred edifices, enclosures for various purposes, and doing many other things in a systematic way according to a pre-arranged, intelligent plan. But it is more probable that structures of this kind, whether intended as a mark of respect, for social requirements, to afford protection, or whatever purpose, were public in their nature and erected by the joint efforts of the whole community. The varieties of earth often intermingled in a mound show that parties were working from different directions at the same time, and the small quantities of one sort or other denote that work was desultory or intermittent. The latter is more plainly shown in mounds which were carried to a certain height and their completion left to a future time. In the interim briars, bushes, even small trees grew up, and were burned off when the work was resumed; the signs being quite distinct in thin layers or streaks of charred matter parallel to the upper surface. Some were thus abandoned and renewed several times, a number of years elapsing between inception and termination. The wall of Fort Ancient, also, shows marks of such interruption. So the size of any earth or stone work is no indication of a large force of workmen; a smaller number, given ample time as was sometimes the case, could as well accomplish the task.

Aside from all this, the amount of labor necessary for the construction of the Mound Builders' remains has been greatly exaggerated.

A regular cone twenty feet high and one hundred feet in diameter at the base, will contain 1940 cubic yards. For one mound that will exceed this size, a hundred will fall below it; but taking it to represent the average and accepting the estimate of 10,000 as correct, the entire amount of earth—and stone—in the mounds of the state will be about 19,400,000 cubic yards.

A regular enclosure 1,000 feet square or 1275 feet in diameter, measuring twenty feet in breadth at the top, forty feet at the base, and six feet high, with four gateways each twenty-five feet wide, will contain 26,000 cubic yards. It is doubtful whether any one is so large. The equivalent of four hundred such will fully equal the contents of all enclosures, making in all about 30,000,000 cubic yards for the entire volume of aboriginal remains in Ohio. No one familiar with them will dispute the liberality of these figures.

A man can easily carry a half a bushel, or five-eighths of a cubic foot of earth; 83,800 such loads will make the mound whose dimensions are used above. If one hundred persons engage in the work, each will have to carry eight hundred and thirty-eight loads; in a day of ten hours, twenty such loads would not be an onerous task. Thus the mound could be finished in forty-two days. With the same force, working in the same way, the illustrative embankment could be completed in five hundred and forty-six days; but a village that would require such a work could furnish a much larger number of laborers.

Or, on the estimate of 30,000,000 cubic yards, one thousand men, each working one hundred days in the year and carrying three wagon-loads of earth or stone in a day, could construct all the works in Ohio, within a century.

(*b*.) PROBABLE AGE OF MOUNDS.

There has not yet been found in one of these structures, under circumstances that put beyond question the fact of its being deposited by the original builders, a single article of such pattern or material as to prove incontestably that it was obtained from Europeans. Reported discoveries of this nature are not authenticated; nothing less can be accepted as testimony of a date more recent than 1492. How far back of this time they may have been erected it is impossible to ascertain. Having once settled compactly and become overgrown, there is no further change due to age. Trees on them are of the same size as those near by; but this proves nothing except that they are older than the timber, which is self-evident, for they would not have been built in the woods. There are few, if any, trees in Ohio four hundred years old; with an annual growth of one-eighth of an inch of new fiber, a tree in that time will reach a circumference of twenty-six feet. Few varieties of timber but will exceed this rate of increase in the fertile ground where most of these remains occur; in fact they should grow more rapidly on the works than elsewhere, as these are usually made of the surface earth and therefore furnish more nutriment to the roots. A cypress tree planted in Philadelphia in 1808, had in 1892 a height of 120 feet and a girth of twenty-eight feet; this however, is a soft wood and grows rapidly. An elm in Chicago known to be just fifty years old measured eight feet and two inches in circumference, three feet from the ground.

Growth-rings are not an accurate test of age: it is not unusual for two or three to form in a year.

The irrational assertion is often made that a mound must be at least five hundred years old for the reason that it is covered with large trees. It has been reserved for a well-known geologist to cap the climax, within a few months, by stating that some mounds are at least a thousand years old, because not only are large trees growing over them, but on the ground are remains of other trees which lived out their period and fell into decay before those now standing had sprung up. This is, in effect, to claim that all trees live five hundred years and no longer; that all trees growing on mounds have reached this age; and that wood in a state of decay will remain exposed to the weather for the same length of time. Absurdity cannot go further.

The roots of trees extend many feet into the interior of mounds; when they decay, the casts contain mold, from the roots themselves or settled in from the surface. If successive generations had flourished on them, it would seem mounds would contain a great number of these casts; but they are comparatively few. This gives reason for supposing the mounds do not reach back many centuries. To avoid such conclusion. the opinion ventured by some geologists that until relatively recent time the Ohio Valley was devoid of forests, has been made to support an argument that the country was a prairie in the time of the Mound Builders. The many timber remains in mounds effectually dispel this hypothesis.

Various earthworks have been encroached upon by streams near which they were built; sometimes a river has partially cut down a mound or embankment and then worked its way in the opposite direction, forming a low timber-covered bottom of considerable width. Such a process is generally supposed to require a very long period; but it may take place in a short time, from the constant shifting of channels in alluvium. Occasionally embankments appear to have been partially destroyed, which were really constructed as they now exist. The line B in Plate III which appears to be the residue of a complete circle originally extending over a portion of the terrace now washed away, was built thus, to reach the bank which is now where it was then.

It is singular, though perhaps only a coincidence, that the cairns and mounds between the Alleghanies and the Blue Ridge, thought to have belonged to tribes which roamed over that region up to the middle of the last century, yield numerous slate gorgets and steatite pipes of the forms common or almost typical to the Ohio mounds, along with relics more common near the sea-coast. Whether this fact, and the almost total absence of grooved axes from the mounds, have any bearing on the question of age, remains to be decided.

On ground not subject to wash or overflow, the accumulation of soil from the decay of vegetation, is nearly three inches in a century. Hence the depth of village-sites beneath the surface offers some clue to the number of years since their abandonment. But there are so many disturbing influences that it is unsafe to place much reliance on such measurements.

Nothing can be judged of the age of a skeleton from its condition; the preservation of bones is dependent entirely upon the protection afforded them, regardless of the length of time they have been buried. If kept perfectly dry they may last thousands of years; if exposed to dampness they may utterly disappear in a very short while.

The existence in Wisconsin of an effigy mound in the form of a mammoth mastodon, and the discovery in Iowa of two pipes of the same pattern, shows that their makers had some knowledge of such an animal. This, also, has led many authors to attribute a very great antiquity to the remains; the same geologist who has seen wood that had lain on the ground in the open air for five centuries, asserts that they must necessarily be many thousand years old. Other writers have assailed vigorously the genuineness of the pipes and the likeness of the mound to its supposed prototype. The only point of agreement seems to be a reluctance to admit the possibility of the mammoth having survived into recent time.

While the bones of this species are frequent in gravel deposits of glacial or post-glacial age, they also occur under other conditions. The pioneer who discovered the Big Bone Lick Springs, twenty miles south of Cincinnati, made tent-poles of mastodon ribs; people now living there remember having, when children, gathered vertebrae which they used as seats or door props. The Springs are in a basin with a very narrow outlet, so the presence of these remains on the surface cannot be attributed altogether to erosion.

When aquatic vegetation once gains a foothold, swamps or shallow lakes fill rapidly; elephant bones, often much nearer to the surface than to the solid ground underneath, are common in such places, the animals probably having mired while seeking food or water.

Instances like these can be accounted for only by admitting the survival of the living species to within a few centuries at the most. Moreover, there is definite proof that it was not unknown to the aborigines; the bones of one were found in Missouri, under circumstances which showed plainly that it had been slain by men, while fast in a bog. Rude weapons were scattered about it and some of the bones were charred. The Mound Builders, indeed, have left no indication that they knew of it; but this is equally true respecting other animals with which they must have been familiar.

It has been alleged that no earthworks are found on the latest or lowest formed terraces. Both statement and inference are wrong; mounds do occur in such places; but if they did not it is only a natural supposition that their builders would avoid situations liable to inundation, when high ground as suitable in all respects could be found close at hand. The same argument could be used to prove that modern buildings, which are usually located above ordinary floods, are older than geological formations near them.

To sum up, there seem to be no data from which can be determined what people built these mounds and enclosures, whence they came, how long they lived here, when or why they left, or what became of them.

It may, however, be considered definitely settled that in no particular were they superior to, or in advance of, many primitive Indian tribes. They hunted with the same kind of weapons. They worked with similar tools. They were patient and plodding. There is nothing that shows they had any appliances or conveniences for economizing time or lightening labor. Agriculture was rudely carried on and practicable only in loose soil.

Under such conditions a dense population is impossible even among the most peaceable people; intestine disputes or warlike neighbors would still further prevent a rapid increase.

(*c*.) SOME DELUSIONS REGARDING THE MOUND BUILDERS.

The records of mound exploration and the efforts to explain or account for all discoveries, go back to the beginning of the present century, and are scattered through every form of literature from a fugitive newspaper paragraph to a philosophic treatise. Much of this material is of little scientific value, being the work of relic hunters, persons whose curiosity has been excited by something they have seen or heard, visionaries seeking proof of a pet hypothesis—and generally finding it;—careless, unskillful, or superficial observers whose statements are unsafe to rely upon no matter how honest may be their intentions. Almost invariably something has been taken for granted, ultimate conclusions predicated from partial examinations, definite assertions based upon hasty surmises, indications used as established facts. Some pretentious volumes are only an expression of opinion based upon partial and often incorrect information interpreted in the light of very limited personal investigation, and depending for acceptance mainly upon the author's reputation for ability in some other profession or branch of scientific work.

The specious fictions of the theorist who lets his enthusiasm run away with his judgment, seems to meet with a more cordial reception than the moderate statement of the explorer who wishes to record only what he has seen. As a result, the prevalent notions concerning all the native races of North America, whether of past or present time, are not at all in accord with the conclusions of those who have given them long and careful attention. There is always room for difference of opinion on questions which must be solved by comparative or analytic study. But in matters that depend entirely upon observation or can be placed beyond controversy by methods at the command of any one who chooses to inform himself regarding them, there can be but one side.

A considerable amount of archæological literature contains such gross errors and manifest perversions of fact, as almost to indicate a deliberate and intentional effort at deception. It is not supposable, however, that unworthy motives can be attributed to a writer on a scientific topic; at the most, he can only be accused of reprehensible carelessness or ignorance of his subject.

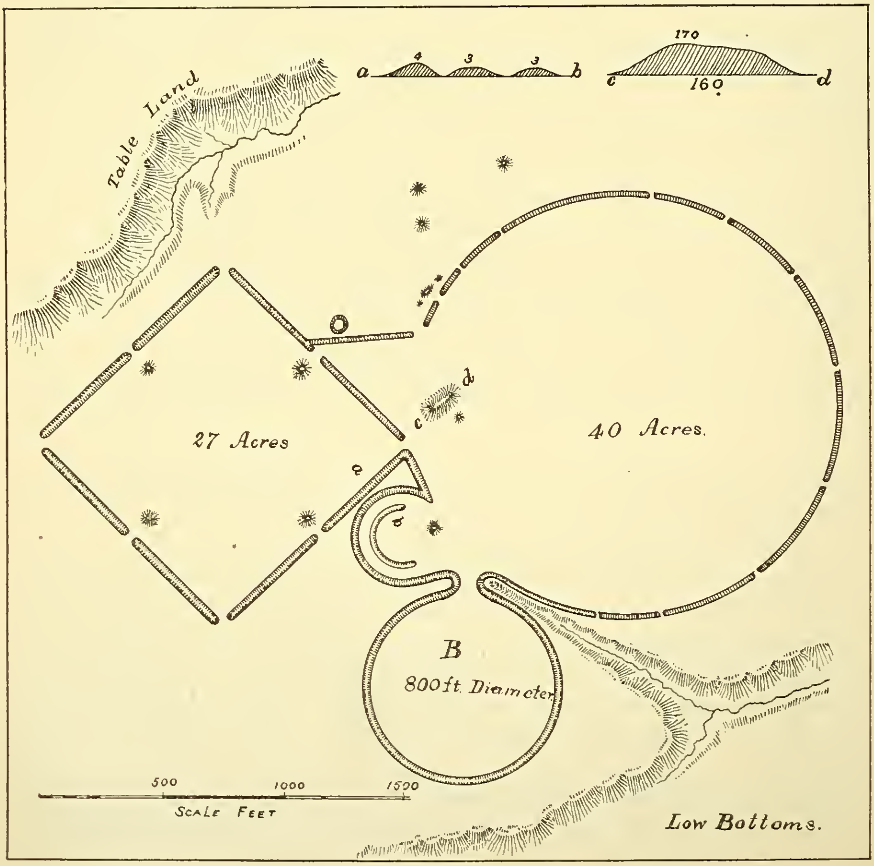
Chief of all these mistakes, the one which has done most to create a totally false idea of the extinct population of the Ohio Valley, and has resisted years of persistent effort to remove from the popular mind, is the pretended geometrical accuracy of the enclosures. Several degrees in angles, scores of feet in lines, rods or even acres in area, have been added to or subtracted from correct measurements to force a resemblance or coincidence between works which in reality widely differ. Absolute symmetry, or identity in form or size, is claimed in numerous cases; whereas there has not been found one true circle, square, octagon, or ellipse, among these works, nor any two that exactly correspond in dimensions, although nearly all of them have recently been very carefully surveyed. There are some with a striking approach to regularity; but none that cannot be laid out with sight-stakes and a rope of sufficient length to reach across them.

Nevertheless, with this assumed mathematical ability as a starting point, aided by the equally assumed perfection of mechanical skill necessary for the fabrication of their various objects of utility or ornament, and further reinforced by similar evidence from remains in other parts of the country, there has been evolved in the minds of some authors a wide-spread, highly civilized nation with a wonderfully developed government; —monarchy, oligarchy, aristocracy, hierarchy, or whatever strikes the writer's fancy.

Many of these errors have been incidentally referred to in the course of this paper. One other must be mentioned.

In Plate IV, the smaller enclosure is represented as a perfect circle 800 feet in diameter. Figure 3 shows its actual shape—an elliptical

PLATE IV. ARCHÆOLOGY. GEOLOGY OF OHIO. VOL. VII



Liberty Township Works.

figure of irregular curvature, with one diameter more than a hundred feet longer than the other. Instead of continuing around the head of the

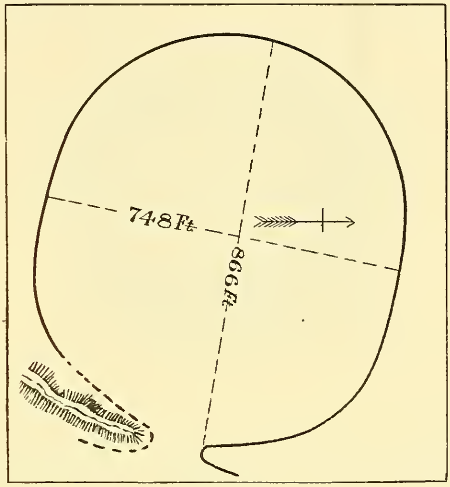


FIG. 3.

ravine south of the entrance, the embankment stops more than 300 feet from the corresponding point on the opposite side. The original forest extends over this portion of the work, and the ground is perfectly level; while the southern part is in a cultivated field, and the wall quite distinct. So there can be no claim that any portion of it has ever been obliterated. Yet in the original description of this plate, the authors claim to have been at great pains to ensure the absolute accuracy of their work. In a foot-note presumably referring to this figure, they give the field notes and diagram of a purported survey in which they make chords of 300 feet—something no surveyor would think of doing—turning off 30° at the end of each, with the angle on the embankment, thus completing their figure with twelve chords. This would form a dodecagon with a perimeter of 3600 feet, which they have inscribed within a "circle" having, according to their figures, a diameter of 800 or a circumference of 2513 feet.

It is not the province of this article to criticise; but when such mistakes are made the foundation of a science, it is well to present them in their proper light.

The minor errors due to hasty observation, or incorrect deductions, are numberless. Mounds are almost invariably represented much steeper than they are. Nearly all cuts of the large mound at Marietta show its height to be equal to its breadth; sometimes it is shown as perpendicular for fully ten feet up its sides. But the base diameter of a mound undisturbed by cultivation is never less than four times and from that to ten times its height. An ideal "section" of the large mound near Licking Reservoir gives the impression that the stones are each several feet thick.

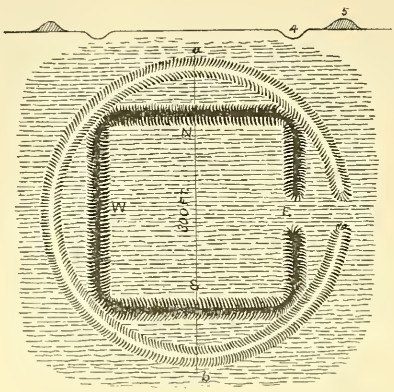


FIG. 4.

Figure 4, a small work in Pike county, shows a ditch of uniform width surrounding a square court, the whole enclosed by a circular embankment which touches the ditch only at the corners. Actually, the ditch occupies the whole space between the inner level and the embankment, the outer margin following the curvature of the latter.

Such details are in themselves trivial; but they show a negligent, slip-shod manner, which casts doubt on more important work. It is unnecessary to multiply instances; they are to be found in nearly all works upon archæology.

A vast amount of toil has been expended in attempting to establish classifications based upon cranial form and development, or other osteological peculiarities; but when, in a single mound, are found skulls that exceed in either direction the limits assigned as the measurements of long and short heads, respectively, or when in the same cemetery they occur of almost every normal variety of size and shape, it is plain that little value can be attached to these variations. If a single tribe remain in one place for centuries, under conditions of life that vary but little in that time, a mediocrity may be reached which will admit of the evolution of a particular type of cranium; but with a roving people, or one subject to alliance with other stocks, the intermingling of different bloods will be attended with a diversity of physical structure affecting not the skull alone, but the entire frame. The skeletons from mounds vary much in size, but none are larger than may be found among any people living a natural life out of doors. The lower jaw is more massive than in civilized races, as more strength was needed for masticating their tough or coarse food. Nothing is proven as to size of individuals, by "slipping the jaw-bone over the face of a full grown man;" it never slips back to the coupyles of the experimenter, and the opening of any V-shaped object will naturally slip over the point of another like it as far as it can go. The teeth frequently met squarely, instead of overlapping, so they were worn down evenly all around; the dentition was the same as in all the human race. Decayed teeth were as common as among whites; and full sets are seldom found.

To conclude here the subject of Mound Builders:—any statement. drawing, or description of remains, which attempts to show they were a race superior to, or different from, all other native tribes of the United States, is not justified by any evidence so far discovered.

SECTION IV.

INDIANS.

Frequent comparison has been made herein with modern or known tribes. Some explanation is necessary.

The popular conception of Indians is based altogether upon one phase of their character, and that, according to civilized ideas, the worst. Histories, especially those relating to frontier life, novels and romances, all picture the Indian as a hunter, warrior, or vagabond. They touch lightly upon, or pass entirely over, the normal condition of sedentary tribes, or the home life of others few of whom spent more than a portion of their time in warfare or the chase.

The Six Nations devised a form of government admirably adapted to their circumstances; they had fortified towns, cultivated a variety of crops, and in later times had orchards; they well understood the value of alliances, planned their campaigns with foresight, and carried them on with skill and vigor. Several southern tribes, as the Cherokees and Natchez, though less predatory, were equally advanced in all respects; their domestic life would compare favorably with that of many agricultural and mining communities of the present time. Tecumseh, Logan, Blackhawk, Cornstalk, Red Jacket, Pontiac, and scores of others whose names will live in history, were the intellectual peers of many prominent men of to-day. Individuals of this stamp are impossible in a degraded or debased community; they must have at least a moderately intelligent ancestry and constituency. To suppose that a brain which could formulate a confederacy such as Tecumseh came near consummating, or a conspiracy like Pontiac's that almost wiped out of being the settlements over a wide territory, could not plan earthworks similar to those found in the Ohio Valley, is nonsensical. No less so is it to assert that a man who will chase a deer a hundred miles or travel several times that distance to attack a foe, or that a woman who will raise a crop of corn, is too lazy to assist in building a mound; or to claim that persons who will maim, starve, or otherwise maltreat themselves, or destroy property representing months of labor, on the death of a chief or leader, would not be at the trouble to carry a few yards of earth if inclined to show their grief or respect in that manner.

The name "Indian," as generally used, is not more definite than the term "European;" the various tribes, in their primitive stage, were as diverse in their manner of life as the people of different countries. The peaceable Mandans or "Ground House Indians," and the blood-thirsty Apaches or Comanches; the energetic Iroquois or restless Shawnees, and the stupid Diggers but little above the beasts;—are entirely unlike in disposition and characteristics.

It is not probable the aboriginal population of the United States was ever much, if any, greater than at present. True, the New England Indians were greatly reduced by a pestilence of some sort about the year 1600; but this was only local, and there seem to have been but a few thousands of them at any time. Smith, in his account of Virginia, speaks of most villages as containing only a few men, and placed miles apart. The Iroquois were unable to send more than a few hundred warriors on a foray. In Ohio, Indian towns of a thousand inhabitants were rare.

No reason exists for supposing a different state of affairs in prehistoric times. The conditions of life were practically the same; and from all indications they were met in the same way.

The ration issued to slaves on southern plantations was a peck of corn-meal, four pounds of bacon, and in some places, a quart of molasses, each week. If the allowance proved inadequate, a comprehensive system of foraging made up the deficiency. On such a basis, supposing that with their crude methods the Indians or Mound Builders could raise only 26 bushels to the acre, a town of one thousand people would require in a year the corn from a field of 500 acres; and much more than 200,000 pounds of fresh meat, to allow for the loss of weight in curing. Nuts and fruits from the forest would considerably augment these supplies.

SECTION V.

RELICS.

In its common meaning this term includes all articles of aboriginal handiwork, under whatever conditions they may be found, or for whatever purpose intended. It is so used here; no distinction is attempted between surface and exhumed specimens.

As noted elsewhere, various substances were imported from foreign localities; but the vast majority of objects found are made of material native to the state or near its borders. In glacial deposits are granite, quartz, diorite, syenite, and other varieties of hard, tough rock suitable for implements and utensils which must withstand rough usage, as axes, hatchets, wedges, club-heads, pestles, mortars, hammers, and the like. In any gravel bank, or along the shores of any stream rising within the area covered by the drift, such stones are abundant. Slate, for ornamental or ceremonial objects, although plentiful around the upper lakes, occurs in the drift only in small amounts as it is too soft to resist the wear to which it is subjected in such transportation. Hematite for paint and sundry small tools or objects of unknown use, like cones or hemispheres, and cannel coal for ornaments, could be obtained in the south-eastern part of the state and in West Virginia. Shells, for domestic use, beads, and wampum, abound in waters containing lime in solution. Flint in beds from a few rods to several square miles in extent, replaces limestone in all the Carboniferous, and to a less extent in the Devonian formations.

No great labor was involved in procuring any of these except the last; shells were obtainable from any convenient stream, and the minerals could be gathered wherever they occurred on the surface or were exposed by erosion.

In working stone, the artisan, after selecting one as close to the shape of the desired object as he could find, with a tough pebble as a hammer went over the surface of his inchoate implement, chipping off angles or projecting parts, pecking small flakes from such portions as required little alteration, until it was as near complete as it could be made by such means. Then with a piece of coarse sandstone he ground off the pitted surface, concluding his work, if he so wished, by polishing with a stone of finer grain. If an edge or groove were required, it was often made before the remainder of the specimen was finished. Axes were grooved entirely or partly around to afford a secure hold for a handle, which was often tightened by a wedge driven in on one side that was flattened or hollowed out for this purpose. Pestles frequently had a depression at the center of the base, for cracking nuts or to prevent the grain from flying from beneath them when struck. Hatchets or celts were of various shapes according to their required use. The hammers themselves were sometimes worked into spheres which, either with or without grooves, were utilized as slung-shots, club-heads, or sinkers for use in fishing. With soft or brittle stones the rubbing process may have been more used than the hammering. Shell, bone, or cannel coal were cut to proper length with sharp or jagged flint when necessary, and rubbed smooth with sandstone; they could not well be pecked or chipped. Hematite was sometimes chipped into form, but usually ground, the powder being used for paint. The different varieties of jasper, chalcedony; hornstone, and other nearly pure siliceous rocks, commonly placed under the generic name of flint, demanded different treatment. Large implements, not requiring careful finish, were made by knocking chips from nodules or blocks with stone hammers, working from the edge of the piece toward the center. The same method was followed with smaller specimens until reduced as near as possible to the desired size and shape, when they were completed with a piece of bone, horn, or other tough substance in which a notch or crease was cut to give a purchase. This being set against the edge of a flint, flakes were split off by quick forcible pressure. The character of the work determined the size of the tool, and degree of force.

With such simple contrivances were made all arrow-heads, knives, and other flint implements of any size or material.

While flint that has long been exposed to the atmosphere can be converted into serviceable weapons, it is too brittle to allow of delicate work. For thin, symmetrical pieces, especially those of large size, unweathered stone was essential. This fact was well known to the people having use for them; and in almost every county along the outcrop of the Coal Measures, from Pennsylvania to Kentucky, are quarries from which the coveted material was obtained. The largest are in Licking, Coshocton, and Perry counties, the first, known as "Flint Ridge," being one of the most extensive in the country. For several miles the surface is honey-combed with pits and trenches; thousands of car-loads of earth and stone have been excavated. In some places more than ten feet in thickness of clay, tough as that in a traveled road, was removed in order to reach the flint. Piles of refuse rock are scattered everywhere, being greatest where it lay nearest the surface.

After the earth had been cleared away over a space as large as needed, the flint was shattered by large fires made on it and kept burning until the underlying bed of limestone was penetrated; water probably being thrown on occasionally to hasten the crumbling. All the fragments were next thrown out, the upper portion of the flint stratum was thickly coated with clay, and intense heat applied to the bottom and to the limestone. The top, left projecting, was then pounded off with heavy boulders from the adjacent surface, and broken into small pieces; most of which, after being partially chipped into shape, were carried away to be completed at the leisure of the artificer. A great many well finished specimens have been collected here, but they are few as compared with the immense quantity of rejected pieces which in the course of the work were broken or found to contain some flaw that rendered them worthless.

Nearly all the knives, arrows, or spears, found on or near Flint Ridge, which have barbs, stems, or tangs, are made of flint from some other locality, while implements of the native material are almost invariably of the triangular or leaf-shape pattern; and the former are far in excess of the latter. But the objects of Flint Ridge stone found farther from home—and they occur from New York to Tennessee, and from Blue Ridge to Illinois—usually resemble in form other worked flints found in the same localities. It would thus appear that the superior quality of this stone for various purposes was widely known; and, as objects made from it are found alike in the largest mounds and on village sites occupied by Indians within a century, that this excellence has long been recognized.

So far as the very limited investigations signify, what is said of this particular quarry in regard to methods of work and disposition of material is true of others. No trace of digging tools is apparent; the earth seems to have been removed with wood or other perishable substances; the flint was worked altogether with stone hammers, with such aid as could be derived from fire.

The very wide range of forms and relics, the diversity of material, and their unlikeness to almost everything belonging to the present inhabitants, have caused some misapprehension or confusion as to their probable uses. This is especially the case with the great quantity of objects whose manufacture may be considered the outcome of esthetic or religious ideas. They are made of nearly all the different kinds of shell, bone, metal, and stone, especially slate and steatite, accessible to their fabricators. Under such names as gorgets, crescents, wands, tubes, banner-stones, amulets, pendants, butterfly gorgets, ear-bobs, bracelets, breast plates, beads, buttons, head-dresses, labrets, nose-rings, charms, and a score of others, they are delineated in many volumes. No detailed description of them would be intelligible unless accompanied by numerous illustrations; and to ascribe a purpose to any pattern, unless a similar one had been seen in actual service, would be as presumptuous as the attempt by an individual entirely ignorant of modern secret societies to explain the meaning of badges, pins, or regalia. No doubt some owe their form merely to a whim or fancy of the maker; others were purely decorative; while many of them were symbolic, or for use in the manifold dances, parades, celebrations, superstitious ceremonies, and other observances, so dear to the minds of an uncultured people. The manner of perforation in some indicates they were for suspension by cords; in others, that they were to be placed on a staff; still others, unperforated, may have been secured in various ways. Nearly all are made of material that would break if carelessly handled; many are of such size or shape that no practical use for them can be imagined. They are to be found in all cabinets and museums, being much sought by collectors on account of their beauty or supposed mysterious significance. A statement that each piece had a certain use, cannot be gainsaid; but the person who makes such claim must give satisfactory reasons for his assertion before it is to be accepted as a fact and not a guess.

There is less trouble in regard to the utensils, weapons, or implements for ordinary work, comprising articles necessary in agriculture, hunting, warfare, or domestic affairs.

Trees could be felled, cut in lengths, split for puncheons, or hollowed into canoes or mortars, with axes, hatchets, wedges, or adzes of stone or thick, strong shells, set with the edge parallel or transverse to the handle, according to their manner of use. Usually fire was applied at the proper points and the charcoal scraped away as it formed; but the remains of logs a foot in diameter that had been cut entirely through by such rude tools, have been exhumed from mounds. Hoes and adzes frequently have notches on each side, the faces being flat; in such cases the end of the handle was placed against one face. Spades had one end inserted in the end of a stick. The handles of all implements were firmly fastened with thongs, rawhide, or sinew. Pestles for pounding corn or acorns varied in length and shape to fit the mortars; these were flat or dished stones, or deep cavities in boulders and stumps or wooden blocks. Among the commoner relics are slabs or angular fragments of sandstone with hemispherical depressions, sometimes only one, sometimes thirty or forty, from an inch to two inches in diameter, pecked or drilled in them; slabs have them on both faces, rougher blocks only on one side. The purpose of these cup-stones is unknown; theories have been advanced that the cavities were for grinding paint, holding nuts to be cracked, containing punk or wood-dust to be ignited by rapid revolution of a stick, steadying the lower end of a spindle, or supporting a drill for boring pipes, tubes, and other large and thick objects; and that where friction would be a hindrance to the work, rawhide well greased, was fitted closely to the sides of the depression. There may be a measure of truth in all these conjectures; none of them is applicable to one-tenth of the specimens.

In making pottery, mussel shells or quartz pebbles were beaten fine and either one, but never both together, mixed with clay; the compound was thoroughly kneaded, molded into form, dried in the open air, and then burned. None of it was glazed; and it is doubtful whether any was painted.

As a rule the rough flint disks found cached, sometimes in considerable quantities, are only unfinished implements, or cores from which flakes are to be split off and worked up as needed; but many of them are dulled or polished around the edge as if used for cutting or scraping. They may have answered for dressing skins, but would be difficult to handle, or to utilize for any other purpose.

Flint—in the popular meaning of the word—was indispensable to a people ignorant of iron. For any weapon or tool requiring a keen edge or sharp point, as knives, arrows, spears and such things, no other stone could replace it. Hatchets, digging-tools, and, to a small extent, ornamental objects were also made of it. Worked pieces are scattered everywhere, in the greatest profusion; in some localities bushels of them may be, or have been, gathered on a space of a few acres. Only the smaller ones were for arrow-points; few so used among modern tribes are as much as two inches in length, and any that long are very slender. Solid flesh is almost as difficult to penetrate as rubber; few men have the strength to draw a bow that would drive a wide or thick flint into the body of a man or large animal. The thicker, larger specimens were probably spear, lance, or club-heads; the thinner, knives; the long, slender ones, drills or perforators, though the latter, if for use in skins or leather, were commonly made of bones ground to a sharp point.

It is a reasonable supposition that small, triangular points, which would remain in the wound when the shaft was pulled out, were used in war; those barbed and tanged for secure attachment, which must be pushed on through the body, or lacerate the flesh when withdrawn, may also have been for this purpose. Arrows for hunting would be of the latter shape, to remain fast in the game and be recovered when it was captured or killed. Spears for slaying large animals were unbarbed that they could be easily withdrawn for repeated thrusts. The twist or curve noticed in so many flints is due altogether to the conchoidal fracture of the stone. The so-called rotary arrow-heads are almost invariably too large for such use, and are intended for skinning knives, the flat faces and chisel edges permitting them to pass readily between the hide and flesh without cutting either. The bevel is produced by pressing off flakes along the edge from only one side instead of equally from both. Undue importance has been attached to serrated flints as being the result of a definite intention. The only difference between them and others of the same general pattern is that wider space was left between the points at which the flaking tool was applied.

The relative scarcity of symmetrical, highly finished, and really artistic specimens of any class, as compared with the abundance of ruder, rougher ones, signifies that a few persons in a community or tribe were more skillful, or had greater aptitude for such work than the majority. It may be that any given form of superior work, as the manufacture of pipes, large, finely shaped flints, certain kinds of ornaments, etc., attained its highest development at the hands of one person whose efforts were confined to this particular forte. Another evidence of this is the occurrence within a limited district of many specimens of a type very rarely found outside of this area; for example, a peculiar flint knife in two or three counties of central Ohio—which, oddly, is also abundant in the Kanawha Valley—, or spear-head along both sides of the Ohio. Many such instances could be cited.

What sort of work the prehistoric people may have done in wood, textile fabrics, feathers, fur, robes, skins, or other perishable material, can never be known; but judging from the few scraps remaining, and from such other specimens as have been preserved, it was probably on a par with that of the present day among tribes but little changed from their condition when first known to the whites.

There are few things of value, beauty, or interest among relics that have not been counterfeited by unscrupulous tricksters eager to profit by the credulity of collectors. To such an extent has this been carried that anything out of the ordinary line is to be viewed with suspicion. Much ingenuity has been displayed in hiding tablets, carvings, and pottery in places where they will afterward be discovered by one unconscious of the deception who will thus be deluded into the belief that he has a genuine alphabetic inscription, effigy of a mastodon or other animal, Mexican idol, paleolithic implement, statue of a Mound Builder, or some other wonderful thing that is to throw a flood of light upon the history of an unknown race. It behooves students to be on the lookout for such frauds, as they appear in the most unexpected places.

CONCLUSION.

FURTHER EXPLORATIONS NECESSARY.

It is not probable any manuscripts, inscriptions, or other records will ever be discovered, which will aid in solving the unanswered questions concerning the Mound Builders. Additional information is to be gained only by investigation of their mounds, cemeteries, and village-sites. This work, to be of value, must be done carefully and thoroughly. Sinking a shaft from the apex, or running a narrow trench in from one side of a mound, will seldom give satisfactory results. Conclusions based upon facts thus brought to light, may be correct; but there can be no certainty that they are even approximately so, for a section at one place may not at all resemble one made at another in the same structure. The assumption is entirely unfounded that all the artificial contents are deposited in a small space in the center; sometimes there is nothing within several feet of it, while remains are found at various other points. There is little doubt that many, if not most, of the mounds which have been opened, yet contain more than has ever been taken out of them. Almost always, a record of the structure of the mound, the position of skeletons, and the arrangement of objects with them, would be the most important part of the work; but these are usually the very features of which no notice is taken by persons who have not had considerable experience in such matters.

PROPER METHODS OF WORK.

The best method of opening a mound, depends upon its size and form. It is useless to waste time upon any part which from disturbance by cultivation or other cause is not where it was placed by the builders. Only the unaltered portion requires attention. If but little changed in shape, the entire mound should be removed. Owing to the accumulation of soil, the bottom may be somewhat below the surrounding surface; for this reason excavation should be carried to a sufficient depth to make sure nothing is overlooked. Frequently the original surface is easily detected by a sod line, or by a slight difference in color; if not, it will be necessary to work along the top of the subsoil. For convenience of description, it is well to draw two lines crossing at a right angle at the center, and other lines, parallel to these, five feet apart, thus dividing the mound into blocks which may be designated by numbers or letters to correspond with a plan drawn on a scale of five feet to the inch. Whatever may be found in one of these blocks is to be shown in its proper position in the drawing. It is best to begin on the side toward one of the cardinal points, and to keep the face or bank in front of the diggers vertical and in straight line from side to side. This is most easily accomplished by undermining with picks and breaking the bank down from the top, taking off a section about a foot in width each time. When a skeleton is reached, the earth should be removed from around and above it until the bones are completely uncovered before being disturbed, in order that the method of burial may be ascertained. In all cases the exact distance and direction of every object from the center should be observed, as well as its height from the bottom if found in the body of the mound. Full notes should be constantly made, and a detailed account of the entire work written in a manner so clear that from it a restoration or model of the mound could be made if desired. This rule should be observed in all excavations.

The same plan could be followed in mounds which from any cause have been reduced in altitude with a corresponding increase in breadth; except that instead of the work beginning at the margin, it may commence on the line to which the mound probably reached when made, and be extended toward either side to the same limits. A convenient method in such mounds is to mark off concentric rings five feet in breadth around the center, undermining and entirely removing the outer one first, and proceeding in the same way successively with the others.

In large mounds where it would be inconvenient or dangerous to work with a bank of such height as would result from carrying out the above suggestions, it is well to cut off the upper half before attacking the lower; or to take off a layer of uniform thickness from the entire surface, leaving a core of the same shape as the original structure, but smaller, which can be examined as first described. If desirable, more than one layer can thus be removed. If the mound is built up in strata, either curved or horizontal, these can be taken off in regular order, and a separate description given of each.

When practicable, careful drawings or photographs, should be made of the entire ground plan; also of the vertical sections at short intervals or wherever they present anything worthy of special notice. When nothing better is to be had, sketches with numerous measurements which may be re-drawn later, are desirable.

The systematic exploration of a cemetery or village-site requires such an expenditure of labor and money that it cannot be attempted except by persons or institutions having ample funds. A trench should be dug entirely across the area to be examined, deep enough to reach below the level at which the site was abandoned. This will be sufficient to expose whatever was left on the original surface, and at the same time show, by the different color or density of the earth, any grave, pit, cache, barbecue-hole, or other excavation that may have been made by the natives. The work should progress at this level as far as the remains extend; the thickness of each deposit, as well as its distance from the present surface, should be carefully measured. Every pit should be cleaned out to the bottom and the depth of each layer of ashes, earth, or whatever else it may contain, accurately measured. All graves should have the earth taken out without changing the position of a bone or a relic until the mode of burial is ascertained with certainty. All these points should be clearly written down, and a uniform system of labeling adopted which will enable the reader to connect intelligently the text, the illustrations, and the specimens. A collection of relics that gives no clue as to how, where, or under what circumstances they were obtained, is of no greater scientific worth than so many pebbles.

AN OHIO MUSEUM.

For two generations Ohio has been ransacked for relics by museums, colleges, and individuals, in many of the states as well as in Europe. If the prehistoric articles from this state, scattered in hundreds of collections, could be brought together, they would form an aggregate probably exceeding in numbers all specimens of American archæology in any museum. And yet, if excavations were carried on in the manner above set forth, there could be gathered a mass of material surpassing what has hitherto been secured. It is time for this work to be undertaken; very few cabinets in the state are accessible except through the kindness of private collectors, many of whom would cheerfully contribute their specimens for the pleasure and instruction of the public, if assured that no loss or damage would ensue. The opportunity is now offered; the new geological building of the Ohio State University has ample room which can be used for this purpose, and here should be established the nucleus of a Museum of Ohio Archæology that would properly represent the great wealth of prehistoric remains within her borders. Large maps and models of all enclosures and fortifications should be made, along with models of mounds so arranged as to display their interior structure and the manner in which their contents were deposited. Thus, and only thus, can future generations gain a clear idea of the nature and appearance of these vestiges, which are being as slowly but as surely blotted out as are the aboriginal conditions of life which gave them existence.

WORKS TO BE CONSULTED.

References to the aboriginal remains of Ohio may be found in hundreds of archæological publications. The reader who wishes to pursue the subject further, will find considerable information in the following volumes. While statements of facts contained in them are to be accepted as correct, he must exercise his judgment and discretion concerning the theories and inferences set forth:

Ancient Monuments of the Mississippi Valley. By Squier and Davis.

Fort Ancient. By Warren K. Moorehead.

Mounds of the Mississippi Valley, Historically Considered. By Lucien Carr.

Primitive Man in Ohio. By Warren K. Moorehead.

Some Early Notices of the Indians of Ohio. By M. F. Force.

Scattered Papers in the Reports of the Bureau of Ethnology, Washington, D. C.; Annual Reports of the Smithsonian Institution; the Reports of the Peabody Museum, Cambridge, Mass.; the Journal of the Cincinnati Historical Society; the Quarterly of the Ohio Historical and Archæological Society, Columbus, Ohio; *Science*, and various other periodicals.

The "Antiquities of Tennessee and the Adjacent States," by Gates P. Thruston, is recommended for comparison; also, "Primitive Industry," by Dr. C. C. Abbott, for its classification of implements and weapons.

CHAPTER II.

BOTANY.

CATALOGUE OF OHIO PLANTS.

BY W. A. KELLERMAN, PROFESSOR OF BOTANY, OHIO STATE UNIVERSITY, AND WM. C. WERNER, ASSISTANT IN BOTANY.

In the various Geological Reports heretofore published both the general and the special features of the topography and geology of Ohio have been recorded. Suffice it therefore to note here that there is only moderate diversity in elevation; though the geological formations exposed are numerous and varied. The soils also exhibit a varied character. They are composed of drift material over a large portion of the state. Sedentary soils occur in the southern portion and alluvium is abundant along the numerous watercourses. The climate is rather uniform, being tempered on the north by a large body of water. In the extreme southern portion of the state there is a barely perceptible approach to a warmer climate.

The flora of the state is therefore rather rich in forms—receiving a few on the north that may be considered as boreal, and a few in the counties bordering on the Ohio river that may, perhaps, correctly be regarded as southern species. Besides, plants occur in the western half of the state which are decidedly significant of the prairie flora. The more broken and hilly area of the east, south, and south-east allies that part of the state botanically to the Appalachian region.

EARLY COLLECTORS.

The flora has received much attention from the people of the state. The early settlers found a magnificent forest that inspired them with awe, though it was to some extent an impediment to their occupancy and tillage of the soil. Many years elapsed before anything in reference to the flora found its way into print, though the lovers of nature, good observers, and real botanists were doubtless numerous.

As making the first though a small contribution to the botanical literature of Ohio, Dr. Daniel Drake of Cincinnati, is to be mentioned. He was a man of great originality, an able physician, and a genial and inspiring teacher. Numerous others deserve mention. Foremost among these is Dr. Jared P. Kirtland of northern Ohio, whose botanical interest and information served to place horticultural pursuits on a higher plane. His influence was most potent in developing interest in Natural History in the entire northwest. Dr. Kellogg was largely instrumental in making known the flora of the northern portion of the state as was also Dr. R. S. Howard—especially through his pupil Dr. N. S. Townshend; who has for years been a teacher of Botany as well as a leader among agriculturists. Dr. John A. Warder of southern Ohio, was an ardent lover of trees and devotees of forest botany of the state owe much to his contagious enthusiasm. Thos. G. Lea of Cincinnati, made important contributions. He was the first to collect the fungi of the state and his catalogue contains a large number of species new to science.

LESQUEREUX, SULLIVANT, AND OTHER BOTANISTS.

Central Ohio was the home of two botanists of world-wide fame; namely, Leo Lesquereux and Wm. S. Sullivant. The former, a palaeobotanist, gave some attention to mosses; the latter, a renowned bryologist, devoted much attention to the local flora and contributed very largely—as did also his brother, Joseph Sullivant, — to the knowledge of the plants of central Ohio. Others who deserve mention are Dr. J. M. Bigelow, Mr. John H. Klippart, Prof. Henry Bolander, Dr. Canfield, Mr. E. J. Ferris, Dr. Jas. Dascomb, Dr. J. S. Newberry, and Dr. H. C. Beardslee

FLORA OF THE WHOLE STATE.

The first author of a flora of the whole state was Dr. J. S. Newberry. It was published in 1859. His own botanical explorations were made for the most part in the northern portion of the state. The second state catalogue (1874) was also published by a botanist of the extreme northern portion of the state, Dr. H. C. Beardslee. He, like the preceding, was a very careful botanist and the contributions of both are highly important. In fact they mark epochs in the botanical history of the state.

WORK OF LATER BOTANISTS.

Justice demands, though space is scarcely available, that some of the later botanists be at least mentioned. Of these, Joseph F. James and C. G. Lloyd of Cincinnati, have done much work on the flowering plants. A. P. Morgan of Hamilton county, has contributed very largely to the development of Mycology in this country and he has made known a large number of the higher fungi of south-western Ohio; he is the author of many new species. Mrs. E. Jane Spence and Miss H. J. Biddlecome have collected extensively at Springfield, Urbana, and Clifton; and many others have largely contributed to the knowledge of Ohio plants. In fact a long list of names would have to be added if this outline sketch of the botanical history of the state made any pretension whatever to completeness.

The publications arranged in chronological order including all printed lists however limited the area covered and all articles relating particularly to Ohio plants, are as follows:

BIBLIOGRAPHY OF OHIO BOTANY.

1815.

Forests of the Miami Country, and Plants Useful in Medicine and the arts. A Natural and Statistical View or picture of Cincinnati and the Miami Country. By Daniel Drake, Cincinnati.

A volume of 255 pages, of which pp. 76–90, inclusive, are devoted to botany. Here nothing farther was "attempted than a catalogue of the forest trees, and such herbaceous plants as are deemed useful in medicine and the arts." Under the head of "Forests of the Miami Country" is given, alphabetically arranged in three columns (the first headed "Families," the second "Species," and third "Popular Name"), a list of one hundred species belonging to about sixty genera, and several undetermined species of the genera Prunus, Crataegus, Mespilus, and Smilax. A long note is given on the species of Aesculus—Ae. flava, L. and Ae. Maxima, n. sp.—presumably mistaken for Ae. glabra, Willd. and Ae. flava. The second sub-head is "Plants Useful in Medicine and the Arts." These are arranged alphabetically under the heads of "Stimulants" (thirteen species), "Tonics" (eight species), "Astringents" (seven species), "Emetics" (nine species), "Cathartics" (six species), "Diuretics" (three species), "Anthelmintics" (three species), "Demulcents" (two species), and "Plants used in Dyeing and the Domestic Arts" (fifteen species). The botanical name, the common name, and the part of the plant used are given in each case. The third and last section is "Calendar of Flora." "Most of the dates given are the mean terms of several years' observation." Thirty-four entries are made, beginning with March 5th, "commons becoming green," and ending with Oct. 30th, "woods leafless."

1818.

Notice of the Scenery, Geology, Mineralogy, Botany, etc., of Belmont county, Ohio, by Caleb Atwater, Esq., of Circleville. American Journal of Science (Silliman's Journal), 1818, Vol. I, p. 226.

Two pages (228–9) of this article are devoted to Botany. Thirty trees are enumerated in tabular form, and a few others, including some shrubs and herbaceous plants, are noted. The uses of a few of them are given.

1831.

Notices of Western Botany and Conchology, by C. W. Short, M. D., and H. H. Eaton, A. M. Transylvania Journal of Medicine and the Associated Sciences. Vol. IX, 1831, p. 69.

An annotated list (pp. 70–73) of fifty species of plants noticed in bloom the preceding fall, on a trip (Sept. 16th to Oct. 1st) from Lexington, Ky., to the southern portion of Ohio (vicinity of Cincinnati). Many of the plants were found on the banks of the Ohio River.

1834.

A Catalogue of Plants growing spontaneously in Franklin Co., Central Ohio, excluding grasses, mosses, lichens, fungi, etc. By John L. Riddell, A. M. The Western Medical Gazette, Vol. II, No. 3, July, 1834, pp. 116–120.

The plants enumerated (317 species) are "arranged under the natural orders approved by Prof. Lindley." Those not native, but naturalized, are marked with a star. The habitats are given for most of the species. The plants were collected during the autumn of 1832, and the spring, summer and autumn of 1833.

1835.

Synopsis of the Flora of the Western States, by John L. Riddell. Western Journal of the Medical and Physical Sciences. Vol. VII, No. XXXI (Second Hexade, Vol. II, No. III), Jan., 1835, pp. 329–374; No. XXXII (Second Hexade, Vol. II, No. IV), April, 1835, pp. 489–556.

The region to which this synopsis or catalogue is intended to apply, "embraces Ohio, Indiana, Illinois, Kentucky, West Tennessee, and Missouri, a small part of Virginia and Pennsylvania, and of the Michigan, Northwest and Missouri territories." The plants of Ohio, unless otherwise accredited, have been personally observed and collected by the writer (John L. Riddell). "The philosophic method of Prof. Lindley is observed in the arrangement." The species are numbered serially, and include flowering plants (1–1724); equiseta (1725–1731); ferns (1732–1769); lycopodaceae (1770–1774); mosses (1776–1785); hepaticae (1786–1789); characeae (1790–1794); and lichenes (1795–1802). The list is preceded by four pages of prefatory remarks, and followed by an index to the genera, of four pages. Stations are given, also time of flowering, color of flower, height of plant, duration of existence (by signs) and the habitats.

1836.

Supplementary Catalogue of Ohio Plants, embracing the species discovered within the state of Ohio in 1835, catalogue and descriptions read and specimens exhibited before the Western Academy of Natural Sciences, March 16, 1836, by John L. Riddell, M. D. Western Journal of the Medical and Physical Sciences, Vol. IX, No. XXXVI (Second Hexade, Vol. III, No. IV), April, 1836, pp. 567–592.

The list contains 170 species, mostly flowering plants and ferns (three Lycopods, two Mosses, and one Liverwort), with localities and stations, general remarks as to size, etc., and a full description of the new species.

1840.

A Catalogue of Plants, native or naturalized, in the vicinity of Columbus, Ohio, by Wm. S. Sullivant, 1840.

A pamphlet of sixty-two pages, giving a mere list of plants which Sullivant collected in Franklin Co. He says, "The collections here listed may be taken, I think, as a tolerably fair representation of the phaenogamous flora of the central parts of this state; nearly all localities, apparently indicating a peculiar vegetation, have been visited." The list (pp. 5–55) contains 779 plants. Seven pages of notes on several species follow the list.

1841.

Florula Lancastriensis, or a Catalogue comprising nearly all the flowering and filicoid plants growing naturally within the limits of Fairfield county, with notes of such as are of medical value, by J. M. Bigelow. Proceedings of Medical Convention of Ohio at Columbus, May, 1841.

Not seen. (Title from Britton's State and Local Floras.)

Florula Lancastriensis: A catalogue of the plants of Fairfield county, by John M. Bigelow and Asa Hor, Lancaster, 1841. A pamphlet of twenty-two pages.

Not seen. (Title from Britton's State and Local Floras.)

1849.

Catalogue of Plants, native and naturalized, collected in the vicinity of Cincinnati, Ohio, during the years 1834–1844, by Thos. G. Lea, Philadelphia, 1849.*

The list is preceded by a "notice" (p. ii.) by Isaac Lea (brother of Thos. G. Lea), who states that the MS. and herbarium were placed in the hands of W. S. Sullivant, who determined the phenogams, mosses and hepaticæ. Edw. Tuckerman identified the lichens, and M. J. Berkley the fungi. Notes and descriptions by the latter are given as foot-notes. The arrangement is according to the natural system. There are enumerated about 698 species of phenogams, nineteen ferns, two equisetaceae, eighty-nine musci, sixty-eight lichens (of which four were new to science) and about 320 fungi (of which about fifty were new), making in all nearly 1,050 species.

*We are indebted for summary of contents to Mr. Davis L. James, to whom we extend thanks for this and other favors

List of the medicinal plants of Ohio, with brief account of their properties, by John M. Bigelow, M. D., Columbus, Ohio, 1849.

Pamphlet of forty-seven pages. (Not seen; given in Britton's State and Local Floras. Torrey Bulletin; vol. X. p. 104).

1852.

Catalogue of Flowering Plants and Ferns observed in the vicinity of Cincinnati, by Joseph Clark. Adopted and published by the Western Academy of Natural Sciences, Cincinnati, 1852.

Pamphlet of thirty pages. The list—preceded only by a list of the officers and curators of the academy, there being no preface—embraces the plants "observed growing in a compass of about six miles around Cincinnati." In a foot-note the author says, "Some of them cannot be found in the circuit * * * * but they were all found as above indicated, within the last fifteen years." The genera of the flowering plants and ferns (Chara flexilis also included) are arranged alphabetically, and the orders are not indicated. No varieties as such are recognized. Six hundred and one species are given, and in an Addenda, by Robert Buchanan, ninety-five more are given, or a total of 696 species.

1854.

The Grasses of Wisconsin and the adjacent States of Iowa, Illinois, Indiana, Ohio and Michigan, and the territory of Minnesota and the region about Lake Superior, by I. A. Lapham. Trans. Wis. State, Agr. Soc. III, 397–488, 1853. Madison, Wis., 1854.

The introduction covers two pages. "For the grasses of Ohio besides my own (Lapham's) observations in that state, I am indebted to the catalogues and communications of Dr. J. L. Riddell, Mr. Wm. S. Sullivant, Mr. Joseph Clark and the late Mr. T. G. Lea." The list contains 149 species. They are arranged in tabular form giving "the scientific name, the common name, the duration and time of flowering, height or length of culms, kind of roots and natural place of growth." Of the 149 species "eleven are found in Ohio and not in the other states or territories. adjoining Wisconsin." Following the tabulation is a general discussion, "artificial arrangement" (key), a full description of all the species mentioned and eleven full paged plates.

1858.

List of the Grasses found in Ohio, by John H. Klippart. Twelfth Annual Report of the Ohio State Board of Agriculture, 1859. Columbus, 1858, p. 37.

This compiled list includes both the native and cultivated grasses, and gives, in tabular form, the scientific name, common name, place where found, condition (wild or cultivated), and flowering time. It covers three pages, and enumerates 105 species.

1859.

Catalogue of the Flowering Plants and Ferns of Ohio, by J. S. Newberry, M. D. Ohio Agricultural Report for 1859, pp. 135–273.

This is "the first effort toward the formation of a complete flora of the state." The list of plants is preceded by a general discussion of the "influences which have determined the distribution of species" over the state, pp. 235–241; and a list of the sources from which the catalogue was compiled, as follows: Catalogue of the plants of Franklin county, by W. Sullivant; catalogue of the plants of Fairfield county, by Drs. Bigelow and Hor; catalogue of the plants of Cincinnati, by Thos. G. Lea; cataogue of the plants of Cincinnati, by Joseph Clark; synopsis of the flora of the Western States, by J. L. Riddell; MS. catalogue of plants in Summit and Cuyahoga counties, by the author.

Localities, as "general," "western," "southern," etc., are given for all species or particular localities for rarer plants. The catalogue includes 1341 species and varieties of flowering plants, and fifty-three vascular cryptograms, or a total of 1394. At this place should, perhaps, be noted the statement of J. H. Klippart, prefixed to the Beardslee Catalogue, which was published in the Ohio Agricultural Report for 1877, to the effect that he, in conjunction with a few others, collected plants and obtained local lists by others, and by this means prepared a catalogue of plants of Ohio, which was submitted to Dr. Newberry for suggestion and correction, and that the latter returned for publication not the original manuscript, but that published whose title is given above.

1860.

List of the Native Forest Trees of Ohio. By John H. Klippart. Ohio Agricultural Report, 1869, pp. 277-8.

This list is appended to Mr. Klippart's article on "Forests, their influence upon Soil and climate," covers two pages, enumerating in tabular form one hundred and seven trees (including both species and varieties, also a few of the larger shrubs) gives the botanical names, the popular names, height in feet, and where (in the State) most abundant.

1865.

Catalogue of Plants Contained in Herbarium of Joseph Clark. By Rachel L. Bodley. Not published. Cincinnati, 1865.

In this printed pamphlet the Cincinnati plants are starred, and number six hundred and seventeen phenogams, and twenty-three ferns.

1872.

New Hepaticae, by C. F. Austin. Bulletin of the Torrey Botanical Club, III, pp. 9. March, 1872.

Original descriptions of species of which three — Jungermannia crenuliformis, J. Sullivantiæ and Frullania Sullivantiæ — are credited to Ohio.

List of Trees Found Growing Indigenously in Ohio. By John Hussey. Twenty-seventh Annual Report of the Ohio State Board of Agriculture for 1872. Columbus, 1873, pp. 32-40.

The list contains both the trees and shrubs, of which two hundred and twenty-seven are enumerated. Localities are given for many of the species, and in several cases notes are added.

1874.

Catalogue of the Plants of Ohio including Flowering Plants, Ferns, Mosses and Liverworts. By H. C. Beardslee. Painesville, Ohio, January, 1874. Pamphlet of nineteen pages. Reprinted in Ohio Agricultural Report, 1877, pp. 346-363.

Dr. Beardslee prepared in the fall of 1873 a catalogue of Ohio plants for publication in the Geological Survey of the State. This list is a condensation of that catalogue, giving "merely a list of genera and species with localities." He reports, including both species and varieties, one thousand one hundred and seventeen Exogens, four hundred and twenty-nine Endogens, and three hundred and eighty-two Acrogens: total one thousand, nine hundred and twenty-eight. Or, rearranging the summary, there are one thousand five hundred and forty-six phenogams, seventy-one vascular cryptogams, two hundred and sixty-one mosses, and fifty hepaticæ.

Report on the Geology of Delaware County. By N. H. Winchell. Report of the Geological Survey of Ohio, 1874. Vol. I, Part I. Geology, p. 272. (Trees, etc., p. 274.)

Of this report two pages (pp. 274-5) are devoted to a list of "Trees, Shrubs, and hardy vines found growing in Delaware County)" furnished by Rev. J. H. Creighton. It is a list comprising the scientific names of one hundred and twenty-two species.

Report on the Geological Survey of Ohio, 1874. Vol. I, p. 415 (Trees p. 416.)

A list of twenty-nine trees which are "characteristic of the county" is given, both the scientific and common names being used.

The Geology of Defiance County. By N. H. Winchell. In report of the Geological Survey of Ohio, 1874, Vol. I, p. 422 (Trees p. 424.)

"In the survey of the county, the following species of trees were noted" namely a list (including scientific and common names) of forty three species.

1875.

Note from Painesville, Ohio. By H. C. Beardslee. Bulletin of the Torrey Botanical Club. Vol. VI, p. 16. 1875.

Notices viviparous species of Scirpus, and occurrence of Fissidens hyalinus, Amarantus Blitum, and Hydrodictyon utriculatum.

1876.

Some interesting Cryptogams found near Painesville, H. C. Beardslee Botanical Bulletin, (Gazette), Vol. I, p. 12. January, 1876.

Discelium nudum found in 1872; Fissidens hyalinus, 1873; Riccia frostii in 1874.

List of Hepaticæ growing in Ohio. Dr. H. C. Beardslee, Painesville, Ohio. Botanical Bulletin (Gazette) Vol. I, p. 22. April 1876.

A list, without stations, of sixty species and varieties.

Forest trees of the United States, Centennial Collection (Varsey) Ohio Trees (Klippart), Ohio Agricultural Report, 1876, pp. 354-388.

This is a reprint of a Report by Dr. Vasey to the Commissioner of Agriculture, and Mr. J. H. Klippart added the word "Ohio" to such as occur in this state.

A peculiar form of Ragweed. Ambrosia artemisiæfolia. By Joseph F. James; Botanical Gazette. Vol. I, p. 63. Dec. 1876.

Specimens found at Loveland, Ohio, with no sterile flowers, but fertile flowers in upright spikes.

1877.

Wolffia (mode of reproduction). By H. C. Beardslee. Botanical Gazette, Vol. I, p. 99. April, 1877.

Indentation and finally fission of the frond.

Camptosorus rhizophyllus Miss H. J. Biddlecome, Botanical Gazette Vol. I, p. 100. April 1877.

Prolongation of basal lobe five inches, in two cases the apex had taken root.

Some Hardy Dentarias. By Joseph F. James. Botanical Gazette. Vol. I, p. 115. June, 1877.

Some specimens of Dentaria laciniata not injured by frost.

Some Nymphæas. By H. C. Beardslee. Botanical Gazette, Vol. II, p. 144. October, 1877.

Nelumbium luteum at Bass Lake. Nymphæa with pink flowers.

1878.

Flora of the Miami Valley. By A. P. Morgan. Published by the Literary Union, Dayton, Ohio, 1878.

A pamphlet of sixty-eight pages, including the Phenogams, Ferns, Mosses, Liverworts, Lichens, and Fungi of Miami, Montgomery, Butler, Warren, and Hamilton Counties.

Botrychium lunarioides var. obliquum. By Mrs. E. J. Spence. Botanical Gazette, Vol. III, p. 39. April, 1878.

Specimen with two disconnected, well-developed spikes.

Report of the Geology of Darke County. By A. C. Lindemuth. Second Report of the Geological Survey of Ohio. Vol. III, part I. Geology, 1878, p. 496.

The "most common forest trees noticed" are given (thirty-two in number) both by popular and botanical name (on pp. 511-2).

1879.

Fresh-water Algae; synopsis of discoveries and researches, in 1878 by Francis Wolle, Bulletin of the Torrey Botanical Club, VI. p. 281 Jan. and Feb., 1879.

Several of the species reported in this article for America are described as new, among them, Chantransia beardslei, found at Painesville, Ohio.

Catalogue of the Flowering Plants, Ferns, and Fungi growing in the vicinity of Cincinnati. By Joseph F. James. Journal of the Cincinnati Society of Natural History, April, 1879; also separate pp. 1-27.

The author compiled the work from personal observation, and from the catalogues of Messrs. Lee and Clark. Assistance from others is also acknowledged. The list of fungi was "copied bodily from the excellent catalogue of Mr. Lea published in 1846," and a few collected since, added. The corrections in nomenclature and orthography were made by Prof. Charles H. Peck. Eight hundred and ninety phenogams and vascular cryptogams (including also Chara flexilis) and three hundred and nineteen fungi are given, or a total of one thousand two hundred and eighteen species and varieties.

Agaricus Morgani Peck. By A. P. Morgan. Botanical Gazette. Vol. IV, p. 208. Sept. 1879.

Notes extremely large specimen, largest in the world; mentions color of spores, green.

Notes from Toledo, Ohio. By J. A. Sanford. Botanical Gazette, Vol. IV, p. 219. October, 1879.

Mentions Schollera, Solidago, Liatris, Amarantis, Zizania, Cornus, and Lactuca.

1880.

Draba verna, L. and Sisymbrium Thaliana, Gaud. biennial. By H. C. Beardslee. Bulletin of the Torrey Botanical Club, Vol. VII, p. 21. February, 1880.

Notices of rosettes of radical leaves of three species, Feb. 18, which were found in the previous fall.

Notes from Painesville, by H. C. Beardslee. Botanical Gazette, Vol. V, p. 43. April, 1880.

Mentions viviparous specimens of Scirpus and Cenchrus and biennial habit of Draba and Sisymbrium Thaliana.

Teratology; Carya alba. By H. C. Beardslee. Bulletin of the Torrey Botanical Club, Vol. VII, p. 54. May, 1880.

Notices occurrence of triangular nuts of Carya alba (apparently C. sulcata).

Double Thalictrum anemonoides. By Mr. Dory. Botanical Gazette, Vol. V, p. 64. June, 1880.

A note by "T. M." stating the occurrence as noted by Mr. Dory at Springfield, Ohio, of a fully double Thalictrum of a rosy tint of white.

New Stations for rare Plants. By A. P. Morgan. Botanical Gazette, Vol. VII, p. 79. July, 1880.

Notes occurrence of Botrychium matricariæfolium at Columbus and Veratrum Woodii at Dayton.

1881.

Notices of the Floras of Cincinnati, published from 1815 to 1879 with some additions and corrections to the catalogue of Joseph F. James. By Davis L. James. In the Journal of the Cincinnati Society of Natural History, January, 1881.

The additions and corrections are numbered to correspond to the numbers in Joseph F. James' Catalogue and consist of ninety-three entries.

Nymphæa odorata. By Davis L. James. Botanical Gazette, Vol. VI, p. 266. Sept., 1881.

Notes structure of the fruit (aril) to secure dispersion of seeds as noticed by Dr. John A. Warder and son at North Bend, Ohio.

Notes from Dayton. By August F. Fœrste. Botanical Gazette, Vol. VI, p. 274. Oct., 1881, and Vol. VII, p. 24. Feb., 1882.

Gives arrangement of leaves in Conobea multifida and Nesæa verticillata; mentions forked pinnæ in Dicksonia and notes occurrence of Lycoperdon pedicellatum at Dayton.

Potamogeton Hillii, n. sp. by Thos. Morong. Botanical Gazette, VI, p. 290. Nov. 1881.

Original description of the species. The same plant was collected at Ashtabula, O., by Rev. E. J. Hill in 1880, but mistaken for a form of P. zosterifolius—see Bot. Gaz., V, 53. April, 1880.

1882.

Woody Plants of Ohio, arranged under their appropriate Botanical orders with remarks upon their uses, qualities and sources. By Jno. A. Warder, M. D., President American Forestry Association, assisted by Davis L. James and Jos. F. James, of the Cincinnati Society of Natural History. Presented at the meeting of the Agricultural Convention of Ohio, in Columbus, January, 1882.

Pamphlet, pp. 1–40. Brief address to the convention referring to prevailing ignorance as to our native forest trees, explanation of the paper (pp. 2–3), explanatory note to the reader (pp. 3–4), "note" by D. L. J. and J. F. J. p. 4, and Woody Plants of Ohio, pp. 5–40. Native species printed in blackfaced type of which two hundred and sixty-one are enumerated. One hundred and thirty-seven introduced species are mentioned accompanied usually, as are the native species, with brief descriptive notes, printed in small capitals, if foreign plants, and in italics if introduced from other portions of the United States. The paper is mostly a record of Dr. Warder's own observations, though many localities are given on the authority of Beardslee and Newberry.

A large Grape-vine. By C. E. Bessey. Bulletin of the Torrey Botanical Club, Vol. IX, p. 11. Jan. 1882.

A colony of large grape-vines (Vitis Labrusca) in Wayne Co., Ohio, with trunks ranging from three inches to over one foot in diameter.

Teratological Note. By A. F. Fœrste. Botanical Gazette, Vol. VII, p. 112. Aug. and Sept., 1882.

Multiplication of parts in Lathyrus palustris at Dayton.

A New Polyporus. By A. P. Morgan. Botanical Gazette, Vol. VII, p. 135. Nov. 1382.

Describes Polyporus reniformis, Morgan, occurring from Dayton to Cincinnati.

Lactuca Scariola, L. By Aug. F. Fœrste. Botanical Gazette, Vol. VII, p. 137. Nov., 1882.

Abundant at Dayton, Put-in-Bay, etc.; places its vertical leaves so as to point to the poles.

1883.

Mycologic Flora of Miami Valley, by A. P. Morgan, in the Journal of the Cincinnati Society of Natural History, Apr. 1883, Jan. 1888, Vol. VI–XI. Nine numbers as follows: April, July, Oct. (1883), Apr. (1884), July, Oct. (1885), Apr. (1887), Jan. (1888), July, Oct. (1888)

It includes full and original descriptions of Hymenomycetes of all the species found, some of which are new and many are illustrated by colored plates.

Large Rhus Toxicodendron, by Aug. F. Fœrste, Botanical Gazette, Vol. VII, p. 245. June, 1883.

Specimen at Dayton seventeen inches in circumference.

Abnormal Trillium. By Jos. F. James. Bulletin of the Torrey Botanical Club, Vol. X, p. 57. May, 1883.

A specimen of T. sessile growing at Cincinnati with parts mostly in fives.

Violet with Runners. By Jos. F. James. Bulletin of the Torrey Botanical Club, Vol. X, p. 57. May, 1883.

Many specimens of Viola striata found near Cincinnati with runners twelve to eighteen inches long.

Chorisis in Podophyllum, by Aug. F. Fœrste, Botanical Gazette, Vol. VIII, p. 259. July, 1883.

Notes on *Dedoublement* in specimen of Podophyllum at Dayton.

New species of North American Fungi, by J. B. Ellis and W. A. Kellerman in American Naturalist, Nov., 1883, pp. 1164–1166.

Fourteen species are enumerated and described of which ten were collected in Ohio, (the remaining in Kansas).

1884.

Report on weeds (by W. S. Devol) second report of the Ohio Agr. Experiment Station for 1883, Columbus, 1884, p. 187.

Notices number of weeds in the state, means of destruction and commonest ones in different sections of the state. A part of the same article is also reported under "Report of Committee on Botany" in the proceedings of Columbus Horticultural Society, Dec. 4, 1884.

New species of Fungi. By Chas. H. Peck. Bulletin of the Torrey Botanical Club, XI, p. 26. Feb., 1884.

Descriptions of new species of which Myriadoporus adustus and Hypomyces xylophilus were from Ohio.

Abnormal Trillium, by Jos. F. James. Botanical Gazette, Vol. IX, p. 113, July, 1884.

Four-parted Trillium erectum, whorl of three leaves and small leaf on peduncle.

Contributions to the Flora of Cincinnati, by Jos. F. James, in the Journal of the Cincinnati Society of Natural History, July, 1884.

The article covers fourteen pages and gives the results of observations of the plants of the vicinity of Cincinnati, which have been accumulating the past two years. Besides critical notes on the species, new localities are given for many plants and a few, not before reported for that region, are given.

1885.

Descriptive notes of some of the newer and least known weeds of the State (W. R. Lazenby) in the Third Annual Report of the Ohio Agr. Experiment Station for 1884, Columbus, 1885, p. 164.

Twelve species are described from notes "from the answers received from the circulars and from observations made by the Station."

1886.

Report on Forestry (by W. R. Lazenby), in Fourth Annual Report of the Ohio Agr. Experiment Station for 1885, Columbus, 1886, pp. 242.

The report covers two pages (242–3) and contains, (1) a "list of the principal timber trees of Ohio," fifty-one species, both common and scientific names are used; (2) a tabulation of "comparative growth and hardiness of forest tree seedlings," sixteen species.

Report on Weeds (by W. S. Devol), in Fourth Annual Report of the Ohio Agr. Experiment Station for 1885, Columbus, 1886, p. 193.

This report covers fourteen pages and includes "weeds on different soils" (p. 193); "general remarks" (p. 194); "descriptive notes of five species" (pp. 194–196); "prolificacy of weeds" (pp. 196–198, essentially the same also in the Journal of the Columbus Horticultural Society, Vol. III, No. 3, March, 1888, pp. 38–43); and a "List of the Plants of Ohio (229 species) which generally appear as weeds" (pp. 198–206).

The Flora of Ross County, Ohio, compared with that of New England, by W. E. Safford, Bulletin of the Torrey Botanical Club, Vol. XIII, p. 114, July, 1886.

Notices a large number of conspicuous plants, many of which do not reach New England.

Natural History of the Grape, by W. R. Lazenby, in Proceedings of the Columbus Horticultural Society, Columbus, Sept. 25, 1886, pp, 4.

A general account of the family and gives four species growing wild in Ohio; Vitis Labrusca, V. âestivalis, V. riparia, and V. cordifolia.

Notes on some Introduced Plants chiefly in Summit county, Ohio, by E. W. Claypole, in Bulletin of the Torrey Botanical Club, Vol. XIII, p. 187, Oct., 1886.

A record of some introduced plants; ten species of which are well established and six represented by a single specimen of each.

1887.

Report on Weeds (by W. S. Devol) in the Fifth Annual Report of the Ohio Agr. Experiment Station for 1886, Columbus, 1887, p. 230.

Sixteen species are named which "have been discovered in the State since the publication of Dr. Beardslee's Catalogue of Plants of Ohio," (pp. 230) (The same list is printed in the Journal of the Columbus Horticultural Society, Vol. III, No. 1, Jan., 1888, p. 47). This list is followed by a "list of plants identified" (pp. 231–3).

Botanical Notes (by W. R. Lazenby) in the Fifth Annual Report of the Ohio Agr. Experiment Station for 1886, Columbus, 1887, pp. 304.

A few short notes are given (p. 304) followed by a list (pp. 305–7) of seventy-four species with their dates of blooming in the years 1882–7.

Notes on Sanguinaria Canadensis by Aug. F. Fœrste, in the Bulletin of the Torrey Botanical Club, Vol. XIX, p. 74, April, 1887.

An article two pages in length and one plate giving the morphology of the plant; locality, Dayton.

List of Algae, by H. L. Jones, in Bulletin of the Scientific Laboratories of Dennison University, May, 1887, Vol. II, pp, 115–6.

A list of thirty-four species, mostly Desmids, found in the Licking Reservoir and the ponds about Granville, Ohio.

Botanical Notes (Liquidambar in Ohio) by Jos. F. James. Bulletin Torrey Botanical Club, Vol. XIV, p. 223, Oct. 4, 1887.

Notes occurrence of Liquidambar near Oxford and the vicinity of Cincinnati.

Plants in bloom in September, October and November, (observed by Moses Craig and reported by W. S. Devol) Journal of the Columbus Horticultural Society, Vol. II, Nos. 10, 11, 12, Oct., Nov., Dec., 1887, pp. 166, 189, 207.

The lists number eighty-eight, fifty-eight and six species respectively.

Note on the color of Caulophyllum thalictroides, by K. B. Claypole. Bulletin of the Torrey Botanical Club, Vol. XIV, p. 258, Dec. 3, 1887.

Notices the less dark color of this species in Ohio than in Canada.

1888.

Botanical Notes (by W. R. Lazenby) in Sixth Annual Report of the Ohio Agr. Experiment Station for 1887, Columbus, 1888, p. 286.

This article consists of "plants named" pp. 286–8. Date of blooming of plants for 1882–7, a list of 317 species (pp. 289–298).

List of Diatoms from Granville, Ohio, by J. L. Deming, in Bulletin of the Scientific Laboratories of Dennison University, April, 1888, Vol. III, pp. 114–5.

A list of twenty-four species preceded by a general account of Diatoms.

Arbor Day Number, Journal of the Columbus Horticultural Society, Vol. III, No. 5, May, 1888.

Devoted to an account of Arbor Day exercises at the Ohio State University to which is appended a list of "Native Trees of Ohio."

List of Algae from Granville, Ohio, by Chas. L. Payne, in Bulletin of Dennison University, Dec., 1888, Vol. IV, Part I, p. 132.

Sixteen species are enumerated as an additional list to that published in 1887 by H. L. Jones. One Spirogyra "appears to be undescribed."

1889.

Preliminary List of the Flowering and Fern Plants of Lorain Co., Ohio, compiled by Albert A. Wright, professor of Geology and Natural History in Oberlin College, Oberlin, Ohio, 1889.

A pamphlet of thirty pages, containing a map of Lorain Co., a preface (pp. 3–5), list of botanical books (p. 5, eight entries) and list of plants (pp. 7–30). The plants introduced from other countries are printed in italics. The list was "made principally by putting together the observations of the compiler and a few friends who have made recent collections in this county * * * also the collection of the late Dr. Jas. Dascomb * * * the species ascribed to this county by Dr. Kellogg in Dr. Newberry's catalogue and those reported by Dr. H. L. Howard * * * in Beardslee's yet unpublished catalogue * * * have all been noted." There are 887 species enumerated.

Report of the Committee on Botany, by Aug. D. Selby, Journal of the Columbus Horticultural Society, Vol. IX, No. 2, June, 1889, p. 35.

Notices the number of plants in bloom in March and gives a list of sixteen species.

Report of the Committee on Botany, by Aug. D. Selby, Columbus Horticultural Society, Vol. IV, No. 4, Dec., 1889, p. 107.

Notices rarity or profusion of blossoms according to deficiency or abundance of moisture and occurrence of new and rare plants to the county.

1890.

A Catalogue of the Uncultivated Flowering Plants growing on the Ohio State University grounds, by Moses Craig, in the Bulletin of the Ohio Agr. Experiment Station, Technical Series, Vol. I, No. 2, May, 1890, pp. 49–110.

The catalogue proper is preceded by an Introduction, Limits of the flora and its physical characters, Geology of the farm, Notes on the climate, Extent and beauty of our flora, Time of blooming of plants, maps, classification, statistics of the catalogue, etc., pp. 49–61. The number of species and varieties enumerated is 468. In nearly every case they are accompanied by full notes as to occurrence, abundance, etc.

A preliminary List of the Plants of Franklin county, Ohio, prepared for the Columbus Horticultural Society, by Aug. D. Selby and Moses Craig, M. S. Committee on Botany for 1890.

A pamphlet of nineteen pages, three of which (3–5) contain the Introduction, twelve (7–18) include the neatly printed list—the genera in black-faced type arranged alphabetically under the orders, and the species alphabetically arranged under the genera—and the last page (19) gives a summary of added and introduced plants. The list contains 1,002 plants, being an addition of 223 to Sullivant's Catalogue published fifty years before.

Mycologic Observations, I. (January, 1890), by A. P. Morgan, Botanical Gazette, Vol. XV, No. 4, April, 1890, p. 34.

Notices many fungi to be seen in Winter, as Agaricus Sepridas, Tremellas, Schizophyllum, Menispora, Aithrosporum, Bactridium, Naematelia, Stereum, Dacrymyces.

Supplementary List to the Plants of Ohio preliminary to a complete catalogue of the flora of the State, by William R. Lazenby and W. C. Werner, Department of Botany and Horticulture, Ohio State University, Columbus, Ohio, 1890.

Native species are printed in heavy faced type, those introduced in small capitals. "The total number of plants, including both species and varieties, enumerated in this list, is one hundred and twenty-three. Of this number sixteen are cryptogams. Deducting these there are one hundred and thirteen indigenous and sixty-four introduced Phaenogams."

Plants blooming in February and March, by Aug. D. Selby, Journal of the Columbus Horticultural Society, Vol. V, No. 2, June, 1890, p. 24.

Gives date of blooming of twenty-four species.

The Snowy Trillium (T. nivale, Riddell), by Aug. D. Selby, Journal of the Columbus Horticultural Society, Vol. V, No. 2, June, 1890, p. 36.

Gives a general description, its distribution and a full page plate.

Prickly Lettuce—An Introduced Weed, by Miss Freda Detmers, Journal of the Columbus Horticultural Society, Vol. V, No. 3, September, 1890, p. 53.

Gives a general description of the plant, illustrated by a plate showing infloresence and leaves, natural size.

Wild Carrot (Daucus Carota L.), by Aug. D. Selby, Journal of the Columbus Horticultural Society, Vol. V, No. 3, September, 1890, p. 70.

Gives a general description and notices its distribution and means of eradication.

The Lakeside Daisy, by Clarence M. Weed, Journal of the Columbus Horticultnral Society, Vol. V, No. 3, September, 1890, p. 72.

Describes and notices occurrences of Actinella acaulis in the limestone plains of the Sandusky Peninsula. (The plant found was Actinella acaulis, var. glabra, and not A. acaulis).

Report of committee on botany, by Aug. D. Selby, Journal of the Columbus Horticultural Society, Vol. V, No. 4, December, 1890, p. 85.

Mentions results of collecting during the year and the new finds at Sellsville, near Columbus.

1891.

Notes from Columbus, Ohio, by Aug. D. Selby, Botanical Gazette, XVI, p. 148. May, 1891,

Notes occurrence of Bidens connata with upwardly barbed awns and gives list of introduced plants on circus grounds of Sells' Brothers near Columbus, Ohio.

Our Native Oaks, by Aug. D. Selby, Journal of the Columbus Horticultural Society, Vol. VI, No. 2, June, 1891, p. 41.

Gives a general account of the oaks and recommends for cultivation for ornamental purposes especially the Pin Oak, also; Yellow, Scarlet and Laurel Oaks.

The Fungous Diseases of Lettuce, by Miss Freda Detmers, Journal of the Columbus Horticultural Society, Vol. VI, No. 2, June, 1891, p. 47.

Notices and describes Septoria Lactucae, Septoria consimilis and Peronospora gangliformis.

Botany—May, (under Communications and Discussions), by Aug. D. Selby, Journal of the Columbus Horticultural Society, Vol. VI, No. 2, June, 1891, p. 63.

Notices the collecting of several rare plants near Columbus.

A Vigorous Foreigner, by C. M. Weed, American Garden, Vol. XII, p. 620.

Notices Lactuca scariola as occurring in Ohio accompanied with figure of the plant.

Some Troublesome Weeds and the Ohio Statutes Relating to Weedy Plants, by Aug. D. Selby, Journal of the Columbus Horticultural Society, Vol. VI, No. 3, September, 1891, p. 96.

Mentions characteristics of a weed and gives the six worst weeds for Franklin county (Wild Carrot, Canada Thistle, Wheat Thief, Moth Mullein, Toad Flax, Ribgrass, and Narrow Dock) and Ohio laws relating to Weeds.

Plants Introduced at Sellsville, near Columbus, Ohio, by W. R. Lazenby. Bulletin of the Torrey Botanical Club, Vol. XVIII, p. 301, Oct. 1891.

Gives a list of eighteen plants occurring in the place used by Sells' Brothers as the winter quarters for their circus and menagerie, seven of which occur elsewhere in the state.

List of plants observed growing wild in the vicinity of Cincinnati, Ohio, by C. G. Lloyd, Cincinnati, Ohio, Oct., 1891.

A pamphlet of eight pages giving list of six hundred and seventeen species of phenogams and vascular cryptogams.

Diseases of the Raspberry and Blackberry, by Miss Freda Detmers. In Bulletin of the Ohio Agricultural Experiment Station Second Series, Vol. IV, No. 6, Oct., 1891, p. 124.

A general account of four parasitic fungi infesting the raspberry and blackberry, namely Gloeosporium venetum, Septoria Rubi, Caeoma nitens, and Blight of Raspberry.

Report of the Committee on Botany, by Aug. D. Selby, Journal of the Columbus Horticultural Society, Vol. VI, No. 4, December, 1891, p. 111.

Mentions activity in collecting plants last year and gives over fifty "Additions to Preliminary List of the plants of Franklin county, Ohio."

Plum Pockets (Exoascus Pruni, Fckl.), by Miss Freda Detmers. Journal of the Columbus Horticultural Societp, Vol. VI, No. 4, December, 1891, p. 113.

Notices occurrence of Exoascus Pruni, the upper portions of twigs of Prunus Americana and on the same both of Monilia fructigenum, Pass. and Phyllosticta prunicola, Sacc.

Apple Scab (Fusicladium dentriticum), by Miss Freda Detmers, in Bulletin of the Ohio Agricultural Experiment Station, Sec. Ser. Vol. IV, No. 9, December, 1891, p. 187.

An account covering three pages, including general remarks, external characters and effect on host, and "microscopical characters."

On the Occurrence of Certain Western Plants at Columbus, Ohio, by Aug. D. Selby Proceedings of the Indiana Academy of Science, 1891, Terre Haute, 1892, p. 74.

Mentions the blending in central Ohio of eastern and western spec es of plants and notices presence of "distinctly western and southwestern plants, introduced by wholesale, as it were," giving twenty such species as found on Sell Brothers' circus grounds at Columbus.

Variations and Intermediate Forms of Certain Asters, by W. C. Werner. Journal of the Cincinnati Society of Natural History, Vol. IV. No. 1, April, 1892, p. 55.

The variations of the species noticed in northern and Central Ohio are Aster Shortii, A. undulatus; A. cordifolius; A. saggittifolius; A. Lindleyanus.

A Fungous Enemy of Plant Lice (*Empusa Aphidis*), by Miss Freda Detmers. Journal of the Columbus Horticultural Society, Vol. VII, No. 1, March, 1892, p. 121.

Notices occurrence of Empusa Aphidis in greenhouse on various species of plant lice, as Phorodon mahaleb, Aphis mali, Aphis on chrysanthemum.

Some Fungous Pests of Greenhouse Plants, by W. A. Kellerman. Journal of the Columbus Horticultural Society, Vol. VII, No. 1. March, 1892, p. 20.

Describes two fungous diseases, carnation rust, (Uromyces carophyllinus [Schrank] Schroet.) and "damping off;" specimens of the former exhibited, now occurring in Ohio.

Catalogue of the Phanerogams and Ferns of Licking County, Ohio by Herbert L. Jones, in Bulletin of the Scientific Laboratories of Denison University, Vol. VII, pp. 4–103, March, 1892.

On pages 4 to 11 inclusive are given the Introduction, Herbaria, Geology of Licking county, Altitude of different points, rainfall, temperature, etc., a list of the worst weeds, times of flowering, trees, locations of special botanical interest, forms of certain species, nomenclature and map. The list of species (pp. 11–101) is accompanied with notes as to localities, dates, etc. The total number of species and varieties enumerated is 945. On page 102 is given a summary of species under distributions as to soil and comparison with other Ohio floras; on p. 103, errata. A map of the county accompanies the catalogue.

On the Flora of Northern Ohio, by Edo Claassen, in American Journal of Pharmacy, March and April, 1892.

This article covers nine pages and describes the explorations of the author made on the Lake Erie shore and islands. Rarer plants, peculiar to many different localities, are named, and finally a more extended list (of several hundred species) of plants more widely distributed concludes the paper.

Two New Genera of Hyphomycetes, by A. P. Morgan. Botanical Gazette, XVII, p. 190, June, 1892

Descriptions are given of Cylindroctadium scoprium, Morgan, and Synthetospora electa, Morgan.

Forest Trees of Ohio for the World's Columbian Exposition (by W. A. Kellerman.) Bulletin No. 5, Ohio World's Fair Commission, Columbus, (1892); also (in part) in First Quarterly Report of the Executive Commissioner for Ohio.

Contains a list of eighty-eight species, giving both botanical and common names; also a list of twenty-three species doubtfully classed as trees; five doubtfully occurring in Ohio.

Reports of Standing Committees: Botany; May. By Aug. D. Selby. Journal of the Columbus Horticultural Society, Vol. VII, No. 2, July, 1892, p. 67.

Notices plants near Central College, allied to Appalachian Flora.

Reports of Standing Committees: Vegetable Pathology; May. By W. A. Kellerman. Journal of the Columbus Horticultural Society, Vol. VII, No. 2, July, 1892, p. 70.

Notices abundance of peach curl, black knot, and bramble rust; mentions weeds as harboring certain fungi which are destructive to crops, hence the necessity of destroying them.

Field Experiments with Wheat, by J. Freemont Hickman, in the Bulletin of the Ohio Agricultural Experiment Station, Sec. Ser., Vol. V, No. 5, Aug. 1892, p. 83.

Under the sub-head of Scab and Smut (p. 93) note is made of prevalence of scab, loose smut and stinking smut or "bunt" on wheat.

Botanical papers of the A. A. A. S.; note on Yellow Pitch Pine, by W. A. Kellerman, Botanical Gazette, XVII, No. 9, Sept., 1892, p. 280.

Notices occurrence of a new variety of Pinus rigida, P. rigida, var- lutea, Kellerman, in Fairfield county, Ohio.

A Preliminary List of the Rusts of Ohio, by Miss Freda Detmers, in the Bulletin of the Ohio Agricultural Experiment Station, Sec. Ser., Vol. V, No. 7, Sep. 1892, p. 133.

In the list (pp. 133–140) of sixty-eight species are given the name of the rust, the name of the plant on which it is found, the locality in, and the time at which it has been collected, together with occasional notes.

Description of a New Phalloid, by A. P. Morgan, in the Journal of the Cincinnati Society of Natural History, Oct., 1892.

A new genus and species (Phallogaster saccatus Morgan) found in Hamilton county, (Morgan); Licking county, (C. J. Herrick); also in New York and Connecticut is described and illustrated by a lithographic plate.

The Wild Plants of Northeastern Ohio; Preliminary List of the Wild Plants of Ashtabula county, by Sara F. Goodrich, Western Reserve School Journal, Geneva, Ohio, Nov., 1892, and Jan., 1893.

A preface precedes the list; the latter gives the scientific and common names of the plants.

New Plants for the Flora of Ohio, by W. C. Werner. Read before the Ohio State Academy of Science, December, 29, 1892. Bulletin of the Ohio Agricultural Experiment Station, Tech. ser., Vol. I, No. 3, April, 1893, p. 235.

Notes the occurrence of Fossombronia cristata, Thuya occidentalis (apparently mistaken by early Ohio collectors for Chamæcyparis thyoides), Monarda clinopodia, Oxalis recurva, Lobelia puberula, Centauria Jacea Cyperus sylvaticus, Eleocharis quadrangulata, Bignonia capreolata, and Opuntia Rafinesquii.

The Ohio Erysipheæ, by Aug. D. Selby. Read before the Ohio State Academy of Science, December 29, 1892. Bulletin of the Ohio Agricultural Experiment Station, Tech. ser., Vol. I, No. 3, April, 1892, p. 213.

Includes a general account of the group and a list of Ohio species with hosts, stations, dates, and collectors, and notes on many of the species

Notes on Rare Ohio Plants, by Aug. D. Selby. Read before the Ohio State Academy of Science, December 29, 1891. Bulletin of the Ohio Agricultural Experiment Station, Tech. ser., Vol. I, No. 3, April 1893, p. 241.

Notes the occurrence of Erysimum aspernum and Gonolobus obliquus at Columbus; and Silene rotundifolia at Ash Cave, Hocking county.

New and Rare Plants for the flora of Ohio, by W. A. Kellerman. Read before the Ohio State Academy of Science, December 30, 1892. Bulletin of the Ohio Agricultural Experiment Station, Tech. ser., Vol. I, No. 3, April, 1893, p. 241.

Notices occurrence of one specimen of Ilex opaca, apparently native in Lawrence county; the occurrence of one specimen of Lea's oak, at Brownsville, Licking county; and Polypodium incanum, at Mineral Springs, Adams county; and an unsuccessful search for Magnolia tripetala, in Lawrence county.

Corrections and Additions to Moses Craig's Catalogue of the uncultivated flowering plants growing on the Ohio State University grounds, by W. A. Kellerman and Wm. C. Werner. Bulletin of the Ohio Agricultural Experiment Station, Tech. ser., Vol. I, No. 3, April, 1893, p. 224.

Gives a large number of corrected identifications and many additional species.

Notes on the Distribution of Some Rare Plants in Ohio, by Wm. C. Werner. Read before the Ohio State Academy of Science, December 30, 1892. Bulletin of the Ohio Agricultural Experiment Station, Tech. ser., Vol. I, No. 3, April, 1893, p. 232.

The following are some of the plants: Sullivantia Ohionis, Iris cristata, Sabbatia angularis, Draba verna, Juncus Canadensis—with extended range indicated.

Additions to the Preliminary List of the Uredineæ of Ohio, by Miss Freda Detmers. Read before the Ohio State Academy of Science, December 30, 1892. Bulletin of the Ohio Agricultural Experiment Station, Tech. ser., Vol. I, No. 3, April, 1893, p. 171.

Gives a general account of the life history of the species of the group and an annotated list of the unreported Ohio species.

The Lichens of Ohio, by E. E. Bogue. Read before the Ohio State Academy of Sciences, December 30, 1892. Journal of the Cincinnati Society of Natural History, April, 1893, p. 37.

1893.

Additions to the Preliminary List of the Flowering and Fern Plants of Lorain County, Ohio, compiled by Albert A. Wright, Oberlin, Ohio, 1893. Laboratory Bulletin, No. 1, Supplement.

A pamphlet of eleven pages, giving a list of 106 additions, all the species being "authenticated by specimens now in the college herbarium."

The Myxomycetes of the Ohio Valley, Ohio, by A. P. Morgan. First paper (read Jan. 3, 1893), Journal of the Cincinnati Society of Natural History, January, 1893.

Gives a general description of the group, followed by descriptions of the species. Twenty-four species (five of them new) belonging to seven genera are described, accompanied by a plate of twelve figures.

Die Glumifloren des Noerdlichen Ohio, von Edo Claassen, Cleveland, Ohio. Pharmaceutische Rundschau, February, 1893.

Gives list of species found along the shore of Lake Erie in the counties of Cuyahoga, Ottawa, Erie, Lake, Medina, Summit, Geauga and Portage.

Ipomaea pandurata, by A. F. Linn. Bulletin of the Torrey Botanical Club, Vol. XX, p. 258, June, 1893.

Notes occurrence of a large root (weight twenty-five pounds) of this species at Springfield.

SCOPE AND CHARACTER OF PRESENT PUBLICATION.

This catalogue is the first to include all the groups of plants represented in Ohio. Our knowledge of the flowering plants and of the higher cryptogams, or flowerless plants, is based on the work of many botanists and hosts of collectors. A large portion of the collected material has passed through our hands and we have visited many portions of the state. But few of our botanists have studied the Mosses, Liverworts, Lichens, Fungi and Algæ and collectors have almost invariably neglected them. The list in the lowest groups (Thallophytes) must be considered very fragmentary and a mere beginning.

The state catalogue also differs from its predecessors in giving stations (with credit to first collectors) for all except the commoner plants. It has been the aim to admit no plant of doubtful occurrence, though in some of the groups, especially in the Algæ, no censorship was possible.

A tabulation for popular use is here inserted, presenting a comprehensive view of the several groups and their relation to each other.

SYNOPSIS OF VEGETABLE KINGDOM.

Phenogams (flowering plants)	Angiosperms	Dicotyls—Ex.—Anemone, Cockle-bur, Mint, Deciduous Trees.
		Monocotyls—Ex.—Lily, Flag, Grasses.
	Gymnosperms	Cycads—Ex.—Cycas, Zamia.
		Conifers—Ex.—Pines, Cedars, Firs.
		Gnetaceae—Ex.—Welwitschia.
Cryptogams (flowerless plants)	Vascular cryptogams	Club-mosses—Ex.--Ground pine, Lycopods.
		Horse-tails—Ex.—Scouring rushes, Equisetum.
		Ferns—Ex.—Maiden hair, Brake, Wood-fern.
	Bryophytes	Mosses—Ex.—Mosses.
		Liverworts—Ex.—Liverworts.
	Thallophytes	Fungi—Ex.—Mushrooms, Rusts, Lichens, Mildews, Yeast-plants.
		Algæ—Ex.—Green Pond Scums, Desmids, Sea-weeds.
		Bacteria—Ex.—Micro-organisms of decay, fermentation, disease, etc.
		Diatoms—Ex.—Diatoms in fresh and salt water.
		Slime Moulds—Ex.—" Flowers of tan," Parasite of Clubfoot, etc.

NOMENCLATURE AND ACKNOWLEDGEMEMTS.

In respect to nomenclature, this can be said; that an attempt has been made to conform to the principies that American and other botanists are now adopting. But it must not be presumed that in the yet unsettled state in the application of strict priority, accuracy has been in all cases attained. The most recent contributions of Dr. N. L. Britton and others in this line have been followed as far as the literature could be made available. The sequence of orders followed by Engler & Prantl, authors of PFLANZEN-FAMILIEN is here adopted. This appropriately displaces the arrangement of De Candolle, nearly a century old, very antiquated and far from natural, though still persisting in the text books.

Thanks are hereby expressed to the various collectors in the state who have favored us with material and to those botanists who have kindly examined and compared specimens for us. The plant lists or catalogues above enumerated have been consulted (the state catalogues of Dr. Newberry and Dr. Beardslee especially being used) and where species are given on their authority, credit in each case has been given.

Finally, the authors would respectfully request collectors to send specimens to the Herbarium of the Ohio State University, particularly of new or rare plants and also those that will extend the known area of distribution over the state or that will illustrate varieties due to local or other causes. Such material will serve as a basis for future contributions to the botany of our state.

Botanical Laboratory, Ohio State University, January, 1893.

RECENT CHANGES IN NOMENCLATURE.

By reason of delay in binding this volume corrections can be inserted to make the Nomenclature correspond to that officially adopted by the American Botanists and published in the "List of Pteridophyta and Spermatophyta of Northeastern North America."

W. A. KELLERMAN.

Ohio State University, January, 1895.

Page	81, 4th	Species.	Strike out "noveboracensis" and add Britt. after "(L.)."
"	83, 5th	"	Change name to Euthamia caroliniana (L.) Greene.
"	83, 6th	"	Change "hirsuta Nutt" to hispida Muhl.
"	83, 8th	"	Change name to Euthamia graminifolia (L.) Nutt.
"	83, 9th	"	Change "latifolia L." to flexicaulis L.
"	84, 8th	"	Change "speciosa angustata" to rigidiuscula (T. & G.) Brt.
"	85, 6th	"	Change "corymbosus Ait." to divaricatus L.
"	85, 9th	"	Change "villosus Torr. & Gr." to pilosus (Willd.) Porter.
"	86, 12th	"	Change "polyphyllus Willd." to faxoni Porter.
"	87, 1st	"	Change "lævicaulis Gray" to firmus (Nees) T. & G.
"	87, 11th	"	Change "bellidifolius Muhl" to pulchellus Mx.
"	88, 1st	"	Change "villosa Walt." to fœtida (L.) B. S. P.
"	91, 9th	"	Change "parviflorus Benth." to microcephalus T. & G.
"	91, 11th	"	Change "mollis (Willd.)" to macrophyllus (Willd.) Britt.
"	91, last	"	Change "senifolia Mx." to major Nutt.
"	93, 3d	"	Change name to Ptilepida acaulis (Nutt.) Britt.
"	93, 9th	"	Change "discoidea DC." to matricarioides (Less.) Porter.
"	94, 10th	"	Strike out "aureus" and change "T. & G." to Muhl.
"	94, 11th	"	Strike out "aureus," also "T. & G."
"	95, 6th	"	Strike out "lappa."
"	96, 1st	"	Change name to Cnicus benedictus L.
"	96, 6–8th	"	Change "Apogon" to Adopogon.
"	97, 3d	"	Change "officinale Weber" to taraxacum (L.) Karst.
"	99, 2d	"	Change name to Legouzia perfoliata (L.) Britt.
"	101, 1st	"	Change "racemosus L." to pubens Mx.
"	101, 4th	"	Change "lantanoides Mx." to alnifolium Marsh.
"	102, 1st	"	Change "vulgaris Mx." to symphoricarpus (L.) MacM.
"	102, 4th	"	Change "glauca Hill" to dioica L.
"	102, 5th	"	Change "grata Ait." to caperifolium L.
"	102, 11th	"	Change "trifida Mœnch" to diervilla (L.) MacM.
"	104, 12th	"	Strike out "patagonica" and "Gray."
"	105, 4th	"	Change "aubletia L" to canadensis (L.) Britt.
"	106, 3d	"	Change name to Mentha longifolia (L.) Huds.
"	106, 4th	"	Change "viridis L." to spicata L.
"	106, 10th	"	Change "mariana L." to origanoides (L.) Britt.
"	106, 11–14th	"	Change "Pycnanthemum" to Kœllia, and terminations of the species "um" to A.
"	107, 1st	"	Change name to Kœllia pilosa (Nutt.) Britt.
"	107, 2nd	"	Change name to Kœllia virginiana (L.) Britt.
"	107, 7th	"	Change name to Clinopodium vulgare L.
"	107, 8th	"	Change name to Clinopodium glabella (Benth.) Kuntze.
"	107, 9th	"	Change name to Clinopodium glabra (Nutt.) Kuntze.
"	108, 9th	"	Change name to Vleckia nepetoides (L.) Raf.
"	108, 10th	"	Change name to Vleckia scrophulariæfolia (Wild.) Raf.
"	108, 12th	"	Change name to Glechoma hederacea L.
"	109, 1st	"	Change "canescens Nutt." to incana Muhl.
"	109, 9th	"	Change "versicolor Nutt." to cordifolia Muhl.
"	109, 12th	"	Change "grandiflora Nutt." to hispidula Mx.
"	111, 6th	"	Change "myosotis Mœnch" to lappula (L.) Karst.
"	112, 3rd	"	Change "virginica (L.) B. S. P." to verna Nutt.
"	112, 10th	"	Change "hirtum Lehm." to gmelina (Mx.) Hitchc.
"	113, 10th	"	Change "cleistantha" to micrantha (Engl. & Gr.) Britt.
"	113, last	"	Change "capreolata L." to crucigera L.
"	114, 4th	"	Change "proboscidea Glox" to louisiana Mill.
"	114, 5th	"	Change name to Thalesia uniflora (L.) Britt.

Page 115,	8th	Species.	Change name to Elatinoides elatine (L.) Wettst.
" 115,	9th	"	Change "vulgaris Mill" to linaria (L). Karst.
" 116,	1st	"	Change "lævigatus Soland," to pentstemon (L.) Britt.
" 116,	2nd	"	Change name to Pentstemon digitalis (Sweet) Nutt.
" 117,	10th	"	Change name to Leptandra virginica (L.) Nutt.
" 117,	12th	"	Change name to Afzelia macrophylla (Nutt.) Kuntze.
" 119,	7th	"	Change name to Physalodes physalodes (L.) Britt.
" 120,	13th	"	Change "nil (L.) Ph." to hederacea Jacq.
" 122,	5th	"	Strike out "incarnata."
" 122,	14th	"	Change name to Cynanchum nigrum (L.) Pers.
" 123,	1st	"	Change name to Vincetoxicum gonocarpos Walt.
" 123,	2nd	"	Change name to Vincetoxicum obliquum (Jacq.) Britt.
" 124,	10th	"	Change "pubescens Lam" to pennsylvanica Marsh.
" 125,	2d	"	Change "viridis Mx." to lanceolata Borck.
" 125,	5th	"	Change name to Mohrodendron carolinum (L.) Britt.
" 126,	2d	"	Change "stricta Ait" to terrestris (L.) B. S. P.
" 126,	3d	"	Change name to Naumburgia thyrsiflora (L.) Duby.
" 126,	last	"	Change "monotropa Crantz" to hypopitys (L.) Small.
" 127,	8th	"	Strike out "corymbosum."
" 128,	7th	"	Change name to Xolisma ligustrina (L.) Britt.
" 128,	last	"	Change "latifolium" to grœnlandicum Oeder.
" 129,	1st	"	Change "Rhododendron lutea (L.)" to Azalea lutea L.
" 131,	10th	"	Change "brevistylis (Torr.) DC." to claytoni (Mx.) B. S. P.
" 131,	11th	"	Change "claytoni (Mx.) B. S. P." to longistylis (Torr.) DC.
" 132,	6th	"	Change name to Conioselinum chinense (L.) B. S. P.
" 132,	7–8th	"	Change to Thaspium trifoliatum aureum (Nutt.) Britt.
" 134,	8th	"	Change "sericea L." to amonum Mill.
" 135,	1st	"	Change name to Chamænerion angustifolium (L.) Scop.
" 135,	3d	"	Change "palustre oliganthum (Mx.) B. S. P." to lineare Muhl.
" 135,	8–9th	"	Change name to Onagra biennis (L.) Scop.
" 135,	10th	"	Change name to Kneiffea puticosa (L.)
" 135,	11th	"	Change name to Onagra oakesiana (Gr.) Britt.
" 135,	12th	"	Change name to Kneiffia pumila (L.) Spach.
" 136,	2d	"	Change "filipes Spach" to michauxii Spach.
" 137,	1st	"	Change name to Decodon verticillata (L.) Ell.
" 137,	2d	"	Change name to Parsonia petiolata (L.) Rusby.
" 137,	3d	"	Change name to Lepargyræa canadensis (L.) Greene.
" 137,	6th	"	Change "vulgaris Mill." to polyacantha Haw.
" 138,	3d	"	Change "muhlenbergii Torr" to labradorica Schrank.
" 138,	11th	"	Change name to Viola scabriuscula (T. & G.) Schw.
" 140,	1st	"	Change "crux-andreæ L." to hypericoides L.
" 140,	5th	"	Change "cistifolium Lam." to sphærocarpum Mx.
" 141,	2d	"	Change name to Malva verticillata crispa L.
" 141,	9th	"	Change "avicennae Gærtn" to abutilon (L.) Rusby.
" 142,	6th	"	Change name to Vitis bicolor LeConte.
" 142,	8th	"	Change name to Ampelopsis cordata Mx.
" 142,	10th	"	Change name to Parthenocissus quinquefolia (L.) Planch.
" 142,	11th	"	Change "riparia Mx." to vulpina L.
" 144,	11th	"	Change name to Acer nigrum Mx. f.
" 145,	1st	"	Change name to Acer negundo L.
" 145,	6th	"	Change "typhina L." to hirta (L.) Sudw.
" 145,	10th	"	Change "ambiguum Nutt." to humile (Raf.) Morong.
" 146,	5th	"	Change "verna L." to palustris L.
" 147,	7th	"	Change "caroliniana Ell." to ostryæfolia Riddell.
" 148,	2nd	"	Change "sanguinea L." to viridescens L.
" 151,	12th	"	Change "melilotoides Mx." to pedunculata (Mill.) Vail.
" 152,	1st	"	Change "violacea (Mx.) Kuntze" to purpurea (Vent.) MacM.
" 152,	6th	"	Change "canadensis L." to carolinensis L.
" 152,	7th	"	Change name to Phaca neglecta T. & G.
" 154,	3rd	"	Change "reticulata (Muhl.) Ph." to virginica (L.) Britton.
" 154,	5th	"	Change "intermedium (Wats.) Britt." to frutescens (L.) Britt.
" 154,	12th	"	Change "glaucifolius Beck." to ochroleucus Hook.
" 155,	7th	"	Change "tuberosa Mœnch." to apios (L.) MacM.
" 155,	9th	"	Change "perennis" to polystachyus (L.) B. S. P.
" 156,	11th	"	Change "spiræa aruncus L." to Aruncus aruncus (L.) Karst.
" 156,	last	"	Change "spiræa rubra (Hill) Britt." to Ulmaria rubra Hill.
" 157,	3rd	"	Change name to Opulaster opulifolius (L.) Kuntze.

Page 157, 10th	Species.	Change name to Rubus baileyanus Britt.
" 159, 7th	"	Change "norvegica L." to monspeliensis L.
" 159, 8th	"	Change name to Comarum palustre L.
" 159, 10th	"	Change "supina L." to paradoxa Nutt.
" 160, 1st	"	Change "poterium (L.) Britt." to sanguisorba (L.) Britt.
" 160, 10th	"	Change name to Aronia arbutifolia (L.) Ell.
" 160, last	"	Change name to Aronia nigra (Willd.) Britt.
" 161, 4th	"	Change name to Cratægus macracantha Lodd.
" 161, 11th	"	Change name to Cratægus punctata Jacq.
" 165, 3–9th	"	Change "Rorippa" to Roripa.
" 165, 10th	"	Change "vulgaris R. Br." to barbarea (L.) MacM.
" 166, 6th	"	Change "ludoviciana Meyer" to virginica (L.) Trel.
" 166, 9th	"	Change name to Iodanthus pinnatifidus (Mx.) Prantl.
" 166, 12th	"	Change name to Dentaria diphylla Mx.
" 166, last	"	Change name to Dentaria laciniata Muhl.
" 167, 1st	"	Change name to Dentaria maxima Nutt.
" 167, 6th	"	Change name to Koniga maritimum (L.) Britt.
" 167, 12th	"	Change name to Descurainia pinnata (Walt.) Britt.
" 167, last	"	Change name to Stenophragma thaliana (L.) Celak.
" 168, 4th	"	Change "Brassica alba (L.) Boiss" to Sinapis alba L.
" 168, 5th	"	Change "arvensis (L.) B. S. P." to sinapistrum Boiss.
" 168, 7th	"	Change "pastoris L." to bursa-pastoris (L.) Weber.
" 169, 8–10th	"	Change "Neckeria" to Capnoides and the terminations of the species "a" to um.
" 170, 8th	"	Change name to Buettneria florida (L.) Kearney.
" 170, last	"	Change name to Buettneria fertilis (Walt.) Kearney.
" 171, 2d	"	Change name to Benzoin benzoin (L.) Coulter.
" 173, 2d	"	Change name to Ranunculus micranthus Nutt.
" 173, 7th	"	Change name to Batrachium divaricatum (Schrk.) Wimm.
" 173, 8th	"	Change name to Cyrtorhyncha cymbalaria (Ph.) Britt.
" 173, 10th	"	Change "delphinifolius terrestris Gr." to purshii Rich.
" 173, 12th	"	Change "Ranunculus ficaria" to Ficaria ficaria (L.) Karst.
" 174, 4th	"	Change "rhomboideus Goldie" to ovalis Raf.
" 174, 7th	"	Change name to Batrachium trichophyllus (Chaix) Bossch.
" 175, 5th	"	Change "exaltatum Ait." to urceolatum Jacq.
" 178, 1st	"	Change "illinoensis (Mx.)" to regia Sims.
" 178, 2d	"	Change "nivea (Nutt.) Otth." to alba Muhl.
" 178, 5th	"	Change "pennsylvanica Mx." to caroliniana Walt.
" 179, 2d	"	Change "natans Raf." to longipedunculatum Muhl.
" 181, 1st	"	Change name to Allionia nyctaginea Mx.
" 181, 3d	"	Change "patula hastata (L.) Gr." to hastata L.
" 181, 4th	"	Change "patula littorale (L.) Gr." to patula L.
" 181, 7th	"	Change "ambrosioides anthelminticum (L.) Gr." to anthelminticum L.
" 182, 7th	"	Change "hypochondriacus L." to hybridus L.
" 182, last	"	Change "celosioides L." to paniculata (L.) Kuntze.
" 183, 10th	"	Change "acre H. B. K." to punctatum Ell.
" 184, 3d	"	Change "dumetorum scandens (L.) Gr." to scandens L.
" 184, 10th	"	Change "lapathifolium incarnatum Wats." to incarnatum Ell.
" 185, 6th	"	Change "I" in the generic name to T.
" 187, 8th	"	Change "bicolor Willd" to platanoides (Lam.) Sudw.
" 187, 10th	"	Change "coccinea tinctoria Gr." to velutina Lam.
" 187, last	"	Substitute the synonym for the name given.
" 188, 3d	"	Change "muhlenbergii humilis (Marsh.) Britt." to prinoides Willd.
" 188, 8th	"	Change "stellata Wang." to minor (Marsh.) Sarg.
" 188, 9th	"	Change name to Castanea pumila (L.) Mill.
" 188, 10th	"	Change name to Castanea dentata (Marsh.) Sudw.
" 188, 11th	"	Change name to Fagus atropunicea (Marsh.) Sudw.
" 188, last	"	Change "cornuti Du Roi" to rostrata Ait.
" 191, 13th	"	Change name to Comptonia peregrina (L.) Coulter.
" 193, 6th	"	Change "innata R. Br." to corallorhiza (L.) Karst.
" 196, 4th	"	Change "pubescens Willd." to hirsutum Mill.
" 196, 9–10th	"	Unite under the name Sysirynchium bermudiana L.
" 198, 2d	"	Change name to Polygonatum biflorum commutatum (R. & S.) Morong.

Page 198,	5–7th	Species.	Change generic name to Vagnera; read Mor. after "(L.)"
" 199,	10th	"	Change name to Uvularia sessilifolia L.
" 200,	7th	"	Change "erythrocarpum Mx." to undulatum Willd.
" 200,	12th	"	Change angustifolium (Ph.) Gr." to gramineum (Ker.) Mor.
" 201,	last	"	Change name to Juncus brachycephalus (Engl.) Buch.
" 202,	13th	"	Change name to Juncoides campestre (L.) Kuntze.
" 202,	last	"	Change name to Juncoides pilosa (L.) Kuntze.
" 203,	2d	"	Change "angustifolia Torr." to lancifolia (Muhl.) Morong.
" 205,	6th	"	Change "diandrus castaneus (Bigel.) Torr." to rivularis Kunth.
" 206,	4th	"	Change "spithaceum Pers." to arundinaceum (L.) Britt.
" 206,	6th	"	Change "compressa Sull." to acuminata (Muhl.) Nees.
" 206,	7th	"	Change "equisetoides Torr." to interstincta (Vahl.) R. & S.
" 206,	12th	"	Change "quadrangulata (Mx.) R. Br." to mutata (L.) R. & S.
" 207,	2d	"	Change name to Stenophyllus capillaris (L.) Britt.
" 207,	10th	"	Change name to Scirpus americanus Pers.
" 208,	1st	"	Change name to Scirpus cyperinum (L.) Kuntze.
" 212,	11th	"	Change "laxiflora styloflexa (Buckl.)" to styloflexa Buckl.
" 213,	12th	"	Change name to Carex flava viridula (Mx.) Bailey.
" 214,	13th	"	Change "rosea retroflexa Torr." to retroflexa Muhl.
" 219,	10th	"	Change "latifolium L." to walteri Poir.
" 224,	2d	"	Change "scabra Willd." to hiemalis (Walt) B. S. P.
" 227,	4th	"	Change name to Korycarpus diandrus (Mx.) Kuntze.
" 227,	last	"	Change "Poa flexuosa Muhl." to Poa cenisia All.
" 228,	2d	"	Change "Poa serotina Ehrh." to Poa flava L.
" 228,	5–12th	"	Change the generic name to Panicularia.
" 228,	5th	"	Change name to Panicularia acutiflora (Torr.) Kuntze.
" 228,	9th	"	Change name to Panicularia aquatica (L.) Kuntze.
" 228,	13th	"	Change "duriuscula L." to ovina duriuscula (L.) Hack.
" 229,	7th	"	Change "mollis L." to hordaceus L.
" 230,	3d	"	Change "pratense Huds." to nodosum L.
" 230,	9th	"	Change name to Hystrix hystrix (L.) Millsp.
" 230,	last	"	Change "macrosperma suffruticosa Munro" to tecta (Walt.) Muhl.
" 231,	3d	"	Change name to Alisma plantago-aquatica L.
" 234,	4th	"	Change name to Kraunhia frutescens (L.) Greene.

Dicotyls.

ANGIOSPERMS.

I. Order COMPOSITÆ.* Sunflower Family.

1. VERNONIA Schreb. Ironweed.

Vernonia fasiculata** Michx.
Cincinnati, Jos. F. James (Cat.); Burgh Hill (Trumbull Co.) Jno. I. King.

Vernonia gigantea (Walt.) (*V. altissima* Nutt.)
Distributed over the whole state.

Vernonia noveboracensis** (L.) Willd.
Lorain Co., A. A. Wright (Cat.); Rio Grande (Gallia Co.) Lizzie Davis.

Vernonia noveboracensis** glauca (L.) (*V. noveboracensis latifolia* Gray.)
Lorain Co., A. A. Wright (Cat.)

2. ELEPHANTOPUS L. Elephant's-foot.

Elephantopus carolinianus Willd.
Near Dayton, O., Dr. J. Eberle, J L. Riddell (Synop. 1835.); Otway (Scioto Co.) W. A. Kellerman; Cincinnati, Jos. F. James (Cat.)

3. EUPATORIUM Tourn. Thoroughwort.

Eupatorium ageratoides L. White Snake-root.
Throughout the state.

Eupatorium altissimum L.
Toledo, J. A. Sanford; Franklin Co., Aug. D. Selby.

Eupatorium aromaticum L.
General, J. S. Newberry, (Cat.)

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* The arrangement of Orders is that of Engler & Prantl in their Natuerliche Pflanzenfamilien.

** It will be noticed that capitals for specific names have in all cases been discarded: the comma between the name and the author, as well as the word "var." are also omitted. This is in accordance with the present usage of the most advanced botanical authorities.

EUPATORIUM COELESTINUM L. Mist-flower.
Over the southern counties.

EUPATORIUM PERFOLIATUM L. Boneset; Thoroughwort.
Common. The leaves and flowering tops are medicinal.

EUPATORIUM PURPUREUM L. Joe-Pye Weed. Trumpet-Weed.
Common over the state.

EUPATORIUM SEROTINUM Mx.
Columbus, on grounds of Sells Brothers' Circus, E. M. Wilcox.

EUPATORIUM SESSILIFOLIUM L. Upland Boneset.
Generally distributed over the state.

4. KUHNIA L.

KUHNIA EUPATORIOIDES L.
Miami county, J. L. Riddell (Synop. 1835); Springfield, Mrs. E. Jane Spence; Rio Grande (Gallia Co.) Lizzie Davis; Lawrence Co., Wm. C. Werner.

5. LACINARIA Hill. (*Liatris* Schreb.) BUTTON SNAKEROOT. BLAZING STAR.

LACINARIA CYLINDRACEA (Mx.) Kuntze (*Liatris cylindracea* Michx.)
Franklin Co., Aug. D. Selby.

LACINARIA GRACILIS (Ph.) Kuntze. (*Liatris gracilis* Ph.)
Oak barrens near Marietta, J. L. Riddell (Synop. 1835.)

LACINARIA SCARIOSA (L.) Hill (*Liatris scariosa* L.)
Catawba Island (Lake Erie) Wm. Krebs; Franklin Co., Aug. D. Selby; Adams Co., W. A. Kellerman; Fulton Co., J. S. Hine.

LACINARIA SPICATA (L.) Kuntze (*Liatris spicata* L.)
Toledo, J. A. Sanford; Springfield, Mrs. E. Jane Spence.

LACINARIA SQUARROSA (L.) Hill (*Liatris squarrosa* L.)
Franklin Co., Aug. D. Selby.

6. GUTIERREZIA Lag.

GUTIERREZIA TEXANA (DC.) Torr & Gray.
Columbus, on grounds of Sells Brothers' Circus, Aug. D. Selby.

7. AMPHIACHYRIS Nutt.

AMPHIACHYRIS DRACUNCULOIDES (DC.) Nutt.
Columbus, on grounds of Sells Brothers' Circus, E. V. Wilcox.

8. CHRYSOPSIS Nutt. GOLDEN ASTER.

CHRYSOPSIS MARIANA (L.) Nutt.
Hocking Co., W. A. Kellerman; Knox Co., Dr. Kellogg, J. S. Newberry (Cat.)

9. SOLIDAGO L. Golden-rod.

Solidago arguta Ait.
Frequent in Northern Ohio; Franklin Co., Aug. D. Selby.

Solidago bicolor L.
Lake Co., Wm. C. Werner; Lorain Co., A. A. Wright (Cat.); Cuyahoga Co., E. Claassen; Licking Co., H. L. Jones (Cat.); Fairfield Co., E. V. Wilcox and S. Renshaw; Lawrence Co., Wm. Werner.

Solidago cæsia L.
Widely distributed.

Solidago canadensis L.
Common ove. the state.

Solidago caroliniana (L.) B. S. P. (*S. tenuifolia* Ph.)
Cleveland, W. Krebs; Franklin Co., E. M. Wilcox.

Solidago hirsuta Nutt. (*S. bico or concolor* Torr & Gray.)
Frequent in south central Ohio.
Lake Co., H. C. Beardslee (Cat).

Solidago juncea ramosa Porter & Britton.
"Ohio, Sullivant," (N. L. Britton, Torrey Bull. Vol. XVIII, Dec. 9, 1891, p. 368)

Solidago lanceolata L.
Frequent.

Solidago latifolia L.
Frequent over the state.

Solidago neglecta Torr & Gray.
"Painesville," H. C. Beardslee (Cat.)

Solidago nemoralis Ait.
Over the whole state.

Solidago odora Ait.
"Ohio," J. L. Riddell (Synop. 1835.)

Solidago ohioensis Riddell.
"Cleves' prairie, Dayton, and two miles south from Columbus," J. L. Riddell (Synop. 1835); Springfield, Mrs. E. Jane Spence; Franklin Co., E. M. Wilcox; Champaign Co., Wm. C. Werner.

Solidago patula Muhl.
Northern and central Ohio; perhaps over the whole state.

Solidago puberula Nutt.
"Painesville," H. C. Beardslee (Cat.)

Solidago riddellii Frank.
"Worthington, (Franklin Co.,) and Dayton," J. L. Riddell (Synop. 1835); Gypsum, (Ottawa Co.,) E. Claassen; Fulton Co. J. S. Hine; Columbus, Wm. C. Werner; Springfield, Mrs. E. Jane Spence; Cincinnati, Jos. F James (Cat.)

SOLIDAGO RIGIDA L.

"Monroeville," (Huron Co.,) H. C. Beardslee, (Cat.); Marblehead, (Ottawa Co.,) E. Claassen; Toledo, J. A. Sanford; Franklin Co., Aug. D. Selby; Lawrence Co., Wm. C. Werner.

SOLIDAGO RUGOSA Mill.

Northern and central Ohio; no specimens seen from southern Ohio.

SOLIDAGO RUPESTRIS RAF.

"Ross Co.," W. E. Safford. (Torrey Bull. Vol. XIII, July 1886, p. 116).

SOLIDAGO SEROTINA Ait.

Northern Ohio, Wm. C. Weruer; W. Krebs; A. A. Wright (Cat.); Licking Co., H L. Jones, (Cat.); Columbus, W. G. Green; Lawrence Co., Wm. C. Werner.

SOLIDAGO SEROTINA GIGANTEA (Ait.) Gray.

Northern Ohio, Wm. C. Werner; E. Claassen; A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.); Clinton Co., J. S. Van Dervort.

SOLIDAGO SHORTII Torr & Gray.

"Ross Co.," W. E. Safford. (Torrey Bull, vol. XIII, July 1886, p. 116.

SOLIDAGO SPECIOSA Nutt.

Toledo, J. A. Sanford; Cleveland, W. Krebs; Franklin Co., W. C. Werner; Cincinnati, Jos. F. James, (Cat.); (Lawrence Co.,) Wm. C. Werner.

SOLIDAGO SPECIOSA ANGUSTATA Torr. & Gray.

"Northern, Ohio, Rare." H. C. Beardslee, (Cat.)

SOLIDAGO SQUARROSA Muhl.

Lorain Co., A. A Wright (Cat.); Cleveland, E. Claassen; "Painesville," H. C. Beardslee (Cat.); Wm. C. Werner; Fairfield Co., E. E. Bogue.

SOLIDAGO STRICTA Ait.

"Prairies Ohio," J. L. Riddell (Synop. 1835); Elyria, (Lorain Co.,) Dr. Kellogg. (Newberry Cat.)

SOLIDAGO ULIGINOSA Nutt.

Painesville, Cranberry Marsh, Licking Reservoir, Wm. C. Werner; "Toboso." Licking Co., H L. Jones (Cat.); Columbus Aug, D. Selby.

SOLIDAGO ULMIFOLIA Muhl.

Widely distributed.

SOLIDAGO VIRGAUREA L.

"Northern Ohio," J. S. Newberry (Cat.); probably a wrong determination.

10. BOLTONIA L'Her.

BOLTONIA ASTEROIDES (L.) L'Her.

"Southern Ohio," J. S. Newberry (Cat.); Port Clinton, E. Claassen; Toledo, J. A. Sanford.

11. SERICOCARPUS Nees. White-topped Aster.

Sericocarpus asteroides (L.) B. S. P. (*S. conyzoides* Nees.)
From Lake Erie to the Ohio River.

12. ASTER L. Starwort; Aster.

Aster acuminatus Michx.
"Northern Ohio, rare," H. C. Beardslee (Cat.)

Aster azureus Lindl.
Franklin Co., Aug. D. Selby; Springfield, Mrs. E. Jane Spence; "Southern Ohio," J. S. Newberry (Cat).

Aster concolor L.
"Southern Ohio," J. S. Newberry (Cat.)

Aster cordifolius L.
Distributed over the state.

Aster corymbosus Ait.
Over the state.

Aster dumosus L.
"General," J. S. Newberry (Cat.)

Aster ericoides L.
Frequent in northern Ohio; Licking Co., H. L. Jones (Cat.); Columbus, Wm. C. Werner; Cincinnati, Jos. F. James (Cat.)

Aster ericoides villosus Torr & Gray.
Frequent throughout the southern half of the state. "Lake Shore," H. C. Beardslee (Cat); To edo, J. A. Sanford; Painesville, Otto Hacker.

Aster infirmus Michx.
"Ohio," J. S. Riddell (Synop. 1835.)

Aster junceus Ait.
Northern Ohio, J. S. Newberry (Cat.); Columbus, Sullivant, (H. C. Beardslee. Cat.); Cincinnati, Jos. F. James (Cat.)

Aster laevis L.
Northern and central portions of the state. Lawrence Co., Wm. C. Werner.

Aster lateriflorus (L.) Britt. (*A. diffusus* Ait.)
Widely distributed.

Aster lateriflorus hirsuticaulis Gray.
Licking Co., H. L. Jones (Cat.)

Aster lindleyanus Torr & Gray.
Franklin Co., Wm. C. Werner.

ASTER LINARIIFOLIUS L.
"Duncan's Plains, Ohio," J. L. Riddell (Synop. 1835;) "General," J. S. Newberry (Cat.)

ASTER LONGIFOLIUS Lam.
Given in previous catalogues, probably A. novi-belgii is the species referred to

ASTER MACROPHYLLUS L.
Northern and central Ohio; perhaps all over the state.

ASTER MULTIFLORUS Ait.
Toledo, J. A. Sanford; Painesville, Wm. C. Werner, Cleveland, Wm. Krebs, Franklin Co., Aug. D. Selby; Cincinnati, Jos. F. James (Cat.)

ASTER NOVAE-ANGLIAE L.
Throughout the state.

ASTER NOVI-BELGII L.
Lake Co., Wm. C. Werner; Richland Co., E. Wilkinson; Licking Co., H. L. Jones (Cat.); Fultonham (Muskingum Co.,) Columbus, Wm. C. Werner.

ASTER OBLONGIFOLIUS Nutt.
"Toledo, J. A. Sanford;" (Lazenby and Werner Sup List). Was taken from a list of names. No authentic specimen.

ASTER PANICULATUS Lam.
Common over the state.

ASTER PATENS Ait.
"Near Dayton," J. L. Rid'ell (Synop. 1835); Painesville, Wm. C. Werner, Licking Co., H L. Jones (Cat.)

ASTER PATENS PHLOGIFOLIUS (Muhl.) Nees.
Painesville, Wm. C. Werner; Portage Co., E. Claassen; Franklin Co., E. V. Wilcox: Springfield, Mrs. E. Jane Spence; Lawrence Co., W. Werner; Cincinnati, Jos. F. James (Cat.)

ASTER PAUCIFLORUS Nutt.
"On grounds of Sells Brothers' Circus, near Columbus, E. V. Wilcox;" (Lazenby and Werner Sup List). No authentic specimen.

ASTER POLYPHYLLUS Willd.
"Prairie, Dayton, M. G. Wi liams;" (J. L. Riddell, Sup. Cat.)

ASTER PRENANTHOIDES Muhl.
Frequent throughout the state.

ASTER PUNICEUS L.
From Lake Erie to the Ohio River.

ASTER PUNICEUS LUCIDULUS Gray.
"A puniceus vimineus Gray, northern Ohio;" H. C. Beardslee (Cat:) may refer to this form.

Aster puniceus laevicaulis Gray.
Licking Co., H. L. Jones (Cat.)

Aster sagittifolius Willd.
Painesville, Columbus, Wm. C. Werner; Springfield, Mrs. E. J. Spence; Licking Licking Co., H. L. Jones (Cat.) Cincinnati, Jos. F. James (Cat.)

Aster salicifolius Ait.
Painesville, Wm. C. Werner; Licking Co., H. L. Jones (Cat.)

Aster sericeus Vent.
"Southern Ohio," J. S. Newberry (Cat.)

Aster shortii Hook.
Apparently over the whole state.

Aster tradescanti L.
Cleveland, W. Krebs; Licking Co., H. L. Jones (Cat.); Columbus, Moses Craig.

Aster umbellatus Mill.
Painesville, Wm. C. Werner; Ashtabula Co., E. E. Bogue; Lorain Co., A. A. Wright (Cat.) Portage Co., E. Claasen; Logan Co., Mrs. E. J. Spence; Champaign Co., Wm. C. Werner.

Aster undulatus L.
From Lake Erie to the Ohio River.

Aster vimineus Lam.
Cleveland, E. Claassen,

13. ERIGERON L. Fleabane.

Erigeron annuus (L.) Daisy Fleabane. Sweet Scabious.
Common over the state.

Erigeron bellidifolius Muhl.
Generally distributed over the whole state.

Erigeron canadensis L.
Throughout the state.

Erigeron philadelphicus L.
Widely distributed over the state.

Erigeron ramosus (Walt.) B. S. P. (*E. strigosus* Muhl.)
Over the whole state.

14. PLUCHEA Cass. Marsh-Fleabane.

Pluchea camphorata (L.) D. C.
"Cincinnati," J. L. Riddell (Synop. 1835.)

PLUCHEA VILLOSA (Walt.) (*P. foetida* L. *P. bifrons* DC.)
Cincinnati, Jos. F. James (Cat.) "Ohio," Gray (Man.)

15. GIFOLIA Cass. (*Filago* Tourn.) COTTON-ROSE.

GIFOLIA GERMANICUM L. (*Filago germanica* L.) Herba Impia.
"General," J. S. Newberry (Cat.)

16. ANTENNARIA Gaertu. (*Anaphalis* D. C.) EVERLASTING.

ANTENNARIA PLANTAGINIFOLIA (L.) Richards. Plantain-leaved Everlasting.
Common over the whole state.

ANTENNARIA MARGARITACEA (L.) Hook. (*Anaphalis margaritacea.* Beuth & Hook.)
Northern Ohio, J. S. Newberry (Cat.); Licking Co., H. L. Jones (Cat.); Ashtabula, Miss S. F. Goodrich.

17. GNAPHALIUM L. CUDWEED.

GNAPHALIUM DECURRENS Ives. Everlasting.
Lorain Co., A. A. Wright (Cat.); Painesville, Wm. C. Werner; Franklin Co., Selby and Craig (Cat.)

GNAPHALIUM OBTUSIFOLIUM L. (*G. polycephalum* Michx.) Common Everlasting.
Over the whole state.

GNAPHALIUM PURPU EUM L. Purplish Cudweed.
Throughout the state, but not abundant.

GNAPHALIUM ULIGINOSUM L. Low Cudweed.
From Lake Erie to the Ohio River.

18. INULA L, ELECAMPANE.

INULA HELENIUM L.
Widely distributed over the state.

19. POLYMNIA. L. LEAF-CUP.

POLYMNIA CANADENSIS L.
Over the whole state.

POLYMNIA UVEDALIA L.
Lawrence Co., W. A. Kellerman; Cincinnati, Jos. F. James (Cat.) "Painesville," H. C. Beardslee (Cat;) Wm. C. Werner.

20. SILPHIUM L. ROSIN-WEED.

SILPHIUM INTEGRIFOLIUM Michx.
"Monroeville," H. C. Beardslee (Cat.)

SILPHIUM LACINIATUM L. Rosin-weed. Compass-Plant.
Given for Ohio in former catalogues. We have seen no specimens.

SILPHIUM PERFOLIATUM L. Cup-Plant.
Common throughout western half of the state. Painesville, H. C. Beardslee (Cat.)

SILPHIUM TEREBINTHINACEUM L. Prairie Dock.
Throughout the western half of the state, from Lake Erie to the Ohio River.

SILPHIUM TEREBINTHINACEUM PINNATIFIDUM (Ell.) Gray.
"Darby Plains, O.," J. L. Riddell (Synop. 1835); Fairfield Co., W. A. Kellerman; Springfield, Mrs. E. Jane Spence; London, Mrs. K. D. Sharpe.

SILPHIUM TRIFOLIATUM L
Throughout the state.

21. PARTHENIUM L.

PARTHENIUM HYSTEROPHORUS L.
Grounds of Sell's Bros. Circus, (near Columbus); W. J. Green.

22. AMBROSIA Tourn. RAGWEED.

AMBROSIA ARTEMISIAEFOLIA L. Roman Wormwood. Hog-weed. Bitter-weed.
Common everywhere in fields and waste-places and along roadsides.

AMBROSIA TRIFIDA L. Great Rag-weed.
Common in low grounds and along streams all over the state.

AMBROSIA TRIFIDA INTEGRIFOLIA (Muhl.) Torr. and Gray.
With the ordinary form.

23. XANTHIUM Tourn. COCKLEBUR. CLOTBUR.

XANTHIUM CANADENSE Mill.
Everywhere over the state.

XANTHIUM CANADENSE ECHINATUM (Murr.) Gray.
Lorain Co., A. A. Wright (Cat.); Columbus, Aug. D. Selby.

XANTHIUM SPINOSUM L.
Dayton, H. A. Surface, Mrs. E. Jane Spence; Cincinnati, Jos. F. James (Cat.)

XANTHIUM STRUMARIUM L.
Cincinnati, Jos. F. James (Cat); Franklin Co., Selby and Craig (Cat.)

24. HELIOPSIS Pers. OX-EYE.

HELIOPSIS HELIANTHOIDES (L.) B. S. P. (*H. laevis* Pers.)
Common all over the state.

Heliopsis scabra Dunal.
Lorain Co., A. A. Wright (Cat.); Painesville, Wm. C. Werner.

25. ECLIPTA L.

Eclipta alba (L.) Hassk.
Throughout central and southern Ohio. Cleveland, Wm. Krebs.

26. BRAUNERIA Neck. (*Echinacea* Moench.) Purple Cone-flower.

Brauneria purpurea (L.) (*Echinacea purpurea* L.)
Toledo, J. A. Sanford; Franklin Co., W. J. Green; Springfield, Mrs. E. Jane Spence; London, Mrs. K. D. Sharpe; Lawrence Co., Wm. C. Werner.

27. RUDBECKIA L. Cone-flower.

Rudbeckia fulgida Ait.
Franklin Co., Wm. C. Werner; Cincinnati, Jos. F. James (Cat.); Licking Co., H. L. Jones (Cat.)

Rudbeckia hirta L.
Common.

Rudbeckia laciniata L.
Common over the state.

Rudbeckia speciosa Wenderoth.
Northern Ohio, J. S. Newberry (Cat.); Champaign Co., Columbus, Wm C. Werner; Cincinnati Jos. F. James (Cat.)

Rudbeckia triloba L.
From Lake Erie to the Ohio River. Throughout the western half of the state.

28. LEPACHYS Raf.

Lepachys pinnata (Vent.) Torr and Gray.
Toledo, J. A. Sanford; Franklin Co. Wm. C. Werner; Springfield, Mrs. E. Jane Spence; Cincinnati, Jos. F. James (Cat.)

29. HELIANTHUS L. Sunflower.

Helianthus annuus L. Common Sunflower.
Lake Co., Wm. C. Werner; Licking Co., H. L. Jones (Cat.); Columbus, Wm. C. Werner (Lazenby and Werner Sup. list); Fairfield Co., E. V. Wilcox and S. Renshaw; Cincinnati, Jos. F. James (Cat.)

Helianthus decapetalus L.
Frequent throughout the state.

Helianthus divaricatus L.
Throughout the state.

HELIANTHUS DORONICOIDES Lam.
"Ohio," Gray (Manual); Licking Co., H. L. Jones (Cat.)

HELIANTHUS GIGANTEUS L.
Ge erally distributed over the western half of the state.

HETIANTHUS GIGANTEUS AMBIGUUS Torr. & Gray.
Pc inesville, H. C. Beardslee (Cat.)

HELIANTHUS GROSSE-SERRATUS Martens.
Springfield, Mrs. E. Jane Spence; Cincinnati, Jos. F. James (Cat.)

HELIANTHUS HIRSUTUS Raf.
Not uncommon.

HELIANTHUS LAETIFLORUS Pers.
Licking Co., H. L. Jones (Cat.)

HELIANTHUS MOLLIS Lam.
Cincinnati, Joseph Clark (Cat.)

HELIANTHUS OCCIDENTALIS Riddell.
Franklin Co., Wm. C. Werner; Fulton Co., J. S. Hine.

HELIANTHUS PARVIFLORUS Benth.
From Lake Erie to the Ohio River.

HELIANTHUS STRUMOSUS L.
Northern Ohio; Cincinnati, Jos. F. James (Cat.)

HELIANTHUS STRUMOSUS MOLLIS (Willd) Torr. and Gray.
Painesville, H. C. Beardslee (Cat.)

HELIANTHUS TRACHELIIFOLIUS Willd.
"General," H. C. Beardslee (Cat.) Lorain Co., A. A. Wright (Cat.)

HELIANTHUS TUBEROSUS L.
Common all over the state.

30. VERBESINA L. (*Actinomeris* Nutt.) CROWNBEARD.

VERBESINA alternifolia (L.) (*Actinomeris alternifolia* L. *A.squarrosa* Nutt.)
Throughout the state.

VERBESINA HELIANTHOIDES Michx.
Springfield, Mrs. E. Jane Spence; Cincinnati, Jos. F. James (Cat.)

VERBESINA OCCIDENTALIS Walt.
"Common," H. C. Beardslee (Cat.)

31. COREOPSIS L. TICKSEED.

COREOPSIS AURICULATA L.
Cincinnati, Jos. F. James (Cat.)

COREOPSIS SENIFOLIA Mx.
Ironton (Lawrence Co.) Wm. C. Werner.

Coreopsis tripteris L. Tall Coreopsis.
From Lake Erie to the Ohio River.

Coreopsis verticillata L.
"Torrey and Gray," (Beardslee Cat.)

32. BIDENS L. Bur-Marigold.

Bidens aristosa (Mx.) Britt. (*Coreopsis aristosa* Mx.)
Cleveland, W. Krebs; Richland Co., E. Wilkinson; Licking Co., H. L. Jones (Cat.); Springfield, Mrs. E. Jane Spence; Franklin and Champaign Counties, Wm. C. Werner.

Bidens beckii Torr.
Geauga Co., Dr. Canfield (Beardslee Cat.)

Bidens bipinnata L.
Common.

Bidens cernua L.
Lorain Co., A. A. Wright (Cat.); Cleveland, W. Krebs; Licking Co., H. L. Jones (Cat.); Franklin Co., Aug. D. Selby.

Bidens connata Muhl. Swamp Beggar Ticks.
Generally distributed.

Bidens discoidea (Torr. and Gray) Britt. (*Coreopsis discoidea* Torr. and Gray.)
Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.)

Bidens frondosa L.
Common.

Bidens laevis (L.) B. S. P. (*B. chrysanthemoides* Mx.)
Common.

Bidens trichosperma (Mx.) Britt. (*Coreopsis trichosperma* Mx.) Tickseed Sunflower. Northern Ohio; Fairfield Co., E. V. Wilcox and S. Renshaw.

33. GALINSOGA Ruiz and Pavon.

Galinsoga parviflora Cav.
Cleveland, W. Krebs; Painesville, Otto Hacker; Columbus, Aug. D. Selby; Columbiana Co., H. Herzer.

34. DYSODIA Cav. Fetid Marigold.

Dysodia papposa (Vent.) Hitch. (*D. chrysanthemoides* Lag.)
Franklin Co., W. J. Green and E. V. Wilcox; Cincinnati, Jos. F. James (Cat.); Ross Co., W. E. Safford (Torr. Bull.)

35. HELENIUM L. Sneeze-weed.

Helenium autumnale L.
Common everywhere.

HELENIUM NUDIFLORUM Nutt.
Grounds of Selis' Bros. Circus near Columbus, E. E. Bogue.

HELENIUM TENUIFOLIUM Nutt.
Grounds of Sells' Bros. Circus near Columbus, W. J. Green.

36. ACTINELLA Pers.

ACTINELLA ACAULIS GLABRA Gray.
Lakeside (Ottawa Co.,) C. M. Weed.

37. ACHILLEA L. YARROW. Milfoil.

ACHILLEA MILLEFOLIUM L.
Common over the whole state.

38. ANTHEMIS L. CHAMOMILE.

ANTHEMIS ARVENSIS L. Corn Chamomile.
Painesville, Wm. C. Werner; Licking Co., H. L. Jones (Cat.)

ANTHEMIS COTULA DC. May-weed.
Common in fields and waste places.

ANTHEMIS NOBILIS L.
W. E. Safford (Torr. Bull. XIII. 116)

39. MATRICARIA Tourn. WILD CHAMOMILE.

MATRICARIA CHAMOMILLA L.
Lake Co., and Lawrence Co., Wm. C. Werner.

MATRICARIA DISCOIDEA DC.
Cincinnati, D. L. James.

40. CHRYSANTHEMUM Tourn. OX-EYE DAISY.

CHRYSANTHEMUM BALSAMITA TANACETOIDES Boiss.
Georgesville, Franklin Co., Wm. C. Werner.

CHRYSANTHEMUM LEUCANTHEMUM L. Ox-eye Daisy. Whiteweed.
Throughout the whole state.

CHRYSANTHEMUM PARTHENIUM (L.) Pers. Fever Few.
Elyria, H. C. Beardslee (Cat.); Fairfield Co., E. V. Wilcox and S. Renshaw.

41. TANACETUM L. TANSY.

TANACETUM VULGARE L. Common Tansy.
Not uncommon.

TANACETUM VULGARE CRISPUM Gray.
Licking Co., H. L. Jones, (Cat.)

42. ARTEMISIA L. Wormwood.

Artemisia abrotanum L.
Cincinnati, Jos. F. James (Cat.)

Artemisia absinthium L. Wormwood.
Lorain Co., A. A. Wright (Cat.)

Artemisia annua L.
Painesville, H. C. Beardslee; Columbus, E. V. Wilcox; Lawrence Co., Wm. C. Werner.

Artemisia biennis Willd.
Painesville, H. C. Beardslee (Cat.); Toledo, J. A. Sanford; Cleveland, W. Krebs; Cincinnati, Jos. F. James (Cat.)

Artemisia canadensis Michx.
Shore of Lake Erie, H. C. Beardslee (Cat.); Cedar Point (Ottawa Co.) E. Claassen.

Artemisia vulgaris L.
Akron, E. W. Claypole (Torr. Bull.); Cincinnati, Jos. F. James (Cat.)

43. TUSSILAGO L. Coltsfoot.

Tussilago farfara L.
Painesville, Wm. C. Werner.

44. ERECHTITES Raf. Fireweed.

Erechtites hieracifolia (L.) Raf
Frequent.

45. SENECIO L. Groundsel.

Senecio aureus L. Golden Ragwort.
Everywhere.

Senecio aureus balsamitæ T. & G.
Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.)

Senecio aureus obovatus (Muhl) T. & G.
Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.); Franklin Co., Wm. C. Werner; Monroe Co., H. Herzer; Chillicothe, R. E. Bower.

Senecio lobatus Pers.
Licking Co., H. L. Jones (Cat.)

Senecio vulgaris L.
Lorain Co., A. A. Wright, (Cat.); Painesville, Wm. C. Werner.

46. CACALIA L. Indian Plantain.

CACALIA ATRIPLICIFOLIA L.
Throughout the state.

CACALIA RENIFORMIS Muhl.
"Miami Country," J. L. Riddell (Synop. 1835.); Licking Co., H. L. Jones (Cat.); Cincinnati, Jos. F. James (Cat.)

CACALIA SUAVEOLENS L.
Painesville, H. C. Beardslee (Cat.); Lorain Co., A. A. Wright (Cat.); Cuyahoga River, W. Krebs; Springfield, Mrs. E. Jane Spence; Cincinnati, Joseph Clark (Cat.)

CACALIA TUBEROSA Nutt.
"Central and Western Ohio," J. S. Newberry (Cat.); Cedar Swamp (Champaign Co.,) Wm. C. Werner.

47. ARCTIUM L. BURDOCK.

ARCTIUM LAPPA L.
All over the state.

ARCTIUM LAPPA MINUS Schk.
Lorain Co., A. A. Wright (Cat.)

48. CARDUUS L. (*Cnicus.*) COMMON OR PLUMED THISTLE.

CARDUUS ALTISSIMUS L. (*Cnicus altissimus* Willd.)
Common over the state.

CARDUUS DISCOLOR (Muhl.) Nutt. (*Cnicus altissimus discolor* Gray.)
From Lake Erie to the Ohio River throughout the western half of the state, but infrequent.

CARDUUS ARVENSIS (L.) Curtis. (*Cnicus arvensis* Hoffm.)
Frequent throughout the northern and central counties; Cincinnati, Jos. F. James (Cat.)

CARDUUS LANCEOLATUS L. (*Cnicus lanceolatus* Hoffm.)
Generally distributed.

CARDUUS MUTICUS (Mx.) Nutt. (*Cnicus muticus* Pursh.)
Apparently over the whole state.

CARDUUS ODORATUS (Muhl.) (*Cnicus pumilus* Torr.)
"General," H. C. Beardslee (Cat.); Ashtabula Co., E. E. Bogue.

CARDUUS VIRGINIANUS L. (*Cnicus virginianus* Pursh.)
Lorain Co., A. A. Wright (Cat.); Cincinnati, Jos. F. James (Cat.)

49. ONOPORDON L. COTTON OR SCOTCH THISTLE.

ONOPORDON ACANTHIUM L.
Sparingly naturalized, J. S. Newberry (Cat.); Cincinnati, Jos. F. James (Cat.)

50. CENTAUREA L. Star Thistle.

Centaurea benedicta L.
"Sparingly naturalized." J. S. Newberry (Cat.)

Centaurea cyanus L. Blue Bottle.
Cleveland, Wm. Krebs; Columbns, Moses Craig; Licking Co., H. L. Jones (Cat.)

Centaurea jacea L.
Richland Co., E. Wilkinson; Columbus, Wm. C. Werner.

Centaurea nigra L. Knapweed.
Painesville, Otto Hacker.

51. CICHORIUM L. Chicory. Succory.

Cichorium intybus L.
Northern Ohio; Franklin Co., E. V. Wilcox; Monroe Co., H. Herzer.

52. APOGON Neck. (*Krigia* L.) Dwarf Dandelion.

Apogon virginicum (L.) Kuntze. (*Krigia amplexicaulis* Nutt.)
From Lake Erie to the Ohio River.

Apogon dandelion (L.) Kuntze. (*Krigia dandelion* Nutt.)
Lorain Co., A. A. Wright (Cat.)

Apogon carolinianum (Nutt.) (*Krigia virginica* Willd.)
Southern Ohio, Leo Lesquereux (Beardslee Cat.)

53. LAPSANA L. Nipple-wort.

Lapsana communis L.
Painesville, Otto Hacker; Columbus, W. R. Lazenby.

54. CREPIS L.

Crepis tectorum L.
Lorain Co., A. A. Wright (Cat.)

55. HIERACIUM L. Hawkweed.

Hieracium canadense Michx.
"Northern Ohio, general" H. C. Beardslee (Cat.)

Hieracium gronovii L.
From Lake Erie to the Ohio River.

Hieracium paniculatum L.
Northern and central Ohio; Cincinnati, Jos. F. James.

Hieracium scabrum Michx.
From Lake Erie to the Ohio River.

Hieracium venosum L.
Not uncommon.

56. LEONTODON L. Fall Dandelion.

Leontodon autumnalis L.
Painesville, Wm. C. Werner.

57. TARAXACUM Hall. Dandelion.

Taraxacum officinale Weber.
Everywhere.

58. LACTUCA L. Lettuce.

Lactuca canadensis L.
Common.

Lactuca floridana (L.) Gaertn.
Apparently over the whole state.

Lactuca hirsuta Muhl.
Licking Co., H. L. Jones (Cat.) The plant given as above by Craig (O. S. U. Flora,) and Lazenby and Werner (Sup. Cat.) is L. floridana.

Lactuca ludoviciana (Nutt.) DC.
"Ohio" J. L. Riddell (Synop. 1835.)

Lactuca pulchella (Ph.) DC.
Columbus, Wm. C. Werner.

Lactuca sagittaefolia Ell. (*L. integrifolia* Bigel.)
Over the state, not abundant.

Lactuca spicata Lam. (*L. leucophaea* Gray).
Throughout the state.

Lactuca spicata integrifolia (Gray) Britton. (*L. leucophaea integrifolia* Gray)
Northern and central Ohio; no specimens seen from southern Ohio.

Lactuca scariola L.
Over the whole State.

Lactuca villosa Jacq. (*L. acuminata* Gray).
"Miami Country," J. L. Riddell (Synop. 1835); Licking Co., H. L. Jones (Cat.), Cincinnati, Jos. F. James (Cat.)

59. PRENANTHES L. Rattlesnake-root.

Prenanthes alba L.
Throughout the state.

PRENANTHES ALTISSIMA L.
Generally distributed.

PRENANTHES ASPERA, Mx.
"Ohio," Gray (Manual).

PRENANTHES CREPIDINEA Michx.
Painesville, Otto Hacker; Columbus, Wm. C. Werner; Cincinnati, Jos. F. James (Cat.)

PRENANTHES RACEMOSA Michx.
Gypsum (Ottawa Co.,) E. Claassen; Toledo, J. A. Sanford; Cleveland, E. Claassen; Springfield, Mrs. E. Jane Spence.

PRENANTHES SERPENTARIA Pursh.
"General," H. C. Beardslee (Cat.); Lorain Co., A. A. Wright (Cat.)

PREUANTHES VIRGATA, Mx.
"Southern and Central Ohio," J. S. Newberry (Cat.)

60. SONCHUS L. Sow Thistle.

SONCHUS ARVENSIS L.
"Introduced, Ohio," J. L. Riddell (Synop. 1835); Painesville, Otto Hacker.

SONCHUS ASPER (L.)
Throughout the state.

SONCHUS OLERACEUS L.
Common over the state.

61. TRAGOPOGON L. Salsify. Goat's-beard.

TRAGOPOGON PORRIFOLIUS L. Salsify. Oyster-plant.
Lorain Co., A. A. Wright (Cat.); Painesville, Wm. C. Werner; Black Lick Franklin Co., Wm. C. Werner.

TRAGOPOGON PRATENSIS L. Goat's-beard.
Ashtabula Co., Sara F. Goodrich.

II. Order CAMPANULACEAE. Campanula Family.

62. CAMPANULA L. Bellflower.

CAMPANULA AMERICANA L.
Frequent.

CAMPANULA APARINOIDES Pursh.
Frequent throughout the state, but not abundant in any locality.

CAMPANULA RAPUNCULOIDES L.
Lorain Co., A. A. Wright (Cat.); Painesville, Otto Hacker.

Campanula rotundifolia L.
Put-in-Bay Island (Lake Erie), H. C. Beardslee (Cat.); Lorain Co., A. A. Wright (Cat.)

63. SPECULARIA Heist. Venus' Looking-glass.

Specularia perfoliata (L.) A. DC.
Throughout the state.

III. Order LOBELIACEAE. Lobelia Family.

64. LOBELIA L. Lobelia.

Lobelia cardinalis L.
Frequent throughout the state.

Lobelia inflata L.
Over the whole state.

Lobelia kalmii L.
Cleveland, W. Krebs; Columbus, E. E. Bogue; Cedar Swamp (Champaign Co.,) Mrs. E. Jane Spence.

Lobelia leptostachys A. DC.
Toledo, J, A. Sanford; Fairfield Co., W. A. Kellerman; Licking Co., H. L. Jones (Cat.); Springfield, Mrs. E. Jane Spence.

Lobelia nuttallii Roem. and Schult.
Was given for Ohio by Lazenby and Werner (Sup. Cat.) from notes by Prof. Lazenby. On examination of the specimen it was found to be Lobelia spicata.

Lobelia puberula Michx.
Rio Grande (Gallia Co.,) J. W. Davis.

Lobelia spicata Lam.
Throughout the state. Infrequent.

Lobelia syphilitica L.
Frequent over the whole state.

IV. Order CURCURBITACEAE. Gourd Family.

65. MICRAMPELES Raf. (*Echinocystis.*) Wild Balsam Apple.

Micrampeles lobata (Mx.) Greene. (*Echinocystis lobata* Torr. and Gray.)
Common throughout the state.

66. SICYOS L. One-seeded Bur-Cucumber.

SICYOS ANGULATUS L.
Frequent throughout the southern half of the state; Lorain Co., A. A. Wright (Cat.); Painesville, Wm. C. Werner.

V. ORDER DIPSACEAE. Teasel Family.

67. DIPSACUS Tourn. TEASEL.

DIPSACUS SYLVESTRIS Mill. Wild Teasel.
Common over the whole state.

VI. ORDER VALERIANACEAE. Valerian Family.

68. VALERIANA L. VALERIAN.

VALERIANA EDULIS Nutt.
Columbus, W. S. Sullivant (H. C. Beardslee Cat.); Cedar Swamp (Champaign Co.,) E. M. Wilcox.

VALERIANA PAUCIFLORA Michx.
Central and southern Ohio; Lorain Co., A. A. Wright (Cat.)

69. VALERIANELLA Tourn. CORN SALAD. LAMB LETTUCE.

VALERIANELLA CHENOPODIFOLIA D. C.
Licking Co., H. L. Jones (Cat.)

VALERIANELLA LOCUSTA (L.) Bettke. (*V. olitoria* Poll.)
Cleveland, W. Krebs; Cincinnati, C. J. Herrick.

VALERIANELLA RADIATA (L.) Dufr.
W. S Sullivant (Cat. 1840); Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.)

VALERIANELLA WOODSIANA PATELLARIA (Sulliv.) Gray.
Franklin Co., W. S. Sullivant (Cat. 1840); Cincinnati, Jos. F. James (Cat.)

VALERIANELLA WOODSIANA UMBILICATA (Sulliv.) Gray.
Throughout south central Ohio.

VII. ORDER CAPRIFOLIACEAE. Honeysuckle Family.

70. SAMBUCUS Tourn. ELDER.

SAMBUCUS CANADENSIS L.
Common all over the state.

SAMBUCUS RACEMOSUS L.
Frequent throughout northern Ohio; Fairfield Co., E. V. Wilcox.

71. VIBURNUM L. ARROW-WOOD. LAURESTINUS.

VIBURNUM ACERIFOLIUM L. Dockmackie. Arrow-wood.
Generally distributed.

VIBURNUM DENTATUM L. Arrow-wood.
Throughout the northern half of the state.

VIBURNUM LANTANOIDES Michx. Hobble-bush. American Wayfaring-tree.
Ashtabula Co., John Ramage; Painesville, H. C. Beardslee (Cat.)

VIBURNUM LENTAGO L. Sweet Viburnum. Sheep-berry.
Probably generally distributed.

VIBURNUM NUDUM L.
"Northern Ohio," J. S. Newberry (Cat.)

VIBURNUM NUDUM CASSINOIDES (L.) Jacq.
Lorain Co., A. A. Wright (Cat.); Painesville, W. C. Werner; Ashtabula Co., E. E. Bogue.

VIBURNUM OPULUS L. Cranberry-tree.
Painesville, H. C. Beardslee (Cat.); Lorain Co., A. A. Wright (Cat.); Cincinnati, Jos. F. James (Cat.)

VIBURNUM PRUNIFOLIUM L. Black Haw.
Frequent throughout the central and southern part of the state, also Lima, W. A. Kellerman.

VIBURNUM PUBESCENS Pursh. Downy Arrow-wood.
Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.); Fairfield Co., E. V. Wilcox and S. Renshaw.

72. TRIOSTEUM L. FEVER-WORT. HORSE-GENTIAN.

TRIOSTEUM ANGUSTIFOLIUM L.
Cincinnati, Joseph Clark (H. C. Beardslee Cat.)

TRIOSTEUM PERFOLIATUM L. Tinker's Weed. Wild Coffee.
Throughout the state.

73. SYMPHORICARPOS Dill. SNOW-BERRY.

SYMPHORICARPOS RACEMOSUS Michx. Snowberry.
Near Cincinnati, J. L. Riddell (Synop. 1835); Painesville, H. C. Beardslee (Cat.)

SYMPHORICARPOS PAUCIFLORUS (Robbins.) (*S. racemosus pauciflorus* Robbins).
Cedar Point (Ottawa Co.,) W. Krebs.

SYMPHORICARPOS VULGARIS Mich. Indian Currant. Coral Berry.
Cincinnati, Joseph Clark (H. C. Beardslee Cat.); Painesville, W. C. Werner; Licking Co., H. L. Jones (Cat.)

74. LONICERA L. HONEYSUCKLE. WOODBINE.

LONICERA CAERULEA L. Mountain Fly-Honeysuckle.
"Northern Ohio," H. C. Beardslee (Cat.)

LONICERA CILIATA Muhl.
Northern Ohio, W. Krebs, W. C. Werner, A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.)

LONICERA GLAUCA Hill.
Champaign Co., W. C. Werner; Springfield, Mrs. E. J. Spence; Licking Co., H. L. Jones (Cat.)

LONICERA GRATA Ait. American Wood-bine.
"Northern Ohio," J. S. Newberry (Cat.)

LONICERA HIRSUTA Eaton. Hairy Honeysuckle.
Northern Ohio; Columbus, Wm. C. Werner.

LONICERA OBLONGIFOLIA Muhl. Swamp Fly-Honeysuckle.
Lake shore, near Cleveland, W. Krebs.

LONICERA SEMPERVIRENS Ait. Trumpet Honeysuckle.
Lorain Co., A. A. Wright (Cat.); Cleveland, W. Krebs; Painesville, W. C. Werner; Licking Co., H. L. Jones (Cat.); Miami Valley, A. P. Morgan (Flora).

LONICERA SULLIVANTII Gray.
Champaign Co., Mrs. E. J. Spence; Columbus, Aug. D. Selby; Fairfield Co., E. V. Wilcox, S. Renshaw; Cincinnati, Jos. F. James (Cat.)

LONICERA XYLOSTEUM L.
Escaped from cultivation, Painesville, O. Hacker.

75. DIERVILLA Tourn. BUSH HONEYSUCKLE.

DIERVILLA TRIFIDA, Moench.
Throughout the northern half of the state.

VIII. ORDER RUBIACEÆ. Madder Family.

76. CEPHALANTHUS L. BUTTON BUSH.

CEPHALANTHUS OCCIDENTALIS L.
Frequent all over the state.

77. OLDENLANDIA L.

OLDENLANDIA UNIFLORA L. (*O. glomerata* Michx.)
Cincinnati, Thos. G. Lea (Cat.)

78. HOUSTONIA L.

HOUSTONIA CAERULEA L. Bluets. Innocence.
Distributed over the whole state.

HOUSTONIA PURPUREA L.
Licking Co., H. L. Jones (Cat.); Loveland (Clermont Co.) Jos. F. James.

HOUSTONIA CILIOLATA, Torr. (*H. purpurea ciliolata* Gray).
Not frequent, but found from northern Ohio to Cincinnati.

HOUSTONIA LONGIFOLIA Gaertn. (*H. purpurea longifolia* Gray).
Frequent throughout the southern half of the state; S. Bass Island (Lake Erie) W. Krebs.

HOUSTONIA TENUIFOLIA Nutt, (*H. purpurea tenuifolia* Gray).
"S. E. Ohio," Gray (Manual).

79. MITCHELLA L. PARTRIDGE BERRY.

MITCHELLA REPENS L.
Throughout the state.

80. SPERMACOCE Dill. BUTTON-WEED.

SPERMACOCE GLABRA Michx.
"Southern Ohio," Asa Gray (Manual).

81. GALIUM L. BEDSTRAW. CLEAVERS.

GALIUM APARINE, L. Cleavers. Goose-grass.
Frequent throughout the state.

GALIUM ASPRELLUM, Michx.
Common throughout the state.

GALIUM BOREALE L. Northern Bedstraw.
"Northern Ohio," H. C. Beardslee (Cat.); Franklin Co., W. S. Sullivant (Cat.); Lorain Co., A. A. Wright (Cat.)

GALIUM CIRCÆZANS Michx. Wild Liquorice.
Over the whole state.

GALIUM CONCINNUM Torr. & Gray.
Frequent all over the the state.

GALIUM LANCEOLATUM Torr. Wild Liquorice.
"General," J. S. Newberry (Cat.); Northern Ohio, A. A. Wright (Cat.); Central Ohio, Mrs. E. Jane Spence, H. L. Jones (Cat.)

GALIUM LATIFOLIUM Michx.
Cincinnati, Joseph Clark (Cat.)

GALIUM PILOSUM Ait.
Youngstown, R. H. Ingraham; Central Ohio, E. V. Wilcox, H. L. Jones (Cat.)

GALIUM TRIFIDUM L. Small Bedstraw.
Generally distributed.

GALIUM TRIFIDUM LATIFOLIUM Torr.
Not abundant but distributed over the state.

GALIUM TRIFIDUM PUSILLUM Gray.
Lorain Co., A. A. Wright (Cat.); Cleveland, W. Krebs; Painesville, W. C. Werner; Columbus, W. C. Werner.

GALIUM TRIFLORUM Michx. Sweet-scented Bedstraw.
Throughout the state.

GALIUM VERNUM L. Yellow Bedstraw.
Painesville, Otto Hacker.

IX. ORDER PLANTAGINACEÆ. Plantain Family.

82. PLANTAGO Tourn. PLANTAIN. RIBWORT.

PLANTAGO CORDATA Lam.
Lorain Co., A. A. Wright (Cat.); Columbus, D. S. Kellicott.

PLANTAGO ELONGATA Ph. (*P. pusilla* Nutt.)
"General" J. S. Newberry (Cat.)

PLANTAGO LANCEOLATA L. Ribgrass. Ripplegrass. English Plantain.
Common.

PLANTAGO MAJOR L.
Painesville, Cedar Swamp (Champaign Co.) W. C. Werner; Licking Co., H. L. Jones (Cat.)

PLANTAGO PATAGONICA ARISTATA (Mx.) Gray.
Painesville, Otto Hacker; Licking Co., H. L. Jones (Cat.); Franklin Co., W. S. Devol.

PLANTAGO RUGELII Decaisne.
Common everywhere.

PLANTAGO VIRGINICA L.
Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.); Sugar Grove, E. V. Wilcox; Lawrence Co., Wm. C. Werner.

X. Order VERBENACEÆ. Vervain Family.

83. PHRYMA L. Lopseed.

Phryma leptostachya L.
Frequent.

84. LIPPIA Houst.

Lippia lanceolata Michx. Fog-fruit.
Throughout the southern half of the state.

85. VERBENA Tourn. Vervain.

Verbena angustifolia Michx.
Kelley's Island, W. Krebs; Cincinnati, J. F. James (Cat.)

Verbena aubletia L.
Miami Valley, A. P. Morgan (Flora).

Verbena bracteosa Michx.
Cincinnati, J. F. James (Cat.); Miami Valley, A. P. Morgan (Flora).

Verbena hastata L. Blue Vervain.
Common.

Verbena stricta Vent. Hoary Vervain.
Cincinnati, J. F. James (Cat.); Painesville, Wm. C. Werner; Columbus, W. J. Green.

Verbena urticæfolia L. White Vervain.
Common.

XI. Order LABIATAE. Mint Family.

86. MENTHA Tourn. Mint.

Mentha aquatica L.
Columbus, A. F. Wilcox.

Mentha arvensis L. Corn Mint.
Lorain Co., A. A. Wright (Cat.); Painesville, Otto Hacker; "Duncan's Plains, Ohio," J. L. Riddell (Synop. 1835.)

Mentha canadensis L. Wild Mint.
Throughout the state.

Mentha canadensis borealis (Mx.) Wood. (*M. canadensis glabrata* Berth).
Ohio, J. L. Riddell (Synop. 1835); Cincinnati, Jos. Clark (Cat.)

MENTHA PIPERITA L. Peppermint.
Widely distributed.

MENTHA SATIVA L. Whorled Mint.
Licking Co., H. L. Jones (Cat.)

MENTHA SYLVESTRIS ALOPECUROIDES (Hall) Baker. Horse Mint.
Franklin Co., E. V. Wilcox.

MENTHA VIRIDIS L.
Northern and central Ohio; Cincinnati, Jos. F. James (Cat.)

87. COLLINSONIA L. HORSE-BALM.

COLLINSONIA CANADENSIS L. Rich-weed. Stone root.
Distributed over the state.

88. LYCOPUS Tourn. WATER-HOREHOUND.

LYCOPUS RUBELLUS Moench.
New Antioch (Clinton Co.,) J. S. Vandervort; Lorain Co., A. A. Wright (Cat.); Painesville and Columbus, Wm. C. Werner.
Licking Co., H. L. Jones (Cat.)

LYCOPUS SINUATUS Ell.
Common.

LYCOPUS EUROPAEUS L.
Lorain Co., A. A. Wright (Cat); Cincinnati, Jos. F. James (Cat.)

LYCOPUS VIRGINICUS L. Bugle-weed.
Common.

89. CUNILA L. DITTANY.

CUNILA MARIANA L. Common Dittany.
Southern half of the state.

90. PYCNANTHEMUM Mx. MOUNTAIN MINT. BASIL.

PYCNANTHEMUM ARISTATUM Mx.
"Ohio," J. L. Riddell (Synop. 1835.)

PYCNANTHEMUM FLEXUOSUM (Walt.) B. S. P. (*P. linifolium* Ph.)
Frequent.

PYCNANTHEMUM INCANUM (L.) Mx.
Throughout the state, but not common.

PYCNANTHEMUM MUTICUM (Mx.) Pers.
Licking Co., R. H. Ingraham, H. L. Jones (Cat.).

PYCNANTHEMUM MUTICUM PILOSUM Gr.
Cleveland, Dover Bay, W. Krebs; Springfield, Mrs. E. J. Spence; Miami Valley, A. P. Morgan (Flora).

PYCNANTHEMUM VIRGINICUM (L.) B. S. P. (*P. lanceolatum* Ph.)
Frequent.

91. ORIGANUM Tourn. WILD MARJORAM.

ORIGANUM VULGARE L.
"Interior O.," Leo Lesquereux (Newberry Cat.)

92. THYMUS Tourn. THYME.

THYMUS SERPYLLUM L. Creeping Thyme.
"Northern Ohio," H. C. Beardslee (Cat.)

92*a*. SATUREIA Tourn.

SATUREIA HORTENSIS L. Summer Savory.
"Ohio," Gray (Man.)

93. HEDEOMA Pers. MOCK PENNYROYAL.

HEDEOMA PULEGIOIDES (L.) Pers. American Pennyroyal.
Common.

94. CALAMINTHA Tourn. CALAMINT.

CALAMINTHA CLINOPODIUM Benth. Basil.
Northern and central Ohio; Fairfield Co., E. V. Wilcox, S. Renshaw.

CALAMINTHA GLABELLA Benth.
"Central Ohio," W. S. Sullivant (Newberry Cat.)

CALAMINTHA GLABRA Nutt. (*C. nuttallii* Gray).
Marblehead, (Ottawa Co.) W. Krebs; Lakeside, Aug. D. Selby; Tiffin (Seneca Co.) W. H. Egbert; Clifton (Green Co.,) Mrs. E. J. Spence.

95. MELISSA L. BALM.

MELISSA OFFICINALIS L. Common Balm.
Occasionally throughout the state.

96. SALVIA L. SAGE.

SALVIA LYRATA L.
Painesville, H. C. Beardslee (Cat.); Rio Grande (Gallia Co.) W. W. Deckard; Lawrence Co., W. C. Werner.

97. MONARDA L. Horse-mint.

Monarda bradburiana Beck.
Cincinnati, Jos. Clark (Cat.); Southern and western Ohio, Thos. G. Clark (Beardslee Cat.)

Monarda citriodora Cerv.
Columbus, grounds of Sells Bros.' circus, Aug. D. Selby.

Monarda clinopodia L.
Richland Co., E. Wilkinson; Fairfield Co., E. V. Wilcox, S. Renshaw; Painesville, Franklin Co., W. C. Werner; New Antioch (Clinton Co.) J. S. Vandervort.

Monarda didyma L. Oswego Tea. Bee-Balm.
Nelson Ledge (Portage Co.) W. Krebs; Cincinnati, Jos. F. James (Cat.)

Monarda fistulosa L.
Painesville, Wm. C. Werner; Defiance Co., J. M. Phillips; Summit Co., W. Krebs; Springfield, Mrs. E. J. Spence.

Monarda punctata L.
"General," J. S. Newberry (Cat.)

98. BLEPHILIA Raf.

Blephilia ciliata (L.) Raf.
Frequent.

Blephilia hirsuta Benth.
Frequent.

99. LOPHANTHUS Benth. Giant Hyssop.

Lophanthus nepetoides (L.) Benth.
Frequent throughout the state.

Lophanthus scrophulariæfolius (Willd.) Benth.
Lorain Co., A. A. Wright (Cat.); Medina Co., W. Krebs; Franklin Co., Aug. D. Selby; Cincinnati, Jos. F. James (Cat.)

100. NEPETA L. Cat-Mint.

Nepeta cataria L. Catnip.
Common.

Nepeta hederacea (L.) B. S. P. (*N. glechoma* Benth) Ground Ivy. Gill-over-the-ground.
Common.

101. SCUTELLARIA L. Skullcap.

SCUTELLARIA CANESCENS Nutt.
Generally distributed.

SCUTELLARIA GALERICULATA L.
Throughout the state.

SCUTELLARIA INTEGRIFOLIA L.
"General," J. S. Newberry (Cat.)

SCUTELLARIA LATERIFLORA L. Mad-dog Skullcap.
Generally distributed.

SCUTELLARIA NERVOSA Pursh.
Throughout the state but not frequent.

SCUTELLARIA PARVULA Mx.
Lake Erie to southern Ohio, but not common.

SCUTELLARIA PILOSA Mx.
"General," J. S. Newberry (Cat.); Licking Co., H. L. Jones (Cat.)

SCUTELLARIA SAXATILIS Riddell.
Licking Co., H. L. Jones (Cat.)

SCUTELLARIA VERSICOLOR Nutt.
Frequent throughout the southern half of the state. Cleveland, Wm. Krebs.

102. BRUNELLA Tourn. SELF-HEAL.

BRUNELLA VULGARIS L. Common Self-heal or Heal-all.
Common.

103. PHYSOSTEGIA Benth. FALSE DRAGON-HEAD.

PHYSOSTEGIA VIRGINIANA (L.) Benth.
Generally distributed.

104. SYNANDRA Nutt.

SYNANDRA GRANDIFLORA Nutt.
Franklin Co., J. E. Gould; Cincinnati, Jos. F. James (Cat.); Lawrence Co., W. C. Werner.

105. MARRUBIUM Tourn. HOREHOUND.

MARRUBIUM VULGARE L. Common Horehound.
Fields and waste places all over the state.

106. STACHYS Tourn. HEDGE-NETTLE.

STACHYS ASPERA Mx.
Throughout the state.

STACHYS ASPERA GLABRA Gray.
Lorain Co., A. A. Wright (Cat.); Licking County, H. L. Jones (Cat.); Columbus, Wm. C. Werner.

STACHYS CORDATA Riddell.
Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.); Cincinnati, Jos. F. James (Cat.)

STACHYS PALUSTRIS L.
Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.); Cincinnati, Jos. F. James (Cat.)

107. GALEOPSIS L. HEMP-NETTLE.

GALEOPSIS TETRAHIT L. Common Hemp-Nettle.
"General," J. S. Newberry (Cat.); Ashtabula Co., Sara F. Goodrich; Miami Valley, A. P. Morgan (Flora).

108. LEONURUS L. MOTHERWORT.

LEONURUS CARDIACA L. Common Motherwort.
Common.

109. LAMIUM L. DEAD-NETTLE.

LAMIUM ALBUM L.
Licking Co., H. L. Jones (Cat.)

LAMIUM AMPLEXICAULE L.
Frequent throughout the state.

LAMIUM MACULATUM L.
Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.)

LAMIUM PURPUREUM L.
Lake Co., W. C. Werner; Lorain Co., A. A. Wright (Cat.)

110. TRICHOSTEMA L. BLUE CURLS.

TRICHOSTEMA DICHOTOMUM L. Bastard Pennyroyal.
Fairfield Co., W. A. Kellerman.

111. ISANTHUS Mx. FALSE PENNYROYAL.

ISANTHUS BRACHIATUS (L.) B. S. P. (*I. caeruleus* Mx.)
Marblehead (Ottawa Co.) W. Krebs; Muskingum Co., W. C. Werner; Warren Co., W. A. Kellerman.

112. TEUCRIUM Tourn. GERMANDER.

TEUCRIUM CANADENSE L. American Germander.
Frequent all over the state.

112*a*. AJUGA L.

AJUGA REPTANS L.
Painesville, Otto Hacker.

XII. ORDER BORRAGINACEÆ. Borage Family.

113. HELIOTROPIUM Tourn. TOURNSOLE. HELIOTROPE.

HELIOTROPIUM INDICUM L.
Cincinnati, Jos. F. James (Cat.)

HELIOTROPIUM ANCHUSÆFOLIUM Poir.
Introduced, Painesville, Wm. C. Werner.

114. CYNOGLOSSUM Tourn. HOUND'S-TONGUE.

CYNOGLOSSUM OFFICINALE L. Common Hound's-Tongue.
Frequent in waste places and roadsides.

CYNOGLOSSUM VIRGINICUM L. Wild Comfrey.
Cleveland, W. Krebs; Painesville, Otto Hacker; Central and southern Ohio.

115. LAPPULA Moench. (*Echinospermum* Lehm.) STICKSEED.

LAPPULA MYOSOTIS Moench. (*Echinospermum lappula* Lehm.)
Common.

LAPPULA VIRGINIANA (L.) Greene. (*Echinospermum virginicum* Lehm.)
Apparantly over the whole state.

116. SYMPHYTUM Tourn. COMFREY.

SYMPHYTUM OFFICINALE L. Common Comfrey.
Appears over the state generally but infrequent.

117. LYCOPSIS L. BUGLOSS.

LYCOPSIS ARVENSIS L. Small Bugloss.
Painesville, Otto Hacker.

118. MERTENSIA Roth. Lungwort.

MERTENSIA VIRGINICA (L.) DC.
From Lake Erie to the Ohio River.

119. MYOSOTIS Dill. SCORPION-GRASS. FORGET-ME-NOT.

MYOSOTIS ARVENSIS (L.) Willd.
Painesville, Otto Hacker; Cleveland, W. Krebs; Franklin Co., Miss Hulda Hoffman; Lorain Co., A. A. Wright (Cat.): Rio Grande, Galia Co., Ruth E. Brockett.

MYOSOTIS LAXA Lehm.
Frequent in marshes and wet places throughout northern Ohio.

MYOSOTIS PALUSTUS (L.) Kelp. True Forget-me-not.
"General," J. S. Newberry (Cat.)

MYOSOTIS VIRGINICA (L.) B. S. P. (*M. verna* Nutt.)
Central and southern Ohio, Lorain Co., A. A. Wright (Cat.); Ashtabula Co., Sara F. Goodrich.

120. ONOSMODIUM Michx. FALSE GROMWELL.

ONOSMODIUM CAROLINIANUM (Lam.) DC.
Several localities in the northern half of the state.

ONOSMODIUM CAROLINIANUM MOLLE Gray.
"Ohio" Gray's Man 5th ed..

ONOSMODIUM VIRGINICUM (L.) DC.
"General," J. S. Newberry (Cat.)

121. LITHOSPERMUM Tourn. GROMWELL. PUCCOON.

LITHOSPERMUM ANGUSTIFOLIUM Michx.
Cedar Point, near Sandusky, W. Krebs.

LITHOSPERMUM ARVENSE L. Corn Gromwell.
Common throughout the state.

LITHOSPERMUM CANESCENS (Mx.) Lehm. Puccoon.
Throughout central and southern Ohio. Toledo, J. A. Sanford.

LITHOSPERMUM HIRTUM Lehm.
Cedar Point (Ottawa Co.) W. Krebs; Toledo, J. A. Sanford.

LITHOSPERMUM LATIFOLIUM Michx.
Toledo, J. A. Sanford. Cincinnati, J. F. James; Lawrence Co., W. C. Werner.

LITHOSPERMUM OFFICINALE L. Common Gromwell.
"Central Ohio," J. S. Newberry (Cat.)

122. ECHIUM Tourn. VIPER'S BUGLOSS.

ECHIUM VULGARE L. Blue-weed.
From Lake Erie to the Ohio River.

XIII .ORDER HYDROPHYLLACEÆ. Waterleaf Family.

123. HYDROPHYLLUM Tourn. WATERLEAF.

HYDROPHYLLUM APPENDICULATUM Mx.
From Lake Erie to the Ohio River.

Hydrophyllum canadense L.
Widely distributed.

Hydrophyllum macrophyllum Nutt.
Central and southern Ohio.

Hydrophyllum virginicum L.
Apparently over the state.

124. PHACELIA Juss.

Phacelia bipinnatifida Michx.
Cincinnati, C. J. Herrick, J. F. James (Cat.)

Phacelia dubia (L.) (*P. parviflora* Ph.)
"Central and southern Ohio," J. S. Newberry (Cat.)

Phacelia fimbriata Michx.
"Central and southern Ohio," J. S. Newberry (Cat.)

Phacelia purshii Buckley.
Throughout the southern half of the state.

XIV. Order ACANTHACEÆ. Acanthus Family.

125. RUELLIA Plumier.

Ruellia ciliosa Pursh.
Springfield, Mrs. E. J. Spence; Licking Co., H. L. Jones (Cat.)

Ruellia strepens L.
Throughout the southern half of the state.

Ruellia strepens cleistantha Gray.
With the type.

126. DIANTHERA Gronov. Water-Willow.

Dianthera americana L.
Islands of Lake Erie and southward to the Ohio River.

XV. Order BIGNONIACÆ. Bignonia Family.

127. BIGNONIA Tourn.

Bignonia capreolata L. Cross-vine.
Lawrence Co., at Ironton and Hanging Rock, W. C. Werner, and in Symmes Creek Valley, W.A. Kellerman.

128. CATALPA Scop., Walt. CATALPA. INDIAN BEAN.

CATALPA CATALPA (L.) Sudworth (*C. bignonioides* Walt.)
Fairly naturalized in southern Ohio, J. H. Warder (W. Pl. O. 1882): Warren and Lawrence Counties, W. A. Kellerman; Licking Co., H. L. Jones (Cat.); Cincinnati; J. F. Jones (Cat.).

CATALPA SPECIOSA Warder.
Nearly naturalized in southwestern Ohio, J. H. Warder (W. Pl. O. 1882).; Lawrence Co., W. A. Kellerman.

129. TECOMA Juss. TRUMPET-FLOWER.

TECOMA RADICANS (L.) Juss.
From Lake Erie to the Ohio River.

XVI. ORDER PEDALIACEAE.

130. MARTYNIA L. UNICORN-PLANT.

MARTYNIA PROBOSCIDEA Glox.
Franklin Co., W. S. Sullivant (Cat. 1840); Cincinnati, J. F. James (Cat.)

XVII. ORDER OROBANCHACEÆ. Broom-Rape Family.

131. APHYLLON Mitchell. NAKED BROOM-RAPE.

APHYLLON UNIFLORUM (L.) Gray. One-flowered Cancer-root.
Distributed throughout the state but not abundant.

132. CONOPHOLIS Walroth. SQUAW-ROOT. CANCER-ROOT.

CONOPHOLIS AMERICANA (L. f.) Wallroth.
Widely distributed.

133. EPIPHEGUS Nutt. BEECH-DROPS. CANCER-ROOT.

EPIPHEGUS VIRGINIANA (L.) Burt.
Over the whole state.

XVIII. ORDER LENTIBULARIACEÆ L. Bladder-wort Family.

134. UTRICULARIA L. BLADDERWORT.

UTRICULARIA CORNUTA Mx.
Central Ohio, W. S. Sullivant (Cat. 1840).
Champaign Co., Wm. C. Werner.

UTRICULARIA GIBBA L.
Central and southern Ohio, J. S. Newberry (Cat.); Cincinnati, Jos. Clark (Cat.)

UTRICULARIA INTERMEDIA Hayne.
Central Ohio, W. S. Sullivant (Cat. 1840); Lorain Co., Dr. Kellogg (Newberry Cat.); Painesille and Champaign Co., Wm. C. Werner.

UTRICULARIA MINOR L.
Northern Ohio, J. S. Newberry (Cat.); Licking Co., H. L. Jones (Cat.); Cincinnati, Thos. G. Lea (Cat.)

UTRICULARIA VULGARIS L.
Northern and central Ohio no specimen seen from the southern part of the state.

XIX. ORDER SCROPHULARIACEÆ Figwort Family.

135. VERBASCUM L. MULLEIN.

VERBASCUM BLATTARIA L. Moth Mullein.
Throughout the state, common in some sections.

VERBASCUM THAPSUS L. Common Mullein.
Throughout the state.

136. LINARIA Tourn. TOAD-FLAX.

LINARIA CANADENSIS (L). Dumont.
"General," J. S. Newberry (Cat.)

LINARIA ELATINE (L.) Mill.
Painesville, Otto Hacker.

LINARIA VULGARIS Mill.
Common.

137. SCROPHULARIA Tourn. Figwort.

SCROPHULARIA MARYLANDICA L. (*S. nodosa marylandica* Gray.)
Widely distributed.

138. CHELONE Tourn. TURTLE-HEAD. SNAKE-HEAD.

CHELONE GLABRA L.
Throughout the state.

139. PENTSTEMON Mitchell. BEARD-TONGUE.

PENTSTEMON HIRSUTUS (L.) Willd. (*P. pubescens* Solander.)
Over the state.

PENTSTEMON LÆVIGATUS Solander.
From Lake Erie to the Ohio River.

PENTSTEMON LÆVIGATUS DIGITALIS Gray.
Ashtabula Co., E. E. Bogue.

140. COLLINSIA, Nutt.

COLLINSIA VERNA Nutt.
Rather frequent throughout the central and southern part of the state; rare northward.

141. MIMULUS L. MONKEY-FLOWER.

MIMULUS ALATUS Ait.
Distributed throughout the state.

MIMULUS RINGENS L.
Frequent.

142. CONOBEA Aublet.

CONOBEA MULTIFIDA (Mx.) Benth.
Lake Side (Ottawa Co.) Aug. D. Selby; Dayton, August F. Foerste (Bot. Gaz., vol. VI, p. 214); Cincinnati, J. F. James (Cat.)

143. GRATIOLA L. HEDGE-HYSSOP.

GRATIOLA AUREA Muhl.
"Eastern and northern Ohio," J. S. Newberry (Cat.)

GRATIOLA VIRGINICA L.
Over the whole state.

144. ILYSANTHES Raf. (FALSE PIMPERNEL.)

ILYSANTHES GRATIOLOIDES (L.) Benth. (*I. riparia* Raf.)
From Lake Erie to the Ohio River.

145. DIGITALIS L.

DIGITALIS LUTEA L.
Cleveland, W. Krebs (introduced).

146. VERONICA L. SPEEDWELL.

VERONICA AGRESTIS L.
Cincinnati, J. F. James (Cat.); Painesville, Otto Hacker; Columbus, Cora McFadden.

VERONICA AMERICANA Schw.
Common.

VERONICA ANAGALLIS L.
Cincinnati, J. F. James (Cat.); Fairfield Co., E. V. Wilcox and S. Renshaw; Franklin Co., Moses Craig.

VERONICA ARVENSIS L.
From Lake Erie to the Ohio River.

VERONICA BYZANTINA (Sibth. and Sm.) B. S. P. (*V. buxbaumii* Tenore)
Painesville, Otto Hacker; Lorain Co., A. A. Wright (Cat.)

VERONICA HEDERAEFOLIA L.
Lorain Co., A. A. Wright (Cat.)

VERONICA OFFICINALIS L.
Common.

VERONICA PEREGRINA L.
Generally distributed over the state.

VERONICA SCUTELLATA L.
Northern and central portion of the state; no specimens seen from the southern counties.

VERONICA SERPYLLIFOLIA L.
Frequent.

VERONICA VIRGINICA L.
Widely distributed.

147. BUCHNERA L. BLUE-HEARTS.

BUCHNERA AMERICANA L.
"Central Ohio," W. S. Sullivant (Newberry Cat.); Fulton Co., J. S. Hine.

148. SEYMERIA Pursh.

SEYMERIA MACROPHYLLA Nutt.
Frequent throughout central and southern Ohio; Toledo, J. A. Sanford.

149. GERARDIA L.

GERARDIA AURICULATA Michx.
Franklin Co., W. S. Sullivant (Cat. 1840). Has not been found by recent collectors.

GERARDIA PURPUREA L.
Catawba Island, W. Krebs; Franklin Co., Wm. C. Werner; Cincinnati, J. F. James (Cat.)

GERARDIA TENUIFOLIA Vahl.
Throughout the state.

150. DASYSTOMA Raf.

DASYSTOMA FLAVA (L.) Wood. (*Gerardia flava* L.)
Cleveland, W. Krebs; Lake Co., Wm. C. Werner; Licking Co., H. L. Jones (Cat.); Fairfield Co., E. V. Wilcox and S. Renshaw.

DASYSTOMA LAEVIGATA (Raf.) (*Gerardia laevigata* Raf.)
Fairfield Co., E. V. Wilcox.

DASYSTOMA PEDICULARIA (L.) Benth. (*Gerardia pedicularia* L.)
Trumbull Co., Dr. Kellogg (Beardslee Cat.); Fulton Co., J. S. Hine.

DASYSTOMA VIRGINICA (L.) (*Gerardia quercifolia* Ph.)
Cleveland, W. Krebs; Lake Co., Wm. C. Werner; Lorain Co., A. A. Wright (Cat.); Cincinnati, Jos. Clark (Cat.); Fulton Co., J. S. Hine.

151. CASTILLEIA Mutis. PAINTED-CUP.

CASTILLEIA COCCINEA (L.) Spreng. Scarlet Painted-cup.
Ironton, (Lawrence Co.) W. C. Werner; Georgesville, Franklin Co., E. V. Wilcox.

152. PEDICULARIS Tourn. LOUSEWORT.

PEDICULARIS CANADENSIS L. Common Lousewort. Wood Betony.
Common.

PEDICULARIS LANCEOLATA Michx.
From Lake Erie to the Ohio River.

153. MELAMPYRUM Tourn. COW-WHEAT.

MELAMPYRUM LINEARE Lam. (*M. americanum* Mx.)
Cleveland, W. Krebs; Lorain Co., A. A. Wright (Cat.); Painesville, Wm. C. Werner.

XX. ORDER SOLANACEÆ. Nightshade Family.

154. SOLANUM Tourn. NIGHTSHADE.

SOLANUM CAROLINENSE L.
Frequent.

SOLANUM DULCAMARA L.
Throughout the state.

SOLANUM NIGRUM L.
Frequent and common in cultivated ground.

SOLANUM ROSTRATUM Dunal.
Franklin Co., W. J. Green; Painesville, O. Hacker; Burghill, (Trumbull Co.) J. I. King; Petersburg, J. A. Crawford.

155. PHYSALIS L. GROUND CHERRY.

PHYSALIS LANCEOTATA Michx.
Throughout central and southern Ohio; Toledo, J. A. Sanford.

PHYSALIS PHILADELPHICA Lam.
Painesville, H. C. Beardslee (Cat.); Lorain Co., A. A. Wright (Cat.); Loveland, J. F. James (Cat.)

PHYSALIS PUBESCENS L.
Painesville, Otto Hacker; Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.); Cincinnati, J. F. James (Cat.)

PHYSALIS VIRGINIANA Mill.
Generally distributed.

PHYSALIS VISCOSA L.
Lorain Co., A. A. Wright (Cat.)

156. NICANDRA Adans. APPLE OF PERU.

NICANDRA PHYSALOIDES (L.) Gærtn.
Springfield, Mrs, E. J. Spence; Franklin Co., E. V. Wilcox; Licking Co., H. L. Jones (Cat.); Cincinnati, J. F. James (Cat.)

157. LYCIUM L. MATRIMONY VINE.

LYCIUM VULGARE (Ait.) Dunal.
Franklin Co., W. C. Werner; Painesville, O. Hacker; Miami Valley, A. P. Morgan (Flora).

158. DATURA L. JAMESTOWN WEED. THORN-APPLE.

DATURA STRAMONIUM L.
Throughout the state.

DATURA TATULA L.
Introduced and widely distributed.

159. HYOSCYAMUS Tourn. HENBANE.

HYOSCYAMUS NIGER L.
Shore of Lake Erie, J. S. Newberry (Cat.)

XXI. POLEMONIACEÆ. Polemonium Family.

160. PHLOX L.

PHLOX DIVARICATA L.
Common.

PHLOX GLABERRIMA L.
Cincinnati, J. F. James (Cat.)

PHLOX MACULATA L. Wild Sweet-William.
Frequet throughout central and southern Ohio; Richland Co., E. Wilkinson.

PHLOX MACULATA CANDIDA Mx.
Columbus, Moses Craig.

PHLOX OVATA L.
Delta (Fulton Co.) M. G. Aumend.

PHLOX PANICULATA L.
Frequent throughout central and southern Ohio; Richland Co., E. Wilkinson.

PHLOX PILOSA L.
Summit Co., W. Krebs; Delta (Fulton Co.) M. G. Aumend; Georgesville Franklin Co., E. V. Wilcox.

PHLOX REPTANS Mx.
"Argillaceous hillsides," J. L. Riddell (Synop. 1835.)

PHLOX SUBULATA L. Ground or Moss Pink.
Brady's Lake (Portage Co.,) W. Krebs; Franklin Co., C. L. Dickey; Lorain Co., A. A. Wright (Cat.); Fairfield Co., E. V. Wilcox and S. Renshaw; Long Lake (Summit Co.,) E. E. Bogue.

161. POLEMONIUM Tourn. GREEK VALERAIN.

POLEMONIUM REPTANS L.
Widely distributed.

XXII. ORDER CONVOLVULACEÆ. Convolvulus Family.

162. IPOMŒA L. MORNING GLORY.

IPOMŒA COCCINEA L.
"Interior and southern Ohio," J. S. Newberry (Cat.)

IPOMŒA LACUNOSA L.
Columbus, J. H. Lageman; Cincinnati, C. J. Herrick, J. F. James (Cat.); Rio Grande (Gallia Co.) Lizzie Davis.

IPOMŒA NIL (L.) Ph.
Central and southern Ohio.

IPOMŒA PAUDURATA (L.) Meyer. Wild Potato-vine. Man-of-the-earth.
From Lake Erie to the Ohio River.

Ipomœa purpurea (L.) Lam.
Cincinnati, J. F. James (Cat.); Licking Co., H. L. Jones (Cat.)

Ipomœa quamoclit L.
Miami Valley, A. P. Morgan (Flora).

163. CONVOLVULUS Tourn. Bindweed.

Convolvulus arvensis L. Bindweed
Throughout the state.

Convolvulus sepium L. Hedge Bindweed.
Common.

Convolvulus repens L. (*C. sepium repens* Gray).
Licking Co., H. L. Jones (Cat.)

Convolvulus spithamæus L.
Apparantly all over the state, infrequent.

164. CUSCUTA Tourn. Dodder.

Cuscuta cephelanthi Englm. (*C. tenuiflora* Englm.)
Lorain Co., A. A. Wright (Cat.); Ashtabula Co., Sara F. Goodrich.

Cuscuta compacta Juss.
Painesville, H. C. Beardslee (Cat.)

Cuscuta epilinum Weihe. Flax Dodder.
"Interior, general," J. S. Newberry (Cat.)

Cuscuta glomerata Choisy.
Licking Co., H. L. Jones (Cat.)

Cuscuta gronovii Willd.
Common.

Cuscuta polygonorum Englm. (*C. chlorocarpa* Englm.)
"General," J. S. Newberry (Cat.)

Cuscuta rostrata Shuttleworth.
Painesville, H. C. Beardslee (Cat.)

XXIII. Order ASCLEPIADACÆ. Milk-weed Family.

165. PERIPLOCA (Tourn.) L.

Periploca graeca L.
Ohio, H. C. Beardslee (Cat.)

166. ACERATES Ell. Green Milkweed.

Acerates floridana Lam. (*A. longifolia* Ell.)
Huron Co., H. C. Beardslee (Cat.)

Acerates viridiflora (Raf.) Ell.
Northern and central Ohio; Cincinnati, J. F. James.

167. ASCLEPIAS L. Milkweed.

Asclepias exaltata (L.) Muhl. (*A. phytolaccoides* Ph.)
From Lake Erie to the Ohio River.

Asclepias incarnata L. Swamp Milkweed.
Common.

Asclepias incarnata pulchra Ehrh.
Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.)

Asclepias obtusifolia Michx.
"General," H. C. Beardslee (Cat.)

Asclepias purpurascens L. Purple Milkweed.
Over the whole state, infrequent.

Asclepias quadrifolia L.
Throughout the state but not abundant.

Asclepias sullivantii Engelm.
Fairfield Co., W. A. Kellerman; Licking Co., H. L. Jones (Cat.)

Asclepias syriaca L. (*A. cornuti* Decaisne.)
Everywhere.

Asclepias tuberosa L. Butterfly-weed. Pleurisy-root.
Widely distributed.

Asclepias variegata L.
Summit Co., Franklin Co., Wm. C. Werner.

Asclepias verticillata L.
Marblehead (Ottawa, Co.) E. Claassen; Springfield, Mrs. E. J. Spence; Fairfield Co., W. A. Kellerman.

168. VINCETOXICUM Moench.

Vincetoxicum nigrum Moench.
Painesville, W. C. Werner.

169. AMPELANUS Raf. (*Enslenia* Nutt.)

Ampelanus albidus (Nutt.) (*Enslenia albida* Nutt.)
Cincinnati, J. F. James (Cat.)

170. GONOLOBUS Michx.

Gonolobus gonocarpos (Walt.) (*G. lævis* Michx.)
Cincinnati, Joseph Clark (Cat.)

Gonolobus obliquus R. Br.
Lawrence Co., W. C. Werner; Columbus, A. D. Selby.

XXIV. Order APOCYNACEÆ. Dogbane Family.

171. VINCA L.

Vinca minor L.
Painesville, Wm. C. Werner; Richland Co., E. Wilkinson; Licking County H. L. Jones (Cat.); Fairfield Co., E. V. Wilcox and S. Renshaw.

172. APOCYNUM Tourn. Dogbane. Indian Hemp.

Apocynum androsæmifolium L. Spreading Dogbane.
Frequent.

Apocynum cannabinum L. Indian Hemp.
Common over the state.

XXV. Order GENTIANACEÆ. Gentian Family.

173. SABBATIA Adans.

Sabbatia angularis (L.) Pursh.
Trumbull Co., R. H. Ingraham; Central Ohio; Cincinnati, J. F. James (Cat.) Sabbatia brachiata reported for Hocking Co. by Adolph Leue seems to be this species.

174. GENTIANA Tourn. Gentian.

Gentiana andrewsii Griseb. Closed Gentian.
Apparently over the whole state.

Gentiana crinita Froel.
Northern Ohio; Columbus, W. C. Werner; Licking Co., H. L. Jones (Cat.)

Gentiana puberula Michx.
"Central Ohio," W. S. Sullivant (Cat.)

Gentiana quinquefolia L.
Lorain Co., A. A. Wright, (Cat.); Cincinnati, Joseph Clark (Cat.)

Gentiana quinquefolia occidentalis (Gray) Hitch.
Springfield, Mrs. E. J. Spence, Georgesville (Franklin Co.) E. V. Wilcox.

GENTIANA SAPONARIA L. Soapwort Gentian.
Cincinnati, Joseph Clark (Cat.); Columbus, W. S. Sullivant (Cat.)

GENTIANA SERRATA Gunner.
Lorain Co., A. A. Wright (Cat.)

GENTIANA VILLOSA L. (*G. ochroleuca* Froel.)
Rio Grande (Gallia Co.) Lizzie Davis.

175. FRASERA Walt. AMERICAN COLUMBO.

FRASERA CAROLINENSE Walt.
Central and southern Ohio; Lorain Co., A. A. Wright (Cat.)

176. OBOLARIA L.

OBOLARIA VIRGINICA L.
From Lake Erie to the Ohio river; rare.

177 BARTONIA Muhl.

BARTONIA VIRGINICA (L.) B. S. P. (*B. tenella* Muhl.)
Licking Reservoir, W. C. Werner; Painesville, H. C. Beardslee; Licking Co., H. L. Jones (Cat.); Lorain Co., A. A. Wright (Cat.)

178. MENYANTHES Tourn. BUCKBEAN.

MENYANTHES TRIFOLIATA L.
Portage Co., W. Krebs; Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.)

179. LIMNANTHEMUM Gmelin. FLOATING HEART.

LIMNANTHEMUM LACUNOSUM (Vent.) Mx.
Painesville, H. C. Beardslee (Cat.)

XXVI. ORDER OLEACEAE. Olive Family.

180. FRAXINUS Tourn. ASH.

FRAXINUS AMERICANA L. White Ash.
Frequent.

FRAXINUS PUBESCENS Lam. Red Ash.
Summit Co., J. S. Newberry (Cat.); Lorain Co., A. A. Wright (Cat.); Franklin Co., W. A. Kellerman; Licking Co., H. L. Jones (Cat.)

FRAXINUS QUADRANGULATA Michx. Blue Ash.
Frequent throughout the central and southern portions of the state.

FRAXINUS NIGRA Marsh. (*F. sambucifolia* Lam.) Black Ash.
Generally distributed over the state.

FRAXINUS VIRIDIS Michx. Green Ash.
"General," J. S. Newberry (Cat.); Miami Valley, A. P. Morgan (Flora).

181. CHIONANTHUS L. FRINGE-TREE.

CHIONANTHUS VIRGINICA L.
Rio Grande (Gallia Co.,) Ruth E. Brockett.

182. LIGUSTRUM Tourn. PRIVET.

LIGUSTRUM VULGARE L.
Lorain Co.. A. A. Wright (Cat.)

XXVII. ORDER STYRACACEAE. Storax Family.

183. MOHRIA Britton. (*Halesia* Ellis.) SNOWDROP OR SILVER BELL-TREE.

MOHRIA CAROLINA (L.) Britton. *Halesia teraptera* L.
Given by Lazenby and Werner (Sup. List.) on the authority of Dr. Warder, but no specimens seem to have been found in the state. The plant occurs in West Virginia.

XXVIII. ORDER EBENACEAE. Ebony Family.

184. DIOSPYROS L. DATE-PLUM. PERSIMMON.

DIOSPYROS VIRGINIANA L.
Throughout the southern half of the state.

XXIX. ORDER PRIMULACEAE. Primrose Family.

184*a*. HOTTONIA L. FEATHERFOIL. WATER VIOLET.

HOTTONIA INFLATA Ell.
New Lyme (Ashtabula Co.) Florence Tuckerman.

185. DODECATHEON L. AMERICAN COWSLIP.

DODECATHEON MEADIA L.
Springfield, Mrs. E. Jane Spence; Cincinnati, Jos. F. James (Cat.); Franklin Co., W. S. Sullivant (Cat.)

186. LYSIMACHIA Tourn. LOOSESTRIFE.

LYSIMACHIA NUMMULARIA L. Moneywo.t.
Escaped from cultivation.

Lysimachia quadrifolia L.
Throughout the state, but infrequent.

Lysimachia stricta Ait.
Generally distributed.

Lysimachia thyrsiflora L. Tufted Loosestrife.
Probably throughout the state; no specimens seen from the southern half of the state.

187. STEIRONEMA Raf. Loosestrife.

Steironema ciliatum Raf.
Common over the state.

Steironema lanceolatum Gray.
Frequent throughout the southern half of the state.

Steironema lanceolatum angustifolium (Lam.) Gray.
Paiuesville, H. C. Beardslee (Cat.)

Steironema lanceolatum hybridum (Mx.) Gray.
Painesville, H. C. Beardslee (Cat.); Franklin Co., W. S. Sullivant (Cat.); Cincinnati, Joseph Clark (Cat.)

Steironema quadriflorum (Sims.) Hitch. (*S. longifolium* Gray.)
Throughout south ceutral Ohio; Islauds iu Lake Erie, Aug. D. Selby, E. Claassen.

188. TRIENTALIS L. Chickweed. Wintergreen.

Trientalis americana (Pers.) Pursh.
Loraiu Co., A. A. Wright (Cat.); Cedar Swamp (Champaign Co.) Mrs. E. Jane Spence.

189. ANAGALLIS Tourn. Pimpernel.

Anagallis arvensis L. Common Pimpernel.
Painesviile, Wm. C. Werner; Gallia Co., Lizzie Davis; Logan Co., Mrs. E. Jane Spence; Cincinnati, Jos. F. James (Cat.)

190. SAMOLUS Tourn. Water Pimpernel. Brook-weed.

Samolus floribundus H. B. K. (*S. valerandi americanus* Gray.)
Throughout the state.

XXX. Order MONOTROPACEAE.

191. HYPOPITYS L. Pine-sap.

Hypopitys monotropa Crautz. (*Monotropa hypopitys* L.)
Not rare.

192. MONOTROPA L. Indian Pipe.

Monotropa uniflora L.
Frequent.

XXXI. Order ERICACEAE. Heath Family.

193. GAYLUSSACIA H. B. K. Huckleberry.

Gaylussacia dumosa (Andr.) Torr. and Gray. Dwarf Huckleberry.
Lorain Co., Dr. Kellogg (J. S. Newberry Cat.)

Gaylussacia frondosa (L.) Torr. and Gray. Blue Tangle. Dangleberry.
"Northern Ohio," J. S. Newberry (Cat.); Fairfield Co., E. V. Wilcox and S. Renshaw. No specimen seen by us.

Gaylussacia resinosa (Ait.) Torr. and Gray. Black Huckleberry.
Frequent throughout the eastern half of the state.

194. VACCINIUM L. Blueberry. Bilberry. Cranberry.

Vaccinium canadense Kalm.
Toledo, J. A. Sanford.

Vaccinium corymbosum L. Common or Swamp Blueberry.
Lorain Co., A. A. Wright (Cat.); Geauga Lake (Summit Co.) E. Claassen; Painesville, Wm. C. Werner; Licking Co., H. L. Jones (Cat.)

Vaccinium atrococcum (Gray). (*V. corymbosum atrococcum* Gray).
Lorain Co., A. A. Wright (Cat.)

Vaccinium corymbosum pallidum Ait.
Northern and eastern Ohio, J. S. Newberry (Cat.)

Vaccinium pennsylvanicum Lam. Dwarf Blueberry.
Frequent throughout sandstone regions.

Vaccinium pennsylvanicum angustifolium Gray.
Thompson Ledge (Geauga Co.) H. C. Beardslee (Cat.)

Vaccinium stamineum L.
Frequent in sandstone soils.

Vaccinium vacillans Kalm. Low Blueberry.
Frequent in sandstone soils.

195. SCHOLLERA Roth. (*Oxycoccus* Pers.) Cranberry.

Schollera macrocarpus (Pers.) (*Oxycoccus macrocarpus* Pers. *Vaccinium macrocarpon* Ait.) Common Cranberry.
Frequent in northern Ohio; Licking Reservoir, H. L. Jones (Cat.)

SCHOLLERA OXYCOCCUS (L.) Roth. (*Vaccinium oxycoccus* L.) Small Cranberry.
"Northern Ohio rare," H. C. Beardslee (Cat.); Lorain Co., A. A. Wright (Cat.)

196. ARCTOSTAPHYLOS Adans. BEARBERRY.

ARCTOSTAPHYLUS UVA-URSI (L.) Spreng. Bearberry.
Cedar Point (Ottawa Co.) W. Krebs.

197. GAULTHERIA L. WINTERGREEN.

GAULTHERIA PROCUMBENS L. Ground Birch. Teaberry.
Frequent over the state.

198. CHAMAEDAPHNE Moench. (*Cassandra* Don.) LEATHER-LEAF.

CHAMAEDAPHNE CALYCULATA (L.) Moench. (*Cassandra calyculata* Don.)
Frequent in sphagnum marshes throughout northern Ohio.

199. OXYDENDRUM DC. SORREL-TREE. SOUR-WOOD.

OXYDENDRUM ARBOREUM (L.) DC.
Throughout the southeastern counties.

200. EPIGÆA L. GROUND LAUREL. TRAILING ARBUTUS.

EPIGÆA REPENS L.
Frequent throughout the eastern half of the state.

201. ANDROMEDA L.

ANDROMEDA LIGUSTRINA Muhl.
Marietta, J. L. Riddell (Synop. 1835.)

ANDROMEDA POLIFOLIA L.
Geauga Co., Wm. C. Werner (H. C. Beardslee Cat.)

202. KALMIA L. AMERICAN LAUREL.

KALMIA ANGUSTIFOLIA L. Sheep Laurel. Lambkill. Wicky.
Central and eastern Ohio, H. C. Beardslee (Cat.)

KALMIA LATIFOLIA L. Calico Bush. Mountain Laurel. Spoon-wood.
Eastern half of the state.

203. LEDUM L. LABRADOR TEA.

LEDUM LATIFOLIUM Ait.
Lorain Co., Dr. Kellogg (Newberry Cat.)

204. RHODODENDRON L. ROSE BAY. AZALEA.

RHODODENDRON LUTEA (L.) (*R. calendulaceum* Torr.)
Sugar Grove (Fairfield Co.) E. V. Wilcox and S. Renshaw; Fairfield Co., J. M. Bigelow (J. S. Newberry Cat.)

RHODODENDRON MAXIMUM L.
Fairfield Co., J. M. Bigelow (J. S. Newberry Cat.); Sugar Grove (Fairfield Co.) E. V. Wilcox and S. Renshaw.

205. AZALEA L.

AZALEA NUDIFLORA L. (*Rhododendron nudiflorum* Torr.)
Painesville, and Ironton (Lawrence Co.) Wm. C. Werner.

AZALEA VISCOSA L. (*Rhododendron viscosum* Torr.)
Painesville, H. C. Beardslee (Cat.)

206. PYROLA Tourn. WINTERGREEN. SHIN-LEAF.

PYROLA ASARIFOLIA Mx. (*P. rotundifolia asarifolia* Hk.)
"Northern Ohio, not uncommon," H. C. Beardslee (Cat.)

PYROLA ELLIPTICA Nutt. Shin-leaf.
Frequent except in limestone regions.

PYROLA ROTUNDIFOLIA L.
Frequent in northern Ohio; Central Ohio, E. V. Wilcox and H. L. Jones (Cat.)

PYROLA SECUNDA L.
Painesville, H. C. Beardslee (Cat.); Lorain Co., A. A. Wright (Cat.)

PYROLA ULIGINOSA Torr. (*P. rotundifolia uliginosa* Gray.)
"Northern Ohio, rare," H. C. Beardslee (Cat.)

207. MONESES Salisb. ONE-FLOWERED PYROLA.

MONESES UNIFLORA (Gray.) (*M. grandiflora* Salisb.)
"Northern Ohio," Lazenby and Werner (Sup. Cat.), from Prof. Lazenby's notes. No herbarium specimen can be found.

208. CHIMAPHILA Pursh. PIPSISSEWA.

CHIMAPHILA MACULATA (L.) Pursh. Spotted Wintergreen.
In sandstone regions.

CHIMAPHILA UMBELLATA (L.) Nutt. Prince's Pine.
Frequent in woods.

209. CLETHRA Gronov. WHITE ALDER.

CLETHRA ALNIFOLIA L. Sweet Pepperbush.
Akron, H. C. Beardslee, Jr. (Lazenby and Werner, Sup. List); not of the Ohio flora as the specimens were transplanted from another state.

XXXII. ORDER UMBELLIFERÆ. Parsley Family.

210. HYDROCOTYLE Tourn. WATER PENNYWORT.

HYDROCOTYLE AMERICANA L.
Painesville, Wm. C. Werner; Cuyahoga Falls (Summit Co.) W. Krebs.

HYDROCOTYLE UMBELLATA L.
"Northern Ohio," J. S. Newberry (Cat.); Portage Co., E. Claassen.

211. ERYNGIUM Tourn. ERYNGO.

ERYNGIUM AQUATICUM L. (*E. yuccæfolium* Michx.) Rattle Snake-Master. Button Snake-root.
Central Ohio, J. L. Riddell (Synop. 1835); W. S. Sullivant (Cat. 1840); not observed by recent collectors.

212. SANICULA Tourn. SANICLE. BLACK SNAKE-ROOT.

SANICULA MARYLANDICA L.
Frequent throughout the state.

SANICULA MARYLANDICA CANADENSIS (L.) Torr.
Frequent throughout the state.

213. CONIUM L. POISON HEMLOCK.

CONIUM MACULATUM L.
Northern Ohio (W. Krebs, Wm. C. Werner); Licking Co., H. L. Jones (Cat.).; Cincinnati, Jos. Clark (Cat.)

214. EULOPHUS Nutt.

EULOPHUS AMERICANUS Nutt.
Central Ohio, W. S. Sullivant (H. C. Beardslee Cat.)

215. ERIGENIA Nutt. HARBINGER-OF-SPRING.

ERIGENIA BULBOSA (Mx.) Nutt.
Over the whole state.

216. CICUTA L. WATER-HEMLOCK.

CICUTA BULBIFERA L.
Throughout the state.

Cicuta maculata L. Spotted Cowbane. Musquash Root. Beaver-Poison.
Common over the whole state.

217. CARUM L. Caraway.

Carum carui L. Caraway.
Painesville, Wm. C. Werner; Cleveland, Wm. Krebs, Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.)

218. ZIZIA Koch.

Zizia aurea (L.) Koch.
Throughout the state.

Zizia cordata (Walt.)
Throughout the state.

219. SIUM Tourn. Water Parsnip.

Sium cicutæfolium. Gmelin.
Frequent in swamps and low grounds.

220. ÆGOPODIUM L. Groutweed.

Aegopodium podagraria L.
Painesville, Otto Hacker.

221. PIMPINELLA L.

Pimpinella integerrima (L.) Gray.
Generally distributed over the whole state.

Pimpinella saxifraga L.
"Sycamore, Ohio," Asa Gray (Manual 6th ed.)

222. DERINGA Adans. (*Cryptotænia* DC.) Honewort.

Deringa canadensis (L.) Kuntze. (*Cryptotænia canadensis* DC.)
Throughout the state.

223. OSMORRHIZA Raf. Sweet Cicely.

Osmorrhiza brevistylis (Torr.) DC.
Generally distributed throughout the state.

Osmorrhiza claytoni (Michx.) B. S. P. (*O. longistylis* DC.)
Frequent throughout the state.

224. CHÆROPHYLLUM L.

CHÆROPHYLLUM PROCUMBENS (L.) Crantz.
Generally distributed.

225. PTILIMNIUM Raf. (*Discopleura* DC.) MOCK BISHOP-WEED.

PTILIMNIUM CAPILLACEA Mx. (*Discopleura capillacea* DC.)
"General," J. S. Newberry (Cat.); Franklin Co., W. S. Sullivant (Cat. 1840); Licking Co., H. L. Jones (Cat.)

226. ÆTHUSA L. FOOL'S PARSLEY.

AETHUSA CYNAPIUM L.
"General," J. S. Newberry (Cat.); Lorain Co., A. A. Wright (Cat.)

227. LIGUSTICUM L. LOVAGE.

LIGUSTICUM CANADENSE L. (*L. actæifolium* Mx.) Nondo. Angelico.
Northern and eastern Ohio, J. S. Newberry (Cat.); Licking Co., H. L. Jones (Cat.)

LIGUSTICUM SCOTICUM L.
Lorain Co., A. A. Wright (Cat.)

228. SELINUM L. (*Conioselinum* Fisch.) HEMLOCK-PARSLEY.

SELINUM CHINENSE (L.) (*Conioselinum canadense* Torr & Gray.)
Cuyahoga Falls, W. Krebs.

229. THASPIUM Nutt. MEADOW-PARSNIP.

THASPIUM AUREUM Nutt.
Generally distributed.

THASPIUM AUREUM CORDATUM (Walt.) B. S. P. (*T. aureum trifoliatum* Coult. & Rose.)
Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.); Cincinnati, J. F. James (Cat.)

THASPIUM BARBINODE (Mx.) Nutt.
Northern Ohio, W. Krebs; Central Ohio, H. L. Jones (Cat.), Aug. D. Selby; Lawrence Co., Wm. C. Werner; Cincinnati, Jos. F. James (Cat.)

THASPIUM BARBINODE ANGUSTIFOLIUM Coult. & Rose.
Toledo, J. A. Sanford; Cleveland, Wm. Krebs.

230. ANGELICA L.

ANGELICA ATROPURPUREA L.
Cleveland, W. Krebs; Richland Co., E. Wilkinson; Columbus, Aug. D. Selby; Licking Co., H. L. Jones (Cat.)

ANGELICA VILLOSA (Walt.) B. S. P. (*A. hirsuta* Muhl.)
Throughout the state.

231. PASTINACA L. PARSNIP.

PASTINACA SATIVA, L.
Fields and waste places, common.

232. OXYPOLIS Raf. (*Tiedemannia* DC.)

OXYPOLIS RIGIDA (L.) (*Tiedemannia rigida* Coult. & Rose.) Cowbane.
Central and southern Ohio; Lorain Co., A. A. Wright (Cat.)

233. HERACLEUM L. COW-PARSNIP.

HERACLEUM LANATUM Michx.
Throughout the state.

234. DAUCUS Tourn. CARROT.

DAUCUS CAROTA L.
Generally distributed, very abundant in some localities.

235. CAUCALIS L.

CAUCALIS ANTHRISCUS (L.) Hudson.
Cincinnati, C. G. Lloyd (Bot. Gaz.), Jos. F. James (Cat.); Painesville, W. C. Werner.

XXXIII. ORDER ARALIACEÆ. Ginseng Family.

236. ARALIA Tourn. GINSENG. WILD SARSAPARILLA.

ARALIA HISPIDA Vent. Bristly Sarsaparilla.
Lake Co., W. C. Werner; Licking Co., H. L. Jones (Cat.)

ARALIA NUDICAULIS L.
Generally distributed throughout the state.

ARALIA RACEMOSA L. Spikenard.
Throughout the state.

ARALIA SPINOSA L. Angelica-tree. Hercules' Club.
Washington Co., Aug. D. Selby; Cincinnati, Jos. F. James (Cat.)

237. PANAX L. (*Aralia* Tourn.)

PANAX QUINQUEFOLIUM L. (*Aralia quinquefolia* Dec. & Planch.) Ginseng.
Rich woods throughout the state, not common.

PANAX TRIFOLIA L. (*Aralia trifolia* Dec. & Planch.) Dwarf Ginseng.
Northern Ohio; also Franklin Co., J. L. Riddell (Synop. 1835.)

XXXIV. ORDER CORNACEÆ. Dogwood Family.

238. CORNUS Tourn. CORNEL. DOGWOOD.

CORNUS ALTERNIFOLIA L. f.
Throughout the northern half of the state.

CORNUS ASPERIFOLIA Michx.
Toledo, J. A. Sanford; Lorain Co., A. A. Wright (Cat.); Franklin Co., Aug. D. Selby; Licking Co., H. L. Jones (Cat.); Springfield, Mrs. E. J. Spence.

CORNUS CANADENSIS L. Dwarf Cornel. Bunch-berry.
"Northern Ohio," J. S Newberry (Cat.); Painesville, Miss L. T. Prescott (H. C. Beardslee Cat.), W. C. Werner; Morgan (Ashtabula Co.) L. B. Tuckerman Licking Co., H. L. Jones (Cat.)

CORNUS CANDIDISSIMA Marshall. (*C. paniculata* L'Her.) Panicled Cornel.
Throughout the state.

CORNUS CIRCINATA L'Her. Round-leaved Cornel or Dogwood.
Lorain Co., A. A. Wright (Cat.); Painesville, W. C. Werner; Ottawa Co., Aug. D. Selby; Franklin Co., Moses Craig.

CORNUS FLORIDA L. Flowering Dogwood.
Over the whole state.

CORNUS SERICEA L.
Generally distributed.

CORNUS STOLONIFERA Michx.
Probably distributed over the most of the state, but no specimens at hand except from the northern half.

239. NYSSA L. TUPELO. PEPPERIDGE. SOUR-GUM TREE.

NYSSA AQUATICA L. (*N. sylvatica* Marsh.) Tupelo. Black or Sour-Gum. Pepperidge.
Throughout the state.

XXXV. ORDER ONAGRACEÆ. Evening-Primrose Family.

240. EPILOBIUM L. WILLOW-HERB.

EPILOBIUM ADENOCAULON Haussk.
Licking Co., H. L. Jones (Cat.); Painesville, Geauga Co., Columbus, Wm. C. Werner; Ashtabula Co., Sara F. Goodrich.

EPILOBIUM ANGUSTIFOLIUM L. Great Willow-herb. Fire-weed.
Lorain Co., A. A. Wright (Cat.); Cleveland, W. Krebs; Lake Co., Geauga Co., W. C. Werner; Ashtabula Co., E. E. Bogue; Delta (Fulton Co.) M. G. Aumend.

EPILOBIUM COLORATUM Muhl.
Lorain Co., A. A. Wright (Cat.); Cleveland, W. Krebs; Fairfield Co., E. V. Wilcox and S. Renshaw; Licking Co., H. L. Jones (Cat.); Rio Grande (Gallia Co.) Lizzie Davis; Cincinnati, Jos. F. James (Cat.) Throughout the state.

EPILOBIUM PALUSTRE OLIGANTHUM (Mx.) B. S. P. (*E. palustre lineare* Gray.)
Northern Ohio, H. C. Beardslee (Cat.); Painesville, Wm. C. Werner; Lorain Co. A. A. Wright (Cat.); Springfield, Mrs. E. J. Spence.

EPILOBIUM STRICTUM Muhl.
Painesville, Wm. C. Werner; Licking Co., H. L. Jones (Cat.)

241. LUDWIGIA L. FALSE LOOSE-STRIFE.

LUDWIGIA ALTERNIFOLIA L. Seed-box.
Throughout the state, probably not abundant in any locality.

LUDWIGIA PALUSTRIS (L.) Ell. Water Purslane.
Common everywhere.

LUDWIGIA POLYCARPA Short & Peter.
"General," J. S. Newberry (Cat.); Toledo, J. A. Sanford; Licking Co., H. L. Jones (Cat.)

242. OENOTHERA L. EVENING PRIMROSE.

OENOTHERA BIENNIS L Common Evening Primrose.
Common all over the state.

OENOTHERA BIENNIS GRANDIFLORA (Ait.) Lindl.
Lorain Co., A. A. Wright (Cat.); Ashtabula Co., E. E. Bogue; Painesville, Wm C. Werner.

OENOTHERA FRUTICOSA L. Sundrops.
Summit Co., W. Krebs; Franklin Co., J. L. Riddell (Sup. Cat. 1836.); W. S. Sullivant (Cat. 1840); Licking Co., H. L. Jones (Cat.); Richland Co., E. Wilkinson; Springfield, Mrs. E. Jane Spence.

OENOTHERA OAKESIANA Robbins.
Lorain Co., A. A. Wright (Cat.)

OENOTHERA PUMILA L.
Frequent north; Fairfield Co., W. A. Kellerman.

OENOTHERA SINUATA L.
Lorain Co., A. A. Wright (Cat.)

243. GAURA L.

GAURA BIENNIS L.
Common throughout the state.

GAURA FILIPES, Spach.
Cincinnati, Dr. Kellogg (J. S. Newberry, Cat.); Lorain Co., A. A. Wright (Cat.)

GAURA PARVIFLORA Dougl.
"Ohio" [?] J. L. Riddell (Sup. Cat. 1836).

244. CIRCÆA Tourn. ENCHANTER'S NIGHT SHADE.

CIRCÆA ALPINA L.
Frequent in the northern part of the state; Franklin Co., J. L. Riddell (Synop. 1835); Springfield, Mrs. E. J. Spence.

CIRCÆA LUTETIANA L.
Over the whole state.

XXXVI. ORDER MELASTOMACEÆ. Melastoma Family.

245. RHEXIA L. DEER-GRASS. MEADOW-BEAUTY.

RHEXIA VIRGINICA L.
Cincinnati, Joseph Clark (H. C. Beardslee Cat.).

XXXVII. ORDER LYTHRACEÆ. Loosestrife Family.

246. ROTALA L.

ROTALA RAMOSIOR Koehne. (*Ammania humilis* Mx.)
Columbus, W. C. Werner; Licking Co., H. L. Jones (Cat.); Cincinnati, Jos. F. James (Cat.)

247. AMMANNIA L.

AMMANNIA COCCINEA Rottb.
"Ohio," Asa Gray (Manual, 5th ed.); Cincinnati, Thos. G. Lea (Cat)

248. LYTHRUM L. LOOSESTRIFE.

LYTHRUM ALATUM. Pursh.
Throughout the state.

LYTHRUM HYSSOPIFOLIA L.
"Central Ohio," W. S. Sullivant (Cat.); Cincinnati, Jos. Clark (Cat.)

LYTHRUM LINEARE L.
Monroeville (Huron Co.) H. C. Beardslee (Cat.)

249. NESÆA Commers. (*Decodon* Gmel.) SWAMP LOOSESTRIFE.

NESÆA VERTICILLATA (L.) H. B. K. (*Decodon verticillata Ell.*)
Northern Ohio (W. Krebs, W. C. Werner, A. A. Wright (Cat.)); Licking Reservoir (Licking Co.) H. L. Jones (Cat.); Dayton, Aug. Foerste (Bot. Gaz. VI. 274).

250. CUPHEA Jacq.

CUPHEA PETIOLATA (L.) Koehne (*C. viscosissima* Jacq.)
Over the southern half of the state.

XXXVIII. ORDER ELÆAGNACEÆ Oleaster Family.

251. SHEPHERDIA Nutt.

SHEPHERDIA CANADENSIS, Nutt.
Frequent in northern Ohio.

XXXIX. ORDER THYMELÆACEÆ. Mezereum Family.

252. DIRCA L. LEATHERWOOD. MOOSEWOOD.

DIRCA PALUSTRIS L.
Scarce but generally distributed.

XL. ORDER CACTACEÆ. Cactus Family.

253. OPUNTIA Tourn. PRICKLY PEAR. INDIAN FIG.

OPUNTIA HUMIFUSA Raf. (*O. rafinesquii* Engelm.)
Cedar Point (Ottawa Co.) W. Krebs.

OPUNTIA VULGARIS Mill.
Southern Ohio, J. A. Warder (Woody Pl. of Ohio); Cincinnati, Jos. F. James; (Cat).

XLI. ORDER PASSIFLORACEÆ. Passion-flower Family.

254. PASSIFLORA L. PASSION-FLOWER.

PASSIFLORA LUTEA L.
Sugar Grove (Fairfield Co.) E. V. Wilcox; Castine (Darke Co.) John Longenbaker; Lawrence Co., W. C. Werner; Cincinnati; Jos. F. James (Cat.)

XLI. Order VIOLACEÆ. Violet Family.

255. VIOLA Tourn. Violet. Heart's-ease.

Viola blanda Willd. Sweet White Violet.
Frequent throughout the northern half of the state. No specimen seen south of Fairfield Co.

Viola canadensis L. Canada Violet.
Frequent throughout the state.

Viola muhlenbergii Torr. (*V. canina muhlenbergii* Gray). Dog Violet.
Lake Co., W. C. Werner; Lorain Co., A. A. Wright (Cat.); Trumbull Co., R. H. Ingraham; Fairfield Co., E. V. Wilcox; Springfield, Mrs. E. J. Spence.

Viola hastata Michx. Halberd-leaved Violet.
Brighton (Cuyahoga Co.) W. Krebs; Cleveland, W. C. Werner; Lake Co., H. C. Beardslee (Cat.); Orwell (Ashtabula Co.) E. E. Bogue.

Viola lanceolata L. Lance-leaved Violet.
Painesville (Lake Co.) H. C. Beardslee (Cat.); Lorain Co. A. A. Wright (Cat.)

Viola obliqua Hill. (*V. palmata cucullata* Gray).
Over the whole state.

Viola palmata L. Common Blue Violet.
Frequent throughout the state.

Viola pedata L.
Painesville, H. C. Beardslee Cat.); Lancaster (Fairfield Co.) J. M. Bigelow (Beardslee (Cat.), Cincinnati, Joseph Clark (Cat.); Lawrence Co., Wm. C. Werner.

Viola primulæfolia L. Primrose-leaved Violet.
"Northern Ohio," J. S. Newberry (Cat.)

Viola pubescens Ait. Downy Yellow Violet.
Generally distributed over the whole state.

Viola pubescens scabriuscula Torr and Gray.
Lorain Co., A. A. Wright (Cat.); Mon oe Co., H. Herzer; Licking Co., H. L. Jones (Cat.); Richland Co., E. Wilkinson; Gallia Co., W. W. Deckard.

Viola rostrata Pursh. Long-spurred Violet.
Generally distributed.

Viola rotundifolia Mich. Round-leaved Violet.
Cuyahoga Co, W. Krebs; Lake Co., Wm. C. Werner; Orwell (Ashtabula Co.) E. E. Bogue.

VIOLA SAGITTATA Ait. Arrow-leaved Violet.
Northern Ohio (H. C. Beardslee, W. Krebs, A. A. Wright (Cat.); Licking Co. (H. L. Jones Cat.); Franklin Co., M. H. Frank; Miami Valley, A. P. Morgan (Flora).

VIOLA STRIATA Ait. Pale Violet.
Frequent over the whole state.

VIOLA TENELLA Muhl. (*V. tricolor arvensis* Gr.) Pansy. Heart's Ease.
Columbus, Moses Craig; Waverly (Pike Co.) C. J. Herrick; Cincinnati, Joseph Clark (Cat.); Lawrence Co., W. C. Werner.

VIOLA TRICOLOR L.
Occasionally found as an escape from gardens; Painesville, O. Hacker.

256. SOLEA Spreng., in part. GREEN VIOLET.

SOLEA CONCOLOR (Forst.) Ging.
Generally distributed over the state.

XLIII. ORDER CISTACEAE. Rock-rose Family.

257. HELIANTHEMUM Tourn. ROCK-ROSE.

HELIANTHEMUM MAJUS (L.) B. S. P. (*H. canadense* Mx.) Frost-Weed.
"Barrens, Dover on the Ohio canal," J. L. Riddell (Synop. 1835); Brady's Lake (Portage Co.,) W. Krebs; Toledo, J. A. Sanford; Fairfield Co., W. A. Kellerman.

258. LECHEA Kalm. PINWEED.

LECHEA LEGGETTII Britt. & Hal. (*Lechea minor* L.)
"Central Ohio," W. S. Sullivant (Cat.)

LECHEA RACEMULOSA Michx.
Marietta, J. L. Riddell (Synop. 1835); Fairfield and Lawrence counties, Wm. C. Werner; Adams Co., W. A. Kellerman.

LECHEA STRICTA Leggett.
Ravenna, Portage Co., R. H. Ingrham.

LECHEA VILLOSA Ell. (*L. major* Michx.)
"Barrens, Dover on the Ohio Canal" J. L. Riddell (Sup. Cat. 1836); Erie and Summit counties, E. Claassen; Toledo, J. A. Sanford.

XLIV. ORDER RESEDACEAE. Mignonette Family.

259. RESEDA Tourn. MIGNONETTE. DYER'S ROCKET.

RESEDA LUTEOLA L. Dyer's Weed or Weld.
Escaped from cultivation; Licking Co., H. L. Jones (Cat.)

XLV. ORDER HYPERICACEAE. St. John's-Wort Family.

260. ASCYRON L. ST. PETER'S-WORT.

ASCYRON CRUX-ANDREAE L.
Sugar Grove (Fairfield Co.) E. V. Wilcox; Lawrence Co., W. C. Werner.

261. HYPERICUM Tourn. ST. JOHN'S-WORT.

HYPERICUM ADPRESSUM Barton.
Painesville, H. C. Beardslee (Cat.)

HYPERICUM ASCYRON L. Great St. John's-Wort.
Not rare in the eastern part of the state.

HYPERICUM CANADENSE L.
"General," J. S. Newberry (Cat.); Cincinnati, Jos. Clark (Cat.)

HYPERICUM CISTIFOLIUM Lam.
Franklin Co., Aug. D. Selby; Cincinnati, Jos. F. James (Cat.)

HYPERICUM DENSIFLORUM Pursh.
Franklin Co., J. L. Riddell (Synop. 1835); Licking Co., H. L. Jones (Cat.)

HYPERICUM ELLIPTICUM Hook.
Painesville, H. C. Beardslee (Cat.), Wm. C. Werner.

HYPERICUM GALIOIDES Lam.
"Darby Plains, Ohio," J. L. Riddell (Synop. 1835.)

HYPERICUM GENTIANOIDES (L.) B. S. P. (*H. nudicaule* Walt.)
"General," J. S. Newberry (Cat.); Portsmouth, J. S. Hine.

HYPERICUM KALMIANUM L. Kalm's St. John's-Wort.
Summit Co., J. S. Newberry (Cat.)

HYPERICUM MACULATUM Walt.
Over the whole state.

HYPERICUM MAJUS (Gray) Britton.
Gypsum (Ottawa Co.) Wm. Krebs. (*H. canadense majus* Gray.)

HYPERICUM MUTILUM L.
Widely distributed.

HYPERICUM PERFORATUM L.
Distributed over the whole state.

HYPERICUM PETIOLATUM Walt. (*Elodes petiolata* Pursh.)
Painesville, W. C. Werner.

HYPERICUM PROLIFICUM L.
Distributed over the state; South Bass Island (Lake Erie), W. Krebs.

HYPERICUM VIRGINICUM L. (*Elodes campanulata* Pursh; *E. virginica* Nutt.)
Franklin Co., J. L. Riddell (Synop. 1835); Northern Ohio (W. C. Werner, W. Krebs, A. A. Wright Cat.); Licking Co., H. L. Jones (Cat.)

XLVI. ORDER MALVACEAE Mallow Family.

262. MALVA L. MALLOW.

MALVA CRISPA L. Curled Mallow.
Ohio, H. C. Beardslee (Cat.)

MALVA MOSCHATA L. Musk Mallow.
Escaped from cultivation; Toledo, J. A. Sanford; Lorain Co., A. A. Wright (Cat.); Cleveland, W. Krebs; Painesville, W. C. Werner.

MALVA ROTUNDIFOLIA L. Common Mallow.
Common in cultivated grounds.

MALVA SYLVESTRIS L. High Mallow.
"General," J. S. Newberry (Cat.); Lorain Co., A. A. Wright (Cat.); Licking Co, H. L. Jones (Cat.)

263. CALLIRRHOE Nutt.

CALLIRRHOE INVOLUCRATA (Mx.) Gray.
On the grounds occupied by Sells Bros'. Circus, Columbus, W. R. Lazenby.

264. NAPAEA Clayt. GLADE MALLOW.

NAPÆA DIOICA L.
Sugar Grove (Fairfield Co.) E. V. Wilcox; Springfield, Mrs. E. J. Spence; Cincinnati, Joseph F. James (Cat.)

265. SIDA L.

SIDA SPINOSA L.
Generally distributed throughout the southern half of the state; Painesville, H. C. Beardslee (Cat.); Lorain Co., A. A. Wright (Cat.)

266. ABUTILON Tourn. INDIAN MALLOW.

ABUTILON AVICENNÆ Gærtn. Velvet-leaf.
Common in fields and waste places.

267. HIBISCUS L. ROSE-MALLOW.

HIBISCUS MILITARIS Cav. Halberd-leaved Rose-mallow.
Cuyahoga Co., J. S. Newberry (Cat.): Columbus, E. E. Bogue; Great Miami river, Dr. J. A. Warder (Woody Pl.); Cincinnati, Jos. Clark (Cat.)

HIBISCUS MOSCHEUTOS L. Swamp Rose-mallow.
Frequent in swamps near shore of Lake Erie, also borders of inland lakes and reservoirs.

HIBISCUS TRIONUM L. Bladder Ketmia.
Perhaps throughout the whole state.

XLVII. ORDER TILIACEÆ. Linden Family.

268. TILIA Tourn. LINDEN. BASSWOOD.

TILIA AMERICANA L. Basswood.
Generally distributed over the state.

TILIA HETEROPHYLLA Vent. White Basswood.
Scioto Co., W. A. Kellerman.

XLVIII. ORDER VITACEÆ. Vine Family.

269. VITIS Tourn. (*Cissus* L. *Ampelopsis* Michx.)

VITIS ÆSTIVALIS Michx. Summer Grape.
"General," J. S. Newberry (Cat.); Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.)

VITIS ÆSTIVALIS BICOLOR (Le Conte.)
Licking Co., H. L. Jones (Cat.); Fairfield Co., W. A. Kellerman.

VITIS CORDIFOLIA Michx. Frost or Chicken Grape.
Over the whole state.

VITIS CORDATA (Mx.) (*V. indivisa* Willd.; *Cissus ampelopsis* Pers.)
"Ohio," Asa Gray (Man. 5th ed.)

VITIS LABRUSCA L. Northern Fox-grape.
"General," J. S. Newberry (Cat.); Lorain Co., A. A. Wright (Cat.)

VITIS QUINQUEFOLIA (L.) Lam. (*Ampelopsis quinquefolia* Mx.) American Woodbine; Five-fingered Ivy; Ampelopsis; Virginia Creeper.
Throughout the state.

VITIS RIPARIA Michx.
Lake Co., Wm. C. Werner; Lorain Co., A. A. Wright (Cat.); Ashtabula Co., Sara F. Goodrich; Franklin Co., Moses Craig; Licking Co., H. L. Jones (Cat.)

XLIX. ORDER RHAMNACEÆ. Buckthorn Family.

270. RHAMNUS Tourn. BUCKTHORN.

RHAMNUS ALNIFOLIA L'Her.
Cuyahoga Co., W. Krebs; Painesville, H. C. Beardslee (Cat.), Wm. C. Werner; Springfield, E. J. Spence; Champaign Co., Wm. C. Werner.

RHAMNUS CAROLINIANA Walt.
"A tall shrub in Kentucky and probably in southern Ohio," J. A. Warder (Woody Pl.)

RHAMNUS LANCEOLATA Pursh.
"General," J. S. Newberry (Cat.): Licking Co., H. L. Jones (Cat.); Cincinnati, Jos. F. James (Cat.)

271. CEANOTHUS L. NEW JERSEY TEA. RED-ROOT.

CEANOTHUS OVATUS Desf.
Northern Ohio rare, H. C. Beardslee (Cat.); Cedar Point, W. Krebs; Lorain Co., A. A. Wright (Cat.)

CEANOTHUS AMERICANUS L. New Jersey Tea.
Generally distributed over the state.

L. ORDER STAPHYLEACEÆ.

272. STAPHYLEA L.

STAPHYLEA TRIFOLIA L. American Bladder-nut.
Generally distributed over the state.

LI. ORDER CELASTRACEÆ. Staff-tree Family.

273. EUONYMUS Tourn. SPINDLE-TREE.

EUONYMUS AMERICANUS L.
"General," J. S. Newberry (Cat.)

EUONYMUS OBOVATUS Nutt. (*E. americanus obovatus* T. & G.)
Distributed over the whole state.

EUONYMUS ATROPURPUREUS Jacq. Burning-bush. Waahoo.
Over the whole state, quite common throughout the southern half.

274. CELASTRUS L. STAFF-TREE. SHRUBBY BITTER-SWEET.

CELASTRUS SCANDENS L.
Distributed over the whole state.

LII. ORDER ILICINEÆ. Holly Tree Family.

275. ILEX L. HOLLY.

ILEX OPACA Ait. American Holly.
Lawrence Co. (one specimen), W. A. Kellerman.

ILEX VERTICILLATA (L.) Gray. Black Alder. Winterberry.
Frequent in swamps and low grounds throughout the state.

276. ILICIOIDES Dumont. (*Nemopanthes* Raf.) MOUNTAIN HOLLY

ILICIOIDES MUCRONATA (L.) Trelease. (*Nemopanthes fascicularis* Raf.)
Lorain Co., A. A. Wright (Cat.); Summit Co., J. S. Newberry (Cat.)

LIII. ORDER SAPINDACEAE. Soap-berry Family.

277. CARDIOSPERMUM L.

CARDIOSPERMUM HALCACABUM Willd. Heart-seed. Balloon Pea.
"Fence corners, etc., four miles north of Cincinnati," Thos. G. Lea (Riddell Sup. Cat.); Pickaway Co., J. L. Riddell (Sup. Cat. 1836.)

278. AESCULUS L. Buckeye.

AESCULUS GLABRA Willd. Fetid or Ohio Buckeye.
Frequent throughout the state.

AESCULUS OCTANDRA Marsh. (*A. flava* Ait.) Sweet Buckeye.
Frequent throughout the southern half of the state.

279. ACER Tourn. MAPLE.

ACER PENNSYLVANICUM L. Striped Maple.
Eastern Ohio, J. S. Newberry (Cat.)

ACER RUBRUM L. Red or Swamp Maple.
Generally distributed over the state.

ACER SACCHARINUM L. (*A. dasycarpum* Ehrh.) White or Silver Maple.
Throughout the whole state.

ACER SACCHARUM Marsh. (*A. saccharinum* Wang.) Sugar or Rock Maple.
Distributed over the whole state.

ACER SACCHARUM NIGRUM (Mx. f.) Britt. (*A. saccharinum nigrum* Torr. & Gray.)
Black Sugar Maple.
Throughout the whole state.

ACER SPICATUM Lam. Mountain Maple.
Over the northern portion of the state.

280. NEGUNDO Moench. ASH-LEAVED MAPLE. BOX-ELDER.

NEGUNDO NEGUNDO (L.) Karst. (*N. aceroides* Moench; *Acer negundo* L.)
Frequent throughout the southern half of the state; Lorain Co., A. A. Wright (Cat.)

LIV. ORDER ANACARDIACEAE. Cashew Family.

281. RHUS L. SUMACH.

RHUS AROMATICA Ait. (*R. canadensis* Marsh.)
Northern Ohio (S. Bass Island, W. Krebs); Central Ohio (Franklin Co., Moses Craig); Southern Ohio (Lawrence Co., W. C. Werner); Adams Co., W. A. Kellerman.)

RHUS COPALLINA L. Dwarf Sumach.
Throughout the state.

RHUS GLABRA L. Smooth Sumach.
Frequent over the whole state.

RHUS RADICANS L. (*R. toxicodendron* L.) Poison Ivy. Poison Oak.
Over the whole state.

RHUS TYPHINA L. Staghorn Sumach.
Throughout the state.

RHUS VERNIX L. (*R. venenata* DC.) Poison Sumach or Dogwood.
In swamps and low grounds throughout the state.

LV. ORDER CALLITRICHACEAE. (*Halorageae.*) Water-Milfoil Family.

282. PROSERPINACA L. MERMAID-WEED.

PROSERPINACA PALUSTRIS L.
Northern Ohio, W. Krebs, W. C. Werner.

PROSERPINACA PECTINATA Lam.
Dayton, J. L. Riddell (Sup. Cat. 1836.)

283. MYRIOPHYLLUM Vaill. WATER-MILFOIL.

MYRIOPHYLLUM AMBIGUUM Nutt.
Licking Co., J. L. Riddell (Sup. Cat. 1836); Cincinnati, Jos. F. Clark (Cat.)

MYRIOPHYLLUM HETEROPHYLLUM Michx.
Ashtabula Co., Sara F. Goodrich.

MYRIOPHYLLUM PINNATUM (Walt.) B. S. P. (*M. scabratum* Mx.)
Summit Lake (Akron) J. L. Riddell (Sup. Cat. 1836); "Not common," H. C. Beardslee (Cat.); Cincinnati, Jos. F. Clark (Cat.)

MYRIOPHYLLUM SPICATUM L.
Generally distributed throughout the state.

MYRIOPHYLLUM TENELLUM Bigelow.
Northern Ohio, H. C. Beardslee (Cat.)

MYRIOPHYLLUM VERTICILLATUM L.
Cincinnati, J. L. Riddell (Synop. 1835); Joseph Clark (Cat. 1852.)
In the supplementary catalogue published a year later, Dr. Riddell makes the statement that "M. verticillatum has not yet been discovered in our state."

284. CALLITRICHE L. WATER STAR-WORT.

CALLITRICHE HETEROPHYLLA Pursh.
Niles (Trumbull Co.) R. H. Ingraham; Lorain Co., A. A. Wright (Cat.); Painesville, H. C. Beardslee (Cat.)

CALLITRICHE VERNA L.
Webbsport (Muskingum Co.) J. L. Riddell (Sup. Cat. 1836); "Common," H. C. Beardslee (Cat.); Lorain Co., A. A. Wright (Cat.)

LVI. ORDER EUPHORBIACEAE. Spurge Family.

285. EUPHORBIA L. SPURGE.

EUPHORBIA COMMUTATA Engelm
Frequent throughout central and southern Ohio; Marblehead (Ottawa Co.) W. Krebs.

EUPHORBIA COROLLATA L.
Throughout the state.

EUPHORBIA CYPERISSIAS L.
Occasionally met with along roadsides as an escape from cultivation.

EUPHORBIA DENTATA Michx.
"Southwestern Ohio," J. S. Newberry (Cat.)

EUPHORBIA HELIOSCOPIA L.
Painesville, O. Hacker.

EUPHORBIA HUMISTRATA Engelm.
Painesville, H. C. Beardslee (Cat.); Champaign Co., Wm. C. Werner.

EUPHORBIA MACULATA L.
Common.

EUPHORBIA MARGINATA Pursh.
Lorain Co., A. A. Wright (Cat.); Cleveland, W. Krebs; Columbus, Aug. D. Selby; Cincinnati, Jos. F. James (Bot. Gaz. II, 64.)

EUPHORBIA NUTANS Lag. (*E. preslii* Guss.; *E. hypericifolia* L.)
Common.

EUPHORBIA OBTUSATA Pursh.
Fairfield Co., S. Renshaw; Licking Co., H. L. Jones (Cat.); Cincinnati, Jos. Clark (Cat.)

EUPHORBIA PEPLUS L.
Cincinnati, Jos. F. Clark (Cat.)

EUPHORBIA PLATYPHYLLA L.
Lake Co., H. C. Beardslee (Cat.); Cleveland, W. Krebs; Cincinnati, Thos. G. Lea (Cat.)

EUPHORBIA POLYGONIFOLIA L.
Frequent along the sandy shores of Lake Erie.

286. PHYLLANTHUS L.

PHYLLANTHUS CAROLINENSIS Walt.
"Southern Ohio," J. S. Newberry (Cat.)

287. CROTON L.

CROTON CAPITATUS Michx.
Columbus, on grounds of Sells Brothers' Circus, Aug. D. Selby.

288. ACALYPHA L. THREE-SEEDED MERCURY.

ACALYPHA CAROLINIANA Ell.
"Southern Ohio," Gray's Manual; Cincinnati, Thos. G. Lea (Cat.)

ACALYPHA VIRGINICA L.
Common.

LVII. ORDER POLYGALACEÆ. Milkwort Family.

289. POLYGALA Tourn. MILKWORT.

POLYGALA BREVIFOLIA Nutt.
J. L. Riddell (Synop. 1835).

POLYGALA CRUCIATA L.
Lorain Co., J. S. Newberry (Cat.)

POLYGALA INCARNATA L.
Central Ohio, W. S. Sullivant (Cat. 1840), but not since collected.

POLYGALA MARIANA Mill. (*P. fastigiata* Nutt.)
Northern Ohio, J. S. Newberry (Cat.)

POLYGALA PAUCIFOLIA Willd.
Lorain Co., A. A. Wright (Cat.); Elyria (Lorain Co.) H. C. Beardslee (Cat.)

POLYGALA POLYGAMA L.
Cleveland, W. Krebs; Painesville, H. C. Beardslee (Cat.)

POLYGALA SANGUINEA L.
Generally distributed.

POLYGALA SENEGA L. Seneca Snakeroot.
Apparently over the whole state.

POLYGALA VERTICILLATA L.
Frequent.

POLYGALA AMBIGUA Nutt. (*P. verticillata ambigua* L.)
Marietta, J. L. Riddell (Synop. 1835); Painesville, W. C. Werner.

LVIII. ORDER SIMARUBACEÆ.

290. AILANTUS.

AILANTUS GLANDULOSUS Desf. Tree of Heaven.
Occasional in the southern half of the state. Naturalized from China.

LIX. ORDER RUTACEÆ. Rue Family.

291. XANTHOXYLUM L. PRICKLY ASH.

XANTHOXYLUM AMERICANUM Mill. Northern Prickly Ash. Toothache Tree.
Generally distributed over the state.

292. PTELEA L. HOP-TREE. SHRUBBY TREFOIL.

PTELEA TRIFOLIATA L.
Apparently throughout the state.

XL. ORDER LINACEÆ. Flax Family.

293. LINUM Tourn. FLAX.

LINUM SULCATUM Riddell.
Licking Co., H. L. Jones (Cat.); Dover (Tuscarawas Co.) J. L. Riddell (Sup. Cat.); Franklin Co., Moses Craig.

LINUM USITATISSIMUM L. Common Flax.
Fields and waste places, frequent along railroad tracks.

LINUM VIRGINIANUM L.
Found rather sparingly throughout the state.

LXI. Order BALSAMINACEAE.

294. IMPATIENS L. Balsam. Jewel-weed.

Impatiens aurea Muhl. (*I. pallida* Nutt.) Pale Touch-me-not.
Common over the whole state.

Impatiens biflora Walt. (*I. fulva* Nutt.) Spotted Touch-me-not.
Common over the whole state.

LXII. Order OXALIDACEAE.

295. OXALIS L. Wood-Sorrel.

Oxalis corniculata L. Yellow Wood-Sorrel.
"Ohio," J. L. Riddell (Synop. 1835); Lorain Co., A. A. Wright (Cat.); Painesville, O. Hacker; Galia Co., W. W. Deckard; Monroe Co., H. Herzer.

Oxalis stricta L. (*O. corniculata stricta* Lav.)
Common throughout the state.

Oxalis recurva Ell.
Marietta, J. L. Riddell (Synop. 1835); Licking Co., H. L. Jones (Cat.); Fairfield Co., E. V. Wilcox; Springfield, Mrs. E. J. Spence; Logan Co., W. A. Kellerman; Galia Co., W. W. Deckard; Franklin Co., Lawrence Co., W. C. Werner.

Oxalis violacea L. Violet Wood-Sorrel.
Distributed over the whole state.

LXIII. Order GERANIACEAE. Geranium Family.

296. GERANIUM Tourn. Cranesbill.

Geranium carolinianum L.
Northern Ohio (W. Krebs, H. C. Beardslee Cat.); A. A. Wright (Cat.); Columbus, Moses Craig; Lawrence Co., W. C. Werner.

Geranium columbinum L.
Painesville, Otto Hacker.

Geranium dissectum L.
Painesville, O. Hacker.

Geranium maculatum Tourn. Wild Cranesbill.
Throughout the state.

Geranium molle L.
Painesville, W. C. Werner.

GERANIUM PUSILLUM L.
Painesville, H. C. Beardslee; Ashtabula Co., Sara F. Goodrich.

GERANIUM ROBERTIANUM L. Herb Robert.
Lorain Co., A. A. Wright (Cat.); S. Bass Island, W. Krebs; Lakeside (Ottawa Co.) E. V. Wilcox; Painesville, O. Hacker.

297. ERODIUM L'Her. STORKSBILL.

ERODIUM CICUTARIUM (L.) L.'Her.
Painesville, W. C. Werner, Franklin Co., Aug. D. Selby; Licking Co., H. L Jones (Cat.); Miami Valley, A. P. Morgan (Flora).

298. FLOERKEA Willd. FALSE MERMAID.

FLOERKEA PROSERPINACOIDES Willd.
Frequent throughout the state.

LXIV. ORDER LEGUMINOSAE. Pulse Family.

299. BAPTISIA Vent. FALSE INDIGO.

BAPTISIA ALBA (L.) R. Br.
Central Ohio, W. S Sullivant (Cat.), J. L. Riddell (Synop.); has not been found by recent collectors.

BAPTISIA AUSTRALIS (L.) R. Br. Blue False Indigo.
Cincinnati, J. L. Riddell (Synop. 1835), Jos. F. James (Cat.)

BAPTISIA LEUCANTHA Torr. and Gray.
Crawford Co., H. Herzer; Franklin Co., E. V. Wilcox; Banks of Ohio River J. S. Newberry (Cat.); Cincinnati, Jos. Clark (Cat.)

BAPTISIA LEUCOPHAEA Nutt.
Cincinnati, Dr. Kellogg (J. S. Newberry Cat.)

BAPTISIA TINCTORIA (L.) R. Br. Wild Indigo.
Northern Ohio (W. C. Werner, R. H. Ingraham, A. A. Wright Cat.); Cincinnati, Jos. Clark (H. C. Beardslee Cat.)

300. CROTALARIA L. RATTLE-BOX.

CROTALARIA SAGITTALIS L.
Cincinnati, Mr. Ward (J. S. Newberry, Cat.)

301. LUPINUS Tourn. LUPINE.

LUPINUS PERENNIS L. Wild Lupine.
Tuscarawas Co., J. L. Riddell (Sup. Cat. 1836); Portage Co., W. Krebs; Painesville, O. Hacker; Summit Co., W. C. Werner; Delta (Fulton Co.) M. G. Aumend.

302. MEDICAGO Tourn. MEDICK.

MEDICAGO LUPULINA L. Black Medick. None Such.
Frequent throughout the state.

MEDICAGO SATIVA L. Lucerne. Alfalfa.
Lorain Co., A. A. Wright (Cat.); Painesville, W. C. Werner; Franklin Co., Moses Craig.

303. MELILOTUS Tourn. SWEET CLOVER.

MELILOTUS ALBA (L) Lam. White Melilot.
Throughout the state, more common than the following.

MELILOTUS OFFICINALIS (L) Lam. Yellow Melilot.
Throughout the state.

304. TRIFOLIUM Tourn. CLOVER.

TRIFOLIUM ARVENSE L. Rabbit-foot or Stone Clover.
Northern Ohio, H. C. Beardslee (Cat.); Painesville, O. Hacker; Lorain Co., A. A. Wright (Cat.); Knox Co., Aug. D. Selby.

TRIFOLIUM HYBRIDUM L. Alsike Clover.
Appears to be generally distributed, escaped from cultivation.

TRIFOLIUM PRATENSE L. Red Clover.
Common over the whole state.

TRIFOLIUM PROCUMBENS L. Low Hop-clover.
Marietta, J. L. Riddell (Synop. 1835); Lorain Co., A. A. Wright (Cat.); Franklin Co., W. J. Green; Licking Co., H. L. Jones (Cat.)

TRIFOLIUM REFLEXUM L. Buffalo Clover.
Painesville, H. C. Beardslee (Cat.); Franklin Co., J. L. Riddell (Synop. 1835); "Western Ohio, General," J. S. Newberry (Cat.); Cincinnati, Jos. Clark (Cat.)

TRIFOLIUM REPENS L. White Clover.
Common throughout the state.

TRIFOLIUM STOLONIFERUM Muhl. Running Buffalo Clover.
Not abundant but rather widely distributed.

305. PSORALEA L.

PSORALEA MELILOTOIDES Michx.
Hocking Co., C. J. Herrick; Lawrence Co., W. C. Werner.

PSORALEA ONOBRYCHIS Nutt.
Throughout the southern half of the state.

306. KUHNISTERA Lam. (*Petalostemon* Mx.) PRAIRIE CLOVER.

KUHNISTERA VIOLACEA (Mx.) Kuntze. (*Petalostemon violaceus* Mx.)
"Near Middletown Ohio," J. L. Riddell (Sup. Cat. 1836.)

307. CRACCA L. (*Tephrosia* Pers.) HOARY PEA.

CRACCA VIRGINIANA L. (*Tephrosia virginiana* Pers.) Goat's Rue. Catgut.
From Lake Erie (J. A. Sanford) to the Ohio river.

308. ROBINIA L. LOCUST-TREE.

ROBINIA HISPIDA L. Bristly Locust or Rose Acacia.
Miami Valley, A. P. Morgan. (Flora).

ROBINIA PSEUDACACIA L. Common Locust or False Acacia.
Generally distributed.

ROBINIA VISCOSA Vent. Clammy Locust-tree.
Ashtabula Co., Sara F. Goodrich; Fairfield Co., W. A. Kellerman; Miami Valley, A. P. Morgan (Flora).

309. ASTRAGALUS Tourn. MILK-VETCH.

ASTRAGALUS CANADENSIS L.
Northern Ohio (J. A. Sanford, W. Krebs); Franklin Co., Aug. D. Selby; Lawrence Co., W. C. Werner.

ASTRAGALUS COOPERI Gray.
Southern Ohio, Jos. Clark (H. C. Beardslee, Cat.); Huron Co., H. C. Beardslee (Cat.); Lorain Co., A. A. Wright (Cat.)

310. STYLOSANTHES Swartz.

STYLOSANTHES BIFLORA (L.) B. S. P. (*S. elatior* Swartz.)
Central and southern Ohio, J. S. Newberry (Cat.); Fairfield Co., W. A. Kellerman.

311. MEIBOMIA Moehr. TICK-TREFOIL.

MEIBOMIA BRACTEOSA (Mx.) Kuntze. (*Desmodium cuspidatum* T. & G.)
Cleveland, W. Krebs; Painesville, W. C. Werner; Springfield, Mrs. E. J. Spence; Cincinnati, Jos. F. James (Cat.)

MEIBOMIA CANADENSIS (L.) Kuntze. (*Desmodium canadense* DC.)
Painesville, W. C. Werner; Licking Co., H. L. Jones (Cat.); Cincinnati, Thos. G. Lea (Cat.)

MEIBOMIA CANESCENS (L.) Kuntze. (*Desmodium canescens* DC.)
Generally distributed over the state.

MEIBOMIA DILLENII (Darlingt.) Kuntze. (*Desmodium dillenii* Darl.)
Throughout the state.

MEIBOMIA GLABELLA (Michx.) Kuntze. (*Desmodium humifusum* Beck.)
Monroe Co., J. L. Riddell (Synop. 1835.)

MEIBOMIA GRANDIFLORA (Walt.) Kuntze. (*Desmodium acuminatum* DC.)
Throughout the state.

MEIBOMIA LAEVIGATA (Nutt.) Kuntze. (*Desmodium laevigatum* DC.)
"Ohio," J. L. Riddell (Synop. 1835.)

MEIBOMIA MARYLANDICA (L.) Kuntze. (*Desmodium marylandicum* F. Boot.)
"Miami River," J. L. Riddell (Synop. 1835); Lancaster (Fairfield Co.) J. M. Bigelow (J. S. Newberry, Cat.); Sugar Grove (Fairfield Co.) Wm. C. Werner.

MEIBOMIA NUDIFLORA (L.) Kuntze. (*Desmodium nudiflorum* DC.)
Frequent throughout the state.

MEIBOMIA OBTUSA (Muhl.) A. M. Vail. (*Desmodium ciliare* DC.)
"Miami county," Ohio, J. L. Riddell (Synop. 1835); Georgesville (Franklin Co.) Wm. C. Werner; Summit Co., Wm. Krebs.

MEIBOMIA PANICULATA (L.) Kuntze. (*Desmodium paniculatum* DC.)
Northern Ohio (E. E. Bogue, W. C. Werner, A. A. Wright Cat.); Central Ohio (Aug. D. Se by, H. L. Jones Cat.); Cincinnati, Jos. F. James (Cat.)

MEIBOMIA PAUCIFLORA (Nutt.) Kuntze. (*Desmodium pauciflorum* DC.)
"General," J. S. Newberry (Cat.); Lorain Co., A. A. Wright (Cat.); New Antioch (Clinton Co.) J. S. Vandervort; Cincinnati, Joseph Clark (Cat.)

MEIBOMIA RIGIDA (Elliott) Kuntze. (*Desmodium r gidum* DC.)
Marietta, J. L. Riddell (Synop. 1835); Northern Ohio, J. S. Newberry (Cat.); Fairfield Co., Franklin Co., Wm. C. Werner.

MEIBOMIA ROTUNDIFOLIA (Mx.) Kuntze. (*Desmodium rotundifolium* DC.)
Throughout the state; probably not abundant in any locality.

MEIBOMIA STRICTA (Ph.) Kuntze. (*Desmodium strictum* DC.)
"Middletown," J. L. Riddell (Synop. 1835.)

MEIBOMIA VIRIDIFLORA (L.) Kuntze. (*Desmodium viridiflorum* Beck.)
Lorain Co., A. A. Wright (Cat.); Cincinnati, Thos. G. Lea (Cat.)

312. LESPEDEZA Michx. BUSH-CLOVER.

LESPEDEZA FRUTESCENS (Willd.) Ell. (*L. capitata* Mx.)
Cuyahoga Co., W. Krebs; Painesville, Franklin Co., W. C. Werner; Cincinnati Jos. Clark (Cat); Miami Valley, A. P. Morgan (Flora).

LESPEDEZA HIRTA (L.) Ell. (*L. polystachya* Mx.)
Throughout the state.

LESPEDEZA PROCUMBENS Mx.
Fairfield Co., Wm. C. Werner.

LESPEDEZA REPENS (L.) Bart.
Frequent throughout the state.

LESPEDEZA RETICULATA (Muhl.) Pers.
Cincinnati, T. G. Lea (Riddell, Sup. Cat. 1836); Painesville, H. C. Beardslee (Cat.); Lorain Co., A. A. Wright (Cat.); Franklin Co., Aug. D. Selby; Scioto Co., W. A. Kellerman.

LESPEDEZA STUVEI Nutt.
Painesville, W. C. Werner; Licking Co., H. L. Jones (Cat.)

LESPEDEZA INTERMEDIUM (Watson) Britt.
Cincinnati, T. G. Lea (Riddell Sup. Cat. 1836); Painesville, Wm. C. Werner; Franklin Co., Aug. D. Selby; Scioto Co., W. A. Kellerman; Muskingum Co., Wm. C. Werner; Monroe Co., H. Herzer; Gallia Co., Lizzie Davis; Fulton Co., J. S. Hine.

LESPEDEZA VIOLACEA (L.) Pers.
Frequent.

313. VICIA Tourn. VETCH. TARE.

VICIA AMERICANA Muhl.
"General," J. S. Newberry (Cat.); Lorain Co., A. A. Wright (Cat.)

VICIA CAROLINIANA Walt.
Throughout the state.

VICIA CRACCA L.
Painesville, H. C. Beardslee (Cat.); Fairfield Co., E. V. Wilcox and S. Renshaw; Columbus, C. E. Morrey; Miami Valley, A. P. Morgan (Flora).

VICIA HIRSUTA (L.) Koch.
Lorain Co., A. A. Wright (Cat.); Painesville, W. C. Werner; Lorain Co., A. A. Wright (Cat.)

VICIA SATIVA L. Common Vetch or Tare.
"Common," H. C. Beardslee (Cat.); Painesville, W. C. Werner.

314. LATHYRUS Tourn. VETCHLING. EVERLASTING PEA.

LATHYRUS GLAUCIFOLIUS Beck. (*L. ochroleucus* Hook.)
Painesville, H. C. Beardslee (Cat.), Wm. C. Werner; Cleveland, W. Krebs; Lorain Co., A. A. Wright (Cat.)

LATHYRUS MARITIMUS (L.) Bigelow. Beach Pea.
Ashtabula Co., Sara F. Goodrich; Lake Co., H. C. Beardslee (Cat.), Wm. C. Werner.

LATHYRUS MYRTIFOLIUS Muhl.
Painesville, H. C. Beardslee (Cat.); Toledo, J. A. Sanford; Ashtabula Co., Sara F. Goodrich; Licking reservoir, Columbus, Wm. C. Werner.

LATHYRUS PALUSTRIS L.
Northern Ohio, H. C. Beardslee (Cat.), A. A. Wright (Cat.), Wm. Krebs, Sara F. Goodrich; Licking reservoir, H. L. Jones (Cat.); Columbus, Wm. C. Werner; Champaign Co., Wm. C. Werner.

LATHYRUS VENOSUS Muhl.
Ohio, J. L. Riddell (Synop. 1835); Painesville, H. C. Beardslee (Cat.); Lorain Co., A. A. Wright (Cat.); Cincinnati, Jos. Clark (Cat.)

315. CLITORIA L. BUTTERFLY-PEA.

CLITORIA MARIANA L.
"Ohio," J. L Riddell (Synop. 1835.)

316. FALCATA Gmel. (*Amphicarpaea* Ell.) HOG PEA-NUT.

FALCATA COMOSA (L.) Kuntze. (*Amphicarpaea comosa* L.; *A. monoica* Ell.)
Generally distributed over the state.

FALCATA PITCHERI (T. & G.) Kuntze. (*Amphicarpaea pitcheri* Torr. and Gray).
Licking Co., H. L. Jones (Cat.)

317. APIOS Boerhaave. GROUND-NUT. WILD BEAN.

APIOS TUBEROSA Moench.
Frequent throughout the state.

318. PHASEOLUS Tourn. KIDNEY BEAN.

PHASEOLUS HELVOLUS L. (*Strophostyles angulosa* Ell.)
Common on the sandy shores of Lake Erie; Licking Co., H. L. Jones (Cat.); Cincinnati, Jos. F. James (Cat.); "Prairie, near Hamilton, Ohio," J. L. Riddell (Synop. 1835.)

PHASEOLUS PERENNIS Walt. Wild Bean.
"General," J. S. Newberry (Cat.)

319. GYMNOCLADUS Lam. KENTUCKY COFFEE-TREE.

GYMNOCLADUS DIOICUS (L.) Koch. (*G. canadensis* Lam.)
Distributed over the state, probably not abundant anywhere.

320. GLEDITSCHIA L. HONEY LOCUST.

GLEDITSCHIA TRIACANTHOS L. Three-thorned Acacia, or Honey-Locust.
Generally distributed but more frequent over the southern half of the state.

321. CASSIA Tourn. SENNA.

CASSIA CHAMÆCRISTA L. Partridge Pea.
Monroeville (Huron Co.) H. C. Beardslee (Cat.); Franklin Co., Aug. D. Selby; Licking Co., H. L. Jones (Cat.); Cincinnati, Jos. F. James (Cat.)

CASSIA MARILANDICA L. Wild Senna.
Frequent in the southern and western parts of the state; Cleveland, W. Krebs.

CASSIA NICTITANS L.
Frequent in the southern half of the state.

322. CERCIS L. RED-BUD. JUDAS-TREE.

CERCIS CANADENSIS L. Red-bud.
Over the whole state, especially abundant in the southern half.

LXV. ORDER ROSACEÆ. Rose Family.

323. PRUNUS Tourn. PLUM, CHERRY, ETC.

PRUNUS AMERICANA Marshall.
Throughout the state.

PRUNUS ANGUSTIFOLIA Marsh. (*P. chicasa* Michx.)
"Naturalized in southern Ohio," J. A. Warder (Woody Pl.)

PRUNUS PENNSYLVANICA L. f. Wild Red Cherry.
Northern Ohio, W. Krebs, Sara F. Goodrich, W. C. Werner, A. A. Wright (Cat.)

PRUNUS PUMILA L.
"Northern Ohio," J. S. Newberry (Cat.)

PRUNUS SEROTINA Ehrh. Wild Black Cherry.
Throughout the state.

PRUNUS VIRGINIANA L. Choke-cherry.
Northern Ohio, A. A. Wright (Cat.), W. C. Werner; Central Ohio, Mrs. E. J. Spence, Aug. D. Selby; Licking Co., H. L. Jones (Cat.)

324. SPIRÆA L. MEADOW-SWEET.

SPIRÆA ARUNCUS L. Goat's Beard.
Distributed throughout the state.

SPIRÆA CORYMBOSA Raf. (*S. betulaefolia corymbosa* Watson.)
Cleveland, W. Krebs; Lorain Co., A. A. Wright (Cat.)

SPIRÆA RUBRA (Hill) Britt. (*S. lobata* Jacq.) Queen of the Prairie.
Cedar Swamp (Champaign Co.) Mrs. E. J. Spence; Cincinnati, Jos. F. James (Cat.); Licking Co., H. L. Jones (Cat.); Lorain Co., A. A. Wright (Cat.)

SPIRÆA SALICIFOLIA L. Common Meadow-Sweet.
Throughout the state.

SPIRÆA TOMENTOSA L. Hard ack. Steeple-Bush.
Silver Lake (Summit Co.) W. Krebs; Mahoning Co., W. C. Werner; Lorain Co., A. A. Wright (Cat.); Amanda (Fairfield Co.) W. A. Kellerman.

325. EPISCOTORUS Raf. (*Neillia; Physocarpus.*)

EPISCOTORUS OPULIFOLIUS (L.) (*Neillia opulifolia* Benth. & Hook., *Physocarpus opulifolius* Maxim., *Spiraea opulifolia* L.)
Distributed throughout the state; S. Bass Island, W. Krebs.

326. PORTERANTHUS Britt. (*Gillenia* Moench.) INDIAN PHYSIC.

PORTERANTHUS STIPULATUS (Muhl.) Britt. (*Gillenia stipulata* Muhl.; *G. stipulacea* Nutt.) American Ipecac.
Southern Ohio, J. S. Newberry (Cat.); Cincinnati, Jos. F. James (Cat.); Athens Co, Aug. D. Selby; Logan Co., W. A. Kellerman.

PORTERANTHUS TRIFOLIATA (L.) Britt. (*Gillenia trifoliata* Moench.) Bowman's Root.
Knox Co., J. S. Newberry (Cat.); Painesville, O. Hacker; Corning (Perry Co.) J. H. Lageman; Dayton, R. Buchanan (J. L. Riddell, Sup. Cat. 1836.)

227. RUBUS Tourn. BRAMBLE.

RUBUS AMERICANUS (Pers.) (*R. triflorus* Richards.) Dwarf Raspberry.
Frequent in northern Ohio; Champaign Co., Mrs. E. J. Spence.

RUBUS CANADENSIS L. Dewberry.
Frequent throughout the state; a double flowered form from Painesville, O. Hacker.

RUBUS CUNEIFOLIUS Pursh. Sand Blackberry.
Lorain Co., Dr. Kellogg (J. S. Newberry, Cat.)

RUBUS HISPIDUS L. Running Swamp-Blackberry.
Northern Ohio.

RUBUS INVISUS (Bailey) Britt. (*R. villosus humifusus* T. & G.)
"Common," H. C. Beardslee (Cat.)

RUBUS OCCIDENTALIS L. Black Raspberry.
Frequent throughout the state.

RUBUS ODORATUS L. Purple Flowering-Raspberry.
Generally distributed over the northern and central portions of the state.

RUBUS STRIGOSUS Michx. Wild Red-Raspberry.
Throughout the state.

RUBUS VILLOSUS Ait. Common Blackberry.
Common over the whole state.

RUBUS VILLOSUS FRONDOSUS Torr.
"Common," H. C. Beardslee (Cat.); Lake Co., O. Hacker.

328. DALIBARDA L.

DALIBARDA REPENS L.
Worthington (Franklin Co.) J. L. Riddell (Synop. 1835); Morgan (Ashtabula Co.) L. B. Tuckerman (Lazenby and Werner, Sup. List); Orwell (Ashtabula Co.) E. E. Bogue.

329. GEUM L. AVENS.

GEUM CANADENSE Jacq. (*G. album* Gmelin.)
Generally distributed.

GEUM CILIATUM Ph. (*G. triflorum* Ph.)
"Ohio," J. L. Riddell (Synop. 1835.)

GEUM RIVALE L. Water, or Purple Avens.
Northern Ohio (W. Krebs, W. C. Werner, E. E. Bogue); Champaign Co., Wm. C. Werner.

GEUM STRICTUM Ait.
Northern Ohio (W. Krebs, W. C. Werner. A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.)

GEUM VERNUM Torr. & Gray.
Frequent in central and southern Ohio; Lorain Co., A. A. Wright (Cat.)

330. WALDSTEINIA Willd.

WALDSTEINIA FRAGARIOIDES (Mx.) Tratt.
Painesville, O. Hacker; Ashtabula Co., Florence Tuckerman; Franklin Co., Aug. D. Selby; Springfield, Mrs. E. J. Spence; Licking Co., H. L. Jones (Cat.); Cincinnati, J. L. Riddell (Synop. 1835.)

331. FRAGARIA Tourn. STRAWBERRY.

FRAGARIA AMERICANA (Porter) Britt. (*F. vesca*, Gray Man.)
Painesville, Wm. C. Werner; Springfield, Mrs. E. J. Spence. *F. vesca*, Lorain Co., A. A. Wright (Cat.) and Cincinnati, Jos. F. James (Cat.) undoubtedly refer to F. Americana.

FRAGARIA VIRGINIANA Mill.
Frequent all over the state.

FRAGARIA VIRGIAIANA ILLINOENSIS (Prince) Gray.
Painesville and Columbus, Wm. C. Werner; Lorain Co., A. A. Wright (Cat.); Gallia Co., W. W. Deckard. Perhaps widely distributed.

332. POTENTILLA L. Cinque-foil. Five-finger.

Potentilla anserina L. Silver-Weed.
Sandy shore of Lake Erie (H. C. Beardslee Cat.), W. Krebs; Lorain Co., A. A. Wright (Cat.)

Potentilla arguta Pursh.
Cedar Point (Erie Co.) and Lakeside (Ottawa Co.), W. Krebs; Painesville, Wm. C. Werner.

Potentilla argentea L. Silvery Cinque-Foil.
Cleveland, Lakeside and Cedar Point, W. Krebs.

Potentilla canadensis L. Common Five-Finger.
Throughout the state.

Potentilla canadensis simplex T. & G.
Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.); Franklin Co., J. L. Riddell (Synop. 1835.)

Potentilla fruticosa L. Shrubby Cinque-Foil.
Central Ohio, W. S. Sullivant (Cat. 1840); Cedar Swamp, Champaign Co., Mrs. E. J. Spence.

Potentilla norvegica L.
Frequent throughout the state.

Potentilla palustris (L.) Scop. Marsh Five-Finger.
Northern Ohio, W. Krebs, A. A. Wright (Cat.); Licking Reservoir, H. L. Jones (Cat.)

Potentilla recta L.
Columbus, W. R. Lazenby; Westerville (Franklin Co.), E. V. Wilcox.

Potentilla supina L.
Painesville and Southern Ohio, H. C. Beardslee (Cat.); Cedar Point (Erie Co.), E. Claassen; Lorain Co., A. A. Wright (Cat.)

333. AGRIMONIA Tourn. Agrimony.

Agrimonia striata Mx. (*A. eupatoria* L.) Common Agrimony.
Frequent over the whole state.

Agrimonia parviflora Ait. Small-flowered Agrimony.
Throughout the state.

334. SANGUISORBA L. (*Poterium* L.) Burnet.

Sanguisorba canadensis L. (*Poterium canadense* Benth. & Hk.) Canadian Burnet.
Northern Ohio, H. C. Beardslee (Cat.), W. Krebs; Central Ohio, Mrs. E. J. Spence, E. E. Bogue; Miami Valley, A. P. Morgan (Flora).

SANGUISORBA POTERIUM (L.) Britt. (*Poterium sanguisorba* L.) Garden Burent.
Painesville, Otto Hacker.

335. ROSA Tourn. ROSE.

ROSA BLANDA Ait.
Throughout the state. Infrequent.

ROSA CANINA L. Dog Rose.
"Southern Ohio," J. A. Warder (Woody Pl.)

ROSA CAROLINA L.
Frequent in swamps and low grounds throughout the state.

ROSA CINNAMOMEA. Cinnamon Rose.
"An old garden variety with double flowers, escaped from cultivation, Southern Ohio," J. A. Warder (Woody Pl.)

ROSA HUMILIS Marsh.
Frequent throughout the state.

ROSA LUCIDA Ehrh.
Painesvil.e, W. C. Werner; Franklin Co., Aug. D. Selby.

ROSA RUBIGINOSA L. Sweetbriar. Eglantine.
Roadsides and uncultivated fields throughout the state.

ROSA SETIGERA Michx. Climbing or Prairie Rose.
Frequent throughout the state.

336. PYRUS L. PEAR. APPLE.

PYRUS ARBUTIFOLIA (L.) L.f. Choke-Berry.
Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.), W. C Werner.

PYRUS ANGUSTIFOLIA Ait.
Franklin Co., J. R. Paddock (J. L. Riddell, Sup. Cat. 1836); Licking Co., H. L. Jones (Cat.)

PYRUS CORONARIA L. American Crab-Apple.
Over the whole state.

PYRUS MALUS L. Apple.
"Frequently found in waste places and along roadsides, Licking Co.," H. L. Jones (Cat.)

PYRUS NIGRA (Willd.) Sarg. (*P. arbutifolia melanocarpa* Hook.)
Throughout the northern and central portions of the state; Gallia Co., J. W. Davis.

337. SORBUS L.

SORBUS SAMBUCIFOLIA (Cham. & Schlecht.) Roem. (*Pyrus sambucifolia* Cham. & Schlecht.)
Elyria (Lorain Co.) H. C. Beardslee (Cat.)

338. CRATAEGUS L. HAWTHORN. WHITE THORN.

CRATAEGUS APIIFOLIA (Marsh.) Michx.
"Ohio," J. L. Riddell (Synop. 1835.)

CRATAEGUS COCCINEA L.
Throughout the state.

CRATAEGUS COCCINEA MACRANTHA Dudley.
Painesville, Wm. C. Werner; Licking Co., H. L. Jones (Cat.)

CRATAEGUS CRUS-GALLI L.
Generally distributed over the state.

CRATAEGUS FLAVA Ait.
Cincinnati, Joseph Clark (Cat.)

CRATAEGUS MOLLIS (T. & G.) Sarg. (*C. coccinea mollis* Torr. and Gray.)
Over the whole state.

CRATAEGUS OXYACANTHA L.
Lorain Co., A. A. Wright (Cat.)

CRATAEGUS SPATHULATA Michx.
"Ohio," J. L. Riddell (Synop. 1835.)

CRATAEGUS TOMENTOSA L.
"Common," H. C. Beardslee (Cat.); Lorain Co., A. A. Wright (Cat.); Franklin Co., Aug. D. Selby; Clermont Co., Jos. F. James.

CRATAEGUS TOMENTOSA PUNCTATA (Jacq.) Gray.
Throughout the state.

339. AMELANCHIER Medic. JUNE-BERRY.

AMELANCHIER ALNIFOLIA Nutt.
Central Ohio, W. S. Sullivant (H. C. Beardslee Cat.)

AMELANCHIER CANADENSIS (L.) Medic. Shad-bush. Service-berry.
Generally distributed.

LXVI. ORDER PLATANACEAE. Plane-tree Family.

340. PLATANUS L. SYCAMORE. BUTTON-WOOD.

PLATANUS OCCIDENTALIS L.
Over the whole state.

LXVII. Order HAMAMELIDEAE. Witch-Hazel Family.

341. HAMAMELIS L. Witch-Hazel.

Hamamelis virginiana L.
Over the whole state.

342. LIQUIDAMBAR L. Sweet-Gum Tree.

Liquidambar styraciflua L. Sweet-Gum. Bilsted.
Southern Ohio, H. C. Beardslee (Cat.); Otway (Scioto Co.) W. A. Kellerman.

LXVIII. Order SAXIFRAGACEAE. Saxifrage Family.

343. SAXIFRAGA L. Saxifrage.

Saxifraga aizoon Jacq.
"Northeastern Ohio," J. S. Newberry (Cat.)

Saxifraga pennsylvanica L.
Throughout the northern half of the state; Miami Valley, A. P. Morgan (Flora).

Saxifraga virginiensis Michx.
Over the whole state.

344. SULLIVANTIA. Torr. and Gray.

Sullivantia sullivantii (T. & G.) Britt. (*S. ohionis* T. & G.)
Highland Co., W. S. Sullivant (J. S. Newberry Cat.); Fultonham (Muskingum Co.) W. C. Werner; Hocking Co., Adams Co., W. A. Kellerman.

345. TIARELLA L. False Mitre-Wort.

Tiarella cordifolia L.
Generally distributed.

346. MITELLA Tourn. Mitre-Wort. Bishop's-Cap.

Mitella diphylla L.
Frequent throughout the state.

Mitella nuda L.
Cleveland, J. S. Newberry (Cat.)

347. HEUCHERA L. Alum-Root.

Heuchera americana L. Common Alum-root.
Distributed throughout the whole state.

Heuchera villosa Michx.
Cincinnati, Mr. Ward (J. S. Newberry Cat.)

348. CHRYSOSPLENIUM Tourn. Golden Saxifrage.

Chrysosplenium americanum Schwein.
Generally distributed throughout the northern and central portions of the state.

349. PARNASSIA Tourn. Grass of Parnassus.

Parnassia caroliniana Michx.
Lorain Co., A. A. Wright (Cat.); Painesville, W. C. Werner; Columbus, E. V. Wilcox; Licking Co., H. L. Jones (Cat.); Cedar Swamp (Champaign Co.) W. C. Werner; Miami Valley, A. P. Morgan (Flora).

350. HYDRANGEA Gronov.

Hydrangea arborescens L. Wild Hydrangea.
Frequent throughout the state.

351. PHILADELPHUS L. Mock-Orange or Syringa.

Philadelphus coronarius L.
"Almost naturalized in southern Ohio," J. A. Warder (Woody Pl.)

Philadelphus inodorus L.
"Almost naturalized in southern Ohio," J. A. Warder (Woody Pl.)

352. RIBES L. Currant. Gooseberry.

Ribes cynosbati L.
Distributed over the whole state.

Ribes floridum L'Her. Wild Black-Currant.
Generally distributed throughout the whole state.

Ribes lacustre Poir
Columbus, Mr. Lapham (J. L. Riddell, Sup. Cat. 1836); Painesville, H. C. Beardslee (Cat.)

Ribes nigrum L.
Escaped from cultivation; Cleveland, W. Krebs; Painesville, O. Hacker.

Ribes oxyacanthoides L.
Franklin Co., J. L. Riddell (Synop. 1835); Lorain Co., A. A. Wright (Cat.); Painesville, Champaign Co., Akron and Lawrence Co., W. C. Werner.

Ribes rotundifolium Michx.
Northern Ohio, H. C. Beardslee (Cat.)

RIBES RUBRUM SUBGLANDULOSUM Maxim.
Geauga Co., Dr. Canfield (J. S. Newberry Cat.); Thompson Ledge (Geauga Co.) H. C. Beardslee (Cat.); Lorain Co., A. A. Wright (Cat.); Painesville, O. Hacker.

LXIX. ORDER SARRACENIACEÆ. PITCHER PLANTS.

353. SARRACENIA Tourn. SIDE-SADDLE FLOWER.

SARRACENIA PURPUREA L. Pitcher-plant. Huntsman's Cup.
Geauga Lake (Portage Co.) W. Krebs; Chardon (Geauga Co.) W. C. Werner; Lorain Co., A. A. Wright (Cat.); Akron (Summit Co.) E. W. Claypole.

LXX. ORDER DROSERACEÆ. Sundew Family.

354. DROSERA L. SUNDEW.

DROSERA INTERMEDIA AMERICANUM DC.
"Northern Ohio," H. C. Beardslee (Cat.)

DROSERA ROTUNDIFOLIA L.
Lorain Co., A. A. Wright (Cat.); Summit Co., W. Krebs and E. Claassen; Lake Co., Otto Hacker; Licking Co., H. L. Jones (Cat.); Champaign Co., Wm. C. Werner.

LXXI. ORDER CRASSULACEÆ. Orpine Family.

355. PENTHORUM Gronov. DITCH STONE-CROP.

PENTHORUM SEDOIDES L.
Common in wet places.

356. SEDUM Tourn. STONE-CROP. ORPINE.

SEDUM ACRE L. Mossy Stone-crop.
"Adventive" H. C. Beardslee (Cat.)

SEDUM PULCHELLUM Mx.
Miami Valley, A. P. Morgan (Flora).

SEDUM TELEPHIOIDES Michx.
"Eastern Ohio," J. S. Newberry (Cat.)

SEDUM TELEPHIUM L. Garden Orpine or Live-for-ever.
Escaped from cultivation, Columbus, Wm. C. Werner; Miami Valley, A. P. Morgan (Flora).

Sedum ternatum (Haw.) Michx.
Generally distributed over the state.

LXXII. Order CAPPARIDACEÆ. Caper Family.

357. POLANISIA Raf.

Polanisia graveolens Raf. (*P. dodecandra* Mx.)
Distributed over the state; West Sister Island (Lake Erie) J. A. Sanford.

LXXIII. Order CRUCIFERÆ. Mustard Family.

358. RORIPPA Scop. (*Nasturtium* R. Br.) Water Cress.

Rorippa americana (Gray) Britt. (*Nasturtium tacustre* Gray.) Lake Cress.
Franklin Co., W. S. Sullivant; Lorain Co., A. A. Wright (Cat.); Licking Go., H. L. Jones (Cat.); Cincinnati, Jos. F. James (Cat.); Madison Co., Mrs. K. D. Sharpe.

Rorippa armoracia (L.) Rusby. (*Nasturtium armoracia* Fries.) Horse raddish.
Escaped from gardens into roadside and waste places.

Rorippa hispida (Desv.) Britt. (*Nasturtium palustre hispida* F. & M.)
Painesville, Wm. C. Werner; Monroe Co., H. Herzer.

Rorippa nasturtium (L.) Britt. (*Nasturtium officinale* R. Br.) True Water Cress.
Common near springs and in clear running water throughout the state.

Rorippa palustre (L.) Britt. (*Nasturtium patustre* L.) Marsh Cress.
Frequent.

Rorippa sessiliflora (Nutt.) Britt. (*Nasturtium sessitiflorum* Nutt.)
Miami Valley, A. P. Morgan (Flora).

Rorippa sylvestris (L.) Britt. (*Nasturtium sylvestre* R. Br.)
Painesville, O. Hacker.

359. BARBAREA R. Br. Winter Cress.

Barbarea vulgaris R. Br. Common Winter Cress. Yellow Rocket.
Over the whole state, most abundant in heavy clay soils.

360. ARABIS L. Rock Cress.

Arabis canadensis L. Sickle-pod.
Over the whole state, probably not common anywhere.

ARABIS BRACHYCARPA (T. & G.) Britt. (*A. confinis* Watson.)
Distributed throughout the state.

ARABIS DENTATA Torr. & Gray.
Throughout the southern half of the state.

ARABIS GLABRA (L.) Bernh. (*A. perfoliata* Lam.) Tower Mustard.
Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.); Cincinnati, Jos. F. James (Cat.); "General," J. S. Newberry (Cat.)

ARABIS HIRSUTA (L.) Scop.
"General," J. S. Newberry (Cat.); Licking Co., H. L. Jones (Cat.); Cincinnati, Jos. F. James (Cat.)

ARABIS LAEVIGATA (Muhl.) Poir.
Over the whole state.

ARABIS LUDOVICIANA Meyer.
Cincinnati, Jos. F. James (Cat.)

ARABIS LYRATA L.
From the northern (Ottawa Co., W. Krebs) to the southern portion of the state (Lawrence Co., W. C. Werner).

ARABIS PATENS Sulliv.
Lorain Co., Dr. Kellogg (J. S. Newberry Cat.); rocky banks of the Scioto River (Franklin Co.) Aug. D. Selby.

361. THELYPODIUM Endl.

THELYPODIUM PINNATIFIDUM (Mx.) Watson.
Frequent over the southern half of the state; Lorain Co., A. A. Wright (Cat.)

362. CARDAMINE L. (Incl. DENTARIA Tourn.)

CARDAMINE ARENICOLA Britton.
Geneva (Ashtabula Co.) Miss Sara F. Goodrich.

CARDAMINE BULBOSA (Schreb.) B. S. P. (*C. rhomboidea* DC.) Spring Cress.
Common over the whole state.

CARDAMINE DIPHYLLA (Mx.) Wood. (*Dentaria diphylla* Michx.)
Distributed over the state.

CARDAMINE DOUGLASSII (Torr.) Britt. (*C. rhomboidea purpurea* Torr.)
Common throughout the whole state.

CARDAMINE FLEXUOSA With. (*C. hirsuta sylvatica* Gr.)
Lorain Co., A. A. Wright (Cat.)

CARDAMINE LACINIATA (Muhl.) Wood. (*Dentaria laciniata* Muhl.)
Common over the whole state.

CARDAMINE MAXIMA (Nutt.) Wood. (*Dentaria maxima* Nutt.)
Cincinnati, Joseph Clark (Cat.); Taylor's Creek, Leo Lesquereux (J. S. Newberry Cat.)

CARDAMINE PENNSYLVANICA Muhl. (*C. hirsuta* L.) Small Bitter Cress.
Common in low grounds.

CARDAMINE PRATENSIS L. CUCKOO FLOWER.
Northern Ohio, W. R. Lazenby and W. C. Werner (Sup. List.)
More than doubtful since not authenticated by specimens.

CARDAMINE ROTUNDIFOLIA Mx. Mountain Water-Cress.
Painesville, H. C. Beardslee; Franklin Co., W. S. Sullivant (Cat. 1840) but not found since; Cincinnati, Jos. F. James (Cat.)

363. ALYSSUM Tourn.

ALYSSUM ALYSSOIDES (L.) Gouan. (*A. calycinum L.*)
Lorain Co., A. A. Wright (Cat.)

ALYSSUM MARITIMUM (L.) Lam.
Lorain Co., A. A. Wright (Cat.)

364. DRABA Dill. WHITLOW-GRASS.

DRABA CAROLINIANA Walt.
Springfield, Mrs. E. J. Spence; Ottawa Co., C. M. Weed; Monroe Co., Rev. H. Herzer.

DRABA INCANA ARABISANS (Mx.) Watson.
Akron, Mr. Clinton (H. C. Beardslee, Cat.)

DRABA VERNA L. Whitlow-Grass.
Found in various places through the state.

365. HESPERIS Tourn. ROCKET.

HESPERIS MATRONALIS L. Dame's Violet.
Franklin Co., Aug. D. Selby.

366. SISYMBRIUM tourn. HEDGE MUSTARD.

SISYMBRIUM OFFICINALE (L.) Scop. Hedge Mustard.
Common in waste places.

SISYMBRIUM PINNATUM (Walt.) Greene (*S. canescens* Nutt.) Tansy Mustard.
Lorain Co., A. A. Wright (Cat.); Miami Valley, A. P. Morgan (Flora); Cincinnati, Jos. F. James (Cat.)

SISYMBRIUM THALIANA (L.) Gaud. Mouse-ear Cress.
Painesville, W. C. Werner; Waverly (Pike Co.) C. J. Herrick.

367. ERYSIMUM Tourn. Treacle Mustard.

Erysimum asperum DC. Western Wall Flower.
Scioto River, near Columbus, A. Ruppersberg and W. O'Kane.

Erysimum cheiranthoides L. Worm-seed Mustard.
Lorain Co., A. A. Wright (Cat.); Brady's Lake (Portage Co.) E. Claasen; Cincinnati, Jos. F. James (Cat.)

368. CAMELINA Crantz False Flax.

Camelina sativa (L.) Crantz.
Lorain Co., A. A. Wright (Cat.); Cleveland, W. Krebs; Lake Co., W. C. Werner· Springfield, Mrs. E. J. Spence; Miami Valley, A. P. Morgan (Flora); Cincinnati; Jos. F. James (Cat.)

369. BRASSICA Tourn.

Brassica alba (L.) Boiss. White Mustard.
Given as general (J. S. Newberry, Cat.); Lorain Co., A. A. Wright (Cat.); Franklin Co., Selby & Craig (Cat.)

Brassica arvensis (L.) B. S. P. (*B. sinapistrum* Boiss.) English Charlock.
Common in waste grounds and fields.

Brassica nigra (L.) Koch. Black Mustard.
"General," (J. S. Newberry, Cat.); Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.); Cincinnati, Jos. F. James (Cat.)

370. BURSA Weber (*Capsella* Medic.) Shepherd's Purse.

Bursa pastoris L. (*Capsella bursa pastoris* Moench.)
Every where in cultivated grounds.

371. LEPIDIUM Tourn. Pepperwort. Peppergrass.

Lepidium campestre (L.) R. Br.
Cincinnati, Joseph Clark (H. C. Beardslee, Cat.); Lorain Co., A. A. Wright (Cat.); Cleveland, W. Krebs; Painesville, O. Hacker; Columbus, Moses Craig.

Lepidium intermedium Gray.
Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.)

Lepidium ruderale L.
Painesville, O. Hacker.

Lepidium virginicum L.
Common as a weed in cultivated ground.

372. THLASPI Tourn. Pennycress.

Thlaspi arvense L.
Cincinnati, J L. Riddell (Synop. 1835); Toledo, J. A. Sanford.

373. CAKILE Tourn. SEA ROCKET.

CAKILE EDENTULATA (Big.) Hook. (*C. americana* Nutt.)
Cleveland, W. Krebs; Painesville, Wm. C. Werner; Lorain Co., A. A. Wright (Cat.)

374. RAPHANUS L.

RAPHANUS RAPHANISTRUM L. Wild Radish.
Lorain Co., A. A. Wright (Cat.); Painesville, O. Hacker; Miami Valley, A. P. Morgan (Flora).

RAPHANUS SATIVUS L. Garden Radish.
Occasionally found as an escape from cultivation.

LXXIV. ORDER FUMARIACEÆ. Fumitory Family.

375. BICUCULLA ADANS. (*Diclytra* Borkh.; *Dicentra* Borkh.) DUTCHMAN'S BREECHES.

BICUCULLA CANADENSIS (Goldie) (*Dicentra canadensis* DC.) Squirrel Corn.
Common over the whole state.

BICUCULLA CUCULLARIA (L.) (*Dicentra cucullaria* DC.) Dutchman's Breeches.
Common over the whole state.

BICUCULLA EXIMIA (Ker.) (*Dicentra eximia* DC.)
Found in Pennsylvania near the Ohio line by C. D. Beadle.

376. ADLUMIA Raf. CLIMBING FUMITORY.

ADLUMIA FUNGOSA (Ait.) Greene (*A. cirrhosa* Raf.)
Little Mt. (Lake Co.) W. C. Werner; Geauga Co., W. C. Werner; Lorain Co. A. A. Wright (Cat.); Knox Co., Aug. D. Selby.

377. NECKERIA Scop. (*Corydalis* Vent.)

NECKERIA AUREA (Willd.) (*Corydalis aurea* Willd.) Golden Corydalis.
Little Mt. (Lake Co.), W. C. Werner; Thompson Ledge (Geauga Co.), W. C Werner; Cincinnati, Jos. F. James (Cat.)

NECKERIA FLAVULA (Raf.) (*Corydalis flavula* DC.)
Franklin Co., W. J. Green; Licking Co., H. L. Jones (Cat.), Cincinnati, Jos. F James (Cat.)

NECKERIA SEMPERVIRENS (L.) (*Corydalis sempervirens* Pers.; *C. glauca* Pursh.) Pale Corydalis.
Dover (Cuyahoga Co.), W. Krebs; Fairfield Co., E. V. Wilcox.

378. FUMARIA Tourn. FUMITORY.

FUMARIA OFFICINALIS L. Common Fumitory; Miami Valley, A. P. Morgan (Flora); "Escaped from gardens," J. S. Newberry (Cat.)

LXXV. ORDER PAPAVERACEÆ. Poppy Family.

379. PAPAVER Tourn. POPPY.

PAPAVER RHOEAS L.
Adventive from Europe, Painesville, W. C. Werner.

PAPAVER SOMNIFERUM L. Common Poppy.
Escaped from cultivation, J. S. Newberry (Cat.); "exists for a year or two in waste places," Licking Co., H. L. Jones (Cat.); Miami Valley, A. P. Morgan (Flora).

380. ARGEMONE L. PRICKLY POPPY.

ARGEMONE MEXICANA L. Mexican Poppy.
"Escaped from gardens," J. S. Newberry (Cat.); Licking Co., H. L. Jones (Cat.) Miami Valley, A. P. Morgan (Flora); Cincinnati, Jos. F. James (Cat.)

381. STYLOPHORUM Nutt. CELANDINE POPPY.

STYLOPHORUM DIPHYLLUM (Mx.) Nutt.
Painesville, H. C. Beardslee. Frequent in the southern half of the state.

382. SANGUINARIA Dill. BLOOD-ROOT.

SANGUINARIA CANADENSIS L.
Distributed over the whol state.

383. CHELIDONIUM L. CELANDINE.

CHELIDONIUM MAJUS L. Celandine.
Frequently found in waste grounds and by road-sides.

LXXXI. ORDER CALYCANTHACEÆ. Calycanthus Family.

384. BEURERA. CAROLINA ALLSPICE.

BEURERA FLORIDA (L.) Kuntze. (*Calycanthus floridus* L.)
Southern Ohio, "Sandstone soils and cultivated in gardens," Dr. J. H. Warder (Woody Pl.) Reported by Lazenby and Werner (Sup. List) on the above authority.

BEURERA FERAX (Willd.) Kuntze. (*Calycanthus laevigatus* Willd.)
Southern Ohio, Dr. J. H. Warder (Woody Pl.)

LXXVII. ORDER LAURACEAE. Laurel Family.

385. SASSAFRAS. Nees.

SASSAFRAS SASSAFRAS (L.) Karst. (*S. officinale* Nees.)
Frequent.

386. BENZOIN Fabric. (*Lindera* Thunb.) Fever-bush. Wild-Allspice.

BENZOIN PSEUDO-BENZOIN (Mx.) (*Lindera benzoin* Blume.) SPICE-BUSH. BENJAMIN-BUSH.
Throughout the state.

LXXVIII. ORDER MENISPERMACEAE. Moonseed Family.

387. MENISPERMUM L. MOONSEED.

MENISPERMUM CANADENSE L. Moonseed.
Throughout the state.

LXXIX. ORDER BERBERIDACEAE. Barberry Family.

388. BERBERIS L. BARBERRY.

BERBERIS VULGARIS L. Common Barberry.
Escaped from cultivation, H. C. Beardslee (Cat.); Lorain Co., A. A. Wright (Cat.) Licking Co., H. L. Jones (Cat.); Miami Valley, A. P. Morgan (Flora).

389. CAULOPHYLLUM Michx. BLUE COHOSH.

CAULOPHYLLUM THALICTROIDES (L.) Mx. Pappoose-Root.
Woods in rich soil, over the whole state.

LXXX. ORDER RANUNCULACEAE. Crowfoot Family.

390. CLEMATIS L. VIRGIN'S-BOWER.

CLEMATIS OCHROLEUCA Ait.
Central Ohio, J. S. Newberry (Cat.); "This identification is possibly erroneous" (Jos. F. James, in Rev. Genus Clematis).

CLEMATIS VIORNA L. Leather-flower.
Frequent through the southern half of the state.

CLEMATIS VIRGINIANA L. Common Virgin's Bower.
Common along river and creek bottoms over the whole state.

391. THALICTRUM Tourn. Meadow-Rue.

Thalictrum dioicum L. Early Meadow Rue.
Frequent.

Thalictrum polygamum Muhl.
From the northern (Painesville, W. C. Werner) to the southern portion of the state (Cincinnati, Jos. F. James Cat.)

Thalictrum purpurascens L.
Generally distributed over the state.

392. ANEMONE Tourn. Wind-flower.

Anemone cylindrica Gray.
Marblehead (Ottawa Co.) W. Krebs; Northern Ohio, J. S. Newberry (Cat.); Lakeside (Ottawa Co.) A. D. Selby.

Anemone quinquefolia L. (A. nemorosa L. Does not, according to Dr. Britton, occur in North America.
Generally distributed throughout the state.

Anemone canadensis L. (*A. pennsylvanica* L.)
Apparently over the whole state.

Anemone virginiana L.
Common throughout the state; a white flowered form with white sepals, flowers one and one-half inches across, Painesville, W. C. Werner.

393. HEPATICA Dill. Liver-leaf.

Hepatica acuta (Pursh.) Britton. (*H. acutiloba* DC.)
Widely distributed over the state.

Hepatica hepatica (L.) Karst. (*H. triloba* Chaix.)
Widely distributed.

394. SYNDESMON Hoffmsg.

Syndesmon thalictroides (L.) Hoffmsg. (*Anemonella thalictroides* Spach.)
Over the whole state; a double flowered form, Springfield, Mr. Dory.

395. TROLLIUS L. Globe-flower.

Trollius laxus Salisb.
Central Ohio, J. S. Newberry (Cat.); Sugar Grove (Fairfield Co.), E. V. Wilcox.

396. TRAUTVETTERIA Fisch. & Mey. False Bugbane.

Trautvetteria carolinensis (Walt.) Vail. (*T. palmata* Fisch. & Mey.)
Mansfield, Dr. Kellogg (H. C. Beardslee, Cat.); Cincinnati, Jos. F. James (Cat.)

397. RANUNCULUS Tourn. CROWFOOT. BUTTERCUP.

RANUNCULUS ABORTIVUS L. Small-flowered Crowfoot.
Common over the whole state.

RANUNCULUS ABORTIVUS MICRANTHUS Gray.
Cincinnati, Joseph Clark (Beardslee, Cat.); Miami Valley, A. P. Morgan (Flora).

RANUNCULUS ACRIS L.
Very abundant in fields and pastures throughout the northern portion of the state; Cincinnati, Jos. F. James (Cat.); Columbus, W. S. Devol; Licking Co., H. L. Jones (Cat.)

RANUNCULUS OBTUSIUSCULUS (*R. ambigens* Watson.) Water Plantain. Spearwort
Frequent in low grounds.

RANUNCULUS ARVENSIS L.
An occasional specimen introduced from Europe found at Painesville, O. Hacker.

RANUNCULUS BULBOSUS L.
Cincinnati, J. L. Riddell (Synop. 1835); Northern Ohio, J. S. Newberry (Cat.)

RANUNCULUS CIRCINATUS Sibth. Stiff Water-crowfoot.
Toledo, J. A. Sanford; Sandusky, Amelia Hammel; Licking Co. H. L. Jones (Cat.); Miami Valley, A. P. Morgan (Flora).

RANUNCULUS CYMBALARIA Pursh. Sea-side Crowfoot.
Northern Ohio, W. R. Lazenby and W. C. Werner (Sup. List), doubtful since authenticated by no specimen.

RANUNCULUS DELPHINIFOLIUS Torr. (*R. multifidus* Pursh.)
Ashtabula Co., Florence Tuckerman; Cleveland, W. Krebs; Painesville, H. C. Beardslee (Cat.); Lorain Co., A. A. Wright (Cat.); Medina Co., J. S. Newberry (Cat.); Franklin Co., Moses Craig.

RANUNCULUS DELPHINIFOLIUS TERRESTRIS Gray. (*R. multifidus terrestris* Gray.
"Northern Ohio," Gray's Manual (6th Edition).

RANUNCULUS FASCICULARIS Muhl.
Toledo, J. A. Sanford; Franklin Co., Aug. D. Selby; Licking Co., H. L. Jones (Cat.); Springfield, Mrs. E. J. Spence.

RANUNCULUS FICARIA L.
Adventive from Europe, Painesville, O. Hacker.

RANUNCULUS HISPIDUS Mx.
Widely distributed but mostly confused by collectors with R. fascicularis Muhl. and R. septentrionalis Poir.

RANUNCULUS PENNSYLVANICUS L. f. Bristly Crowfoot.
Common over the whole state.
RANUNCULUS PUSILLUS Poir.
J. S. Newberry (Cat.)

RANUNCULUS RECURVATUS Poir. Hooked Crowfoot.
Common over the whole state.

RANUNCULUS REPENS L.
Introduced from Europe, Painesville, W. C. Werner; Lorain Co., A. A. Wright (Cat.)

RANUNCULUS REPTANS L. (*R. flammula reptans* E. Meyer). Creeping Spearwort.
Cincinnati, Joseph Clark (H. C. Beardslee, Cat.)

RANUNCULUS RHOMBOIDEUS Goldie.
Sandusky, Dr. Kellogg (H. C. Beardslee Cat.)

RANUNCULUS SCELERATUS L. Cursed Crowfoot.
Frequent in ditches.

RANUNCULUS SEPTENTRIONALIS Poir.
Generally distributed over the state.

RANUNCULUS TRICHOPHYLLUS Chaix. (*R. aquatilis trichophyllus* Gray).
Throughout the whole state.

398. CALTHA L. MARSH MARIGOLD.

CALTHA PALUSTRIS L.
Over the whole state.

399. HYDRASTIS Ellis.

HYDRASTIS CANADENSIS L.
Occurs over the whole state.

400. COPTIS Salisb.

COPTIS TRIFOLIA (L.) Salisb.
Portage Co., W. Krebs; Painesville, Wm. C. Werner; Lorain Co., A. A. Wright (Cat.)

401. ISOPYRUM L.

ISOPYRUM BITERNATUM (Raf.) Torr. & Gray.
Frequent throughout the southern half of the state; Lorain Co., A. A. Wright (Cat.)

402. NIGELLA L.

NIGELLA DAMASCENA L. Fennel-flower.
Escaped from cultivation, Southern Ohio, J. S. Hine.

403. AQUILEGIA Tourn. COLUMBINE.

AQUILEGIA CANADENSIS L. Wild Columbine.
Usually on rocky banks, widely distributed.

AQUILEGIA VULGARIS L. Garden Columbine.
Escaped from cultivation, Thompson Ledge (Geauga Co.) W. C. Werner; London (Madison Co.) Mrs. K. D. Sharpe.

404. DELPHINIUM Tourn.

DELPHINIUM CAROLINIANUM Walt. (*D. azureum* Michx.)
Adams Co., W. A. Kellerman.

DELPHINIUM CONSOLIDA L.
Sparingly escaped from cultivation.

DELPHINIUM EXALTATUM Ait. Tall Larkspur.
Georgesville (Franklin Co.) E. V. Wilcox; Licking Co., H. L. Jones (Cat.)

DELPHINIUM TRICORNE Michx. Dwarf Larkspur.
Frequent throughout the southern half of the state.

405. ACONITUM Tourn. MONKSHOOD.

ACONITUM NOVEBORACENSE Gray.
Cuyahoga Falls (Summit Co.) E. Claassen.

ACONITUM UNCINATUM L.
Summit Co., J. S. Newberry (Cat); Cuyahoga Falls, H. C. Beardslee (Cat.)

406. ACTAEA L. BANEBERRY. COHOSH.

ACTAEA ALBA (L.) Mill. White Baneberry.
Generally distributed throughout the state.

ACTAEA RUBRA (Ait.) Willd. (*A. spicata rubra* Ait.) Red Baneberry.
Generally distributed throughout the state.

407. CIMICIFUGA L. BUGBANE.

CIMICIFUGA RACEMOSA (L.) Nutt. Black Snakeroot. Black Cohosh.
Abundant throughout the whole state.

LXXXI. ORDER ANONACEÆ. Custard-Apple Family.

408. ASIMINA Adans. PAPAW.

ASIMINA TRILOBA (L.) Dunal. Common Papaw.
Common throughout the state, usually in rich soil.

LXXXII. Order MAGNOLIACEÆ. Magnolia Family.

409. MAGNOLIA L.

Magnolia acuminata L. Cucumber Tree.
Extending from Lake Erie (Painesville, W. C. Werner) through the eastern and central portion of the state (Franklin Co., Aug. D. Selby) to the Ohio River (Lawrence Co., W. A. Kellerman).

Magnolia virginiana L. (*M. glauca* L.) Laurel Magnolia. Sweet Bay.
Given by W. R. Lazenby and W. C. Werner (Sup. List) on authority of Dr. J A. Warder, but it seems that Dr. Warder did not report it as native.

Magnolia tripetala L. (*M. umbrella* Lam.) Umbrella Tree.
"Probably native in the southeastern counties of the state," Dr. J. A. Warder (Woody Pl.) An unsuccessful search was made for it in Lawrence Co., where if anywhere in the state, it should be found (W. A. Kellerman).

410. LIRIODENDRON L. Tulip-Tree.

Liriodendron tulipiferum L.
Extending from Lake Erie (H. C. Beardslee, A. A. Wright, Lor. Co., Cat.) to the Ohio River (W. C. Werner, Jos. F. James, Cat.)

411. JEFFERSONIA Barton. Twin-leaf.

Jeffersonia diphylla (L.) Pers.
Throughout the state.

412. PODOPHYLLUM. May-Apple. Mandrake

Podophyllum peltatum L.
Common throughout the state.

LXXXIII. Order CERATOPHYLLACEÆ. Hornwort Family.

413. CERATOPHYLLUM L. Hornwort.

Ceratophyllum demersum L.
Lorain Co., A. A. Wright (Cat.); Painesville, Wm. C. Werner; Cincinnati, Jos. F. James (Cat.)

Ceratopyllum demersum echinatum Gray.
Franklin Co., W. S. Sullivant (Cat.)

LXXXIV. Order NYMPHAEACEÆ. Water-Lily Family.

414. BRASENIA Schreb. Water-Shield.

BRASENIA PURPUREA Mx. (*B. peltata* Pursh).
Lorain Co., A. A. Wright (Cat.); Geauga Lake (Geauga Co.), Silver Lake (Summit Co.) W. Krebs; Myer's Lake (Stark Co.) W. L. Crubaugh.

415. NYMPHAEA. YELLOW POND LILY. SPATTER-DOCK.

NYMPHAEA ADVENA Soland. (*Nuphar advena* Ait.)
Widely distributed over the state.

NYMPHAEA MICROPHYLLA Pers. (*Nuphar kalmianum* Ait.)
Painesville, H. C. Beardslee (Cat.)

416. CASTALIA Salisb. WATER-NYMPH. WATER LILY.

CASTALIA ODORATA (Dryanda) Greene. (*Nymphaea odorata* Ait.) Sweet scented Water Lily.
Inland lakes (Summit Co.) Wm. Krebs; Licking Co., H. L. Jones (Cat).

CASTALIA TUBEROSA (Paine) Greene (*C. reniformis* DC.; *Nymphaea reniformis* DC.) Tuber-bearing Water Lily.
Lorain Co., A. A. Wright (Cat.); "Common," H. C. Beardslee (Cat.); Licking Co., H. L. Jones (Cat.)

417. NELUMBO Tourn. SACRED BEAN.

NELUMBO LUTEA (Willd.) Pers. Yellow Nelumbo or Water Chinquapin.
Bass Lake (Geauga Co.) and Sandusky Bay, H. C. Beardslee (Cat.); Cincinnati, Jos. F. James (Cat.); Licking Co., H. L. Jones (Cat.)

LXXXV. ORDER CARYOPHYLLACEÆ. Pink Family.

418. DIANTHUS L. PINK. CARNATION.

DIANTHUS ARMERIA L. Deptford Pink.
Along roadsides around Granville and especially in the south-eastern part of the township, Licking Co., H. L. Jones (Cat.)

419. SAPONARIA L.

SAPONARIA OFFICINALIS L. Soapwort. Bouncing Bet.
Common along roadsides and in waste places over the state.

420. SILENE L. CATCHFLY. CAMPION.

SILENE ANTIRRHINA L. Sleepy Catchfly.
Throughout the state.

SILENE ARMERIA L. Sweet-William. Catchfly.
Escaped in a few places, H. L. Jones (Licking Co., Cat.)

SILENE ILLINOENSIS (Mx.) (*S. regia* Sims.) Royal Catchfly.
Franklin Co., W. S. Sullivant (Cat. 1840) not seen here by recent collectors; Springfield, Mrs. E. J. Spence; London (Madison Co.) Mrs. K. D. Sharpe; Cincinnati, Joseph Clark (Cat.)

SILENE NIVEA (Nutt.) Otth.
Central Ohio, W. S. Sullivant (H. C. Beardslee, Cat.); Cincinnati, J. L. Riddell (Sup. Cat. 1836,) Joseph Clark (Cat.)

SILENE NOCTIFLORA L. Night-flowering Catchfly.
Northern Ohio; Columbus, W. C. Werner; Lancaster (Fairfield Co.) J. M. Bigelow (J. S. Newberry Cat.)

SILENE NOCTURNA L. Night Catchfly.
Dayton, M. G. Williams (J. L. Riddell Sup. Cat. 1836).

SILENE PENNSYLVANICA Michx.
Monroe Co., H. Herzer; Lawrence Co., W. C. Werner; Cincinnati, Jos. F. James (Cat.)

SILENE ROTUNDIFOLIA Nutt. Round-leaved Catchfly.
Ash Cave (Hocking Co.) Aug. D. Selby; Southern Ohio, J. S. Newberry (Cat.)

SILENE STELLATA (L.) Ait. Starry Campion.
Generally distributed over the state.

SILENE VIRGINICA L. Fire Pink. Catchfly.
Widely distributed.

SILENE VULGARIS (Moench.) Garcke. (*S. cucubalus* Wibel.; *S. inflata* Smith).
Miami Valley, A. P. Morgan (Flora).

421. AGROSTEMMA L.

AGROSTEMMA GITHAGO L. (*Lychnis githago* Lam.) Corn Cockle.
In grain fields and waste places throughout the state; a specimen with white flowers collected at Painesville (W. C. Werner.)

422. LYCHNIS Tourn. COCKLE.

LYCHNIS CORONARIA Desv.
Apparently wild at Christmas Rock (Fairfield Co.) W. A. Kellerman.

LYCHNIS VESPERTINA Sibth. Evening Cockle.
Cleveland, W. Krebs; Painesville, Otto Hacker.

423. CERASTIUM L. MOUSE-EAR CHICKWEED.

CERASTIUM ARVENSE L. Field Chickweed.
Lorain Co., A. A. Wright (Cat.); Trumbull Co., R. H. Ingraham; Cincinnati, Jos. F. James (Cat.)

CERASTIUM ARVENSE OBLONGIFOLUIM (Torr.) Britt. & Holl.
Lorain Co., J. S. Newberry (Cat.); Miami Valley, A. P. Morgan (Flora).

CERASTIUM NUTANS Raf.
Generally distributed over the state.

CERASTIUM VISCOSUM L.
Apparently over the whole state.

CERASTIUM VULGATUM L. Larger Mouse-ear Chickweed.
Frequent throughout the state.

424. ALSINE L. (*Stellaria* L.) CHICKWEED. STARWORT.

ALSINE BOREALIS (Bigel.) Britt. (*Stellaria borealis* Bigel.) Northern Starwort.
Painesville, H. C. Beardslee (Cat.)

ALSINE GRAMINEA (Muhl.) Britt.
Near Cleveland, Wm. Krebs.

ALSINE LONGIFOLIA (Muhl.) Britt. (*Stellaria longifolia* Muhl.) Long-leaved St tchwort.
Frequent throughout the state.

ALSINE LONGIPES (Goldie) Britton. (*Stellaria longipes* Goldie.) Long-stalked Stitchwort.
Northern Ohio, J. S. Newberry (Cat.); Franklin Co., J. L. Riddell (Synop. 1835).

ALSINE MEDIA L. (*Stellaria media* Smith.)
Common in fields and gardens.

ALSINE PUBERA (Mx.) Britt. (*Stellaria pubera* Michx.) Great Chickweed.
Frequent throughout the southern portion of the state; not observed north of Fairfield County.

ALSINE ULIGINOSA (Murr.) Britt. (*Stellaria uliginosa* Murr.) Swamp Chickweed.
"Ohio," J. L. Riddell (Synop. 1835), though he questioned its occurrence in Ohio.

425. ARENARIA L. SANDWORT.

ARENARIA LATERIFLORA L.
Lake Co., Otto Hacker; Franklin Co., W. C. Werner, E. M. Wilcox.

ARENARIA STRICTA Mx. (*A. michauxii* Hook.)
Cedar Point, E. Claassen; South Bass Island (Lake Erie) W. Krebs; Put-in-Bay Island (Lake Erie) H. C. Beardslee (Cat.); Franklin Co., W. S. Sullivant (Cat. 1840) but not re-collected since.

ARENARIA SERPYLLIFOLIA L. Thyme-leaved Sandwort.
Frequent in fields and waste places throughout the state.

426. SAGINA L. PEARLWORT.

SAGINA APETALA L.
Ironton (Lawrence Co.) W. C. Werner.

SAGINA PROCUMBENS L.
Painesville, O. Hacker.

427. SPERGULA L. SPURREY.

SPERGULA ARVENSIS L. CORN SPURREY.
"General," (J. S. Newberry Cat.); Painesville, W. C. Werner.

428. TISSA Adans. (*Buda.*)

TISSA RUBRA (L.) Britt. (*Buda rubra* Dumort; *Spergularia rubra* Presl.)
Painesville, W. C. Werner.

429 ANYCHIA Mx. FORKED CHICKWEED.

ANYCHIA CANADENSIS (L.) B. S. P. (*A. capillacea* DC.)
Licking Co., H. L. Jones (Cat.); Monroe Co., H. Herzer; Painesville and Columbus, Wm. C. Werner.

ANYCHIA DICHOTOMA Mx.
Frequent throughout the southern half of the state.

430. MOLLUGO L. INDIAN CHICKWEED.

MOLLUGO VERTICILLATA L.
Throughout the state.

LXXXVI. ORDER PORTULACACEAE. Purslane Family.

431. PORTULACA Tourn. PURSLANE.

PORTULACA OLERACEA L.
Common in cultivated ground.

432. CLAYTONIA Gronov. SPRING-BEAUTY.

CLAYTONIA CAROLINIANA Michx.
"General," J. S. Newberry (Cat.); "Common," H. C. Beardslee (Cat.)

CLAYTONIA PERFOLIATA Donn.
Painesville, introduced, Otto Hacker.

CLAYTONIA VIRGINICA L.
Over the whole State.

LXXXVII. ORDER NYCTAGINACEAE. Four O'clock Family.

433. OXYBAPHUS Vahl.

OXYBAPHUS NYCTAGINEUS Sweet.
Cincinnati, Jos. F. James (Cat.)

LXXXVIII. ORDER PHYTOLACCACEÆ. Pokeweed Family.

434. PHYTOLACCA Tourn. POKEWEED.

PHYTOLACCA DECANDRA L.
Common.

LXXXIX. ORDER CHENOPODIACEÆ. Goosefoot Family.

435. ATRIPLEX Tourn. ORACHE.

ATRIPLEX PATULA HASTATA (L.) Gray.
Roadsides and waste places from Lake Erie to the Ohio River.

ATRIPLEX PATULA LITTORALE (L.) Gray.
Cleveland, H. C. Beardslee (Cat.)

436. CHENOPODIUM Tourn. GOOSEFOOT. PIGWEED.

CHENOPODIUM ALBUM L. Lamb's-Quarters.
Common. The var. VIRIDE occurs in northern Ohio.

CHENOPODIUM AMBROSIOIDES L. Mexican Tea.
"General," J. S. Newberry (Cat.); Cincinnati, Jos. F. James (Cat.)

CHENOPODIUM AMBROSIOIDES ANTHELMINTICUM (L.) Gray. Wormseed.
Occasionally found in waste places and roadsides throughout the state.

CHENOPODIUM BOSCIANUM Moq.
Lorain Co., A. A. Wright (Cat.); Painesville and Columbus, Wm. C. Werner.

CHENOPODIUM BOTRYS L. Jerusalem Oak. Feather Geranium.
Cleveland, W. Krebs; Lake Co., W. C. Werner; Corning, J. H. Lageman; Berea, H. Herzer; Lucas Co., J. S. Hine; Cincinnati, Jos. F. James (Cat.)

CHENOPODIUM CAPITATUM (L.) Watson. (*Blitum capitatum* L.) Strawberry Blite
Northern Ohio, J. S. Newberry (Cat.)

CHENOPODIUN GLAUCUM L.
Toledo, J. A. Sanford.

CHENOPODIUM HYBRIDUM L. Maple-leaved Goosefoot.
Northern Ohio, W. Krebs, O. Hacker, A. A. Wright (Cat.); Central Ohio, H. L. Jones (Cat.), S. Renshaw.

CHENOPODIUM MURALE L.
Elyria, H. C. Beardslee (Cat.); Toledo, J. A. Sanford.

CHENOPODIUM POLYSPERMUM L.
Cincinnati, Jos. F. James (Cat.)

CHENOPODIUM URBICUM L.
Cleveland, W. Krebs; Port Clinton (Ottawa Co.) E. Claassen; Cincinnati, Joseph Clark (Cat.)

XC. ORDER AMARANTACEÆ. Amaranth Family.

437. AMARANTUS Tourn. AMARANTH.

AMARANTUS ALBUS L. Tumble Weed.
Frequent in cultivated fields.

AMARANTUS BLITOIDES Watson.
Lorain Co., A. A. Wright (Cat.); Lake Co., Franklin Co., W. C. Werner; Fairfield Co., E. V. Wilcox, S. Renshaw.

AMARANTUS CRISPUS Braun.
"Naturalized," Painesville (H. C. Beardslee Cat.)

AMARANTUS HYBRIDUS CHLOROSTACHYS (Willd.)
Common over the State.

AMARANTUS HYPOCHONDRIACUS L.
Cincinnati, Jos. F. James (Cat.); A hybrid between this and A. retroflexus found at Painesville, Wm. C. Werner.

AMARANTUS PUMILUS Raf.
Lorain Co., Dr. Kellogg (J. S. Newberry Cat.)

AMARANTUS RETROFLEXUS L.
Commonly reported by collectors, but doubtless to be referred to A. hybridus chlorostachys.

AMARANTUS SPINOSUS L. Thorny Amaranth.
Painesville, H. C. Beardslee (Cat.); Columbus, W. J. Green; Cincinnati, Jos. F. James (Cat.); Miami Valley, A. P. Morgan (Flora).

438. ACNIDA Mitch. WATER-HEMP.

ACNIDA CANNABINA L.
Columbus, W. S. Sullivant (Cat. 1840); Cincinnati, Joseph Clark (Cat.)

ACNIDA TAMARISCINA (Nutt.) Wood. (*A. tuberculata* Moq.)
Painesville, O. Hacker; Columbus, W. C. Werner.

439. IRESINE P. Browne.

IRESINE CELOSIOIDES L.
Cincinnati, Joseph Clark (Cat.)

XCI. Order POLYGONACEÆ. Buckwheat Family.

440. FAGOPYRUM Tourn. Buckwheat.

Fagopyrum fagopyrum (L.) Karst. (*F. esculentum* Moench.) Buckwheat.
Fields and waste places.

441. RUMEX L. Dock. Sorrel.

Rumex acetosella L. Field or Sheep Sorrel.
Common.

Rumex altissimus Wood. Pale Dock.
Painesville, Wm. C. Werner; Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones; Cincinnati, Joseph Clark (Cat.)

Rumex britannica L. Great Water-Dock.
Lake Co., Franklin Co., Wm. C. Werner; Licking Co., H. L. Jones (Cat.); Cincinnati, Jos. F. James (Cat.)

Rumex crispus L. Curled Dock.
Common.

Rumex obtusifolius L. Bitter Dock.
Common.

Rumex salicifolius Weinmann. White Dock.
Painesville, H. C. Beardslee (Cat.)

Rumex sanguineus L.
Common, H. C. Beardslee (Cat.)

Rumex verticillatus L.
Frequent.

442. POLYGONUM Tourn. Knotweed.

Polygonum acre H. B. K. Water Smartweed.
Common.

Polygonum amphibium L.
Painesville, H. C. Beardslee (Cat.); Licking Co., H. L. Jones (Cat.); Cincinnati, Thos. G. Lea (Cat.)

Polygonum arifolium L. Halbred-leaved Tear-thumb.
Frequent in swamps and low places.

Polygonum aviculare L.
Common.

Polygonum careyi Olney.
Painesville, H. C. Beardslee (Cat.); Licking Co., H. L. Jones (Cat.)

POLYGONUM CILINODE Mx.
"General," J. S. Newberry (Cat.); Lorain Co., A. A. Wright (Cat.)

POLYGONUM CONVOLVULUS L. Black Bindweed.
Common.

POLYGONUM DUMETORUM SCANDENS (L.) Gray. Climbing False Buckwheat.
Frequent.

POLYGONUM EMERSUM (Mx.) Britt. (*P. muhlenbergii* Wats.)
Painesville and Columbus, Wm. C. Werner; Licking Co., H. L. Jones (Cat.) Fairfield Co., E. V. Wilcox, S. Renshaw.

POLYGONUM ERECTUM L.
Common.

POLYGONUM HARTWRIGHTII Gray.
Leib's Island (Licking Reservoir) H. L. Jones (Cat.); Springfield, Mrs. E. J. Spence.

POLYGONUM HYDROPIPER L. Common Smartweed or Water-Pepper.
Common.

POLYGONUM HYDROPIPEROIDES Mx. Mild Water-Pepper.
Common.

POLYGONUM LAPATHIFOLIUM L.
Lake Co., W. C. Werner; Licking Co., H. L. Jones (Cat.); Columbus, Aug. D. Selby; Cincinnati, Joseph Clark (Cat.)

POLYGONUM LAPATHIFOLIUM INCARNATUM Wats.
Lorain Co., A. A. Wright (Cat.); Painesville, W. C. Werner; Licking Co., H. L. Jones (Cat.)

POLYGONUM ORIENTALE L.
Occasionally found escaped from cultivation.

POLYGONUM PENNSYLVANICUM L.
Common.

POLYGONUM PERSICARIA L. Lady's Thumb.
Common.

POLYGONUM RAMOSISSIMUM Mx.
Painesville, O. Hacker; Lake Shore, J. S. Newberry (Cat.); Cleveland H. C. Beardslee (Cat.)

POLYGONUM SAGITTATUM L. Arrow-leaved Tear-thumb.
Common.

POLYGONUM TENUE Mx.
Central Ohio, W. S. Sullivant (Cat. 1840.)

POLYGONUM VIRGINIANUM L.
Frequent.

XCII. Order PODOSTEMACEÆ. River-weed Family.

443. PODOSTEMON Mx. River-weed.

Podostemon ceratophyllus Mx.
"General," J. S. Newberry (Cat.); "Ohio River," J. L. Riddell (Synop. 1835).

XCIII. Order ARISTOLOCHIACEÆ. Birthwort Family.

444. ASARUM Tourn. Asarabacca. Wild Ginger.

Asarum canadense L.
Frequent.

445. ARISTOLOCHIA Tourn. Birthwort.

Aristolochia serpentaria L.
Throughout the state.

XCIV. Order LORANTHACEÆ. Mistletoe Family.

446. PHORADENDRON Nutt. False Mistletoe.

Phoradendron flavescens (Ph.) Nutt.
In the line of counties on the Ohio River, also the counties adjoining these, but not seen nor reported further north.

XCV. Order SANTALACEÆ. Sandalwood Family.

447. COMANDRA Nutt. Bastard Toad-flax.

Comandra umbellata (L.) Nutt.
Northern Ohio, W. Krebs, W. C. Werner, A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.)

XCVI. Order MORACEÆ. Mulberry Family.

448. IOXYLON Raf. Osage Orange. Bois D'Arc.

Ioxylon pomiferum Raf. (*Maclura aurantiaca* Nutt.)
Sparingly naturalized in central and southern Ohio.

449. MORUS Tourn. Mulberry.

Morus alba L. White Mulberry.
"Common," H. C. Beardslee (Cat.); Cincinnati, Jos. F. James (Cat.)

Morus rubra L. Red Mulberry.
Throughout the state.

XCVII. Order ULMACEÆ. Elm Family.

450. ULMUS L. Elm.

Ulmus americana L. American or White Elm.
Common.

Ulmus pubescens Walt. (*U. fulva* Mx.) Slippery or Red Elm.
Frequent.

Ulmus racemosa Thomas. Cork or Rock Elm.
Lorain Co., A. A. Wright (Cat.); Ashtabula Co., Miss E. J. Phillips; Licking Co. H. L. Jones (Cat.); Columbus, W. A. Kellerman; Cincinnati, Jos. F. James (Cat.)

XCVIII. Order CANNABACEÆ. Hop Family.

451. HUMULUS L. Hop.

Humulus lupulus L.
Occasionally found in waste places and alluvial soils of water courses.

452. CANNABIS Tourn. Hemp.

Cannabis sativa L. Hemp.
Northern Ohio, Wm. C. Werner, A. A. Wright (Cat.); Central Ohio, Wm. C. Werner, H. L. Jones (Cat.); Cincinnati, Jos. F. James (Cat.)

XCIX. Order URTICACEÆ. Nettle Family.

453. CELTIS Tourn. Nettle-tree. Hackberry.

Celtis occidentalis L. Sugarberry. Hackberry.
Frequent in central and southern Ohio; South Bass Island, W. Krebs; Lorain Co., A. A. Wright (Cat.)

454. URTICA Tourn. Nettle.

Urtica dioica L.
Lorain Co., A. A. Wright (Cat.); Cincinnati, Joseph Clark (Cat.)

URTICA GRACILIS L.
Common in alluvial soil.

URTICA URENS L.
"Interior Ohio," J. S. Newberry (Cat.)

455. URTICASTRUM Fabric. (*Laportea* Gaudichaud.) WOOD-NETTLE.

URTICASTRUM DIVARICATUM (L.) Kuntze. (*Laportea canadensis* Gaudichaud.)
Frequent.

456. ADICEA Raf. (*Pilea* Lindl.) RICHWEED. CLEARWEED.

ADICEA PUMILA (L.) Raf. (*Pilea pumila* Gray.) Richweed. Clearweed.
Common.

457. BOEHMERIA Jacq. FALSE NETTLE.

BOEHMERIA CYLINDRICA (L.) Willd.
Common.

458. PARIETARIA Tourn. PELLITORY.

PARIETARIA PENNSYLVANICA Muhl.
Frequent.

C. ORDER FAGACEÆ. Oak Family.

459. QUERCUS L. OAK.

QUERCUS ALBA L. White Oak.
Throughout the state.

QUERCUS BICOLOR Willd. Swamp White Oak.
Throughout the state.

QUERCUS COCCINEA Wang. Scarlet Oak.
Fr quent.

QUERCUS COCCINEA TINCTORIA Gray. Quercitron, Yellow-barked or Black Oak.
Generally distributed.

QUERCUS ILICIFOLIA Wang.
"Ohio," Gray's Manual; "General," J. S. Newberry (Cat.)

QUERCUS IMBRICARIA Michx. Laurel Oak.
Throughout the state.

QUERCUS LEANA Nutt. (*Q. imbricaria* x *coccinea*.) Lea's Oak.
Preston (Hamilton Co.) one tree A. P. Morgan; Cincinnati (one tree) Jos. F. James (Cat.); Brownsville (Licking Co.) one tree—since cut down, W. A. Kellerman; but doubtless other specimens occur in the state.

QUERCUS MACROCARPA Michx. Bur-oak, Over-cup or Mossy-cup Oak.
Generally distributed.

QUERCUS MUHLENBERGII Engelm. Yellow Oak. Chestnut Oak.
Frequent throughout the southern half of the state.

QUERCUS MUHLENBERGII HUMILIS (Marsh.) Britt. (*Q. prinoides* Willd.)
Southern Ohio, J. A. Warder (Woody Plants of Ohio); Q. prinoides Willd. Moses Craig (O. S. U. Flora) is Q. muhlenbergii.

QUERCUS NIGRA L. Black Jack.
Lawrence Co., W. A. Kellerman.

QUERCUS PALUSTRIS Du Roi. Swamp, Spanish or Pin Oak.
Frequent over the state.

QUERCUS PRINUS L. Chestnut Oak.
Licking Co., H. L. Jones (Cat.); Fairfield Co., E. V. Wilcox and S. Renshaw; Ross Co., Lawrence Co., Scioto Co., W. A. Kellerman; Cincinnati, Jos. F James (Cat.)

QUERCUS RUBRA L. Red Oak.
Over the whole state.

QUERCUS STELLATA Wang. Post Oak. Iron Oak.
Fairfield, Muskingum, Lawrence and Scioto counties, W. A. Kellerman; "General," J. S. Newberry (Cat.); "Darby Plains," J. L. Riddell (Synop. 1835).

460. FAGUS L. (*Castanea* Tourn.) CHESTNUT.

FAGUS PUMILA L. (*Castanea pumila* Mill.) Chinquapin.
Marietta, J. L. Riddell (Synop. 1835); "Southern Ohio," H. C. Beardslee (Cat.);

FAGUS CASTANEA DENTATA Marsh. (*Castanea sativa americana* Watson.) CHESTNUT.
Throughout the southern half of the state except on limestone soils.

461. CASTANEA Scop. (*Fagus* Tourn.) BEECH.

CASTANEA LATIFOLIA (Wang.) (*Fagus ferruginea* Ait.) BEECH.
Over the whole state.

CI. ORDER BETULACEAE. Birch Family.

462. CORYLUS Tourn. HAZEL-NUT. FILBERT.

CORYLUS AMERICANA Nutt. Wild Hazel-nut.
Throughout the state.

CORYLUS CORNUTI DuRoi. (*C. rostrata* Ait.) Beaked Hazel-nut.
Painesville, H. C. Beardslee (Cat.)

463. OSTRYA Micheli. HOP-HORNBEAM. IRON-WOOD.

OSTRYA VIRGINICA (Mill.) Willd. American Hop-Hornbeam. Iron-wood.
Frequent.

464. CARPINUS L. HORNBEAM. IRON-WOOD.

CARPINUS CAROLINIANA Watson.
Frequent over the state.

465. BETULA Tourn. BIRCH.

BETULA LENTA L. Cherry Birch. Sweet or Black Birch.
Fairfield, Hocking and Athens counties, W. A. Kellerman.

BETULA LUTEA Mx. f. Yellow or Gray Birch.
Lorain Co., A. A. Wright (Cat.); Lake Co., Wm. C. Werner; Ashtabula Co., E. E. Bogue, Sara F. Goodrich.

BETULA NIGRA L. River or Red Birch.
Hocking Co., Lawrence Co., Scioto Co., W. Kellerman; "General," J. S. Newberry (Cat.)

BETULA POPULIFOLIA Ait. American White Birch. Gray Birch.
"A large tree in the north, but does not abound in central and southern Ohio." Dr. J. A. Warder (Woody Plants).

BETULA PUMILA L. Low Birch.
Central and northern Ohio, J. S. Newberry (Cat.); Cedar Swamp (Champaign Co.) W. C. Werner.

466. ALNUS Tourn. ALDER.

ALNUS INCANA (L.) Willd. Speckled or Hoary Alder.
Northern Ohio, W. Krebs, Wm. C. Werner; Licking Co., H. L. Jones (Cat.) Fairfield Co., E. V. Wilcox and S. Renshaw.

ALNUS RUGOSA (DuRoi) Koch. (*A. serrulata* Willd.) Smooth Alder.
Frequent in northern and central Ohio; Scioto Co., W. A. Kellerman.

CII. ORDER SALICACEÆ. Willow Family.

467. SALIX Tourn. WILLOW. OSIER.

SALIX ALBA L. White Willow.
" General," J. S. Newberry (Cat.); Painesville, Wm. C. Werner; Licking Co., H. L. Jones (Cat.); Champaign Co., Wm. C. Werner; Columbus. E. E. Bogue.

SALIX ALBA CAERULEA (Smith) Koch.
Lorain Co., A. A. Wright (Cat.)

SALIX ALBA VITELLINA (L.) Gray.
"General," J. S. Newberry (Cat.); Painesville, Otto Hacker; Cincinnati, Joseph Clark (Cat.)

SALIX AMYGDALOIDES Anders.
Northern Ohio, J. S. Newberry (Cat.), Wm. C. Werner, Otto Hacker.

SALIX BABYLONICA Tourn. Weeping Willow.
Cincinnati, Joseph Clark (Cat.)

SALIX CANDIDA Willd. Sage Willow. Hoary Willow.
Central and Northern Ohio, J. S. Newberry (Cat.)

SALIX CORDATA Muhl.
"Common," J. S. Newberry (Cat.); Lorain Co., A. A. Wright (Cat.): Licking Co., H. L. Jones (Cat.); Akron and Columbus, Wm. C. Werner. A willow intermediate between *S. cordata* and *S. adenophylla* was collected at Cedar Point (Ottawa Co.) by Aug. D. Selby.

SALIX CORDATA ANGUSTATA Anders.
Lima, W. A. Kellerman; Columbus, Wm. C. Werner.

SALIX DISCOLOR Muhl.
"Common," J. S. Newberry (Cat.); Painesville, Wm. C. Werner; Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.); Columbus, Wm. C. Werner; Cincinnati, Jos. F. James (Cat.)

SALIX DISCOLOR PRINOIDES (Ph.) Anders.
Painesville, Otto Hacker.

SALIX FRAGILIS L. Crack Willow.
Painesville, Otto Hacker; Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.); Columbus, Wm. C. Werner; Cincinnati, Jos. F. James (Cat.)

SALIX HUMILIS Marsh. Prairie Willow.
"General," J. S. Newberry (Cat.); Painesville, Otto Hacker; Licking Co., H. L. Jones (Cat.)

SALIX LONGIFOLIA Muhl.
"Common," J. S. Newberry (Cat.); Painesville, Wm C. Werner; Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.); Columbus, Wm. C. Werner; Cincinnati, Jos. F. James (Cat.)

SALIX LUCIDA Muhl. Shining Willow.
"Common," J. S. Newberry (Cat.); Lorain Co., A. A. Wright (Cat.); Painesville and Akron, Wm. C. Werner.

SALIX NIGRA Marsh. Black Willow.
Common throughout the state.

SALIX NIGRA FALCATA Torr.
"Common," J. S. Newberry (Cat.); Painesville, Otto Hacker.

SALIX PETIOLARIS Smith.
"General," J. S. Newberry (Cat.); Lorain Co., A. A. Wright (Cat.)

SALIX PURPUREA L.
Introduced, Painesville, Otto Hacker.

SALIX ROSTRATA Richardson.
Painesville, H. C. Beardslee (Cat.), Otto Hacker.

SALIX SERICEA Marsh. Silky Willow.
"General," J. S. Newberry (Cat.); Painesville, Otto Hacker; Lorain Co., A. A. Wright (Cat.); Columbus, Wm. C. Werner; Cincinnati, Jos. F. James (Cat.)

SALIX TRISTIS Ait. Dwarf Gray Willow.
"General," J. S. Newberry (Cat.)

468. POPULUS Tourn. POPLAR. ASPEN.

POPULUS ALBA L. White Poplar.
Painesville, Wm. C. Werner; Licking Co., H. L. Jones (Cat.), Miami Valley, A. P. Morgan (Flora); Cincinnati, J. F. James (Cat.)

POPULUS BALSAMIFERA L. Balsam Poplar. Tacamahac.
Painesville, Wm. C. Werner; Licking Co., H. L. Jones (Cat.); Miami Valley, A. P. Morgan (Flora).

POPULUS BALSAMIFERA CANDICANS (Ait.) Gray. Balm of Gilead.
Miami Valley, A. P. Morgan (Flora); Cincinnati, Jos. F. James (Cat.)

POPULUS DILATATA Ait.
Miami Valley, A. P. Morgan (Flora); Cincinnati, Jos. F. James (Cat.)

POPULUS GRANDIDENTATA Michx. Large-toothed Aspen.
From Lake Erie to the Ohio River.

POPULUS HETEROPHYLLA L. Downy Poplar.
Painesville, Otto Hacker.

POPULUS MONILIFERA Ait. Cotton-wood. Necklace Poplar.
Throughout the state.

POPULUS TREMULOIDES Michx. American Aspen.
Toledo, W. A. Kellerman; Painesville, Wm. C. Werner; Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.); Columbus, Wm. C. Werner.

CIII. ORDER MYRICACEÆ. Sweet-Gale Family.

469. MYRICA L. BAYBERRY. WAX-MYRTLE.

MYRICA ASPLENIFOLIA (L.) Banks. Sweet Fern.
Little Mt. (near Painesville) Mr. Ferris; Kent (Portage Co.) Dr. Dow (H. C. Beardslee, Cat.); Portage Co. Wm. Krebs; Fulton Co., J. S. Hine.

MYRICA CERIFERA L. Bayberry. Wax-Myrtle.
Painesville, H. C. Beardslee (Cat.); Presque Isle (Lake Erie) J. L. Riddell (Synop. 1835).

CIV. Order JUGLANDACEÆ. Walnut Family.

470. HICORIA Raf. Hickory.

Hicoria alba (L.) Britt. (*Carya tomentosa* Nutt.)
"General," J. S. Newberry (Cat.); Scioto Co., W. A. Kellerman; Miami Valley, A. P. Morgan (Flora); Cincinnati, Jos. F. James (Cat.)

Hicoria glabra (Mill.) Britt. (*Carya porcina* Nutt.) Pig-nut or Broom Hickory.
Frequent.

Hicoria microcarpa (Nutt.) Britt. (*Carya microcarpa* Nutt.)
"General," J. S. Newberry (Cat.)

Hicoria minima (Marsh.) Britt. (*Carya amara* Nutt.) Bitter-nut or Swamp Hickory.
Frequent.

Hicoria ovata (Mill.) Britt. (*Carya alba* Nutt.) Shell-bark or Shag-bark Hickory.
Frequent.

Hicoria sulcata (Willd.) Britt. (*Carya sulcata* Nutt.)
Lorain Co., A. A. Wright (Cat.); Central and Southern Ohio.

471. JUGLANS L. Walnut.

Juglans cinerea L. Butternut. White Walnut.
Frequent.

Juglans nigra L. Black Walnut.
Common.

CV. Order PIPERACEÆ. Pepper Family.

472. SAURURUS L. Lizard's Tail.

Saururus cernuus L.
Common.

Monocotyls.

CVI. Order ORCHIDACEÆ. Orchis Family.

473. ACHROANTHUS Raf. (*Microstylis* Nutt.) Adder's Mouth.

Achroanthus uniflora (Mx.) Raf. (*Microstylis ophioglossoides* Nutt.)
Fairfield Co., Wm. C. Werner.

474. LEPTORCHIS Du Pet. Thou. (*Liparis* Richard).

Leptorchis liliifolia (L.) Kuntze. (!*Liparis liliifolia* (L.) Richard).
Licking Co., H. L. Jones (Cat.); Sugar Grove, W. C. Werner; Cincinnati, Jos. F. James (Cat.)

Leptorchis loeselii (L.) (*Liparis loeselii* (L.) Richard).
Lake Co., Otto Hacker; Cuyahoga Falls, W. Krebs; Champaign Co., Wm. C. Werner; Miami Valley, A. P. Morgan (Flora).

475. APLECTRUM Nutt. Putty-Root. Adam and Eve.

Aplectrum spicatum (Walt.) B. S. P. (*A. hiemale* Nutt.)
In rich woods throughout the state, infrequent.

476. CORALLORHIZA Haller. Coral-Root.

Corallorhiza multiflora Nutt.
Throughout the state.

Corallorhiza innata R. Br.
Southwestern "Ohio," Gray (Man.), J. S. Newberry (Cat.); Cincinnati, Thos. G. Lea (Cat.)

Corallorhiza odontorhiza (Sw.) Nutt.
Painesville, Fairfield Co., Wm. C. Werner; Fredonia, R. H. Ingraham; Licking Co., H. L. Jones (Cat.); Miami Valley, A. P. Morgan (Flora); Cincinnati, Jos. F. James (Cat.)

477. TIPULARIA Nutt. Crane-fly Orchis.

Tipularia unifolia (Muhl.) B. S. P. (*T. discolor* Nutt.)
Lorain Co., A. A. Wright (Cat.)

478. LISTERA R. Brown. TWAYBLADE.

LISTERA CORDATA (L.) R. Brown.
"Eastern and Northern, O.," J. S. Newberry (Cat.)

479. GYROSTACHYS Pers. (*Spiranthes* Richard). LADIES' TRESSES.

GYROSTACHYS CERNUA (L.) Kuntze. (*Spiranthes cernua* (L.) Richard.)
Generally distributed.

GYROSTACHYS GRACILIS (Bigel.) Kuntze. (*Spiranthes gracilis* Bigelow.)
"General," J. S. Newberry (Cat.); Painesville, Wm. C. Werner; Licking Co., H. L. Jones (Cat.); Adams and Hocking counties, W. A. Kellerman; Cincinnati, Jos. F. James (Cat.)

GYROSTACHYS LATIFOLIA (Torr.) Kuntze. (*Spiranthes latifolia* Torr.)
"Northern O.," J. S. Newberry (Cat.); Painesville, Wm. C. Werner; Columbus, E. E. Bogue; Miami Valley, A. P. Morgan (Flora).

480. PERAMIUM Salisb. (*Goodyera* R. Br.) RATTLESNAKE PLANTAIN.

PERAMIUM PUBESCENS (Willd.) (*Goodyera pubescens* R. Br.)
In rich woods throughout the state, infrequent.

PERAMIUM REPENS (L.) Salisb. (*Goodyera repens* R. Br.)
"General," J. S. Newberry (Cat.); Licking Co., H. L. Jones (Cat.)

481. ARETHUSA Gronov.

ARETHUSA BULBOSA L.
Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.)

482. LIMODORUM (*Calopogon* R. Br.)

LIMODORUM TUBEROSUM L. (*Calopogon pulchellus* R. Br.)
Geauga Lake, W. Krebs; Lorain Co., A. A. Wright (Cat.); Painesville, W. C. Werner; Licking Co., H. L. Jones (Cat.)

483. POGONIA Juss.

POGONIA TRIANTHOPHORA (Sw.) B. S. P. (*P. pendula* Lindl.)
Scarce but distributed throughout the state.

POGONIA OPHIOGLOSSOIDES (L.) Ker.
Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.)

POGONIA VERTICILLATA (Willd.) Nutt.
Painesville, H. C. Beardslee (Cat.); Fairfield Co., S. Renshaw.

484. ORCHIS L.

ORCHIS SPECTABILIS L. Showy Orchis.
In woods throughout the state.

ORCHIS ROTUNDIFOLIA Pursh.
Licking Co., H. L. Jones (Cat.)

485. HABENARIA Willd. REIN ORCHIS.

HABENARIA BLEPHARIGLOTTIS (With.) Torr. White Fringed Orchis.
Munson Pond (Geauga Co.) H. C. Beardslee (Cat.)

HABENARIA BRACTEATA (Willd.) R. Br.
Lorain Co., A. A. Wright (Cat.); Cuyahoga Co., W. C. Werner; Ashtabula Co., A. C. Bogue; Miami Valley, A. P. Morgan (Flora.)

HABENARIA CILIARIS (L.) R. Br. Yellow Fringed Orchis.
Painesville, H. C. Beardslee (Cat.); Fulton Co., J. S. Hine.

HABENARIA CLAVELLATA (Mx.) (*H. tridentata* (Willd.) Hook.)
Painesville, H. C. Beardslee (Cat.); Summit Co., W. Krebs; Licking Co., H. L. Jones (Cat.); Cedar Swamp (Champaign Co.), Wm. C. Werner.

HABENARIA FLAVA (L.) Gray. (*H. virescens* Spreng.)
Lorain Co., A. A. Wright (Cat.); Franklin Co., Moses Craig.

HABENARIA GRANDIFLORA (Bigel.) Torr. (*H. fimbriata* R. Br.)
Franklin Co., W. S. Sullivant (Cat. 1840.)

HABENARIA HOOKERI (Ph.) Torr.
Lake Co., Wm. C. Werner; Lorain Co., A. A. Wright (Cat.)

HABENARIA HYPERBOREA (L.) R. Br.
"Northern O.," J. S. Newberry (Cat.)

HABENARIA LACERA (Mx.) R. Br. Ragged Fringed Orchis.
Frequent in northern Ohio; Licking Co., H. L. Jones (Cat.)

HABENARIA LEUCOPHÆA (Nutt.) Gray.
Columbus, W. S. Sullivant (Cat. 1840).

HABENARIA ORBICULATA (Ph.) Torr.
Cleveland, W. Krebs; Lorain Co., A. A. Wright (Cat.); Painesville, W. C. Werner; Licking Co., H. L. Jones (Cat.)

HABENARIA PERAMŒNA Gray.
Sugar Grove (Fairfield Co.), E. V. Wilcox; Rio Grande (Gallia Co.), Lizzie Davis; Cincinnati, Jos. F. James (Cat.)

HABENARIA PSYCODES (L.) Gray.
Throughout the state but not abundant.

486. CYPRIPEDIUM L. LADY'S SLIPPER. MOCCASON-FLOWER.

CYPRIPEDIUM ACAULE Ait. Stemless Lady's Slipper.
Cleveland, W. Krebs; Lake Co., W. C. Werner; Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.); Fairfield Co., E. V. Wilcox, S. Renshaw; Stark Co., W. L. Crubaugh; Rio Grande, W. W. Deckard.

CYPRIPEDIUM CANDIDUM Willd. Small White Lady's Slipper.
"Central O.," W. S. Sullivant (Cat. 1840); Dayton, R. Buchanan (J. L. Riddell, Synop. 1835).

CYPRIPEDIUM PARVIFLORUM Salisb. Smaller Yellow Lady's Slipper.
Lorain Co., A. A. Wright (Cat.); Central O, W. S. Sullivant (Cat.); Champaign Co., Wm. C. Werner; Stark Co., Ella Keeler.

CYPRIPEDIUM PUBESCENS Willd. Larger Yellow Lady's Slipper.
Not common, but distributed from Lake Erie to Southern Ohio.

CYPRIPEDIUM REGINÆ Walt. (*C. spectabile* Swartz.) Showy Lady's Slipper.
Licking Co., H. L. Jones (Cat.); Champaign Co., Mrs. E. J. Spence; Cincinnati, Jos. F. James (Cat.)

CVII. ORDER IRIDACEÆ. Iris Family.

488. IRIS Tourn. FLOWER DE LUCE.

IRIS CRISTATA Ait. Crested Dwarf Iris.
Near Cleveland, W. Krebs; Lorain Co., A. A. Wright (Cat.); Trumbull Co., R. H. Ingraham; Franklin Co., W. C. Werner; Logan Co., W. A. Kellerman; Lawrence Co., A. D. Selby.

IRIS LACUSTRIS Nutt. Lake Dwarf Iris.
Hocking Co., J. M. Bigelow (J. S. Nswberry Cat.)

IRIS VERSICOLOR L. Larger Blue Flag.
Generally distributed throughout the state.

489. SISYRINCHIUM L. BLUE-EYED GRASS.

SISYRINCHIUM ANCEPS Cav.
Lorain Co., A. A. Wright (Cat)

SISYRINCHIUM ANGUSTIFOLIUM Mill.
Generally distributed.

CVIII. ORDER DIOSCOREACEÆ. Yam Family.

490. DIOSCOREA Plumier. YAM.

DIOSCOREA VILLOSA L. Generally distributed.

CIX. Order AMARYLLIDACEÆ. Amaryllis Family.

491. HYPOXIS L. Star-Grass.

Hypoxis hirsuta (L.) (*H. erecta* L.)
Cleveland, W. Krebs; Akron, W. C. Werner; Licking Co., H. L. Jones (Cat.); Fairfield Co., E. V. Wilcox, S. Renshaw; Lawrence Co., W. C. Werner; Miami Valley, A. P. Morgan (Flora).

CX. Order HAEMODORACEÆ. Bloodwort Family.

487. ALETRIS L. Colic-root. Star-grass.

Aletris farinosa L.
"General," H. C. Beardslee (Cat.); Franklin Co., W. S. Sullivant (Cat.)

CXI. Order LILIACEÆ. Lily Family.

492. SMILAX Tourn. Greenbrier. Cat-brier.

Smilax bona-nox L.
"General," J. S. Newberry (Cat.); Licking Co., H. L. Jones (Cat.); Ross Co., W. Safford (Torr. Bull. XIII. 117); Cincinnati, Joseph Clark (Cat.)

Smilax ecirrhata Watson.
Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.)

Smilax glauca Walt.
"General," J. S. Newberry (Cat.); Licking Co., H. L. Jones (Cat.)

Smilax herbacea L. Carrion-Flower.
Throughout the state.

Smilax hispida Muhl.
Lorain Co., A. A. Wright (Cat.); "General," J. S. Newberry (Cat.); Painesville, H. C. Beardslee (Cat.); Licking Co., H. L. Jones (Cat.); Miami Valley, A. P. Morgan (Flora); Cincinnati, Jos. F. James (Cat.)

Smilax pseudo-china L.
"Woods, Worthington, Ohio," J. L. Riddell (Synop. 1835).

Smilax rotundifolia L. Common Greenbrier. Horse-brier.
Common.

Smilax rotundifolia quadrangularis Gray.
Lorain Co., A. A. Wright (Cat.); "General," J. S. Newberry (Cat.)

493. ASPARAGUS Tourn. Asparagus.

ASPARAGUS OFFICINALIS L. Garden Asparagus.
Throughout the state.

494. POLYGONATUM Tourn. SOLOMON'S SEAL.

POLYGONATUM COMMUTATUM (Schult.) (*P. gigauteum* Dietr.)
Alluvial soil throughout the state.

POLYGONATUM BIFLORUM (Walt.) Ell. Smaller Solomon's Seal.
Generally distributed.

495. STREPTOPUS Mx. TWISTED-STALK.

STREPTOPUS AMPLEXIFOLIUS DC.
Summit Co., J. S. Newberry (Cat.); Painesville, H. C. Beardslee (Cat.)

496. UNIFOLIUM Adans. (*Smilacina* Desf.) FALSE SOLOMON'S SEAL.

UNIFOLIUM RACEMOSUM (L.) Britton. (*Smilacina racemosa* Desf.) False Spikenard.
Frequent.

UNIFOLIUM STELLATUM (L.) Greene. (*Smilacina stellata* Desf.)
Throughout the northern half of the state. No specimens at hand from south of Columbus.

UNIFOLIUM TRIFOLIUM (L.) Greene. (*Smilacina trifolia* Desf.)
Lorain Co., A. A. Wright (Cat.); Summit Co., J. S. Newberry (Cat.)

UNIFOLIUM CANADENSE (Desf.) Greene. (*Maianthemum canadense* Desf.) (*Smilacina bifolia canadensis* Gray).
Generally distributed.

497. HEMEROCALLIS L. DAY LILY.

HEMEROCALLIS FULVA L. Common Day Lily.
Occasionally met with as an escape from cultivation.

498. ALLIUM L. ONION. GARLIC.

ALLIUM CANADENSE Kalm. Wild Garlic.
Common.

ALLIUM CERNUUM Roth. Wild Onion.
Lake Erie to Ohio River.

ALLIUM STELLATUM Fraser.
Put-in-Bay Island (Lake Erie) H. C. Beardslee (Cat.)

ALLIUM TRICOCCUM Ait. Wild Leek.
Generally distributed.

ALLIUM VINEALE L.
Columbus, W. R. Lazenby.

499. MUSCARI Tourn. GRAPE HYACINTH.

MUSCARI BOTRYOIDES Mill.
Lorain Co., A. A. Wright (Cat.)

500. CAMASSIA Lindl. (*Scilla*).

CAMASSIA FRASERI Torr. (*Scilla fraseri* Gray). Eastern Camass. Wild Hyacinth.
Generally distributed.

501. CHAMÆLIRIUM Willd. DEVIL'S BIT.

CHAMÆLIRIUM LUTEUM (L.) Gr. (*C. carolinianum* Willd.) Blazing Star.
Northern O., Wm. Krebs, Wm. C. Werner; Richland Co., E. Wilkinson; Licking Co., H. L. Jones (Cat.); Lawrence Co., Wm. C. Werner.

502. LILIUM L. LILY.

LILIUM PHILADELPHICUM, L. Wild Orange. Red Lily.
"General," J. S. Newberry (Cat.); "Darby Plains," J. L. Riddell (Synop. 1835); Franklin Co., W. S. Sullivant (Cat); Toledo, J. A. Sanford; Delta (Fulton Co.) M. G. Aumend; Painesville, Wm. C. Werner.

LILIUM CANADENSE L. Wild Yellow Lily.
Over the whole state.

LILIUM SUPERBUM L. Turk's-cap Lily.
Painesville, Wm. C. Werner; Licking Co., H. L. Jones (Cat.); Franklin Co., Selby & Craig (Cat.); Cincinnati, Jos. F. James (Cat.)

503. ERYTHRONIUM L. DOG'S TOOTH VIOLET.

ERYTHRONIUM ALBIDUM Nutt. White Dog's-tooth Violet.
Throughout the state.

ERYTHRONIUM AMERICANUM Ker. Yellow Adder's Tongue.
Widely distributed.

504. OAKESIA Watson.

OAKESIA SESSILIFOLIA (L.) Watson. (*Uvularia sessilifolia* L.)
Lake Co., Wm. C. Werner; Niles, R. H. Ingraham; Gallia Co., Ruth E. Brockett.

505. UVULARIA L. BELLWORT.

UVULARIA GRANDIFLORA Smith.
Lake Erie to Southern Ohio.

UVULARIA PERFOLIATA L.
Throughout the state.

506. DISPORUM Salisb.

DISPORUM LANUGINOSUM Benth. & Hook. (*Prosartes lanuginosa* Don.)
Lake Co., W. C. Werner; Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.); Rio Grande (Gallia Co.) J. W. Davis.

507. CLINTONIA Raf.

CLINTONIA BOREALIS (Ait.) Raf.
"Northern O.," J, S. Newberry (Cat.)

508. MEDEOLA Gronov. INDIAN CUCUMBER-ROOT.

MEDEOLA VIRGINIANA L.
Not abundant but gennerally distributed.

509. TRILLIUM L. WAKE ROBIN. BIRTHROOT.

TRILLIUM CERNUUM L
"General," J. S. Newberry (Cat.), Licking Co., H. L. Jones (Cat.); Cincinnati, Jos. F. James (Cat.)

TRILLIUM ERECTUM L.
Widely distributed.

TRILLIUM ERYTHROCARPUM Mx. Painted Trillium.
"Northern Ohio," J. S. Newberry (Cat,)

TRILLIUM GRANDIFLORUM Salisb.
Generally distributed

TRILLIUM NIVALE Riddell. Dwarf White Trillium.
Franklin Co., Aug. D. Selby.

TRILLIUM RECURVATUM Beck.
Cincinnati, Jos. F. James (Cat.)

TRILLIUM SESSILE L.
Frequent throughout the southern half of the state.

510 STENANTHIUM Gray.

STENANTHIUM ANGUSTIFOLIUM (Ph) Gray.
Central and Southern Ohio, J. S. Newberry (Cat.)

STENANTHIUM ROBUSTUM Watson.
Licking Co., H. L. Jones (Cat.); Amanda (Fairfield Co.,) W. A. Kellerman.
Undoubtedly the S. Angustifolium of former catalogues.

511. ZYGADENUS Mx.

ZYGADENUS ELEGANS Pursh.
Central Ohio, W. S. Sullivant (Cat.); Cedar Swamp (Champaign Co.) Wm. C. Werner.

ZYGADENUS GLABERRIMUS Mx.
Summit Co., J. S. Newberry (Cat.)

512. MELANTHIUM Linn.

MELANTHIUM VIRGINICUM L. Bunch-Flower.
Richland Co., E. Wilkinson; Franklin Co., W. S. Sullivant (Cat.); Cincinnati, Joseph Clark (Cat.)

513. VERATRUM Tourn. FALSE HELLEBORE.

VERATRUM VIRIDE Ait. American White Hellebore. Indian Poke.
Lake Co., W. C. Werner; Ashtabula Co., Sara F. Goodrich.

VERATRUM WOODSII Robbins.
Dayton, A. P. Morgan (Bot. Gaz. VII. 79.)

CXII. ORDER JUNCACEÆ. Rush Family.

514. JUNCUS Tourn. RUSH. BOG-RUSH.

JUNCUS ACUMINATUS Mx.
Throughout the state.

JUNCUS ALPINUS INSIGNIS Fries.
Cleveland, E. Claassen; Painesville, Wm. C. Werner. This last the J. articulatus (Lazenby & Werner Supp. list).

JUNCUS ARTICULATUS L.
Cleveland, E. Claassen.

JUNCUS BALTICUS LITTORALIS Engelm.
Sandy shore of Lake Erie, H. C. Beardslee (Cat.)

JUNCUS BUFONIUS L.
Frequent throughout Northern Ohio; Licking Co., H. L. Jones (Cat.); Miami Valley, A. P. Morgan (Flora).

JUNCUS BRACHYCARPUS Engelm.
"Ohio," Gray (Man.)

JUNCUS CANADENSIS J. Gay.
Sandusky, E. L. Mosely; Painesville, W. C. Werner; Wood Co., Albert Neifer; Cuyahoga Co., E. Claassen; Licking Reservoir, Wm. C. Werner.

JUNCUS CANADENSIS BRACHYCEPHALUS Engelm.
Cleveland, E. Claassen; Painesville, Columbus and Champaign Co., W. C. Werner.

JUNCUS EFFUSUS L. Common or Soft Rush.
Common.

JUNCUS FILIFORMIS L.
Lorain Co., A. A. Wright) Cat.) ; Licking Co., H. L. Jones (Cat.).

JUNCUS GERARDI Loisel. Black Grass.
Lake shore, rare, H. C. Beardslee (Cat.)

JUNCUS MARGINATUS Rostk.
Lake Co., O. Hacker; Wood Co., Albert Neifer; Tiffin (Seneca Co.) W. H. Egbert; Franklin Co., W. S. Sullivant (Cat.); Fairfield Co., Wm. C. Werner; Cincinnati, Jos. F. James (Cat.)

JUNCUS MILITARIS Bigel.
"Southern Ohio," J. S. Newberry (Cat.)

JUNCUS NODOSUS L.
Wood Co., Albert Neifer; Marshes along Lake Erie, H. C. Beardslee (Cat.); Cuyahogo Co., E. Claassen; Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.); Painesville, Franklin Co., Wm. C. Werner.

JUNCUS NODOSUS MEGACEPHALUS Torr.
Sandusky, E. L. Mosely; Lorain Co., A. A. Wright (Cat.); Wood Co., Albert Neifer; Columbus and Licking Reservoir, Wm. C. Werner.

JUNCUS PELOCARPUS E. Meyer.
"General," J. S. Newberry.

JUNCUS SCIRPOIDES Lam.
"General," J. S. Newberry (Cat.); Franklin Co., W. S. Sullivant (Cat.); Cincinnati, Jos. F. James (Cat.)

JUNCUS SETACEUS Rostk.
"Southern Ohio," J. S. Newberry (Cat.)

JUNCUS STYGIUS L.
"Northern Ohio," Leo Lesquereux (J. S. Newberry, Cat.)

JUNCUS TENUIS Willd.
Common.

515. LUZULA DC. WOOD-RUSH.

LUZULA CAMPESTRIS (L.) DC.
Throughout the state.

LUZULA PILOSA (L.) Wilid. (*L. vernalis* DC.)
Throughout the state.

CXIII. Order PONTEDERIACEÆ. Pickerel-Weed Family.

516. PONTEDERIA L. Pickerel-Weed.

Pontederia cordata L.
Frequent in marshes along the shores of Lake Erie; Licking Co., H. L. Jones (Cat.)

Pontederia cordata angustifolia Torr.
Painesville, H. C. Beardslee.

517. HETERANTHERA Ruiz & Pav. Mud-Plantain.

Heteranthera dubia Jacq. (*H. graminea* Vahl.)
Throughout the state.

Heteranthera reniformis Ruiz & Pav.
Cincinnati, Joseph Clark (H. C. Beardslee, Cat.), Jos. F. James (Cat.); "Lockbourne, Ohio," J. L. Riddell (Synop. 1835).

CXIV. Order COMMELINACEÆ. Spiderwort Family.

518. COMMELINA Dill. Day-Flower.

Commelina virginica L.
Cincinnati, Joseph Clark (Cat.)

519. TRADESCANTIA L. Spiderwort.

Tradescantia pilosa Lehm.
"Ohio," Gray (Man.); Miami Valley, A. P. Morgan (Flora).

Tradescantia virginica L. Common Spiderwort.
Central and Southern Ohio; Lorain Co., A. A. Wright (Cat.)

CXV. Order XYRIDACEÆ. Yellow-Eyed Grass Family.

520. XYRIS Gronov. Yellow-Eyed Grass.

Xyris caroliniana Walt.
"General," J. S. Newberry (Cat.); Ohio, H. C. Beardslee (Cat.)

Xyris flexuosa Muhl.
Portage Co., W. Krebs; Wood Co., Albert Neiffer; Lancaster (Fairfield Co.), J. M. Bigelow (H. C. Beardslee Cat.)

CXVI. Order LEMNACEÆ. Duckweed Family.

521. LEMNA L. Duckweed. Duck's-meat.

Lemna minor L.
Throughout the state.

Lemna minor orbiculata Austin.
Lorain Co., A. A. Wright (Cat.)

Lemna trisulca L.
Generally distributed.

522. SPIRODELA Schleiden.

Spirodela polyrrhiza (L.) Schleiden.
Frequent.

523. WOLFFIA Horkel.

Wolffia columbiana Karsten.
Painesville, H. C. Beardslee (Cat.), Wm. C. Werner; Licking Co., H. L. Jones (Cat.), Fairfield Co., E. V. Wilcox; Pond west of Big Miami, D. L. James.

CXVII. Order ARACEÆ, Arum Family.

ACORUS L. Sweet-Flag. Calamus.

Acorus calamus L.
Throughout the State.

525. SPATHYEMA Raf. (*Symplocarpus* Salisb.) Skunk Cabbage.

Spathyema foetida (L.) Raf. (*Symplocarpus foetidus* Salisb.) Skunk Cabbage.
Frequent.

526. CALLA L. Water Arum.

Calla palustris L.
Lorain Co., A. A. Wright (Cat.); Painesville, H. C. Beardslee (Cat.); Ashtabula Co., E. E. Bogue; Alliance, W. L. Crubaugh.

527. PELTANDRA Raf. Arrow Arum.

Peltandra virginica (L.) Raf. (*P. undulata* Raf.)
Lorain Co., A. A. Wright (Cat.); Cleveland, Wm. Krebs; Painesville, Wm. C. Werner; Licking Co., H. L. Jones (Cat.); Pickaway Co., J. L. Riddell (Synop. 1835).

528. ARISÆMA Martius. INDIAN TURNIP. DRAGON ARUM.

ARISÆMA DRACONTIUM (L.) Schott. Green Dragon. Dragon-root.
Generally distributed.

ARISÆMA TRIPHYLLUM (L.) Torr. Indian Turnip.
Frequent.

CXVII. ORDER CYPERACEÆ, Sedge Family.

529. CYPERUS Tourn.

CYPERUS ARISTATUS Rottb.
Wood Co., Albert Neifer; Toledo, J. A. Sanford; Licking Co., H. L. Jones (Cat.); Franklin Co., Wm. C. Werner, Fairfield Co., E. V. Wilcox; Miami Valley, A. P. Morgan (Flora).

CYPERUS DENTATUS Torr.
Licking Co., H. L. Jones (Cat.)

CYPERUS DIANDRUS Torr.
Throughout the state.

CYPERUS DIANDRUS CASTANEUS (Bigel.) Torr.
Painesville and Columbus, Wm. C. Werner.

CYPERUS ERYTHRORHIZOS Muhl.
Painesville, H. C. Beardslee (Cat.) Wm. C. Werner; Cleveland, E. Claassen; Lorain Co., A. A. Wright (Cat.); Columbus, Wm. C. Werner.

CYPERUS ESCULENTUS L.
Throughout the state.

CYPERUS FILICULMIS Vahl.
Cleveland and Summit Co., E. Claassen; Wood Co., Albert Neifer; Lake Co., Franklin Co., Wm. C. Werner.

CYPERUS FLAVESCENS L.
Painesville, Fairfield Co., Wm. C. Werner; Licking Co., H. L. Jones (Cat.); Cincinnati, Jos. Clark (Cat.)

CYPERUS LANCASTRIENSIS Porter.
Cincinnati, J. F. James (Cat)

CYPERUS OVULARIS (Vahl.) Torr.
"General," J. S. Newberry (Cat.)

CYPERUS RETROFRACTUS Torr.
"Central and Southern Ohio," J. S. Newberry (Cat.)

CYPERUS SCHWEINITZII Torr.
Cedar Point and Port Clinton (Ottawa Co.,), E. Claassen; Sandusky, E. L. Mosely.

CYPERUS SPECIOSUS Vahl.
Painesville, Columbus, Wm. C. Werner.

CYPERUS STRIGOSUS L.
Common over the whole state.

530. KYLLINGA, Rottboell.

KYLLINGA PUMILA Mx.
Cincinnati, J. F. James (Cat.); Franklin and Fairfield counties, W. C. Werner.

531. DULICHIUM Pers.

DULICHIUM SPATHACEUM (L.) Pers.
Lake Co., Wm. C. Werner; Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.); Cincinnati, Joseph Clark (Cat.)

532. ELEOCHARIS R. Br. SPIKE-RUSH.

ELEOCHARIS ACICULARIS (L.) R. Brown.
Throughout the state.

ELEOCHARIS COMPRESSA Sullivant.
"Central Ohio," W. S. Sullivant (H. C. Beardslee, Cat.)

ELEOCHARIS EQUISETOIDES Torr.
"General" J. S. Newberry (Cat.)

ELEOCHARIS INTERMEDIA (Muhl.) Shultes.
Columbus, Wm. C. Werner; Cincinnati, J. F. James (Cat.)

ELEOCHARIS OLIVACEA Torr.
"Southern Ohio," Leo Lesquereux (J. S. Newberry, Cat.)

ELEOCHARIS OVATA (Roth.) R. Brown.
Throughout the state.

ELEOCHARIS PALUSTRIS (L.) R. Brown.
Painesville, Wm. C. Werner; Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.), Wm. C. Werner; Fairfield Co., E. V. Wilcox; Cincinnati, Jos. F. James (Cat.)

ELEOCHARIS QUADRANGULATA (Mx.) R. Br.
Summit Co., E. Claassen.

ELEOCHARIS ROSTELLATA Torr.
"General," J. S. Newberry (Cat.)

ELEOCHARIS TENUIS (Willd.) Schultes.
Lorain Co., A. A. Wright (Cat.); Miami Valley, A. P. Morgan (Flora); Cincinnati, Jos. F. James (Cat,)

533. FIMBRISTYLIS Vahl.

FIMBRISTYLIS AUTUMNALIS (L. (Roem, & Schult).
Wood Co., Albert Neifer; Fairfield Co., Wm. C. Werner; Hocking Co., W. A. Kellerman; Cincinnati, Thos. G. Lea (Cat.)

FIMBRISTYLIS CAPILLARIS (L.) Gray.
Cedar Swamp (Champaign Co.) Wm. C. Werner.

534. SCIRPUS Tourn. BULRUSH or CLUBRUSH.

SCIRPUS ATROVIRENS Muhl.
Throughout the state.

SCIRPUS DEBILIS Pursh.
North of Crystal Lake (Summit Co.,) E. Claassen; Painesville, W. C. Werner.

SCIRPUS FLUVIATILIS (Torr.) Gray.
Lake Co., Wm. C. Werner; Medina Co., E. Claassen; Cuyahoga Co., Wm. C. Werner; Lorain Co., A. A. Wright (Cat.); Wood Co., Albert Neifer; Licking Co., H. L. Jones (Cat.), Wm. C. Werner; Fairfield Co., E. V. Wilcox.

SCIRPUS LACUSTRIS L.
Lake Co., Wm. C. Werner; Cuyahoga Co., E. Claassen; Wood Co., Albert. Neifer; Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.), Wm. C. Werner; Madison Co., Mrs. K. D. Sharpe; Fairfield Co., E. V. Wilcox.

SCIRPUS MARITIMUS L.
"General," J. S. Newberry (Cat.)

SCIRPUS PLANIFOLIUS Muhl.
Painesville, H. C. Beardslee (Cat.), Wm. C. Werner; Toledo, J. A. Sanford; Fairfield Co., Wm. C. Werner.

SCIRPUS POLYPHYLLUS Vahl.
Lake Co., Wm. C. Werner; Cuyahoga Co., E. Claassen; Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.); Cincinnati, Jos. F. James (Cat.)

SCIRPUS PUNGENS Vahl.
Over the State.

SCIRPUS SUBTERMINALS Torr.
Painesville, H. C. Beardslee (Cat.)

SCIRPUS SYLVATICUS L.
Richland Co., E. Wilkinson.

SCIRPUS TORREYI Olney.
Painesville, H. C. Beardslee (Cat.), W. C. Werner.

535. ERIOPHORUM L. COTTON-GRASS.

ERIOPHORUM ALPINUM L.
"Northern Ohio," J. S. Newberry (Cat.)

ERIOPHORUM CYPERINUM L.
Widely distributed.

ERIOPHORUM GRACILE Koch.
Plymouth Marsh near Ashtabula, H. C. Beardslee (Cat.)

ERIOPHORUM LINEATUM Benth. & Hook.
Widely distributed.

ERIOPHORUM POLYSTACHYON L.
Painesville, H. C. Beardslee (Cat.), W. C. Werner.

ERIOPHORUM POLYSTACHYON LATIFOLIUM Gr.
Painesville, H. C. Beardslee (Cat.)

ERIOPHORUM VAGINATUM L.
Painesville, H. C. Beardslee (Cat.)

ERIOPHORUM VIRGINICUM L.
Lake Co., Geauga Co., Wm. C. Werner; Portage Co., E. Claassen; Licking Co., H. L. Jones (Cat.), Wm. C. Werner.

ERIOPHORUM VIRGINICUM ALBUM Gray.
Lorain Co., A. A. Wright (Cat.)

535*a*. FUIRENA Bottboell. UMBRELLA-GRASS.

FUIRENA SQUARROSA Michx.
"Northern Ohio," J. S. Newberry (Cat.)
Probably the var. pumila Torr. would be the plant in question.

536. RHYNCHOSPORA Vahl. BEAK-RUSH.

RHYNCHOSPORA ALBA (L.) Vahl.
Plymouth marsh near Ashtabula, H. C. Beardslee (Cat.); Geauga Co., E. Claassen; Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.), Wm. C. Werner; Cedar Swamp (Champaign Co.) Wm. C. Werner.

RHYNCOSPORA CAPILLACEA Torr.
Cedar Swamp (Champaign Co) Wm. C. Werner.

RHYNCHOSPORA CORNICULATA Gray.
"General," J. S. Newberry (Cat.)

RHYNCHOSPORA FUSCA (L.) Roem. & Shultes.
"General," J. S. Newberry (Cat.)

RHYNCHOSPORA GLOMERATA (L.) Vahl.
Lake Co., Otto Hacker; Wood Co., Albert Neifer; Plymouth Marsh (Ashtabula Co.) H. C. Beardslee (Cat.); Licking Co., H. L. Jones (Cat.); Fairfield Co., W. A. Kellerman.

537. CLADIUM. P. Browne. Twig-Rush.

Cladium mariscoides (Muhl.) Torr.
Cedar Swamp (Champaign Co.) Wm. C. Werner.

538. SCLERIA Berl. Nut-Rush.

Scleria pauciflora Muhl.
"Central Ohio," W. S. Sullivant (Cat. 1840).

Sceleria triglomerata Michx.
"Central Ohio," W. S. Sullivant (Cat. 1840); Wood Co., Albert Neifer.

Sceleria verticillata Muhl.
Columbus, Cedar Swamp (Champaign Co.) Wm. C. Werner.

539. CAREX Ruppius. Sedge.

Carex albolutescens Schw. (*C. fœnea* Gray Man. not Willd.)
Painesville, Wm. C. Werner.

Carex albursina Sheldon. (*C. laxiflora latifolia* Boott.)
Painesville, Wm. C. Werner; Lorain Co., A. A. Wright (Cat.); Lima (Allen Co. W. A. Kellerman; Tiffin (Seneca Co.) W. H. Egbert; Columbus, Ironton (Lawrence Co.) Wm. C. Werner; Chillicothe (Ross Co.) R. E. Bower.

Carex amphibola Steud (*C. grisea angustifolia* Boott.)
Painesville, Columbus, Fairfield Co., Wm. C. Werner.

Carex aquatilis Wahl.
Painesville, H. C. Beardslee (Cat.), Wm. C. Werner; Toledo, J. A. Sanford; Lorain Co., A. A. Wright (Cat.)

Carex arctata Boott.
Ohio, H. C. Beardslee (Cat.)

Carex asa-grayi Bailey. (*Carex grayii* Carey.)
Ashtabula Co., Sara F. Goodrich; Painesville, Wm. C. Werner; Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.); Columbus, Moses Craig; Champaign Co., Wm. C. Werner; Clinton Co., J. S. Vandervort; Cincinnati, Thos. G. Lea (Cat.)

Carex aurea Nutt.
Northern Ohio, J. S. Newberry (Cat.)

Carex bromoides Schkuhr.
Throughout the state.

Carex bullata Schkuhr.
Franklin Co., W. S. Sullivant (Cat. 1840).

Carex canescens L.
Portage Co., E. Claassen; Painesville, Summit Co., Wm. C. Werner; Lorain Co., A. A. Wright (Cat.)

Carex careyana Toor.
Painesville, H. C. Beardslee (Cat.), Otto Hacker; Lorain Co., A. A. Wright (Cat.); Columbus, Wm. C. Werner; Cincinnati, Jos. F. James (Cat.)

Carex cephalophora Muhl.
From Lake Erie to the Ohio River.

Carex cephaloidea Dewey.
Painesville, H. C. Beardslee (Cat.); Columbus, Wm. C. Werner.

Carex chordorhiza Ehrh.
"Northern Ohio," J. S. Newberry (Cat.)

Carex conjuncta Boott.
Columbus, Wm. C. Werner.

Carex conoidea Schkuhr.
Painesville, Wm. C. Werner.

Carex communis Bailey.
Throughout the state.

Carex communis wheeleri Bailey.
Fairfield Co., Wm. C. Werner.

Carex crinita Lam.
Cuyahoga Co., E. Claassen; Painesville, Wm. C. Werner; Ashtabula Co., Sara F. Goodrich; Lorain Co., A. A. Wright (Cat.); Richland Co., E. Wilkinson; Fairfield Co., Wm. C. Werner; Cincinnati, Jos. F. James (Cat.)

Carex crus-corvi Shutlew.
Wood Co., Albert Neifer; "Southern Ohio," J. S. Newberry (Cat.)

Carex davisii Schwein. & Torr.
Painesville, Otto Hacker; Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.); Franklin Co., Wm. C. Werner; Chillicothe (Ross Co.) R. E. Bower; Oxford (Butler Co.) Ada G. Wing; Cincinnati, Thos. G. Lea (Cat.)

Carex debilis rudgei Bailey.
Cleveland. E Claassen; Painesv lle, Wm. C. Werner; Lorain Co., A. A. Wright (Cat.); Summit Co., Wm. C. Werner.

Carex decomposita Muhl.
Franklin Co., W. S. Sullivant (Cat.); Miami Valley, A. P. Morgan (Flora); Cincinnati, Thos. G. Lea (Cat.)

Carex deweyana Schwein.
Northern Ohio, J. S. Newberry (Cat.)

Carex digitalis Willd.
Cuyahoga Co., E. Claassen; Painesville, Wm. C Werner; Lorain Co., A. A. Wright (Cat.); Franklin Co., Fairfield Co., Wm. C. Werner.

Carex digitalis copulata Bailey.
Lake Co., Summit Co., Franklin Co., Wm. C. Werner.

CAREX DURIFOLIA Bailey. (*Carex backii* Boott.)
"Ohio," A. Gray (Man.)

CAREX EBURNEA Boott.
Cuyahoga Falls, Summit, Co., Wm. C. Werner.

CAREX FILIFORMIS L.
Painesville, H. C. Beardslee (Cat.); Miami Valley, A. P. Morgan (Flora); Cincinnati, Thos. G. Lea (Cat.)

CAREX FILIFORMIS LANUGINOSA (Michx.) B. S. P.
Painesville, H. C. Beardslee (Cat.), Wm. C. Werner; Cedar Point (Ottawa Co.) E. Claassen; Lorain Co., A. A. Wright (Cat.); Wood Co., Albert Neifer; Toledo, J. A. Sanford; Fairfield Co., Wm. C. Werner; Cincinnati, Thos. G. Lea (Cat.)

CAREX FLAVA L.
"Northern Ohio." J. S. Newberry (Cat.); Cedar Swamp (Champaign Co.) Wm C. Werner; Miami Valley, A. P. Morgan (Flora).

CAREX FLAVA VIRIDULA Bailey.
"Northern Ohio," J. S. Newberry (Cat.)

CAREX FOLLICULATA L.
"Miami Country," J. L. Riddell (Synop. 1835).

CAREX FORMOSA Dewey.
"Northern and Eastern Ohio," J. S. Newberry (Cat.)

CAREX FRANKII Kunth. (*C. stenloepsis* Torr.)
Painesville, Wm. C. Werner; Tiffin (Seneca Co.) W. H. Egbert; Sandusky, E. L. Moseley; Licking Co., H, L. Jones (Cat.); Columbus, Wm. C. Werner; Madison Co., Mrs. K. D. Sharpe; Fairfield Co., E. V. Wilcox; Cincinnati, Jos. F. James (Cat.); Clinton Co., J. S. Vandervort.

CAREX FUSCA All.
Toledo, J. A. Sanford; Lorain Co., A. A. Wright (Cat.)

CAREX GLAUCODEA Tuckerm.
Franklin Co., Aug. D. Selby.

CAREX GRACILLIMA Schwein.
Painesville, Wm. C. Werner; Ashtabula Co., Sara F. Goodrich; Cuyahoga Co., E. Claassen; Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.); Franklin Co., Fairfield Co., Wm. C. Werner.

CAREX GRACILLIMA X PUBESCENS Bailey.
"Columbus," W. S. Sullivant A. Gray (Man.)

CAREX GRANULARIS Muhl.
Widely distributed.

CAREX GRANULARIS HALEANA Porter.
Painesville, Wm. C. Werner.

CAREX GRISEA Wahl.
Painesville, Wm. C. Werner; Lorain Co., A. A. Wright (Cat.); Columbus, Wm. C. Werner; Madison Co., Mrs. K. D. Sharpe; Miami Valley, A. P. Morgan (Flora); Gincinnati, Thos. G. Lea (Cat.); Hanging Rock (Lawrence Co.) Wm. C. Werner.

CAREX HITCHCOCKIANA Dewey.
Painesville, Otto Hacker Lorain Co., A. A. Wright (Cat.); Fairfield Co., Wm. C. Werner; Oxford (Butler Co.) Ada G. Wing; Cincinnati, Thos. G. Lea (Cat.)

CAREX HYSTRICINA Muhl.
Throughout the state.

CAREX INTERIOR CAPILLACEA Bailey.
Licking Reservoir (Licking Co.) Wm. C. Werner.

CAREX INTUMESCENS Rudge.
Painesville, Wm. C. Werner; Cuyahoga Co., E. Claassen; Ashtabula Co., Sara F. Goodrich; Lorain Co., A. A. Wright (Cat.); Licking Co, H. L. Jones (Cat.); Columbus, Wm. C. Werner; Cincinnati, Jos. F. James (Cat.)

CAREX JAMESII Schweiu.
Painesville, H. C. Beardslee (Cat.), Wm. C. Werner; Cuyahoga Co., Portage, Co., E. Claassen; Lorain Co., A. A. Wright (Cat.); Columbus, Fairfield Co., Wm. C. Werner; Oxford (Butler Co.) Ada G. Wing; Cincinnati, Jos. F, James (Cat.)

CAREX LAXICULMIS Schw.
Ashtabula Co., Sara F. Goodrich; Lorain Co., A. A. Wright (Cat.); Painesville, Sugar Grove (Fairfield Co.) W. C. Werner.

CAREX LAXIFLORA Lam.
Painesville, Cuyahoga Falls (Summit Co.) Wm. C. Werner; Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.); Columbus, Fairfield Co.) Lawrence Co., Wm. C. Werner; Cincinnati, Jos. F. James (Cat.)

CAREX LAXIFLORA BLANDA Boott. (*C. laxiflora striatula* Carey.)
Painesville, Columbus, Wm. C. Werner; Cedar Point (Ottawa Co.) E. Claasen; Hanging Rock (Lawrence Co.) Wm. C. Werner.

CAREX LAXIFLORA PATULIFOLIA Carey.
Painesville, Cuyahoga Falls, (Summit Co.) Wm. C. Werner; Lorain Co., A. A. Wright (Cat.); Tiffin, (Seneca Co.) W. H. Egbert; Lima, (Allen Co.) W. A. Kellerman; Licking Co., H. L. Jones (Cat.); Fairfield Co., E. V. Wilcox; Lawrence Co., Wm. C. Werner.

CAREX LAXIFLORA STYLOFLEXA (Buckley) Boott.
Licking Co., H. L. Jones (Cat.)

CAREX LAXIFLORA VARIANS Bailey.
Painesville, Cuyahoga Falls, Wm. C. Werner; Sandusky, E. L. Moseley; Columbus, Lawrence Co., Wm. C. Werner.

CATEX LIMOSA L.
"Plymouth Marsh" near Ashtabula, H. C. Beardslee (Cat.)

CAREX LONGIROSTRIS Torr.
"Northern Ohio," J. S. Newberry (Cat.)

CAREX LUPULINA Muhl.
Distributed throughout the state.

CAREX LUPULINA PEDUNCULATA Dewey.
Painesville, Licking Reservoir (Licking Co.) Wm. C. Werner; Ashtabula Co., Sara F. Goodrich.

CAREX LUPULINA POLYSTACHYA Schwein. and Torr.
Painesville, Otto Hacker; Prospect (Marion Co.) E. E. Boyne.

CAREX LURIDA Wahl.
Over the state.

CAREX MONILE Tuckerm.
Ashtabula Co., Sara F. Goodrich; Painesville, H. C. Beardslee (Cat.); Wm. C. Werner; Cuyahoga Co., E. Claasen; Toledo, J. A. Sanford; Wood Co., Albert Neifer; Columbus, Wm. C. Werner.

CAREX MUHLENBERGII Schkuhr.
Painesville, Wm. C. Werner; Sandusky, E. L. Moseley; Toledo, J. A. Sanford; Wood Co., Albert Neifer; Cincinnati, Thos. G. Lea (Cat.)

CAREX MUHLENBERGII ENERVIS Boott.
Lorain Co., A. A. Wright (Cat.)

CAREX MURICATA L.
Painesville, H. C. Beardslee (Cat.); "Southern Ohio, rare," J. S. Newberry (Cat.)

CAREX MUSKINGUMENSIS Schw.
Cincinnati, J. F. James (Cat.)

CAREX NOVÆ-ANGLIÆ Schw.
"Northern Ohio," J. S. Newberry (Cat.)

CAREX ŒDERI Ehrh.
"Northern Ohio," J. S. Newberry (Cat.)

CAREX OLIGOCARPA Schkuhr.
Painesville, Wm. C. Werner; Cuyahoga Co., Geauga Co., E. Claasen; Licking Co., H. L. Jones (Cat.); Columbus, Wm. C. Werner; Ross Co., R. E. Bower Cincinnati, Jos. F. James (Cat.)

CAREX OLIGOSPERMA Mx.
"Plymouth Marsh" near Ashtabula, H. C. Beardslee (Cat.)

CAREX PALESCENS L.
Lorain Co., A. A. Wright (Cat.)

CAREX PEDUNCULATA Muhl.
Painesville, Otto Hacker; Cuyahoga Co., E. Claasen.

Carex pennsylvanica Lam.
Distributed throughout the state.

Carex plantaginea Lam.
Painesville, H. C. Beardslee (Cat.), Otto Hacker; Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.); Cuyahoga Falls (Summit Co.) Wm. C. Werner.

Carex platyphylla Carey.
Painesville, H. C. Beardslee (Cat.), Wm. C. Werner; Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.); Fairfield Co., Wm. C. Werner; Miami Valley, A. P. Morgan (Flora).

Carex polytrichoides Muhl.
Painesville, Columbus, Wm. C. Werner; Miami Valley, A. P. Morgan (Flora).

Carex prasina Wahl.
Cuyahoga Co., E. Claassen; Painesville, Wm. C. Werner; Niles (Trumbull Co.) R. H. Ingraham; Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.); Columbus, Wm. C. Werner; Cincinnati, C. G. Lloyd.

Carex pseudo-cyperus L.
Licking Co., H. L. Jones (Cat.)

Carex pseudo-cyperus americana Hochst.
Painesville, Wm. C. Werner; Portage Co., E. Claassen; Lorain Co., A. A. Wright (Cat.); Licking Reservoir (Licking Co.) Columbus, Wm. C. Werner; Cincinnati, Jos. F. James (Cat.)

Carex pubescens Muhl.
Painesville, Wm. C. Werner; Cuyahoga Co., E. Claassen; Lorain Co., A. A. Wright (Cat.); Toledo, J. A. Sanford; Columbus, Ironton (Lawrence Co.) W. C. Werner; Cincinnati, Jos. Clark (Cat.)

Carex rigida goodenovii Bailey. (*C. vulgaris* Fries.)
Lorain Co., A. A. Wright (Cat.)

Carex riparia W. Curtis.
Painesville, Wm. C. Werner; Cuyahoga C., E. Claassen; Lorain Co., A. A. Wright (Cat.); Toledo, J. A. Sanford; Summit Co., Champaign Co., Columbus, Lawrence Co., Wm. C. Werner; Ciuciunati, Thos. G. Lea (Cat.)

Carex rosea Schkuhr.
Throughout the state.

Carex rosea radiata Dewey.
Lorain Co., A. A. Wright (Cat.); Cuyahoga Falls (Summit Co.) Wm. C. Werner.

Carex rosea retroflexa (Muhl.) Torr.
Painesville, H. C. Beardslee (Cat.)

Carex scabrata Schw.
Painesville, H. C. Beardslee (Cat.), Wm. C. Werner; Cuyahoga Falls (Summit Co.) Wm. C. Weruer.

CAREX SCOPARIA Schk.
Frequent.

CAREX SCOPARIA MINOR Boott.
"Northern Ohio, Painesville," H. C. Beardslee (Cat.)

CAREX SHORTIANA Dewey.
Lorain Co., A. A. Wright (Cat.); Wood Co., Albert Neifer; Licking Co., H. L. Jones (Cat.); Columbus, Wm. C. Werner; Miami Valley, A. P. Morgan (Flora); Cincinnati, Jos. F. James (Cat.)

CAREX SICCATA Dewy.
Miami Valley, A. P. Morgan (Flora).

CAREX SPARGANOIDES Muhl.
Occurring over the whole state.

CAREX SQUARROSA L.
Painesville, H. C. Beardslee (Cat.), Wm. C. Werner; Cuyahoga Co., E. Claassen; Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.); Columbus, Wm. C. Werner; Clinton Co., J. S. Vandervort.

CAREX STERILIS Willd. (*C. echinata microstachys* Boeckl.)
Painesville, Wm. C. Werner; Lorain Co., A. A. Wright (Cat.)

CAREX STERILIS EXCELSIOR Bailey. (*C. echinata* of Amer. authors.)
Lorain Co., A. A. Wright (Cat.); Cedar Swamp (Champaign Co.) Wm. C. Werner.

CAREX STIPATA.
Throughout the state.

CAREX STRAMINEA Willd.
Painesville, Otto Hacker; Lorain Co., A. A. Wright (Cat.); Toledo, J. A. Sanford; Wood Co., Albert Neifer; Columbus, Wm. C. Werner; Richland Co, E. Wilkinson; Ross Co., R. E. Bower.

CAREX STRAMINEA ALATA (Torr.) Bailey.
Painesville, Otto Hacker.

CAREX STRAMINEA APERTA Boott.
H. C. Beardslee (Cat.) No locality given.

CAREX STRAMINEA CRAWEI Boott.
Darby Plains (Franklin Co.) W. S. Sullivant.

CAREX STRAMINEA FERRUGINEA (Gray) Bailey. (*C. fœnea* var? *ferruginea* Gray Man. 5th ed.)
"Ohio," L. H. Bailey, Torr. Bull. vol. XX., Nov. 15, 1893, p. 421.

CAREX STRAMINEA MIRABILIS (Dewey) Tuckerm.
Painesville, Otto Haeker; Cuyahoga Falls (Summit Co.) Wm. C. Werner.

CAREX STRICTA Lam.

Painesville, Wm. C. Werner; Trumbull Co., R. H. Ingraham; Cuyahoga Co., E. Claassen; Wood Co., Albert Neifer; Lorain Co., A. A. Wright (Cat.); Champaign Co., Columbus, Wm. C. Werner; Richland Co., E. Wilkinson; Miami Valley, A. P. Morgan (Flora).

CAREX TENELLA Schk.

Lorain Co., A. A. Wright (Cat.)

CAREX TENUIFLORA Wahl.

"Northern Ohio," J. S. Newberry (Cat.)

CAREX TERETIUSCULA Gooden.

Painesville, H. C. Beardslee (Cat.), Wm. C. Werner; Lorain Co., A. A. Wright (Cat.); Toledo, J. A. Sanford; Licking Reservoir (Licking Co.) Wm. C. Werner; Miami Valley, A. P. Morgan (Flora).

CAREX TERETIUSCULA RAMOSA Boott.

Painesville, Wm. C. Werner.

CAREX TETANICA Schk.

Painesville, H. C. Beardslee (Cat.), Wm. C. Werner; Lorain Co., A. A. Wright (Cat.)

CAREX TETANICA MEADII Bailey.

"Ohio," A. Gray (Man. 5th ed.)

CAREX TETANICA WOODII Bailey.

Painesville, Cedar Swamp (Champaign Co.) Wm. C. Werner.

CAREX TORTA Boot.

Painesville, Columbus, Wm. C. Werner.

CAREX TRIBULOIDES Wahl.

Throughout the state.

CAREX TRIBULOIDES CRISTATA (Schw.) Bailey.

Painesville, Wm. C. Werner; Lorain Co., A. A. Wright (Cat.); Wood Co., Albert Neifer; Toledo, J. A. Sanford; Columbus, Wm. C. Werner; Cincinnati, Thos. G. Lea (Cat.)

CAREX TRICEPS HIRSUTA (Willd.) Bailey.

Lake Co., Mahoning Co., Wm. C. Werner; Lorain Co., A. A. Wright (Cat.); Franklin Co., Lawrence Co., Wm. C. Werner; Cincinnati, Joseph F. James (Cat.)

CAREX TRICHOCARPA Muhl.

Painesville, Otto Hacker; Lorain Co., A. A. Wright (Cat.); Columbus, Wm. C. Werner; Licking Co., H. L. Jones (Cat.); Miami Valley, A. P. Morgan (Flora).

CAREX TRICHOCARPA ARISTATA Bailey.

"Northern Ohio," J. S. Newberry (Cat.)

CAREX TRISPERMA Dewey.
Painesville, H. C. Beardslee (Cat.); Portage Co., E. Claassen; Lorain Co., A. A. Wright (Cat.)

CAREX TUCKERMANII Dewey.
Lorain Co., A. A. Wright (Cat.); Cuyahoga Co., E. Claassen; Champaign Co., Wm. C. Werner.

CAREX UMBELLATA Schkuhr.
Lorain Co., A. A. Wright (Cat.); "Southern Ohio, rare" J. S. Newberry (Cat.)

CAREX UTRICULATA Boott.
Painesville, Otto Hacker; Geauga Co., E. Claassen; Lorain Co., A. A. Wright (Cat.); Columbus, Wm. C. Werner; Cincinnati, Thos. G. Lea (Cat.)

CAREX VARIA Muhl.
Painesville, Summit Co., Wm. C. Werner; Cuyahoga Co., E. Claassen; Lorain Co., A. A. Wright (Cat); Licking Co., H. L. Jones (Cat.); Columbus, Wm. C. Werner; Monroe Co., H. Herzer.

CAREX VIRESCENS Muhl.
Ashtabula Co., Sara F. Goodrich; Painesville, Wm. C. Werner; Cuyahoga Co.; E. Claassen; Lorain Co., A. A. Wright (Cat.): Licking Co., H. L. Jones (Cat.): Cincinnati, Jos. Clark (Cat.)

CAREX VIRESCENS COSTATA Dewey.
Painesville, Wm. C. Werner; Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones; Fairfield Co., Lawrence Co., Wm. C. Werner.

CAREX VULPINOIDES Mx.
Not uncommon.

CAREX WILLDENOVII Schk.
Parma (Cuyahoga Co.) E. Claassen; Cincinnati, Thos. G. Lea (Cat.)

CXIX. GRAMINEÆ. Grass Family.

539*a*. ERIANTHUS Michx. WOOLY BEARD GRASS.

ERIANTHUS ALOPECUROIDES (L.) Ell. (*E. saccharoides* Michx.)
Cincinnati, Jos. F. James (Cat.)

540. ANDROPOGON Royen. BEARD GRASS.

ANDROPOGON BELVISII Desv. (*A. argenteus* Ell.)
"Tupper Plains," J. Jennings (Lazenby & Werner sup. list). Not authenticated by a specimen.

ANDROPOGON GLOMERATUS (Walt.) B. S. P. (*A. macrourus* Michx.)
Cincinnati, Jos. Clark (Cat.)

ANDROPOGON NUTANS AVENACEUS (Michx.) Hack. (*Chrysopogon nutans* (L.) Benth.) Indian Grass. Wood Grass.
Painesville, Wm. C. Werner; Wood Co., Albert Neifer; Sandusky, E. L. Moseley; Marion Co., W. D. Whipps; Franklin Co., Champaign Co., Wm. C. Werner; Cincinnati, Jos. F. James (Cat.)

ANDROPOGON PROVINCIALIS Lam. (*A. furcatus* Muhl.)
Painesville, Wm. C. Werner; Lorain Co., A. A. Wright (Cat.); Wood Co., Albert Neifer; Franklin Co., Champaign Co., Wm. C. Werner.

ANDROPOGON SCOPARIUS Michx.
Trumbull Co., R. H. Ingraham; Cuyahoga Co., E. Claassen; Wood Co, Albert Neifer; Franklin Co., Moses Craig; Licking Co., H. L. Jones (Cat.)

ANDROPOGON VIRGINICUS L.
Muskingum Co., Wm. C. Werner; Fairfield Co., Morgan Co., W. A. Kellerman; Rio Grande (Gallia Co.) J. W. Davis; Springbora (Warren Co.) L. M. Gregg; Lawrence Co., Wm. C. Werner; Cincinnati, Jos. Clark (Cat.)

541. PASPALUM L.

PASPALUM MUCRONATUM Muhl. (*P. fluitans* Kunth.)
"Southern Ohio," A. Gray (Man. 5th Ed.); Cincinnati, Thos. G. Lea (Cat.).

PASPALUM SETACEUM Michx.
Painesville, H. C. Beardslee (Cat.), Wm. C. Werner; Sugar Grove (Fairfield Co.) E. V. Wilcox.

542. PANICUM L. PANIC GRASS.

PANICUM AGROSTOIDES Muhl.
Painesville, Wm. C. Werner; Cleveland, E. Claassen; Ashtabula Co., Sara F. Goodrich; Lorain Co., A. A. Wright (Cat.): Licking Co., H. L. Jones (Cat.); Fairfield Co., W. A. Kellerman.

PANICUM CAPILLARE L. Old Witch Grass.
Distributed over the state.

PANICUM CAPILLARE FLEXILE Gattinger.
Columbus, Wm. C. Werner.

PANICUM CLANDESTINUM L.
Painesville, Wm. C. Werner; Toledo, J. A. Sanford; Lorain Co., A. A. Wright (Cat.); Licking Co,. H. L. Jones (Cat.); Fairfield Co., Cincinnati, Jos. F. James (Cat.)

PANICUM COMMUTATUM Schultes.
Fairfield Co., Lawrence Co., Wm. C. Werner.

PANICUM CRUS-GALLI L.
Widely distributed.

PANICUM CRUS-GALLI HISPIDUM (Muhl) Torr.
Painesville, Wm. C. Werner.

PANICUM DEPAUPERATUM Muhl.
Painesville, Wm. C. Werner; Lorain Co., A. A. Wright (Cat.); Cincinnati, Jos F. James (Cat.); Franklin Co., Lawrence Co., Wm. C. Werner.

PANICUM DEPAUPERATUM INVOLUTUM (Torr.)
Georgesville, Franklin Co., Wm. C. Werner.

PANICUM DEPAUPERATUM LAXIFLORUM.
Ironton (Lawrence Co.) Wm. C. Werner.

PANICUM DICHOTOMUM L.
From Lake Erie to the Ohio river.

PANICUM FILIFORME L.
Franklin Co., W. S. Sullivant (Cat.)

PANICUM LINEARE Krock. (*P. glabrum* Schrad.)
Painesville, H. C. Beardslee (Cat.), Wm. C. Werner; Cleveland, E. Claassen; Lorain Co., A. A. Wright (Cat.); Columbus, Wm. C. Werner; Fairfield Co., E. V. Wilcox.

PANICUM LATIFOLIUM L.
Painesville, Wm. C. Werner; Cuyahoga Co., E. Claassen; Lorain Co., A. A. Wright (Cat.); Muskingum Co., W. R. Beattie; Lawrence Co., Wm. C. Werner; Cincinnati, Jos. F. James (Cat.)

PANICUM MICROCARPON Muhl.
Franklin Co., Aug. D. Selby; Fairfield Co., Wm. C. Werner.

PANICUM NITIDUM VILLOSUM Gray.
Painesville, Wm. C. Werner.

PANICUM PROLIFERUM Lam.
Painesville, H. C. Beardslee (Cat.), Wm. C. Werner; Cleveland, E. Claassen; Lorain Co., A. A. Wright (Cat.); Marion Co., W. D. Phillips; Franklin Co., Wm. C. Werner; Cincinnati, Jos. F. James (Cat.)

PANICUM SANGUINALE L. Common Crab or Finger Grass.
Common.

PANICUM SCOPARIUM Lam.
Sandusky, E. L. Moseley; Wood Co., Albert Neifer.

PANICUM VIRGATUM L.
Frequent along the sandy shores of Lake Erie.
Wood Co., Albert Neifer; Marion Co., W. D. Whipps; Franklin Co., Aug. D. Selby; Cincinnati, Jos. F. James (Cat.)

PANICUM XANTHOPHYSUM Gray.
"Northern Ohio," J. S. Newberry (Cat.)

543. CHÆRAPHIS R. Br. (*Setaria* Beauv.) BRISTLY FOXTAIL GRASS.

CHÆRAPHIS GLAUCA (L.) Kuntze. (*Setaria glauca* Beauv.) Foxtail Pigeon Grass.
Abundant.

CHÆRAPHIS ITALICA GERMANICA (L.) Kuntze. (*Setaria italica* Kunth.)
Cleveland, E. Claassen; Fairfield Co., E. V. Wilcox, S. Renshaw; Painesville, H. C. Beardslee (Cat.); Wm. C. Werner.

CHÆRAPHIS VERTICILLATA (L.) Porter. (*Setaria verticillata* L.)
Licking Co., H. L. Jones (Cat.)

CHÆRAPHIS VIRIDIS (L.) Porter. (*Setaria viridis* Beauv.) Green Foxtail. Bottle-grass.
Common.

544. CENCHRUS L. HEDGEHOG OR BURGRASS.

CENCHRUS TRIBULOIDES L.
Throughout the state.

545. ZIZANIOPSIS Doel. and Aschers.

ZIZANIOPSIS MILIACEA Doel. and Aschers. (*Zizania miliacea* Michx.)
"Southern Ohio," J. S. Newberry (Cat.)

546. ZIZANIA Gronov. Water or Indian Rice.

ZIZANIA AQUATICA L. Indian Rice. Water Oats.
Lake Co., Wm. C. Werner; Cuyahoga Co., E. Claasen; Toledo, J. A. Sanford; Wood Co., Albert Neifer; Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Janes (Cat.); Franklin Co., Wm. C. Werner; Fairfield Co., E. V. Wilcox; Cincinnati, Jos. F. James (Cat.)

547. HOMALOCENCHRUS Mieg. (*Leersia* Swartz.)

HOMALOCENCHRUS LENTICULARIS (Michx.). (*Leersia lenticularis* Michx.)
"Wet places," Germantown and Cincinnati, J. L. Riddell (Synop. 1835).

HOMALOCENCHRUS ORYZOIDES (L.) Poll. (*Leersia oryzoides* Swartz.) Rice cut grass.
Generally distributed over the state.

HOMALOCENCHRUS VIRGINICA (Willd.) Britt. (*Leersia virginica* Willd.) White grass.
Throughout the state.

548. PHALARIS L. CANARY GRASS.

PHALARIS ARUNDINACEA L. Reed Canary Grass.
Widely distributed.

PHALARIS CANARIENSIS L.
Cleveland, Wm. C. Werner; Wood Co., Albert Neifer; Columbus, W. R. Lazenby; Cincinnati, Jos. F. James (Cat.)

549. ANTHOXANTHUM L. SWEET VERNAL GRASS.

ANTHOXANTHUM ODORATUM L.
Painesville, Akron, Wm. C. Werner; Youngstown, R. H. Ingraham; Lorain Co., A. A. Wright (Cat.); Cincinnati, Jos. Clark (Cat.)

550. SAVASTANA Schrank. (*Hierochloe* Gmelin.) HOLY-GRASS.

SAVASTANA ODORATA L. (*Hierochloe borealis* Roem. & Shultes.) Vanilla or Seneca Grass.
Niles (Trumbull Co.) R. H. Ingraham; Columbus, Wm. C. Werner.

551. ARISTIDA L. TRIPLE-AWNED GRASS.

ARISTIDA DICHOTOMA Michx.
Fairfield Co., Wm. C. Werner.

ARISTIDA STRICTA Michx.
"General," J. S. Newberry (Cat.)

552. STIPA L. FEATHER GRASS.

STIPA AVENACEA L. Black Oat-Grass.
"General," J. S. Newberry (Cat.)

STIPA SPARTEA Trin. Porcupine Grass.
Cedar Point (Erie Co.) E. Claassen; Wood Co., Albert Neifer.

553. ORYZOPSIS Michx. MOUNTAIN RICE.

ORYZOPSIS ASPERIFOLIA Mx.
J. S. Newberry (Cat.) No locality given.

ORYZOPSIS JUNCEA (Mx.) B. S. P. (*O. canadensis* Torr.)
"Little Mountain" (Lake Co.) H. C. Beardslee (Cat.)

ORYZOPSIS MELANOCARPA Muhl.
Lorain Co., A. A. Wright (Cat.); Painesville H. C. Beardslee (Cat.); Franklin Co., W. S. Sullivant (Cat.)

554. MILIUM Tourn. MILLET GRASS.

MILIUM EFFUSUM L.
Painesville, H. C. B ardslee (Cat.), Wm. C. Werner; Cuyahoga Co., E. Classen; Lorain Co., A. A. Wright (Cat.); Franklin Co., Aug. D. Selby; Licking Co., H. L. Jones (Cat.)

555. MUHLENBERGIA Schreb. DROP-SEED GRASS.

MUHLENBERGIA CAPILLARIS (Lam.) Trin.
"General," J. S. Newberry (Cat.)

MUHLENBERGIA DIFFUSA Schreb.
Throughout the state.

MUHLENBERGIA MEXICANA (L.) Trin.
Throughout the state.

MUHLENBERGIA RACEMOSA (Michx.) B. S. P. (*M. glomerata* Trin.)
Cuyahoga Co., E. Claassen; Cedar Swamp (Champaign Co.) Wm. C. Werner; the specimens represent slender forms. Franklin Co., W. S. Sullivant (Cat.)

MUHLENBERGIA SOBOLIFERA (Muhl.) Trin.
Licking Co., H. L. Jones (Cat.); Cincinnati, Thos. G. Lea (Cat.)

MUHLENBERGIA SYLVATICA T. & G.
Huron Co., J. A. Sanford; Licking Co., H. L. Jones (Cat.); Cedar Swamp (Champaign Co.) Wm. C. Werner; Franklin Co., W. S. Sullivant (Cat.)

MUHLENBERGIA TENUIFLORA (Willd.) B. S. P. (*M. willdenovii* Trin.)
Painesville, Wm. C. Werner; Niles (Trumbull Co.) R. H. Ingraham; Cuyahoga Co., E. Claassen; Franklin Co., Wm. C. Werner; Fairfield Co., E. V. Wilcox Cincinnati, Jos. Clark (Cat.)

556. BRACHYELYTRUM Beauv.

BRACHYELYTRUM ERECTUM (Schreb.) Beauv. (*B. aristatum* Beauv.)
Painesville, Wm. C. Werner; Trumbull Co., R. H. Ingraham; Cuyahoga Co., E. Claassen; Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.); Columbus, Wm. C. Werner.

557. PHLEUM L. CAT'S TAIL GRASS.

PHLEUM PRATENSE L. Timothy.
Over the state.

558. ALOPECURUS L. FOXTAIL GRASS.

Alopecurus geniculatus L. Floating Foxtail.
Franklin Co., W. S. Sullivant (Cat.)

Alopecurus geniculatus aristulatus (Mx.) Torr.
"Put-in-Bay Island," Lake Erie, H. C. Beardslee (Cat.); Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.); Columbus, Wm. C. Werner.

Alopecurus pratensis L.
Cincinnati, Jos. Clark (Cat.)

559. BOUTELOUA Lag. Muskit Grass.

Bouteloua curtipendula (Mx.) Gray. (*B. racemosa* Lag.)
Adams Co., W. A. Kellerman; Franklin Co., Aug. D. Selby.

560. SPOROBOLUS R. Br. Drop-seed Grass. Rush Grass.

Sporobolus asper (Mx.) Kunth.
Lorain Co., A. A. Wright (Cat.)

Sporobolus brevifolius (Nutt.) Scribn. (*S. cuspidatus* Torr.)
Georgesville, Franklin Co., Wm. C. Werner.

Sporobolus cryptandrus (Torr.) Gray.
Sand beaches of Lake Erie; Painesville, Wm. C. Werner; Lorain Co., A. A. Wright (Cat.) Toledo, J. A. Sanford; Sandusky, E. L. Mosely; Catawba Island, E. Claassen.

Sporobolus heterolepis Gray.
Georgesville (Franklin Co.), Cedar Swamp (Champaign Co.) Wm. C. Werner.

Sporobolus vaginæflorus (Torr.) Vasey.
Painesville, Wm. C. Werner; Cleveland, E. Claassen; Lorain Co., A. A. Wright (Cat.); Champaign Co., Columbus, Wm. C. Werner; Fairfield Co., E. V. Wilcox.

561. CINNA L. Wood Reed-Grass.

Cinna arundinacea L.
Widely distributed.

Cinna latifolia (Trev.) Geiesb. (*C. pendula* Trin.)
Painesville, H. C. Beardslee (Cat.)

562. AGROSTIS L. Bent Grass.

Agrostis alba L. Fiorin or White Bent Grass.
Throughont the state.

Agrostis alba vulgaris (With.) Thurb. Red-top Herd's Grass.
Over the whole state.

AGROSTIS EXARATA Trin.
Painesville, Wm. C. Werner; Cleveland, E. Claassen; Franklin Co., Fairfield Co., Wm. C. Werner.

AGROSTIS SCABRA Willd. Hair Grass.
Painesville, Otto Hacker; Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.); Franklin Co., W. S. Sullivant (Cat.); Ironton (Lawrence Co.) Wm. C. Werner; Cincinnati, Jos. Clark (Cat.)

AGROSTIS PERENNANS (Walt.) Tuckerm.
Painesville, Wm. C. Werner; Lorain Co., A. A. Wright (Cat.); Columbus, Rendville (Perry Co.) Wm. C. Werner; Licking Co., H. L. Jones (Cat.); Cincinnati, Thos. G. Lea (Cat.)

563. CALAMAGROSTIS Adans. REED BENT GRASS.

CALAMAGROSTIS CANADENSIS (Michx.) Beauv. Blue Joint Grass.
Ashtabula Co., Sara F. Goodrich; Painesville, Wm. C. Werner; Lorain Co., A. A. Wright (Cat.); Toledo, J. A. Sanford; Wood Co., Albert Neifer; Marion Co., W. D. Whipps; Summit Co., E. Claassen; Franklin Co., W. S. Sullivant (Cat.)

563*a*. AMMOPHILA Host.

AMMOPHILA ARENARIA (L.) Link. (*A. arundinacea* Host.) Sea Sand-Reed.
Cedar Point (Ottawa Co.) E. Claassen, Aug. D. Selby.

564. HOLCUS L. MEADOW SOFT GRASS.

HOLCUS LANATUS L.
Painesville, H. C. Beardslee (Cat.), Wm. C. Werner; Niles (Trumbull Co.) R. H. Ingraham; Cleveland, E. Claassen.

565. DESCHAMPSIA Beauv.

DESCHAMPSIA CAESPITOSA (L.) Beauv.
"Northern Ohio," J. S. Newberry (Cat.); Cedar Swamp (Champaign Co.) Wm. C. Werner.

DESCHAMPSIA FLEXUOSA (L.) Griesb. Common Hair Grass.
"Central and Southern Ohio," J. S. Newberry (Cat.); Portage Co., E. Claassen.

566. TRISETUM Pers.

TRISETUM PALUSTRE (Mx.) Torr.
Painesville, Wm. C. Werner.

TRISETUM SPICATUM MOLLE (Mx.) Scrib.
"Northern Ohio," J. S. Newberry (Cat.)

567. AVENA Tourn. OAT.

AVENA FATUA L.
Licking Co., H. L. Jones (Cat.); Columbus, on grounds of Sells Brothers' circus, Wm. C. Werner.

AVENA STRIATA Michx.
"Northern Ohio," J. S. Newberry (Cat.); Cincinnati, Jos. F. James (Cat.)

568. ARRHENATHERUM Beauv. OAT GRASS.

ARRHENATHERUM ELATIUS (L.) Mert. & Koch. (*A. avenaceum* Beauv.)
Painesville, Columbus, Wm. C. Werner; Cincinnati, Thos. G. Lea (Cat.)

569. DANTHONIA DC. WILD OAT GRASS.

DANTHONIA SPICATA (L.) Beauv.
Frequent.

570. CAPRIOLA Adans. (*Cynodon* Rich.) BERMUDA or SCUTCH GRASS.

CAPRIOLA DACTYLON (L.) Kuntze. (*Cynodon dactylon* (L.) Pers.)
Licking Co., H. L. Jones (Cat.)

571. SPARTINA Schreb. CORD or MARSH GRASS.

SPARTINA CYNOSUROIDES (L.) Willd.
Painesville, Wm. C. Werner; Cuyahoga Co., Summit Co., E. Claassen; Lorain Co., A. A. Wright (Cat.); Sandusky, E. L. Moseley; Wood Co., Albert Neifer; Columbus, E. E. Bogue.

572. ELEUSINE Gaertn. CRAB GRASS, YARD GRASS.

ELEUSINE INDICA (L.) Gaertn. Dog's Tail or Wire Grass.
Widely distributed.

573. LEPTOCHLOA Beauv.

LEPTOCHLOA MUCRONATA (Mx.) Kunth.
"Southern Ohio," J. S. Newberry (Cat.)

574. PHRAGMITES Trin. REED.

PHRAGMITES PHRAGMITES (L.) Karst. (*P. communis* Trin.)
Ashtabula Co., E. E. Bogue; Mahoning Co., Lake Co., Wm. C. Werner; Cuyahoga Co., E. Claassen; Lorain Co., A. A. Wright (Cat.); Wood Co., Albert Neifer; Marion Co., W. D. Whipps; Franklin Co., W. S. Sullivant (Cat.)

575. SIEGLINGIA Bern. (*Triodia* R. Br.)

SIEGLINGIA SESLEROIDES (Mx.) Scrib. (*Triodia cuprea* Jacq.) Tall Red Top.
Painesville, Wm. C. Werner; Lorain Co., A. A. Wright (Cat.); Catawba Island, E. Claassen; Wood Co., Albert Neifer; Marion Co., W. D. Whipps; Warren Co., L. M. Gregg; Licking Co., H. L. Jones (Cat.); Cincinnati, Jos. F. James (Cat.)

SIEGLINGIA PURPUREA (Walt.) Kuntze. (*Triodia purpurea* Hack.) Sand Grass.
Frequent along the sand beaches of Lake Brie.

577. ERAGROSTIS Beauv.

ERAGROSTIS CAPILLARIS (L.) Nees.
Painesville, Otto Hacker; Licking Co., H. L. Jones (Cat.); Columbus, Wm. C. Werner; Cincinnati, Jos. Clark (Cat.)

ERAGROSTIS CAROLINIANA (Spring.) Scrib. (*E. purshii* Schrad.)
Painesville, Wm. C. Werner; Cleveland, E. Claassen; Lorain Co., A. A. Wright (Cat.); Wood Co., Albert Neifer; Columbus, Wm. C. Werner; Licking Co., H. L. Jones (Cat.); Athens, W. A. Kellerman.

ERAGROSTIS ERAGROSTIS (L.) Karst. (*E. minor* Host.)
Licking Co., H. L. Jones (Cat.); Painesville, Wm. C. Werner.

ERAGROSTIS FRANKII Meyer.
Frequent throughout the northern half of the state; no specimens seen from south of Fairfield Co.

ERAGROSTIS HYPNOIDES (Lam.) B. S. P. (*E. reptans* Nees.)
Frequent along the borders of streams.

ERAGROSTIS MAJOR Host.
Common in cultivated ground and waste places.

ERAGROSTIS PECTINACEA (Mx.) Steud.
"Ohio," A. Gray (Man.)

ERAGROSTIS PILOSA (L.) Beauv.
Painesville, Otto Hacker; Licking Co., H. L. Jones (Cat.); Cincinnati, Jos. F. James (Cat.)

578. KŒLERIA Pers.

KŒLERIA CRISTATA (L.) Pers.
Franklin Co., W. S. Sullivant (Cat.)

579. EATONIA Raf.

EATONIA DUDLEYI Vasey.
Cuyahoga Co., E. Claassen; Marion Co., W. D. Whipps; Painesville, Columbus, Fairfield Co., Lawrence Co., Wm. C. Werner; Logan (Hocking Co.) W. A. Kellerman.

EATONIA OBTUSATA (Mx.) Gray.
Franklin Co., W. S. Sullivant (Cat.); Cincinnati, Thos. G. Lea (Cat.)

EATONIA PENNSYLVANICA (Spreng.) Gray.
Painesville, Wm. C. Werner; Cuyahoga Co., E. Claassen; Lorain Co., A. A. Wright (Cat.); Toledo, J. A. Sanford; Columbus, Fairfield Co., Wm. C. Werner; Licking Co., H. L. Jones (Cat.)

580. MELICA L. MELIC-GRASS.

MELICA MUTICA Walt.
Franklin Co., W. S. Sullivant (Cat.)

581. DIARRHENA Raf.

DIARRHENA DIANDRA (Mx.) Hitch. (*D. americana* Beauv.)
Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.); Cincinnati, Jos. Clark (Cat.); Franklin Co., Wm. C. Werner.

582. UNIOLA L. SPIKE-GRASS.

UNIOLA LATIFOLIA Mx.
Cincinnati, Jos. Clark (Cat.)

583. DACTYLIS. L. ORCHARD-GRASS.

DACTYLIS GLOMERATA L.
Common.

584. POA L. MEADOW-GRASS. SPEAR-GRASS.

POA ALSODES Gray.
Painesville, H. C. Beardslee (Cat.); Wm. C. Werner; Cleveland, E. Claassen; Lorain Co., A. A. Wright (Cat.); Cuyahoga Falls (Summit Co.), Hanging Rock (Lawrence Co.) Wm. C. Werner.

POA ANNUA L.
Frequent.

POA BREVIFOLIA Muhl.
Niles (Trumbull Co.) R. H. Ingraham; Painesville, Columbus, Wm. C. Werner; Cuyahoga Co., E. Claassen; Lorain Co., A. A. Wright (Cat.); Ironton (Lawrence Co.) Wm. C. Werner.

POA COMPRESSA L. Wire-grass. English Blue-grass.
Over the whole state.

POA DEBILIS Torr.
Lake Co., Franklin Co., Wm. C. Werner.

POA FLEXUOSA Muhl.
Licking Co. H. L. Jones (Cat.)

POA PRATENSIS L. June grass. Spear-grass. Kentucky blue grass.
Everywhere.

POA SEROTINA Ehrh. False red top. Fowl Meadow-grass
Painesville, H. C. Beardslee (Cat), Wm. C. Werner; Geauga Co., E. Claassen; Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.)

POA SYLVESTRIS Gray.
Lorain Co., A. A. Wright (Cat.); Painesville, Columbus, Lawrence Co., Wm. C. Werner.

POA TRIVIALIS L.
Painesville, Otto Hacker; Lorain Co., A. A. Wright (Cat.); Franklin Co., W. S. Sullivant (Cat.); Cincinnati, Joseph Clark (Cat.)

585. GLYCERIA R. Br. MANNA-GRASS.

GLYCERIA BREVIFOLIA (Muhl.) Schult. (*G. acutiflora* Torr.)
Lancaster (Fairfield Co.) J. M. Bigelow (J. S. Newberry, Cat.); Licking Co., H L. Jones (Cat.)

GLYCERIA CANADENSIS (Mx.) Trin. Rattlesnake grass.
Painesville, Wm. C. Werner; Summit Co., E. Claassen; Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.)

GLYCERIA ELONGATA (Torr.) Trin.
Painesville, H. C. Beardslee (Cat.), Wm. C. Werner, Licking Co., H. L. Jones (Cat.)

GLYCERIA FLUITANS (L.) Torr.
Lake Co., Wm. C. Werner; Lorain Co., A. A. Wright (Cat.); Wood Co., Albert Neifer; Franklin Co., Wm. C. Werner; Licking Co., H. L. Jones (Cat.); Cincinnati, Thos. G. Lea (Cat.)

GLYCERIA GRANDIS Watson. Reed meadow-grass.
Painesville, H. C. Beardslee (Cat.)

GLYCERIA NERVATA (Willd.) Trin. Fowl meadow-grass.
From Lake Erie to the Ohio River.

GLYCERIA OBTUSA (Nutt.) Trin.
"Southern Ohio," J. L. Riddell (J. S. Newberry, Cat.)

GLYCERIA PALLIDA (Eddy) Trin.
Painesville, H. C. Beardslee (Cat.); Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.)

586. FESTUCA L. FESTUCA-GRASS.

FESTUCA DURIUSCULA L. (*F. ovina duriuscula* Gr.) Sheep's Fescue.
"Northern Ohio," Leo Lesquereux (J. S. Newberry, Cat.)

FESTUCA ELATIOR L. Taller or Meadow Fescue.
Frequent throughout the state.

FESTUCA ELATIOR PRATENSIS Gray.
Cleveland, E. Claassen; Licking Co., H. L. Jones (Cat.); Cincinnati, Thos. G. Lea (Cat.)

FESTUCA NUTANS Willd.
Frequent in woods throughout the state.

FESTUCA OCTOFLORA Walt. (*F. tenella* Willd.)
Painesville, Otto Hacker; Cedar Point (Erie Co.) E. Claassen; Toledo, J. A. Sanford; Ironton (Lawrence Co.), Wm. C. Werner.

FESTUCA OVINA L. Sheep's Fescue.
Painesville, Otto Hacker.

587. BROMUS L. BROME GRASS.

BROMUS CILIATUS L.
Frequent throughout the state.

BROMUS KALMII Gray.
Georgesville (Franklin Co.) Wm. C. Werner.

BROMUS MOLLIS L.
Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.)

BROMUS PURGANS L. (*B. ciliatus purgans* Gray.)
Painesville, Wm. C. Werner; Lorain Co., A. A. Wright (Cat.); Wood Co., Albert Neifer; Licking Co., H. L. Jones (Cat.); Franklin Co., Wm. C. Werner; Cincinnati, Jos. F. James (Cat.)

BROMUS RACEMOSUS L. Upright Chess,
Frequent in waste places and cultivated fields.

BROMUS SECALINUS L. Chess. Cheat.
Frequent in grain fields and waste places.

BROMUS STERILIS L.
Painesville, Columbus, Wm. C. Werner.

BROMUS TECTORUM L.
Painesville, Wm. C. Werner; Cleveland, H. C. Beardslee, Jr., this specimen referred to as *B. sterilis* in Lazenby & Werner Sup. List. Licking Co., H. L. Jones (Cat.)

588. LOLIUM L. DARNEL.

LOLIUM PERENNE L. Common Darnel. Ray or Rye-Grass.
Lake Co., Wm. C. Werner; Cleveland, E. Claassen; Lorain Co., A. A. Wright (Cat.); Wood Co., Albert Neifer; Marion Co, W. D. Whipps; Licking Co., H L. Jones (Cat.); Cincinnati, Jos. F. James (Cat.)

589. AGROPYRUM Gaertn.

AGROPYRUM REPENS Beauv. Quack-Grass. Couch-Grass. Quick-Grass.
Frequent in fields and waste places.

590. HORDEUM Tourn.

HORDEUM JUBATUM L. Squirrel-Tail Grass.
"Lake Shore," H. C. Beardslee (Cat.); Wickliffe (Lake Co.) E. Claassen; Lorain Co., A. A. Wright (Cat.); Wood Co., Albert Neifer.

HORDEUM PRATENSE Huds.
"Ohio," A. Gray (Man.)

591. ELYMUS L. LYME-GRASS. WILD RYE.

ELYMUS CANADENSIS L.
Throughout the state.

ELYMUS CANADENSIS GLAUCIFOLIUS (Muhl.) Gray.
Lorain Co., A. A. Wright (Cat.); Painesville, Wm. C. Werner; Wood Co., Albert Neifer.

ELYMUS STRIATUS Willd.
Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.); Cincinnati, Jos. F. James (Cat.)

ELYMUS STRIATUS VILLOSUS Gray.
Painesville, H. C. Beardslee (Cat.), Wm C. Werner; Columbus, Wm. C. Werner.

ELYMUS VIRGINICUM L.
Throughout the state.

592. ASPRELLA Willd. BOTTLE-BRUSH GRASS.

ASPRELLA HYSTRIX (L.) Willd.
Frequent.

592*a*. ARUNDINARIA Michx. CANE.

ARUNDINARIA MACROSPERMA SUFFRUTICOSA Munro. Switch Cane. Small Cane.
Miami Valley, A. P. Morgan (Flora).

CXX. Order HYDROCHARIDACEÆ. Frog's-bit Family.

593. ELODEA Mx. Water-Weed.

Elodea canadensis Mx.
Occurring generally over the state.

594. VALLISNERIA L. Tape Grass. Eel Grass.

Vallisneria spiralis L.
Generally distributed over the state.

CXXI. ALISMACEÆ. Water Plantain Family.

595. ALISMA L. Water Plantain.

Alisma plantago L.
Common.

596. SAGITTARIA L. Arrow-Head.

Sagittaria heterophylla Ph.
Painesville, Otto Hacker; Licking Co., H. L. Jones (Cat.)

Sagittaria heterophylla angustifolia Englm.
Licking Co., H. L. Jones (Cat.)

Saggittaria heterophylla elliptica Englm.
Painesville, Otto Hacker.

Sagittaria heterophylla rigida (Ph.) Morong.
Painesville, Otto Hacker; Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.)

Sagittaria sagittaefolia L. (*S. variabilis* Englm.)
Common and very variable.

Sagittaria sagittaefolia angustifolia (Englm.) Britt.
Licking Co., H. L. Jones (Cat.)

Sagittaria sagittaefolia diversifolia Englm.
Lorain Co., A. A. Wright (Cat.); Franklin Co., Selby & Craig (Cat.)

Sagittaria sagittaefolia gracilis (Pursh.) Englm.
Licking Co., H. L. Jones (Cat.)

Sagittaria sagittaefolia latifolia (Willd.) Britt.
Licking Co., H. L. Jones (Cat.)

Sagittaria sagittaefolia obtusa (Willd.) Britt.
Licking Co., H L Jones (Cat.)

CXXII. ORDER JUNCAGINACEÆ. Arrow Grass Family.

597. TRIGLOCHIN L. ARROW-GRASS.

TRIGLOCHIN MARITIMA L.
Franklin Co., W. S. Sullivant (Cat. 1840); Cedar Swamp (Champaign Co.) Wm. C. Werner.

TRIGLOCHIN PALUSTRIS L.
Franklin Co., W. S. Sullivant (Cat. 1840.)

598. SCHEUCHZERIA L.

SCHEUCHZERIA PALUSTRIS L.
Lorain Co., A. A. Wright (Cat.); Licking Reservoir, Wm. C. Werner.

CXXIII. ORDER POTAMOGETONACEÆ. Pond-weed Family.

599. POTAMOGETON L. POND-WEED.

POTAMOGETON AMPLIFOLIUS Tuck.
Congress Lake (Stark Co.) W. L. Crubaugh.

POTAMOGETON FOLIOSUS Raf. (*P. pauciflorus* Ph.)
Congress Lake (Stark Co.) W. L. Crubaugh.

POTAMOGETON HETEROPHYLLUS Schreb.
"General, Northern Ohio," H. C. Beardslee (Cat.)

POTAMOGETON HETEROPHYLLUS MAXIMUS Morong.
Painesville, Wm. C. Werner.

POTAMOGETON DIVERSIFOLIUS Raf. (*P. hybridus* Mx.)
Painesville, H. C. Beardslee (Cat.)

POTAMOGETON LONCHITES Tuckm.
"General, Northern Ohio," H. C. Beardslee (Cat.); Painesville, Wm. C. Werner

POTAMOGETON LUCENS L.
"Northern Ohio, rare," H. C. Beardslee (Cat.)

POTAMOGETON NATANS L.
Common.

POTAMOGETON NUTTALLII Cham. & Schl. (*P. pennsylvanicus* Willd.)
"General," H. C. Beardslee (Cat.)

POTAMOGETON OBTUSIFOLIUS Mert. & Koch.
Lorain Co., A. A. Wright (Cat.)

POTAMOGETON PECTINATUS L.
Not uncommon.

POTAMOGETON PERFOLIATUS L.
Painesville, Wm. C. Werner; Cleveland (inland lakes), Wm. Krebs.

POTAMOGETON PRAELONGUS Wulf.
"Northern Ohio, rare," H. C. Beardslee (Cat.)

POTAMOGETON ROBBINSII Oakes.
Geauga Co., Dr. Canfield (H. C. Beardslee Cat.); Summit Co., E. Claassen.

POTAMOGETON SPIRILLUS Tuckm.
Painesville, H. C. Beardslee (Cat.)

POTAMOGETON ZOSTERAEFOLIUS Schum.
"General," J. S. Newberry (Cat.); "common," H. C. Beardslee (Cat.); Congress Lake (Stark Co.), W. L. Crubaugh.

600. ZANNICHELLIA Micheli. HORNED POND-WEED.

ZANNICHELLIA PALUSTRIS L.
"Common," H. C. Beardslee (Cat.); Athens, W. A. Kellerman; Cincinnati, Thos. G. Lea (Cat.), C. B. Going (Jos. F. James Cat.)

601. NAIAS L. Naiad.

NAIAS FLEXILIS (Willd.) Rost. & Schmidt.
Painesville, Wm. C. Werner; Silver Lake, Wm. Krebs; Columbus, J. H. Lageman; Cincinnati, Thos. G. Lea (Cat.).

CXXV. ORDER SPARGANIACEÆ. Bur-reed Family.

602. SPARGANIUM Tourn. BUR-REED.

SPARGANIUM ANDROCLADIUM (Englm.) Morong. (*S. simplex androcladium* Englm.)
Frequent.

SPARGANIUM EURYCARPUM Englm.
Frequent.

CXXVI. ORDER TYPHACEÆ. Cat-tail Family.

603. TYPHA Tourn. CAT-TAIL FLAG.

TYPHA AUGUSTIFOLIA L.
"General," J. S. Newberry (Cat.); Lorain Co., A. A. Wright (Cat.)

TYPHA LATIFOLIA L.
Common.

(Misplaced Genera.)

604 (2*a*) AGERATUM L.

Ageratum conyzoides L.
Southern Ohio, Miss Jones (Lazenby & Werner, Sup. List.)

605. (195*a*) Chiogenes Salisb. Creeping Snowberry.

Chiogenes hispidula (L.) T. & G. (*C. serpyllifolia* Salisb.)
Tamarack Swamp near Myer's Lake, Canton, E. W. Vickers.

606. (442*a*) Polygonella Michx.

Polygonella articulata Meisn. (*Polygonum articulatum* Gray).
"Lake shore, rare" H. C. Beardsler (Cat.)

607. (307*a*) WISTARIA Nutt.

Wistaria frutescens Poir.
Miami Valley, A. P. Morgan (Flora).

CXXVII (XXIV*a*) Order LOGANIACEÆ.

608. (172*a*) SPIGELIA L. Pink Root. Worm Grass.

Spigelia marilandica L. Maryland Pink root.
Miami Valley, A. P. Morgan (Flora).

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TO THE

FLOWERING PLANTS (ANGIOSPERMES).

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Gymnosperms.

Order CONIFERÆ. Pine Family.

1. PINUS Tourn. Pine.

Pinus divaricata (Ait.) Sudw. (*P. banksiana* Lamb.) Gray or Northern Scrub Pine.
"Southern and Northern Ohio," J. S. Newberry (Cat.); Marietta, Ohio, rare; J. L. Riddell (Synop. 1835). Not reported recently nor found by us.

Pinus virginiana Mill. (*P. inops* Ait.) Jersey or Scrub Pine.
With the Pitch Pine in southern part of the state.

Pinus resinosa Ait. Red Pine.
"Northern Ohio," H. C. Beardslee (Cat.)

Pinus rigida Mill. Pitch Pine.
Throughout the southern half of the state.

Pinus strobus L. White Pine.
Lorain Co., A. A. Wright (Cat.); Lake Co., Wm. C. Werner.

2. LARIX Tourn. Larch.

Larix laricina (Du Roi) Koch. (*L. americana* Michx.) American or Black Larch. Tamarack.
Summit Co., E. W. Claypole; Licking Co., H. L. Jones (Cat.); Ashtabula Co., E. E. Bogue.

3. TSUGA Carrière. Hemlock.

Tsuga canadensis (L.) Carr.
Frequent throughout the northern half of the state, extending southward to Ross and Hocking counties.

4. THUJA Tourn. Arbor Vitæ.

Thuja occidentalis L. Arbor Vitæ. White Cedar.
Urbana (Champaign Co.) Wm. C. Werner; Franklin Co., Wm. C. Werner; "Falls of the Little Miami," Daniel Drake in "Pictures of Cincinnati, 1815; Ross Co., W. A. Kellerman; Miami Valley, A. P. Morgan (Flora).

5. CHÆMÆCYPARIS Spach. White Cedar. Cypress.

Chæmæcyparis thyoides (L.) B. S. P. (*C. spæroidea* Spach. *Cupressus thyoides* L.)
This, in the older Catalogues, undoubtedly refers to *Thuja occidentalis* L.

6. JUNIPERUS L. Juniper.

Juniperus communis L. Common Juniper.
Summit Co., J. S. Newberry (Cat.); Painesville, Wm. C. Werner; Cuyahoga Co., Wm. Krebs.

Juniperus virginiana L. Red Cedar or Savin.
Throughout the state.

TAXUS Tourn. Yew.

Taxus minor (Michx.) Britt. (*T. canadensis* Willd.) American Yew. Ground Hemlock.
Throughout the northern half of the state.

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TO THE

GENERA OF GYMNOSPERMS.

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Vascular Cryptogams.

I. Order SELAGINELLACEÆ.

1. SELAGINELLA Beauv.

SELAGINELLA RUPESTRIS (L.) Spring.
"General," J. S. Newberry (Cat.)

II. Order ISOETACEÆ.

2. ISOETES L. Quillwort.

ISOETES LACUSTRIS L.
"Northern Ohio, Rare," H. C. Beardslee (Cat.)

III. Order SALVINIACEÆ.

3. AZOLLA Lam.

AZOLLA CAROLINIANA Willd.
Painesville, H. C. Beardslee (Cat.), Wm. C. Werner.

IV. Order LYCOPODIACEÆ.

4. LYCOPODIUM L. Club Moss.

LYCOPODIUM ANNOTINUM L.
"Northern Ohio," J. S. Newberry (Cat.); "Central Ohio," J. L. Riddell (Synop. 1835).

LYCOPODIUM CAROLINIANUM L.
"Southern Ohio," J. S. Newberry (Cat,)

LYCOPODIUM CLAVATUM L.
"Northern Ohio," J. S. Newberry (Cat.); Fairfield Co., E. V. Wilcox, S. Renshaw.

LYCOPODIUM COMPLANATUM L.
"General," J. S. Newberry (Cat.); Licking Co., H. L. Jones (Cat.); Lorain Co., A. A. Wright (Cat.)

Lycopodium lucidulum Mx.
Not abundant, but over the state.

Lycopodium obscurum L. (*L. dendroideum* Michx.)
Licking Co., H. L. Jones (Cat.); Ashtabula Co., Sara F. Goodrich.

Lycopodium inundatum L.
"Northern Ohio," J. S. Newberry (Cat.)

V. Order EQUISETACÆ. Horsetail Family.

5. EQUISETUM L. Horsetail. Scouring Rush.

Equisetum arvense L. Common Horsetail.
Widely distributed in gravelly or sandy soil.

Equisetum hyemale L. Scouring Rush. Shave Grass.
Over the whole state along wet banks.

Equisetum lævigatum A. Braun.
Summit Co., E. Claassen.

Equisetum limosum L. Horsetail.
Lake Marshes, H. C. Beardslee (Cat.); Lorain Co., A. A. Wright (Cat.); Cincinnati, J. F. James (Cat.); Painesville, Wm. C. Werner; "Hoffman's Prairie near Dayton," J. L. Riddell (Synop. 1835).

Equisetum robustum A. Braun. Horsetail.
Painesville, H. C. Beardslee (Cat.); Cincinnati, Thos. G. Lea (Cat).

Equisetum scirpoides Mx. Horsetail.
"Northern Ohio," J. S. Newberry (Cat.)

Equisetum sylvaticum L. Horsetail.
"Low Woods, Central Ohio," J. L. Riddell (Synop. 1835); Painesville, Otto Hacker; Cincinnati, J. F. James (Cat.)

Equisetum variegatum Schleich.
Black River, Dr. Kellogg (J. S. Newberry Cat.); Painesville, W. C. Werner.

VI. Order FILICES. Fern Family.

6. POLYPODIUM L. Polypody.

Polypodium polypodioides (L.) Hitch. (*P. incanum* Swtz.)
Monroe, J. L. Riddell (Synop. 1835); Cincinnati, J. F. James (cat.); Adams Co., W. A. Kellerman; Miami Valley, A. P. Morgan (Flora.)

Polypodium vulgare L.
Common.

7. ADIANTUM L. Maidenhair.

Adiantum pedatum L.
Throughout the whole state.

8. PTERIS L. Brake or Bracken.

Pteris aquilina L. Common Brake.
From Lake Erie to the Ohio River.

9. PELLÆA Link. Cliff Brake.

Pellæa atropurpurea (L.) Link. Cliff Brake.
"Put-in-Bay Island" Lake Erie, H. C. Beardslee (Cat.); Springfield, Miss H. J. Biddlecome; Franklin Co., Aug. D. Selby; Adams Co., W. A. Kellerman.

10. WOODWARDIA J. E. Smith. Chain-fern.

Woodwardia areolata (L.) Moore. (*W. angustifolia* Smith).
Northern and Eastern Ohic, J. S. Newberry (Cat.)

Woodwardia virginica (L.) J. E. Smith.
"Munson Pond" (Geauga Co.) H. C. Beardslee (Cat.); Portage Co., E. Claassen

11. ASPLENIUM L. Spleenwort.

Asplenium acrostichoides Sw. (*A. thelypteroides* Mx.)
Over the whole state.

Asplenium angustifolium Mx.
Throughout the whole state.

Asplenium filix-foemina (L.) Bernh.
Common throughout the state.

Asplenium montanum Willd.
Elyria, Lorain Co., Dr. Kellogg, (J. S. Newberry Cat.); Lorain Co., A. A. Wrigh. (Cat.); Cuyahoga Falls (Summit Co.) Wm. Krebs; Clifton (Greene Co.) Mrs. E. J. Spence; along the Mahoning River, E. W. Vickers.

Asplenium pinnatifidum (Muhl.) Nutt.
Licking Co., H. L. Jones (Cat.); Lawrence Co., W. C. Werner; Elyria, Dr. Kellogg (J. S. Newberry Cat.); Sugar Grove, Fairfield Co., E. V. Wilcox, S. Renshaw; Hocking Co., W. A. Kellerman.

Asplenium platyneuron (L.) Oakes. (*A. ebeneum* Ait.)
Apparently over the whole state.

Asplenium ruta-muraria L.
"Central Ohio," W. S. Sullivant (Cat.); Miami Valley A. P. Morgan (Flora.)

Asplenium trichomanes L.
Widely distributed.

12. CAMPTOSORUS Link. Walking Leaf.

Camptosorus rhizophyllus (L.) Link.
Widely distributed.

13. PHEGOPTERIS Fee. Beech Fern.

Phegopteris connectilis (Mx.) B. S. P. (*P. polypodioides* Fee.)
Cleveland, W. Krebs; Lorain Co., A. A. Wright (Cat.); Painesville, H. C. Beardslee (Cat.); Thompson Ledge (Geauga Co.), Cuyahoga Falls (Summit Co.) Wm. C. Werner; Youngstown, R. H. Ingraham.

Phegopteris dryopteris (L.) Fee.
Thomson Ledge, H. C. Beardslee (Cat.)

Phegopteris hexagonoptera (Michx.) Fee.
Throughout the state.

14. DRYOPTERIS Adams. (*Aspidium* Swartz.) Shield Fern. Wood Fern.

Dryopteris acrostichoides (Mx.) Kuntze. (*Aspidium acrostichoides* Swartz. Christmas Fern.
Common over the state.

Dryopteris acrostichoides schweinitzii (Beck) B. S. P. (*Aspidium acrostichoides incisum* Gr.)
Licking Co., H. L. Jones (Cat.); Central Ohio, W. S. Sullivant (Cat.); Miami Valley, A. P. Morgan (Flora).

Dryopteris cristata (L.) A. Gray. (*Aspidium cristatum* Swartz.)
Lorain Co., A. A. Wright (Cat.); Cedar Swamp (Urbana) Mrs. E. J. Spence; Lake Co., Licking reservoir (Licking Co.) Wm. C. Werner.

Dryopteris cristata clintoniana (D. C. Eaton) Underw. (*Aspidium cristatum clintonianum* D. C. Eaton.)
Painesville, H. C. Beardslee (Cat.), O. Hacker.

Dryopteris goldieana (Hook.) Gray. (*Aspidium goldieanum* Hook.)
Widely distributed.

Dryopteris marginalis (L.) Gray. (*Aspidium marginale* Swartz.)
Common throughout the state.

Dryopteris noveboracensis (L.) Gray. (*Aspidium noveboracense* Swartz)
Throughout the state.

Dryopteris spinulosa (Retz.) Kuntze. (*Aspidium spinulosum* Swartz)
Not uncommon.

Dryopteris spinulosa dilatata (Hoffm.) Underw. (*Aspidium spinulosum dilatatum* Hook.)
"General," H. C. Beardslee (Cat.)

DRYOPTERIS SPINULOSA INTERMEDIA (Muhl.) Underw. (*Aspidium spinulosum intermedium* D. C. Eaton.)
Sandusky, E. L. Mosely; Lorain Co., A. A. Wright (Cat.); Fairfield Co., E. V. Wilcox, S. Renshaw; Franklin Co., Aug. D. Selby; Painesville, H. C. Beardslee (Cat.), Wm. C. Werner; Ashtabula Co., Sara F. Goodrich.

DRYOPTERIS THELYPTERIS (L.) Gray. (*Aspidium thelypteris* Swartz)
Widely distributed.

15. CYSTOPTERIS Bernhardi. BLADDER FERN.

CYSTOPTERIS BULBIFERA (L.) Bernh.
Throughout the state.

CYSTOPTERIS FRAGILIS (L.) Bernh.
Widely distributed.

16. ONOCLEA L.

ONOCLEA SENSIBILIS L.
Widely distributed.

ONOCLEA STRUTHIOPTERIS (L.) Hoffmann.
Lorain Co., A. A. Wright (Cat.); Painesville, H. C. Beardslee (Cat.); Wm. C. Werner.

17. WOODSIA R. Brown.

WOODSIA GLABELLA R. Brown.
Elyria, Lorain Co., Dr. Kellogg (J. S. Newberry Cat.)

WOODSIA ILVENSIS R. Brown.
Licking Co., H. L. Jones (Cat.)

WOODSIA OBTUSA (Spreng.) Torr.
Springfield, Miss H. J. Biddlecome; Licking Co., H. L. Jones (Cat.); Fairfield Co., A. D. Selby. Painesville, H. C. Beardslee (Cat.); Franklin Co., Lawrence Co., Wm. C. Werner.

19. LYGODIUM Swartz. CLIMBING FERN.

LYGODIUM PALMATUM (Bernh.) Swartz.
"Southhern and Eastern Ohio," J. S. Newberry (Cat.)

20. OSMUNDA L. FLOWERING FERN.

OSMUNDA CINNAMOMEA L Cinnamon Fern.
Occurring over the state.

OSMUNDA CLAYTONIANA L.
Widely distributed.

OSMUNDA REGALIS L.
Not uncommon.

VI. Order OPHIOGLOSSACEÆ.

21. BOTRYCHIUM Swartz. Moonwort.

Botrychium matricariaefolium Braun.
Columbus, A. P. Morgan (Bot. Gaz., July 1882.)

Botrychium lanceolatum (Gmel.) Angstroem.
"Ohio," Gray's Manual.

Botrychium simplex Hitchcock.
Elyria (Loraiu Co.) Dr. Kellogg (Newberry Cat.)

Botrychium ternatum intermedium Eaton.
Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.)

Botrychium ternatum lunarioides Milde.
Cincinnati, J. F. James (Cat.); Painesville, H. C. Beardslee (Cat.)

Botrychium ternatum obliquum (Muhl.) Milde.
Lorain Co., A. A Wright (Cat.); Cincinnati, J. F. James; Franklin Co., Aug. D. Selby; Painesville, H. C. Beardslee (Cat.); Ashtabula Co., Sara F. Goodrich; Springfield, Mrs. E. J. Spence.

Botrychium ternatum dissectum (Spreng.) Milde.
Lorain Co., A. A. Wright (Cat.); Painesville, Columbus, Wm. C. Werner; Cincinnati, J. F. James (Cat.); Franklin Co., Aug. D. Selby.

Botrychium virginianum (L.) Swartz.
From Lake Erie to the Ohio River.

22. OPHIOGLOSSUM L. Adder's Tongue.

Ophioglossum vulgatum L.
Columbiana Co., H. Wolfgang; Franklin Co., L. H. McFadden; Cinciunati, J. F. James (Cat.); Painesville, H. C. Beardslee (Cat.), Otto Hacker.

Bryophyta.*

Class I.—SPHAGNA.

1. SPHAGNUM L. Bog Moss.

Sphagnum acutifolium Ehrh.
Ohio, H. C. Beardslee (Cat.) ; Cedar Swamp (Champaign Co.) Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

Sphagnum cuspidatum (Ehrh.) R. & W.
Ohio, H. C. Beardslee (Cat.)

Sphagnum recurvum (Beauv.) Russ & Warnst. (*S. cuspidatum recurvum* Beauv.)
Ohio, H. C. Beardslee (Cat.)

Sphagnum cymbifolium Ehrh.
Ohio, H. C. Beardslee (Cat.); Miami Valley, A. P. Morgan (Flora).

Sphagnum squarrosum Pers.
Ohio, Leo Lesquereux (H. C. Beardslee, Cat.)

Sphagnum strictum Lindb. (*S. girgensohnii* Russow.)
Painesville, H. C. Beardslee (Cat.)

Sphagnum subsecundum Nees.
Ohio, Leo Lesquereux (H. C. Beardslee, Cat.)

Sphagnum subsecundum lescurii (Sull.) Aust.
Ohio, H. C. Beardslee (Cat.)

Class 2.—MUSCI.

Sub-Class I.—ACROCARPI.

I. POLYTRICHACEÆ.

2. POLYTRICHUM L.

Polytrichum commune L.
"Common," H. C. Beardslee (Cat.)

*Thanks are due Mrs. Britton for aid in identifying the specimens and correcting the nomenclature (Wm. C. Werner

POLYTRICHUM GRACILE Menzies.
"Ohio," Leo Lesquereux (H. C. Beardslee, Cat.)

POLYTRICHUM JUNIPERUM Willd.
"Common," H. C. Beardslee (Cat.)

POLYTRICHUM OHIOENSE Ren. & Card. (*P. formosum* Sull., not Hedw.)
"Common," H. C. Beardslee (Cat.)

POLYTRICHUM PILIFERUM Schreb.
"Ohio," Leo Lesquereux (H. C. Beardslee, Cat.)

POLYTRICHUM TENUE Menzies. (*Pogonatum brevicaule* Beauv.)
Painesville, Rendville (Perry Co.), Fairfield Co., W. C. Werner.

3. CATHARINEA Ehrh. (*Atrichum* Beauv.)

CATHARINEA ANGUSTATA Brid. (*Atrichum angustatum* Br. & Sch.)
Painesville, Franklin Co., Fairfield Co., Wm. C. Werner; Springfield, Miss. H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

CATHARINEA UNDULATA (L.) Web. & Mohr. (*Atrichum undulatum* Beauv.)
Frequent.

II. BUXBAUMIACEÆ.

4. BUXBAUMIA Haller.

BUXBAUMIA APHYLLA L.
Painesville, Wm. C. Werner.

III. GEORGIACEÆ.

5. GEORGIA Ehrh.

GEORGIA PELLUCIDA (L.) Rabenh. (*Tetraphis pellucida* Hedw.)
Painesville, Sugar Grove (Fairfield Co.) Wm. C. Werner; Champaign Co., Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

IV. FISSIDENTACEÆ.

6. FISSIDENS Hedw.

FISSIDENS ADIANTOIDES (L.) Hedw.
Painesville, Lawrence Co., Wm. C. Werner; Cedar Swamp (Champaign Co.) Miss H. J. Biddlecome, Wm. C. Werner; Miami Valley, A. P. Morgan (Flora).

FISSIDENS BRYOIDES (L.) Hedw.
Painesville, Columbus, Wm. C. Werner.

FISSIDENS DECIPIENS DeNot.
Fultonham (Muskingum Co.) Wm. C. Werner; Cedar Swamp (Champaign Co.) Miss H. J. Biddlecome.

FISSIDENS EXIGUUS Sull.
"Ohio," Leo Lesquereux (H. C. Beardslee, Cat.); Columbus, Wm. C. Werner.

FISSIDENS HYALINUS Hook. & Wils.
"Moist rocky ledges at Bank Lick near Cincinnati, T. G. Lea;" "clay banks near Painesville, H. C. Beardslee, very rare" (Lesq. & James, Man.)

FISSIDENS INCURVUS Web. & Mohr.
"Ohio," Leo Lesquereux (H. C. Beardslee, Cat.); Springfield, Miss H. J. Biddlecome.

FISSIDENS JULIANUS (Savi.) Schimp. (*Conomitrium julianum* Mont.)
"Ohio," Leo Lesquereux (H. C. Beardslee, Cat.)

FISSIDENS MINUTULUS Sull.
"Ohio," Leo Lesquereux (H. C. Beardslee, Cat.); Painesville, Columbus, Rendville (Perry Co.) Wm. C. Werner; Springfield, Miss H. J. Biddlecome.

FISSIDENS OBTUSIFOLIUS Wils.
Springfield, Miss H, J. Biddlecome; "Cincinnati, Thos. G. Lea, Sugar Grove (Fairfield Co.)" Lesquereux & James (Man.)

FISSIDENS OSMUNDOIDES (Sw.) Hedw.
"Ohio," Leo Lesquereux (H. C. Beardslee, Cat.); Cedar Swamp (Champaign Co.) Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

FISSIDENS SUBBASILARIS Hedw.
"Ohio," Leo Lesquereux (H. C. Beardslee, Cat.); Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

FISSIDENS TAXIFOLIUS (L.) Hedw.
Painesville, Cedar Swamp (Champaign Co.) Wm. C. Werner; Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

V. MNIACEÆ.

7. ASTROPHYLLUM Neck. (*Mnium* L.)

ASTROHYLLUM CUSPIDATUM (L.) Lindb. (*Mnium affine* Bland.)
Throughout the state.

ASTROPHYLLUM CUSPIDATUM ELATUM Br. & Sch.
"On damp sandstone rocks in woods, Southern Ohio," Lesq. & James (Man.)

ASTROPHYLLUM LYCOPODIOIDES (Hook.) Lindb.
Painesville, H. C. Beardslee (Cat.), Wm. C. Werner.

ASTROPHYLLUM MARGINATUM (Dicks.) Lindb. (*Mnium serratum* Laich.)
"Ohio," Leo Lesquereux (H. C. Beardslee, Cat.)

Astrophyllum punctatum (L.) Lindb.
"Common," H. C. Beardslee (Cat.)

Astrophyllum rostratum (Schrad.) Lindb.
Cedar Swamp (Champaign Co.) Wm. C. Werner.

Astrophyllum spinulosum Br. & Sch.
Painesville, H. C. Beardslee (Cat.), Wm. C. Werner.

Astrophyllum stellare (Reichard) Lindb.
"Common," H. C. Beardslee (Cat.); Springfield, Miss H. J. Biddlecome.

Astrophyllum sylvaticum Lindb. (*Mnium cuspidatum* Hedw.)
Ashtabula Co., Sara F. Goodrich; Painesville, Franklin Co., Wm. C. Werner; Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora.)

8. TIMMIA Hedw.

Timmia megapolitana Hedw.
Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

9. SPHÆROCEPHALUS Neck. (*Aulocomnium* Schwæg.)

Sahærocephalus heterostichus (Brid.) Britt. m. (*Aulacomnium heterostichum* Br. & Sch.)
Througout the state.

Sphærocephalus palustris (L.) Lindb. (*Aulacomnium palustre* Schwægr.)
Painesville, Wm C. Werner.

Sphærocephalus palustris polycephalum Br. & Sch.
Cedar Swamp (Champaign Co.) Wm. C. Werner.

VI. MEESIACEÆ.

10. MEESIA Hedw.

Meesia longiseta Hedw.
"Cranberry swamps in Northern Ohio; not rare," Lesq. & James (Man.)

Meesia triquetra (L.) Angstr. (*M. tristicha* Funck.)
"Southern Ohio," H. C. Beardslee (Cat.)

Meesea uliginosa Hedw.
"Northern Ohio," Leo Lesquereux. (H. C. Beardslee, Cat.)

VII. BARTRAMIACEÆ.

11. BARTRAMIA Hedw.

BARTRAMIA POMIFORMIS (L.) Hedw.
Painesville, Franklin Co., Wm. C. Werner; Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

12. PHILONOTIS Brid.

PHILONOTIS FONTANA Brid.
Painesville, Sugar Grove (Fairfield Co.) Wm. C. Werner.

PHILONOTIS MUHLENBERGII Brid. (*Bartramia marchica* Sull.)
Painesville, H. C. Beardslee (Cat.), Wm. C. Werner; Springfield, Miss H. J. Biddlecome.

VIII. BRYACEÆ.

13. BRYUM L.

BRYUM ALBICANS (Wahl.) Brid. (*Webera albicans* Schimp.)
Painesville, H. C. Beardslee (Cat.); Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

BRYUM ARGENTEUM L.
Painesville, Columbus, Wm. C. Werner; Miami Valley, A. P. Morgan (Flora).

BRYUM BICOLOR Dicks. (*B. atropurpureum* Wahl.)
"Ohio," Leo Lesquereux (H. C. Beardslee, Cat.)

BRYUM BIMUM Schreb.
Painesville, Wm. C. Werner; Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

BRYUM CAESPITICIUM Hedw.
Painesville, Sugar Grove (Fairfield Co.) Wm. C. Werner.

BRYUM CRUDUM Schreb.
Painesville, H. C. Beardslee (Cat.) Wm. C. Werner.

BRYUM INTERMEDIUM Brid.
Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

BRYUM LESCURIANUM Sull.
Lancaster (Fairfield Co.) Leo Lesquereux (H. C. Beardslee, Cat.); Painesville, Wm. C. Werner.

BRYUM NUTANS Schreb.
"Common," H. C. Beardslee (Cat.)

Bryum pallescens Schleich.
Painesville, H. C. Beardslee (Cat.)

Bryum proliferum (L.) Sibth. (*B. roseum* Schreb.)
Painesville, Columbus, Fairfield Co., Wm. C. Werner; Cedar Swamp (Champaign Co.) Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

Bryum pendulum (Hornsch.) Schimp. (*B. cernuum* Br. & Sch.)
"Southern Ohio," Leo Lesquereux (H. C. Beardslee, Cat.); Springfield, Miss H. J. Biddlecome.

Bryum uliginosum Bruch. & Schimp.
Painesville, H. C. Beardslee (Cat.); Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

Bryum ventricosum Dicks. (*B. pseudotriquetrum* Schwægr.)
"Lancaster" (Fairfield Co.) Leo Lesquereux (H. C. Beardslee, Cat.); Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

14. LEPTOBRYUM Wils.

Leptrobryum pyriforme (L.) Wils. (*Bryum pyriforme* Hedw.)
Painesville, Wm. C. Werner; Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

IX. FUNARIACEÆ.

15. FUNARIA Schreb.

Funaria flavicans Michx.
"Ohio," Leo Lesquereux (H. C. Beardslee, Cat.)

Funaria hygrometrica (L.) Sibth.
Throughout the state.

Funaria hygrometrica calvescens Br. & Sch.
"Ohio," Leo Lesquereux (H. C. Beardslee, Cat.)

16. APHANOREGMA Sulliv.

Aphanoregma serrata (Hook. & Wils.) Sulliv.
"Ohio," Leo Lesquereux (H. C. Beardslee, Cat.); Miami Valley A. P. Morgan (Flora).

17. PHYSCOMITRELLA Schimp.

Physcomitrella patens Schimp.
"Rare," Leo Lesquereux (H. C. Beardslee, Cat.)

18. PHYSCOMITRIUM Brid.

PHYSCOMITRIUM IMMERSUM Sulliv.
Painesville, H. C. Beardslee (Cat.), Wm. C. Werner; "River banks Southern Ohio," Thos. G. Lea (Lesq. & James, Man.)

PHYSCOMITRIUM TURBINATUM (Michx.) Mueller. (*P. pyriforme* of Amer. authors fide E. G. Britton).
Painesville, Ironton (Lawrence Co.), Wm. C. Werner; Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

X. DISCELIEÆ

19. DISCELIUM Brid.

DISCELIUM NUDUM Dicks.
Painesville, H. C. Beardslee (Cat.)

XI. SCHISTOSTEGEÆ.

20. SCHISTOSTEGIA Mohr.

SCHISTOSTEGIA OSMUMDACEA Web. & Mohr.
Thompson Ledge (Geauga Co.) Otto Hacker.

XII. SPLACHNACEÆ.

21. SPLACHNUM L.

SPLACHNUM AMPULLACIUM L.
"Cranberry swamps of Ohio," Lesquereux & James (Man.)

XIII. WEBERACEÆ.

22. WEBERA Ehrh.

WEBERA SESSILIS (Schmid.) Lindb. (*Diphyscium foliosum* Mohr.)
Painesville, Wm. C. Werner.

23. POHLIA Hedw.

POHLIA ELONGATA Hedw. (*Webera elongata* Schwaegr.)
Thompson Ledge (Geauga Co.) Wm. C. Werner.

XIV. TORTULACEÆ.

24. TORTULA Hedw.

TORTULA MUCRONIFOLIA Schwægr. (*Barbula mucronifolia* Bruch & Schimp.)
"Ohio," Leo Lesquereux (H. C. Beardslee, Cat.); Miami Valley, A. P. Morgan (Flora).

25. LEERSIA Hedw.

LEERSIA LACINIATA Hedw. (*Encalypta ciliata* Hedw.)
"Ohio," Leo Lesquereux (H. C. Beardslee, Cat.)

26. BARBULA Hedw.

BARBULA CONVOLUTA Hedw.
"Ohio," Leo Lesquereux (H. C. Beardslee, Cat.)

BARBULA CURVIROSTRIS (Ehrh.) Lindb. (*Gymnostomum curvirostrum* Hedw.)
Painesville, Wm. C. Werner; Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

BARBULA FALLAX Hedw.
Painesville, H. C. Beardslee (Cat.), Wm. C. Werner; Dayton, Miss H. J. Biddlecome.

BARBULA HUMILIS Hedw. (*B. cæspitosa* Schwægr.)
Painesville, H. C. Beardslee (Cat.), Wm. C. Werner; Cedar Swamp (Champaign Co.) Miss H. J. Biddlecome, Wm. C. Werner; Franklin Co., Wm. C. Werner; Miami Valley, A. P. Morgan (Flora).

BARBULA LONGIFOLIA (Dicks.) Lindb. (*Trichostomum tophaceum* Brid.)
Springfield, Miss H. J. Biddlecome.

BARBULA RIGIDULA Schimp. (*Trichostomum rigidulum* Smith.)
Painesville, H. C. Beardslee (Cat.)

BARBULA RUBELLA (Hoffm.) Mitt. (*Didymodum rubellus* Br. & Sch.)
"Cedar Swamp, near Urbana" Leo Lesquereux (H. C. Beardslee, Cat.); Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

BARBULA UNGUICULATA (Huds.) Hedw.
Painesville, Sugar Grove (Fairfield Co.) Wm. C. Werner; Dayton, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

27. PHASCUM L.

PHASCUM CUSPIDATUM Schreb.
"Common," H. C. Beardslee (Cat.)

28. MOLLIA Schrank.

MOLLIA ÆRUGINOSA (Sm.) Lindb. (*Gymnostomum rupestre* Schægr.)
Painesville, Wm. C. Werner; Miss H. J. Biddlecome.

MOLLIA CALCAREA (N. & H.) Lindb. (*Gymnostomum calcareum* Nees & Hornsch.)
Painesville, H. C. Beardslee (Cat.)

MOLLIA VIRIDULA Hedw. (*Weisia viridula* Hedw.)
Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

MOLLIA VIRIDULA GYMNOSTOMOIDES (Brid.) Braithw. (*Hymenostomum microstomum* Aust.)
"Ohio," Leo Lesquereux (H. C. Beardslee, Cat.)

29. ASTOMUM Hampe.

ASTOMUM NITIDULUM Schimp.
"Ohio rare," Leo Lesquereux (H. C. Beardslee, Cat.)

ASTOMUM NITIDULUM PYGMÆUM Lesq.
"Central Ohio," Lesquereux & James (Man.)

ASTOMUM SULLIVANTII (Schimp.) Hampe.
"Ohio," Leo Lesquereux (H. C. Beardslee, Cat.)

30. SPHÆRANGIUM Schimp.

SPHÆRANGIUM TRIQUETRUM Schimp.
"Ohio," Leo Lesquereux (H. C. Beardslee, Cat.)

31. POTTIA Ehrh.

POTTIA TRUNCATULA (L.) Lindb. (*P. truncata* Fuern.)
Miami Valley, A. P. Morgan (Flora).

32. DESMATODON Brid.

DESMATODON ARENACEUS Sull. & Lesq.
"Lancaster" (Fairfield Co.,) Leo Lesquereux (H. C. Beardslee, Cat.); "Sandstone rocks, Central Ohio," Lesquereux & James (Man.)

DESMATODON PLINTHOBIUS Sull. & Lesq.
"Southern Ohio, Lancaster," Leo Lesquereux (H. C. Beardslee, Cat.)

DESMATODON PORTERI James.
Springfield, Miss H. J. Biddlecome.

33. EPHEMERUM Hampe.

EPHEMERUM COHÆRANS (Hedw.) Muell.
"Cincinnati," Leo Lesquereux (H. C. Beardslee, Cat.)

EPHEMERUM CRASSINERVUM Schwægr.
"Common," H. C. Beardslee (Cat.)

EPHEMERUM STENOPHYLLUM Schimp.
"Ohio," Lesquereux & James (Man.)

XV. DICRANACEÆ.

34. LEUCOBRYUM Hampe.

LEUCOBRYUM GLAUCUM (L.) Schimp.
Frequent.

LEUCOBRYUM ALBIDUM (Brid.) Lindb. (*L. minus* Hampe.)
"Sandusky," Leo Lesquereux (H. C. Beardslee, Cat.); Sugar Grove (Fairfield Co.,) Cedar Swamp (Champaign Co.), Ironton (Lawrence Co.) Wm. C. Werner.

35. DICRANUM Hedw.

DICRANUM BONJEANI DeNot. (*D. palustre* LaPyl.)
"Peat bogs, Northern Ohio," Lesquereux & James (Man.); Sugar Grove (Fairfield Co.) Wm. C. Werner.

DICRANUM FLAGELLARE Hedw.
Painesville, Franklin Co., Wm. C. Werner; Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

DICRANUM FULVUM Hook.
Painesville, Wm. C. Werner; Fairfield Co., W. A. Kellerman.

DICRANUM FUSCESCENS Turn.
Painesville, H. C. Beardslee (Cat.), Wm. C. Werner.

DICRANUM MONTANUM Hedw.
Painesville, H. C. Beardslee (Cat.); Cedar Swamp (Champaign Co.) Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

DICRANUM SCHRADERI Web. & Mohr.
"Common," H. C. Beardslee (Cat.)

DICRANUM SCOPARIUM (L.) Hedw.
Frequent.

DICRANUM SPURIUM Hedw.
"Ohio," Leo Lesquereux (H. C. Beardslee, Cat.)

DICRANUM UNDULATUM Ehrh.
"Ohio," Leo Lesquereux (H. C. Beardslee, Cat.)

DICRANUM VIRIDE (Sull. & Lesq.) Schimp.
Springfield, Miss H. J. Biddlecome.

36. BRYOZIPHIUM Mitt.

BRYOZIPHIUM NORVEGICUM (Brid.) Mitt. (*Eustichia norvegica* Brid.)
"Middle Ohio," Lesquereux & James (Man.)

37. SELIGERIA Br. & Sch.

SELIGERIA PUSILLA (Ehrh.) Br. & Sch.
"Kelley's Island, Lake Erie," Leo Lesquereux (Lesq. & James, Man.)

SELIGERIA TRIFARIA (Brid.) Lindb. (*S. tristicha* Br. & Sch.)
"Limestone rocks, in shaded ravines, Central Ohio (Sullivant); very rare," (Lesq. & James, Man.)

38. TREMATODON Michx.

TREMATODON AMBIGENS (Hedw.) Hornsch.
"Southern Ohio," Leo Lesquereux (H. C. Beardslee, Cat.)

TREMATODON LONGICOLLIS Michx.
"Northern Ohio," Leo Lesquereux (H. C. Beardslee, Cat.)

39. ANISOTHECIUM Mitt.

ANISOTHECIUM RUBRUM (Huds.) Lindb. (*Dicranella varia* Schimp.)
Painesville, Franklin Co., Wm. C. Werner; Dayton, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

ANISOTHECIUM RUFESCENS (Dicks.) Lindb. (*Dicranella rufescens* Schimp.)
Painesville, H. C. Beardslee (Cat.), Wm. C. Werner; Miami Valley, A. P. Morgan (Flora).

40. DICRANELLA Schimp.

DICRANELLA CERVICULATA (Hedw.) Schimp.
"Very rare," Leo Lesquereux (H. C. Beardslee, Cat.)

DICRANELLA HETEROMALLA (L.) Schimp.
Painesville, Ironton (Lawrence Co.) Wm. C. Werner; Miami Valley, A. P. Morgan (Flora).

DICRANELLA HETEROMALLA ORTHOCARPA (Aust.) C. Muell.
Painesville, Wm. C. Werner; Miami Valley, A. P. Morgan (Flora).

DICRANELLA HETEROMALLA STRICTA Schimp.
Painesville, H. C. Beardslee (Cat.), Wm. C. Werner.

41. DICRANODONTIUM Br. & Sch.

DICRANODONTIUM DENUDATUS (Brid.) Britton, m. (*D. longirostre* Br. & Sch.)
"Southern Ohio," Leo Lesquereux (H. C. Beardslee, Cat.)

42. CAMPYLOPUS Brid.

CAMPYLOPUS LEANUS Sull.
"Ohio, rare," Leo Lesquereux (H. C. Beardslee, Cat.)

43. ONCOPHORUS Brid.

ONCOPHORUS VIRENS (Sw.) Brid. (*Cynodontium virens* Schimp.)
Painesville, H. C. Beardslee (Cat.), Wm. C. Werner.

44. RHABDOWEISIA Br. & Sch.

RHABDOWEISIA FUGAX (Hedw.) Br. & Sch.
Painesville, H. C. Beardslee (Cat.)

45. BRUCHIA Schwægr.

BRUCHIA BREVICOLLIS Lesq. & James.
Sugar Grove (Fairfield Co.) Wm. C. Werner.

BRUCHIA FLEXUOSA (Schwægr.) C. Muell.
"Common," H. C. Beardslee (Cat.)

46. DITRICHUM Timm.

DITRICHUM PALLIDUM (Schreb.) Hampe. (*Trichostomum paltidum* Hedw.)
Painesville, Ironton, Wm. C. Werner; Miami Valley, A. P. Morgan (Flora).

DITRICHUM TORTILE (Schrad.) Hampe. (*Trichostomum tortile* Schrad.)
Painesville, Wm. C. Werner.

DITRICHUM VAGINANS (Sull.) Hampe. (*Trichostomum vaginans* Sull.)
"Ohio," Leo Lesquereux (H. C. Beardslee, Cat.)

47. PLEURIDIUM Brid.

PLEURIDIUM SUBULATUM (Sehreb.) Lindb. (*P. alternifolium* Brid.)
"Common," H. C. Beardslee (Cat.)

PLEURIDIUM SUBULATUM LANCASTRINESE Sull. & Lesq.
"Lancaster Ohio," Lesquereux & James (Man.)

48. ARCHIDIUM Brid.

ARCHIDIUM OHIOENSE Schimp.
"Central Ohio," Lesquereux & James (Man.)

49. CERATODON Brid.

CERATODON PURPUREUS (L.) Brid.
Painesville, Columbus, Wm. C. Werner; Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

XVI. GRIMMIACEÆ.

50. WEISSIA Ehrh.

WEISSIA AMERICANA (Pallis.) Lindb. (*Ulota hutchinsiæ* Schimp.)
Painesville, H. C. Beardslee (Cat.)

WEISSIA COARCTATA (Pallis.) Lindb. (*Ulota ludwigii* Brid.)
Painesville, H. C. Beardslee (Cat.)

WEISSIA ULOPHYLLA CRISPULA (Bruch.) Hammar. (*Ulota crispula* Brid.)
Painesville, H. C. Beardslee (Cat.)

51. ORTHOTRICHUM Hedw.

ORTHOTRICHUM ANOMALUM PECKII Sull. (*O. peckii* Aust.)
Painesville, H. C. Beardslee (Cat.)

ORTHOTRICHUM CUPULATUM Hoffm. (*O. strangulatum* Beauv.)
Painesville, Franklin Co., Wm. C. Werner; Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora); "Ohio river," Leo Lesquereux (H. C. Beardslee, Cat.)

ORTHOTRICHUM LESCURII Aust. (*O. cupulatum minus* Sull.)
"On limestone rocks along the Ohio river," Leo Lesquereux (Lesq. & James, Man.)

ORTHOTRICHUM OHIOENSE Sull.
Painesville, Ironton, Wm. C. Werner.

ORTHOTRICHUM OHIOENSE CITRINUM (Aust.) Lesq. & James. (*O. citrinum* Aust.)
Painesville, Wm. C. Werner.

52. DRUMMONDIA Hook.

DRUMMONDIA CLAVELLATA Hook.
Painesville, Columbus, Wm. C. Werner; Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

53. PTYCHOMITRIUM Br. & Sch.

PTYCHOMITRIUM INCURVUM (Schwægr.) Sull.
"Very common in southern Ohio," Lesquereux & James (Man.)

54. GRIMMIA Ehrh.

GRIMMIA APOCARPA (L.) Hedw.
Painesville, Franklin Co., Wm. C. Werner; Springfield, Miss H. J. Biddlecome.

GRIMMIA APOCARPA RIVULARIS Nees & Hornsch.
"Ohio," Leo Lesquereux (H. C. Beardslee, Cat.)

GRIMMIA CAMPESTRIS (Burch, M S.) Hook. (*G. leucophæa* Grev.)
"Ohio," Leo Lesquereux (H. C. Beardslee, Cat.)

GRIMMIA CONFERTA Funck.
Painesville, H. C. Beardslee (Cat.)

GRIMMIA PENNSYLVANICA Schwægr.
"Lancaster," Leo Lesquereux (H. C. Beardslee, Cat.); Painesville, Wm. C. Werner; Miami Valley, A. P. Morgan (Flora).

SUB-CLASS 2.—PLEUROCARPI.

XVII. HYPNACEÆ.

55. THUIDIUM Br. & Sch.

THUIDIUM DELICATULUM (L.) Mitt. (*Hypnum tamariscinum* Sull. & Lesq.)
"Very common," H. C. Beardslee (Cat.); Painesville, Wm. C. Werner.

THUIDIUM GRACILE Bruch. & Schimp.
Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

THUIDIUM GRACILE LANCASTRIENSE Sull. & Lesq.
"Ohio," Leo Lesquereux (H. C. Beardslee, Cat.)

THUIDIUM MINUTILUM (Hedw.) Br. & Sch.
Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

THUIDIUM PALUDOSUM (Sull.) Rau & Hervey.
"Not rare in the cranberry marshes of Northern Ohio," Lesq. & James (Man.)

THUIDIUM PYGMÆUM (Br. & Sch.) Sull. & Lesq.
"Plymouth marsh" near Ashtabula, H. C. Beardslee (Cat.); "Limestone rocks, in thin close mats, in shaded ravines, Central Ohio, rare," Lesquereux & James (Man.); Springfield, Miss H. J. Biddlecome.

THUIDIUM RECOGNITUM (Hedw.) Lindb.
Cedar Swamp (Champaign Co.) Miss H. J. Biddlecome, Wm. C. Werner; Miami Valley, A. P. Morgan (Flora).

THUIDIUM SCITUM (Beauv.) Aust.
Painesville, H. C. Beardslee; Springfield, Miss H. J. Biddlecome.

THUIDIUM SCITUM ÆSTIVALE Aust.
Painesville, H. C. Beardslee; Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

56. LESKEA Hedw.

LESKEA DENTICULATA Sull.
"Southern Ohio," Leo Lesquereux (H. C. Beardslee, Cat.); Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgau (Flora).

LESKEA OBSCURA Hedw.
Painesville, Wm. C. Werner.

LESKEA POLYCARPA Ehrh.
Dayton, Miss H. J. Biddlecome; Franklin Co., Wm. C. Werner.

LESKEA TRISTIS Cesati.
Painesville, Wm. C. Werner; Springfield, Miss H. J. Biddlecome; Miami Valley A. P. Morgan (Flora).

57. ANOMODON Hook. & Tayl.

ANOMODON APICULATUS Br. & Sch.
Painesville, H. C. Beardslee (Cat.), Wm. C. Werner.

ANOMODON ATTENUATUS (Schreb.) Hueben.
Painesville, Fairfield Co., Rendville (Perry Co.) Wm. C. Werner; Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

ANOMODON OBTUSIFOLIUS Br. & Sch.
Painesville, Franklin Co., Wm. C. Werner; Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

ANOMODON ROSTRATUS (Hedw.) Schimp.
Painesville, Fairfield Co., Wm. C. Werner; Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

58. AMBLYSTEGIUM Br. & Sch.

AMBLYSTEGIUM ADNATUM Hedw.
Painesville, H. C. Beardslee (Cat.); Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora); Columbus, Wm. C. Werner.

AMBLYSTEGIUM ADUNCUM (L.) Lindb. (*Hypnum uncinatum* Hedw.)
Painesville, Columbus, Cedar Swamp (Champaign Co.) Wm. C. Werner.

AMBLYSTEGIUM CHRYSOPHYLLUM (Brid.) DeNot.
Painesville, Sugar Grove (Fairfield Co.) Wm. C. Werner; Cedar Swamp (Champaign Co.) Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

AMBLYSTEGIUM CORDIFOLIUM (Hedw.) DeNot.
Painesville, Wm. C. Werner.

AMBLYSTEGIUM FILICINUM (L.) Lind.
Painesville, Wm. C. Werner; Cedar Swamp (Champaign Co.) Miss H. J. Biddlecome, Wm. C. Werner; Miami Valley, A. P. Morgan (Flora).

AMBLYSTEGIUM FLUITANS (L.) DeNot.
Franklin Co., Wm. C. Werner.

AMBLYSTEGIUM FLUVIATILE (Swartz.) Br. & Sch.
Sugar Grove (Fairfield Co.) Wm. C. Werner; Springfield, Miss H. J. Biddlecome.

AMBLYSTEGIUM GIGANTEUM (Sch.) DeNot.
"Urbana," Leo Lesquereux (H. C. Beardslee, Cat.)

AMBLYSTEGIUM HYGROPHILUM (Jur.) Schimp. (*Hypnum bergenense* Aust.)
Painesville, H. C. Beardslee (Cat.), Wm. C. Werner.

AMBLYSTEGIUM IRRIGUUM (Hook. & Wils.) Br. & Sch.
Yellow Springs (Greene Co.) Miss H. J. Biddlecome.

AMBLYSTEGIUM MINUTISSIMUM Sull. & Lesq.
"Ohio," Lesq. & James (Man.)

AMBLYSTEGIUM REVOLVENS (Sw.) DeNot.
"Southern Ohio," Leo Lesquereux (H. C. Beardslee, Cat.)

AMBLYSTEGIUM RIPARIUM (L.) Br. & Sch.
Painesville, Franklin Co., William C. Werner; Cedar Swamp (Champaign Co.) Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

AMBLYSTEGIUM SERPENS (L.) Br. & Sch.
Painesville, Wm. C. Werner; Springfield, Miss H. J. Biddlecome.

AMBLYSTEGIUM ORTHOCLADON (Beauv.) Br. & Sch.
Painesville, H. C. Beardslee (Cat.), Wm. C. Werner; Franklin Co., Fairfield Co., Wm. C. Werner; Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

AMBLYSTEGIUM STELLATUM (Schreb.) Lindb.
Cedar Swamp (Champaign Co.) Wm. C. Werner.

AMBLYSTEGIUM STRAMINEUM (Dicks.) DeNot.
"Sandusky," Leo Lesquereux (H. C. Beardslee, Cat.)

AMBLYSTEGIUM TRIFARIUM (Web. & Mohr.)
"Sandusky," Leo Lesquereux (H. C. Beardslee, Cat.); "Peat bogs Northern Ohio, Lesquereux," (Lesquereux & James, Man.)

AMBLYSTEGIUM VARIUM (Hedw.) Lindb. (*Hypnun radicale* Br. & Sch.)
Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora); Ironton, Wm. C. Werner.

AMBLYSTEGIUM WATSONII (Sch.) Lindb. (*Hypnun aduncum* Hedw.)
Painesville, H. C. Beardslee (Cat.); Cedar Swamp (Champaign Co.) Wm. C. Werner; Miami Valley, A. P. Morgan (Flora).

AMBLYSTEGIUM WATSONII GRACILESCENS (Br. & Sch.)
Painesville, H. C. Beardslee (Cat.)

59. HYPNUM L.

HYPNUM ACUMINATUM Beauv.
Painesville, Rendville (Perry Co.) Wm. C. Werner; Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

HYPNUM ACUMINATUM SETOSUM Sull. & Lesq.
Columbus, Wm. C. Werner.

HYPNUM ACUMINATUM RUPNICOLUM Sull. & Lesq.
"Ohio," Leo Lesquereux (H. C. Beardslee, Cat.)

HYPNUM ALLEGHANIENSE C. Muell.
Painesville, H. C. Beardslee; Clifton (Greene Co.) Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

HYPNUM BOSCII Schwægr.
Painesville, Sugar Grove, Ironton, Wm. C. Werner; Cedar Swamp (Champaign Co.) Miss H. J. Biddlecome; Miami Va.ley, A. P. Morgan (Flora).

HYPNUM CYLINDROCARPUM C. Muell.
Cedar Swamp (Champaign Co.) Miss H. J. Biddlecome; Miami Valley A. P. Morgan (Flora).

HYPNUM DEMISSUM Wils.
Miami Valley, A. P. Morgan (Flora).

HYPNUM DEPLANATUM Schimp.
Springfield, Miss H. J. Biddlecome; Miami Valley A. P. Morgan (Flora).

HYPNUM DIVERSIFOLIUM Schimp.
"Lancaster," Leo Lesquereux (H. C. Beardslee, Cat.); "dry sandy hills under chestnut trees, Ohio, Lesquereux," (Lesq. & James, Man.)

HYPNUM FERTILE Sendt.
Cedar Swamp (Champaign Co.) Miss H. J. Biddlecome.

HYPNUM GEOPHILUM Aust.
Springfield, Miss H. J. Biddlecome.

HYPNUM HIANS Hedw.
Painesville, Rendville (Perry Co.) Wm. C. Werner; Clifton (Greene Co.) Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

Hypnum lætum Brid.
Painesville, Rendville (Perry Co.) Wm. C. Werner; Clifton (Greene Co.) Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

Hypnum microcarpum C. Muell.
"Cedar swamps, Ohio," Lesquereux & James (Man.); Miami Valley, A. P. Morgan (Flora).

Hypnum mildeanum Schimp. (*H. acutum* Mitt.)
Painesville, H. C. Beardslee (Cat.), Wm. C. Werner; Cedar Swamp (Champaign Co.) Miss H. J. Biddlecome.

Hypnum muellerianum Hook. fil.
"Ohio," Leo Lesquereux (Lesq. & James, Man.)

Hypnum novæ-angliæ Sull. & Lesq.
Painesville, H. C. Beardslee (Cat.)

Hypnum piliferum Schreb.
Painesville, H. C. Beardslee (Cat.); Cedar Swamp (Champaign Co.) Miss H. J. Biddlecome.

Hypnum plumosum Hudson. (*H. sa'ebrosum* Hoffm.)
"Common," H. C. Beardslee (Cat.)

Hypnum pseudoplumosum Brid. (*H. plumosum* Sw.)
"Common," H. C. Beardslee (Cat.)

Hypnum recurvans Schwægr.
Painesville, Wm. C. Werner; Fairfield Co., W. A. Kellerman.

Hypnum rivulare Bruch.
Painesville, H. C. Beardslee (Cat.), Wm. C. Werner; Springfield, Miss H. J. Biddlecome.

Hypnum rutabulum L.
Painesville, Wm. C. Werner; Cedar Swamp (Champaign Co.) Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

Hypnum rusciforme Weiss.
"Ohio," Leo Lesquereux (H. C. Beardslee, Cat.)

Hypnum scorpoides L.
"Cranberry marshes northern Ohio," Leo Lesquereux (Lesq. & James, Man.); "Urbana," Leo Lesquereux (H. C. Beardslee, Cat.); Cedar Swamp (Champaign Co.) Wm. C. Werner.

Hypnum serrulatum Hedw.
Painesville, Wm. C. Werner; Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

Hypnum strigosum Hoff.
Painesville, Wm. C. Werner; Cedar Swamp (Champaign Co.) Miss H. J. Biddlecome.

Hypnum sullivantii Spruce.
Painesville, H. C. Beardslee (Cat.); Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora); Sugar Grove (Fairfield Co.) Wm. C. Werner.

Hypnum turfaceum Lindb.
Painesville, H. C. Beardslee (Cat.), Wm. C. Werner.

Hypnum viride Lam. (*H. populeum* Hedw.)
"Ohio," Leo Lesquereux (H. C. Beardslee, Cat.)

60. HOMALOTHECIUM Br. & Sch.

Homalothecium subcapillatum (Hedw.) Br. & Sch.
"Ohio," Leo Lesquereux (H. C. Beardslee, Cat.); Springfield, Miss H. J. Biddlecome.

61. CAMPTOTHECIUM Schimp.

Camptothecium nitens (Schreb.) Schimp. (*Hypnum nitens* Schreb.)
"Southern Ohio," Leo Lesquereux (H. C. Beardslee, Cat.)

XVIII. STEREODONTACEÆ.

62. MYURELLA Br. & Sch.

Myurella careyana Sull.
Miami Valley, A. P. Morgan (Flora).

63. HABRODON Schimp.

Habrodon notarissii Schimp.
"Trunks of trees, Central Ohio," W. S. Sullivant (Lesq. & James, Man.)

64. ANACAMPTODON Brid.

Anacamptodon splachnoides Brid.
Springfield, Miss H. J. Biddlecome.

65. THELIA Sull.

Thelia asprella (Schimp.) Sull.
Springfield, Miss H. J. Biddlecome; Columbus, Wm. C. Werner.

THELIA HIRTELLA (Hedw.) Sull.
Painesville, Columbus, Wm. C. Werner; Cedar Swamp (Champaign Co.) Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

66. HYLOCOMIUM Br. & Sch.

HYLOCOMIUM BREVIROSTRE (Ehrh.) Br. & Sch.
Painesville, H. C. Beardslee (Cat.), Wm. C. Werner.

HYLOCOMIUM PARIETINUM (L.) Lindb. (*Hypnum schreberi* Willd.)
Painesville, Wm. C. Werner; Miami Valley, A. P. Morgan (Flora).

HYLOCOMIUM PROLIFERUM (L.) Lindb. (*Hypnum splendens* Br. & Sch.)
"Common," H. C. Beardslee (Cat.)

HYLOCOMIUM RUGOSUM (L.) De Not.
Painesville, Wm. C. Werner; Clifton (Greene Co.) Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

HYLOCOMIUM TRIQUETRUM (L.) Br. & Sch.
Painesville, Sugar Grove (Fairfield Co.) Wm. C. Werner; Cedar Swamp (Champaign Co.,) Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

67. CAMPYLIUM Mitt.

CAMPYLIUM HISPIDULUM (Brid.) Mitt. (*Hypnum hispidulum* Brid.)
Painesville, Thompson Ledge (Geauga Co), Columbus, Ironton, Wm. C. Werner; Richland Co., E. Wilkinson; Cedar Swamp (Champaign Co.) Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

68. CTENIDIUM Mitt.

CTENIDIUM MOLLUSCUM (Hedw.) Mitt) (*Hypnum molluscum* Hedw.)
Painesville, Wm. C. Werner; Cedar Swamp (Champaign Co.) Miss H. J. Biddlecome.

69. PTILIUM DeNot.

PTILIUM CRISTA-CASTRENSE (L.) DeNot. (*Hypnum crista-castrensis* L.)
"Northern Ohio," H. C. Beardslee (Cat.)

70. STEREODON Mitt.

STEREODON CONFERVOIDES Brid. (*Amblystegium confervoides* Brid.)
Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

STEREODON CURVIFOLIUS (Hedw.) Brid. (*Hypnum curvifolium* Hedw.)

Painesville, Sugar Grove, Cedar Swamp (Champaign Co.) Wm. C. Werner Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

STEREODON CUPRESSIFORME (L.) Brid. (*Hypnum cupressiforme* L.)
"Common," H. C. Beardslee (Cat.)

STEREODON CUPRESSIFORME ERICETORUM Br. & Sch.
Rendville (Perry Co.) Wm. C. Werner.

STEREODON CUPRESSIFORME FILIFORME Brid.
On limestone rock near Columbus, Wm. C. Werner.

STEREODON HALDANIANUM (Grev.) Lindb. (*Hypnum haldanianum* Grev.)
Painesville, H. C. Beardslee (Cat.); Rendville (Perry Co.) Wm. C. Werner.

STEREODON IMPONENS (Hedw.) Brid. (*Hypnum imponens* Hedw.)
Painesville, Columbus, Wm. C. Werner; Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

STEREODON PALLESCENS (Hedw.) Lindb. (*Hypnum reptile* Michx.)
Springfield, Miss H. J. Biddlecome.

STEREODON PRATENSE (Koch.) Britt. m. (*Hypnum pratense* Koch.)
Columbus, Wm. C. Werner.

71. PYLAISIA Br. & Sch.

PYLAISIA INTRICATA (Hedw.) Br. & Sch.
Painesville, Rendville (Perry Co.) Wm. C. Werner; Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

PYLAISIA SUBDENTICULATA Schimp.
"On the bark of trees, Central Ohio," W. S. Sullivant (Lesq. & James, Man.); Springfield, Miss H. J. Biddlecome.

PYLAISIA VELUTINA Br. & Sch.
Black Lick (Franklin Co.), Cedar Swamp (Champaign Co.) Wm. C. Werner.

72. PLAGIOTHECIUM Br. & Sch.

PLAGIOTHECIUM DENTICULATUM (L.) Br. & Sch. (*Hypnum denticulatum* L.)
Painesville, Columbus, Wm. C. Werner.

PLAGIOTHECIUM SULLIVANTÆ Schimp.
Painesville, H. C. Beardslee (Cat.); "Lancaster," Leo Lesquereux (H. C. Beardslee, Cat.); "Moist sandstone rocks and shaded banks in pine woods, Ohio," Lesquereux & James (Man.)

PLAGIOTHECIUM PULCHELLUM Br. & Sch. (*Hypnum pulchellum* Dicks.)
Cedar Swamp (Champaign Co.) Wm. C. Werner.

PLAGIOTHECIUM SYLVATICUM (Huds.) Br. & Sch.
Painesville, H. C. Beardslee (Cat.); Cedar Swamp (Champaign Co.) Miss H. J. Biddlecome.

73. CYLINDROTHECIUM Br. & Sch.

CYLINDROTHECIUM BREVISETUM (Wils.) Br. & Sch.
Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

CYLINDROTHECIUM CLADORRHIZANS (Hedw.) Schimp.
Painesville, Wm. C. Werner; Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

CYLINDROTHECIUM COMPRESSUM Br. & Sch.
Columbus, Leo Lesquereux (H. C. Beardslee, Cat.)

CYLINDROTHECIUM SEDUCTRIX (Hedw.) Sull.
Painesville, Columbus, Wm. C. Werner; Fairfield Co., W. A. Kellerman; Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

74. ENTODON C. Muell.

ENTODON PALATINUS (Neck.) Lindb. (*Platygyrium repens* Br. & Sch.)
Painesville, Columbus, Wm. C. Werner; Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

XIX. NECKERACEÆ.

75. NECKERA Hedw.

NECKERA PENNATA (L.) Hedw.
Cedar Swamp (Champaign Co.) Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

76. CLIMACIUM Web. & Mohr.

CLIMACIUM AMERICANUM Brid.
Frequent.

77. FONTINALIS L.

FONTINALIS BIFORMIS Sull.
Painesville, H. C. Beardslee (Cat.); Woodlands, in rivulets, Central Ohio, Lesquereux & James (Man.)

78. LEPTODON Mohr.

LEPTODON OHIOENSE Sull.
"Central Ohio, on trees in swampy woods; not rare," Lesquereux & James (Man.)

LEPTODON TRICHOMITRION (Hedw.) Mohr.
Painesville, Cedar Swamp (Champaign Co.) Wm. C. Werner; Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

LEPTODON TRICHOMITRIUM IMMERSUM Lesq. & James.
"Cincinnati," Leo Lesquereux (H. C. Beardslee, Cat.)

79. LEUCODON Schwægr.

LEUCODON BRACHYPUS Brid.
"Common," H. C. Beardslee (Cat.)

LEUCODON JULACEUS (Hedw.) Sull.
Painesville, Columbus, Sugar Grove, Cedar Swamp, Rendville (Perry Co.) Wm. C. Werner; Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

80. HEDWIGIA Ehrh.

HEDWIGIA CILIATA Ehrh.
Painesville, Franklin Co., Sugar Grove, Ironton, Wm. C. Werner; Springfield, Miss H. J. Biddlecome; Miami Valley, A. P. Morgan (Flora).

XX. HOOKERIEÆ.

81. HOOKERIA Tayl.

HOOKERIA SULLIVANTII Muell.
"Lancaster," Leo Lesquereux (H. C. Beardslee, Cat.); "Middle Ohio," W. S. Sullivant (Lesquereux & James Man.)

Index to Mosses.

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H

Hepaticae; Liverworts.

JUNGERMANIACEÆ.

1. FRULLANIA Raddi.

FRULLANIA AEOLOTIS Nees. (*Lejeunia aeolotis* Nees.)
Cedar Swamp (Urbana) Mrs. E. J. Spence; Painesville, Columbus, Fairfield Co., Muskingum Co., Wm. C. Werner.

FRULLANIA ASAGRAYANA Mont.
Sugar Grove (Fairfield Co.); Lawrence Co., W. C. Werner.

FRULLANIA EBORACENSIS Lehm. (*Lejeunia eboracensis* Gottsche.)
Throughout the state.

FRULLANIA FRAGILIFOLIA Tayl. (*Frullania sullivantiae* Aust.)
On trees in Cedar Swamp (Urbana) W. S. Sullivant (L. M. Underwood, Hep. Cat.), Miss H. J. Biddlecome; Wm. C. Werner.

FRULLANIA SQUARROSA Nees. (*Lejeunia squarrosa* Nees.
Cedar Swamp (Urbana) W. S. Sullivant (L. M. Underwood, Hep. Cat.), Mrs. E. J. Spence; Painesville, Columbus (Lawrence Co) Wm. C. Werner.

FRULLANIA VIRGINICA Lehm.
Throughout the state.

2. LEJEUNIA Libert.

LEJEUNIA CALCAREA Libert.
Cedar Swamp (Urbana) Miss H. J. Liddlecome, Wm. C. Werner.

LEJEUNIA CLYPEATA (Schw.) Sull. (*Phragmicomia clypeata* Sull.)
Cedar Swamp (Urbana) Mrs. E. J. Spence; Painesville, Wm. C. Werner.

LEJEUNIA SERPYLLIFOLIA AMERICANA Lindb. (*Lejeunia cavifolia* Aust.;
Painesville, H. C. Beardslee (Cat.), Wm. C. Werner.

3. RADULA Dumort.

Radula complanata (L.) Dumort.
Springfield, Miss H. J. Biddlecome; Painesville, Franklin Co., Fairfield Co., Perry Co., Wm. C. Werner.

Radula obconica Sull.
Ohio, H. C. Beardslee (Cat.); Cedar Swamp (Urbana) W. S. Sullivant (H. C. Beardslee, Cat.), Mrs. E. J. Spence, Wm. C. Werner.

4. PORELLA Dill.

Porella dentata Lindb. (*Madotheca rivularis* Nees.
Yellow Springs (Green Co.) W. S. Sullivant (H. C. Beardslee, Cat.)

Porella platyphylla (L.) Lindb. (*Madotheca platyphylla* Dumort.)
Common.

5. PTILIDIUM Nees.

Ptilidium ciliare Nees. (*Blepharozia ciliaris* Dumort.)
Painesville, Summit Co., Wm. C. Werner.

6. TRICHOCOLEA Dumort.

Trichocolea biddlecomiae Aust.
Cedar Swamp (Urbana) Miss H. J. Biddlecome.

Trichocolea tomentella (Ehrh) Dumort.
Cedar Swamp (Urbana) Mrs. E. J. Spence.

7. BAZZANIA S. F. Gray.

Bazzania trilobata (L.) S. F. Gray. (*Mastigobryum trilobatum* Nees.)
Painesville, Fairfield Co., Wm. C. Werner; Cedar Swamp (Urbana) Mrs. E. J. Spence.

8. BLEPHAROSTOMA Dumort.

Blepharostoma tricophyllum (L.) Dumort. (*Jungermannia tricophylla* L.)
Ohio, H. C. Beardslee (Cat.)

9. CEPHALOZIA Dumort.

Cephalozia bicuspidata Dumort.
Cedar Swamp (Champaign Co.) Wm. C. Werner.

Cephalozia curvifolia Dicks.
Painesville, H. C. Beardslee (Cat.); Ashtabula Co., E. E. Bogue; Columbus Cedar Swamp (Urbana) Wm. C. Werner.

CEPHALOZIA MULTIFLORA Lindb.
Cedar Swamp (Urbana) Miss H. J. Biddlecome.

CEPHALOZIA SULLIVANTII Aust.
Ohio, H. C. Beardslee (Cat.); Springfield, Miss H. J. Biddlecome.

10. ODONTOSCHISMA Dumort.

ODONTOSCHISMA DENUDATA (Nees) Dumort. (*O. hubeneriana* Rabenh.)
Cedar Swamp (Urbana) Miss H. J. Biddlecome.

ODONTOSCHISMA SPHAGNI (Dicks.) Dumort.
H. C. Beardslee (Cat.)

11. KANTIA S. F. Gray.

KANTIA TRICHOMANIS (L.) Lindb. (*Calypogeia trichomania* Corda.)
Cedar Swamp (Urbana) Miss H. J. Biddlecome.

12. SCAPANIA Dumort.

SCAPANIA NEMOROSA (L.) Dumort.
Painesville, Cuyahoga Falls, Columbus, Fairfield Co., Wm. C. Werner; Cedar Swamp (Urbana) Mrs. E. J. Spence.

13. DIPLOPHYLLUM Dumort.

DIPLOPHYLLUM TAXIFOLIUM (Wahlb.) Dumort. (*Scapania albicans taxifolium* Nees.)
Ohio, H. C. Beardslee (Cat.); Fairfield Co., Wm. C. Werner.

14. GEOCALYX Nees.

GEOCALYX GRAVEOLENS Nees.
Clifton (Green Co.) Miss H. J. Biddlecome; Painesville, Champaign Co., Wm. C. Werner.

15. LOPHOCOLEA Dumort.

LOPHOCOLEA BIDENTATA Dumort.
Columbus, Wm. C. Werner.

LOPHOCOLEA HETEROPHYLLA Schrad. Nees.
Springfield, Miss H. J. Biddlecome; Lake, Franklin, Fairfield and Muskingum counties, Wm. C. Werner.

LOPHOCOLEA MACOUNI Aust.
Painesville, H. C. Beardslee (Cat.)

LOPHOCOLEA MINOR Nees.
Painesville, H. C. Beardslee (Cat.)

16. CHILO_YPHUS Corda.

CHILOCYPHUS ASCENDENS Dumort.
Painesville, Wm. C. Werner; Springfield, Miss H. J. Biddlecome.

CHILOCYPHUS POLYANTHOS (L.) Corda.
Ohio, H. C. Beardslee (Cat.)

17. PLAGIOCHILA Dumort.

PLAGIOCHILA ASPLENIOIDES Nees. & Mont.
Clifton (Green Co.) Miss H. J. Biddlecome.

PLAGIOCHILA INTERRUPTA Dumort. (*P. macrostoma* Sull.)
Ohio, W. S. Sullivant (H. C. Beardslee, Cat.)

PLAGIOCHILA PORELLOIDES Lindb.
Ohio, H. C. Beardslee (Cat.); Fairfield Co., Wm. C. Werner.

18. HARPANTHUS Nees.

HARPANTHUS SCUTATUS Spruce.
Painesville, H. C. Beardslee (Cat.); Clifton (Green Co.) Miss H. J. Biddlecome.

19. JUNGERMANNIA Micheli.

JUNGERMANNIA INCISA Schrad.
Cedar Swamp (Urbana) Miss H. J. Biddlecome.

JUNGERMANNIA SCHRADERI Martins.
Painesville, Franklin Co., Champaign Co., Fairfield Co., Wm. C. Werner.

20. MARSUPELLA Dumort.

MARSUPELLA SPHACELATA Dumort. (*Sarcoscyphus sphacelatus* Nees., *Nardia sphacelata* B. Gr.)
Ohio, H. C. Beardslee (Cat.)

21. NARDIA S. F. Gray.

NARDIA CRENULATA (Smith) Lindb. (*Jungermannia crenulata* Lindb.)
Painesville, H. C. Beardslee (Cat.)

NARDIA CRENULIFORMIS Lindb. (*Jungermannia crenuliformis* Aust.)
Painesville, H. C. Beardslee (Cat.); Coshocton Co., O. Sullivant (Gray's Man. 6th Ed.)

NARDIA HYALINA Lyell. (*Jungermannia hyalin* Lyell.)
Ohio, Leo Lesquereux (H. C. Beardslee, Cat.)

22. FOSSOMBRONIA Raddi.

FOSSOMBRONIA CRISTATA Lindb.
Rendville (Perry Co.) W. C. Werner.

23. PALLAVICINIA S. F. Gray.

PALLAVICINIA LYELLII S. F. Gray. (*Steetzia lyellii* Lehm.)
Champaign Co., Columbus, Wm. C. Werner.

24. BLASIA Micheli.

BLASIA PUSILLA L.
Ohio, H. C. Beardslee (Cat.); Painesville, Wm. C. Werner.

25. PELLIA Raddi.

PELLIA ENDIVIAEFOLIA Dumort.
Cedar Swamp (Champaign Co.) Wm. C. Werner.

26. METZGERIA Raddi.

METZGERIA CONJUGATA Lindb.
Ironton (Lawrence Co.) Wm. C. Werner.

27. ANEURA Dumort.

ANEURA LATIFRONS Lindb.
Cedar Swamp (Urbana) Miss J. M. Biddlecome, Wm. C. Werner.

ANEURA PINGUIS (L.) Dumort.
Ohio, W. S. Sullivant (H. C. Beardslee, Cat.); Cedar Swamp (Urbana) Miss H. J. Biddlecome.

ANEURA SESSILIS Spreng.
Ohio, W. S. Sullivant, (H. C. Beardslee, Cat.); Cedar Swamp (Urbana) Miss H. J. Biddlecome.

ANTHOCEROTACEÆ.

28. ANTHOCEROS Micheli.

ANTHOCEROS LÆVIS L.
Ohio, H. C. Beardslee (Cat.); Rendville (Perry Co.) Wm. C. Werner.

Anthoceros punctatus (L.)
Ohio, H. C. Beardslee (Cat.)

29. NOTOTHYLAS Sull.

Notothylas urelanospora Sull.
Ohio, W. S. Sullivant (H. C. Beardslee, Cat.)

Notothylas orbicularis Sull. (*Notothylas valvata* Sull.
Ohio, W. S. Sullivant (H. C. Beardslee, Cat.)

MARCHANTIACEÆ.

30. MARCHANTIA Marchant f.

Marchantia polymorpha L.
Frequent.

31. CONOCEPHALUS Neck.

Conocephalus conicus (L.) Dumort.
Throughout the state.

32. GRIMALDIA Raddi.

Grimaldia rupestris Lindb. (*Duvalia rupestris* Nels.)
Springfield, Mrs. E. J. Spence.

33. ASTRELLA Beauv.

Astrella hemispherica Beauv.
Springfield, Mrs. H. J. Biddlecome.

34. LUNULARIA Micheli.

Lunularia vulgaris Raddi.
Ohio, H. C. Beardslee (Cat.); Painesville, Wm. C. Werner.

RICCACEÆ.

35. RICCIA Micheli.

Riccia fluitans L.
Newark (J. L. Riddell, Sup. Cat. 1835); Painesville, Champaign Co., Wm. C. Werner; Ashtabu'a Co., E. E. Bogue.

RICCIA FROSTII Aust.
Painesville, H. C. Beardslee (Lazenby & Werner, Sup. List).

RICCIA LUTÉSCENS Schw.
Painesville, Otto Hacker.

RICCIA NATANS L.
Painesville, Franklin Co., Wm. C. Werner; Cleveland, Wm. Krebs. A terrestrial form from Leetonia (Columbiana Co.) H. G. Wolfgang.

Index

TO THE

GENERA OF HEPATICÆ.

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Lichenes; Lichens.*

PARMELIACEI.

1. RAMALINA Ach. De Not.

RAMALINA CALICARIS (L.) Fr.
Fairfield Co., W. A. Kellerman; Champaign Co., Mrs. E. J. Spence, Miss H. J. Biddlecome.

RAMALINA CALICARIS CANALICULATA Fr.
Ashtabula Co., E. E. Bogue.

RAMALINA CALICARIS FASTIGIATA Fr.
Near Cincinnati, Thos. G. Lea (Cat.); Fairfield Co., W. A. Kellerman; Ashtabula Co., E. E. Bogue.

RAMALINA CALICARIS FRAXINEA Fr.
Painesville, Wm. C. Werner; Ashtabula Co., E. E. Bogue; Fairfield Co., W. A. Kellerman.

RAMALARIA POLLONARIA (Ach.)
Ashtabula Co., E. E. Bogue.

2. CETRARIA (Ach.) F. Mull.

CETRARIA ALEURITES (Ach) Th. Fr.
On bare dead branches of Pinus virginiana, Fairfield Co., E. E. Bogue.

CETRARIA AURESCENS Tuck.
On bare dead branches of Pinus virginiana, Fairfield Co., E. E. Bogue.

CETRARIA CILIARIS Ach.
Champaign Co., Mrs. E. J. Spence, Mrs. H. J. Biddlecome, Wm. C. Werner; on bare dead branches of Pinus virginana, Fairfield Co., E. E. Bogue.

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*Lichens are ascomycetous fungi, but are seperated here for convenience. Most of the specimens were submitted to Dr. Eckfeldt, Miss Clara Cummings and F. LeRoy Sargent to whom thanks are hereby expressed. Miss Biddlecome's and Mrs Spence's specimens were when collected, submitted to Prof. Tuckerman and Mr. Austin.

3. EVERNIA Ach.

EVERNIA FURFURACEA (L.) Mann.
On pine bark, Fairfield Co., E. E. Bogue.

4. USNEA (Dill.) Ach.

USNEA ANGULATA Ach.
Cedar Swamp (Urbana) Mrs. E. J. Spence, Miss H. J. Biddlecome.

USNEA BARBATA (L.) Fr.
Stockport (Morgan Co.) W. A. Kellerman; Springfield, Mrs. E. J. Spence.

USNEA BARBATA FLORIDA Fr.
Widely distributed.

USNEA BARBATA FLORIDA * * *rubiginea* Mx.
Fairfield Co., E. E. Bogue.

USNEA BARBATA HIRTA Fr.
Frequent.

5. THELOSCHISTES NORM emend.

THELOSCHISTES CONCOLOR (Dicks.) Tuck.
Common on neglected apple trees.

THELOSCHISTES PERIENTINUS (L.) Norm.
Near Cincinnati, Thos. G. Lea (Cat.); Painesville, W. C. Werner; Marion Co., E. E. Bogue.

THELOCHISTES PERIETINUS POLYCARPUS Ehrh.
Ashtabula Co., E. E. Bogue; Champaign Co., Miss H. J. Biddlecome.

6. PARMELIA (Ach.) DeNot.

PARMELIA BORRERI RUDECTA Tuck.
Champaign Co., Mrs. E. J. Spence, Miss H. J. Biddlecome; Ashtabula Co., Franklin Co., E. E. Bogue.

PARMELIA CAPERATA (L.) Ach.
Common on trees, fences and rocks. In fruit, Ashtabula Co., Fairfield Co., E. E. Bogue.

PARMELIA CETRATA Ach.
Champaign Co., Miss H. J. Biddlecome.

PARMELIA COLPODES (Ach.) Nyl.
On tree trunks throughout the state.

PARMELIA CRINITA Ach.
On tree trunks. In fruit, Marion (Prospect Co.), Franklin Co., E. E. Bogue.

PARMELIA OLIVACEAE (L.) Ach.
Orwell (Ashtabula Co.) E. E. Bogue.

PARMELIA PERFORATA (Jacq.) Ach.
Frequent throughout the state.

PARMELIA PERLATA (L.) Ach.
Franklin Co., E. E. Bogue.

PARMELIA PERTUSA Schaer.
Champaign Co., Miss H. J. Biddlecome.

PARMELIA SAXITILIS (L.) Fr.
Cedar Swamp (Urbana) Mrs. E. J. Spence; Springfield, Miss H. J. Biddlecome.

PARMELIA TILIACEA (Hoffm.) Floerk.
Champaign Co., Mrs. E. J. Spence, Miss H. J. Biddlecome; Orwell (Ashtabula Co.) E. E. Bogue; Morgan Co., W. A. Kellerman.

7. PHYSCIA (DC., Fr.) Th. Fr.

PHYSCIA ADGLUTINATA (Floerk) Nyl.
Champaign Co., Miss H. J. Biddlecome; on trunks and branches of apple, basswood, buckeye and hickory, Franklin Co., Marion Co., E. E. Bogue.

PHYSCIA AQUILA DETONSA Tuck.
Not abundant but widely distributed.

PHYSCIA ASTROIDEA (Fr.) Nyl.
Champaign Co., Miss H. J. Biddlecome.

PHYSCIA COMOSA (Schw.) Nyl. (*P. galactophylla* Tuck.)
Near Cincinnati, Thos. G. Lea (Cat.); Cedar Swamp (Urbana) Miss H. J. Biddlecome.

PHYSCIA LEANA Tuck.
On tree trunks, near Cincinnati, Thos. G. Lea (Cat.)

PHYSCIA LEUCOMELLA (L.) Michx.
Near Cincinnati, Thos. G. Lea (Cat.); Cedar Swamp (Urbana) Miss H. J. Biddlecome.

PHYSCIA OBSCURA (Ehrh) Nyl.
Common on limestone fences, trunks and branches of many species of trees.

PHYSCIA PULVERULENTA (Schreb.) Nyl.
Common on limestone fences and tree trunks.

PHYSCIA SPECIOSA (Wulf.) Nyl.
Champaign Co., Mrs. E. J. Spence, Miss H. J. Biddlecome, Wm. C. Werner.

PHYSCIA SPECIOSA HYPOLEUCA (Muhl.) Tuck.
Champaign Co., Mrs. E. J. Spence, Miss H. J. Biddlecome.

PHYSCIA STELLARIS (L.) Tuck.
Throughout the state on tree trunks and branches. Abundant on old Osage hedges.

PHYSCIA TRIBACIA (Ach.) Nyl.
On hickory bark, Ashtabula Co., Fairfield Co., Franklin Co., E. E. Bogue.

8. PYXINE Fr. Tuck.

PYXINE SOREDIATA Fr.
Champaign Co., Mrs. E. J. Spence, Miss H. J. Biddlecome; Orwell (Ashtabula Co.) E. E. Bogue.

9. MYRANGIUM Mont. & Berk.

MYRANGIUM DURIAEI (Mont. & Berk.) Tuck.
On hard hickory wood, Preston (Hamilton Co.) A. P. Morgan.

10. UMBILICARIA Hoffm.

UMBILICARIA DILLENII Tuck.
On rocks, Sugar Grove (Fairfield Co) W. C. Werner, E. E. Bogue.

UMBILICARIA PUSTULATA (L.) Hoffm.
On rocks, Sugar Grove (Fairfield Co.) W. C. Werner, E. E. Bogue.

11. STICTA (Schreb.) Fr.

STICTA AMPLISSIMA (Scop.) Mass.
Common on tree trunks throughout the state.

STICTA AURATA (Sm.) Ach.
On tree trunks near Cincinnati, Thos. G. Lea (Cat.)

STICTA PULMONARIA (L.) Ach.
At base of trees, common.

STICTA QUERCIZANS (Mx.) Ach.
On rocks Fairfield Co., Wm. C. Werner.

12. NEPHROMA Ach.

NEPHROMA HELVETICUM Ach.
On tree trunks near Cincinnati, Thos. G. Lea (Cat.); Cedar Swamp (Urbana) Mrs. E. J. Spence; Clifton (Green Co.) Miss H. J. Biddlecome.

13. PELTIGERA (Willd., Hoffm.) Fee.

PELTIGERA APTHOSA (K.) Hoffm.
Champaign Co., Mrs. E. J. Spence.

PELTIGERA CANINA (L.) Hoffm. (*Peltidea canina* Ach.)
Damp places, J. L. Riddell (Synopsis, 1835); rotten trunks, near Cincinnati, Thos. G. Lea (Cat.); Champaign Co., Mrs. E. J. Spence, Miss H. J. Biddlecome; Ashtabula Co, E. E. Bogue.

PELTIGERA CANINA SPURIA Ach.
Champaign Co., Miss H. J. Biddlecome.

PELTIGERA HORIZONTALIS (L.) Hoffm.
Near Cincinnati, Thos. G. Lea (Cat.); Clifton (Green Co.) Miss H. J. Biddlecome; Fairfield Co., W. A. Kellerman; Painesville, Wm. C. Werner.

PELTIGERA POLYDACTYLA (Neck) Hoffm.
Common on earth and rotten wood.

PELTIGERA RUFESCENS (Neck) Hoffm.
Champaign Co., Mrs. E. J. Spence, Miss H. J. Biddlecome; Summit Co., E. E. Bogue.

PELTIGERA SCUTATA (Dicks.) Leight.
Cedar Swamp (Urbana) Miss H. J. Biddlecome; Marion Co., E. E. Bogue.

14. HEPPIA Naeg.

HEPPIA DESPREAUXII (*Solorina despreauxii* Montag.)
"On the earth," near Cincinnati, Thos. G. Lea (Cat.)

15. PANNARIA Delis.

PANNARIA LEUCOSTICA Tuck.
On Oak bark, Sugar Grove (Fairfield Co.) E. E. Bogue.

PANNARIA RUBIGINOSA (Thunb.) Delis.
Champaign Co., Mrs. E. J. Spence.

16. COLLEMA Hoffm., Fr.

COLLEMA CRISPUM Borr.
Champaign Co., Miss H. J. Biddlecome.

Collema cyrtaspis Tuck.
Champaign Co., Mrs. E. J. Spence, Miss H. J. Biddlecome.

Collema flaccidum Ach.
Champaign Co., Mrs. E. J. Spence.

Collema nigrescens (Huds.) Ach.
Champaign Co., Mrs. E. J. Spence, Miss H. J. Biddlecome; on bark, Wm. C. Werner.

Collema pycnocarpum Nyl.
Springfield, Miss H. J. Biddlecome.

Collema ryssoleum Tuck.
Springfield, Miss H. J. Biddlecome.

Collema tenax (Sw.) Ach.
Springfield, Miss H. J. Biddlecome.

17. LEPTOGIUM Fr., Nyl.

Leptogium lacerum (Sw.) Fr.
Springfield, Miss H. J. Biddlecome; Prospect (Marion Co.) E. E. Bogue.

Leptogium myochroum (Ehrh.) Tuck.
Springfield, Miss H. J. Biddlecome; Orwell (Ashtabula Co.) E. E. Bogue.

Leptogium myochroum saturninum (Sm.) Schaer.
Springfield, Mrs. E. J. Spence.

Leptogium pulchellum (Ach.) Nyl.
Common on tree trunks.

Leptogium tremelloides (L. fil.) Fr.
On sandstone rocks, Fairfield Co., Wm. C. Werner.

18. PLACODIUM (DC.) Naeg. & Hepp.

Placodium aurantiacum (Lightf.) Naeg. & Hepp.
Windsor (Ashtabula Co.) E. E. Bogue; on bark, Painesville, Wm. C. Werner.

Placodium camptidium Tuck.
Ohio, Miss H. J. Biddlecome (Tuck. N. A. Lichens).

Placodium cinnabarina (Sm. f.) Fr. (*Biatora cinnabarina* Sm. f. Fr.)
"On trunks," near Cincinnati, Thos. G. Lea (Cat.)

Placodium cerinum (Hedw.) Naeg. & Hepp.
Champaign Co., Mrs. E. J. Spence, Miss H. J. Biddlecome; Ashtabula Co., Franklin Co., Marion Co., Fairfield Co., E. E. Bogue.

PLACODIUM FERRUGINEUM (Hudds.) Hepp.
Frequent on rocks and old fences.

19. LECANORA Ach. Tuck.

LECANORA CERVINA (Pers.) Nyl.
On trunks and rails, near Cincinnati, Thos. G. Lea (Cat.)

LECANORA HAGENI Ach.
Champaign Co., Mrs. E. J. Spence, Miss H. J. Biddlecome.

LECANORA MACULATA Ach.
Champaign Co., Miss H. J. Biddlecome.

LECANORA PALLESCENS (L.) Schaer.
Frequent on trunks, especially chestnut.

LECANORA PALLESCENS ROSELLA Tuck.
Near Cincinnati, Thos. G. Lea (Cat.); Champaign Co., Miss H. J. Biddlecome.

LECANORA PRIVIGNA (Ach.) Nyl.
Fairfield Co., W. A. Kellerman, Wm. C. Werner; Summit Co., E. E. Bogue.

LECANORA SUBFUSCA (L.) Ach.
Frequent on trunks.

LECANORA SUBFUSCA DISTANS Ach.
"On trunks," near Cincinnati, Thos. G. Lea (Cat.)

LECANORA TARTAREA (L.) Ach.
Champaign Co., Mrs. E. J. Spence, Miss H. J. Biddlecome; Sugar Grove (Fairfield Co.) W. C. Werner.

LECANORA VARIA (Ehrh.) Nyl.
"On old rails," near Cincinnati, Thos. G. Lea (Cat.); Summit Co., Franklin Co., Licking Co., Fairfield Co., E. E. Bogue.

20. RINODINIA Mass., Tuck.

RINODINIA SOPHODES ATROCINEREA Nyl.
"On trunks and rails," near Cincinnati, Thos. G. Lea (Cat.); Windsor (Ashtabula Co.) E. E. Bogue.

21. PERTUSARIA DC.

PERTUSARIA COMMUNIS DC. (*P. pertusa* Fr.)
Springfield, Miss H. J. Biddlecome; Windsor (Ashtabula Co.) E. E. Bogue; "on trunks" near Cincinnati, Thos. G. Lea (Cat.); Fairfield Co., Wm. C. Werner; on Blue Beech, Franklin Co., E. E. Bogue.

PERTUSARIA LEIOPLACA (Ach.) Nyl.
On maple, Painesville, Wm. C. Werner; Springfield, Miss H. J. Biddlecome; on bark of butternut, Franklin Co., Sugar Grove (Fairfield Co.) E. E. Bogue.

PERTUSARIA MULTIPUNCTA (Turn.) Nyl.
On trunks near Cincinnati, Thos. G. Lea (Cat.); Springfield, Miss H. J. Biddlecome.

PERTUSARIA VELATA (Turn.) Nyl.
Springfield, Miss H. J. Biddlecome; Fairfield Co., W. A. Kellerman; Cedar Swamp (Champaign Co.) W. C. Werner; Franklin Co., Orwell (Ashtabula Co.) E. E. Bogue.

LECIDEACEI.

22. CLADONIA Hoffm.

CLADONIA CARIOSA (Ach.) Spreng.
Fairfield Co., E. E. Bogue.

CLADONIA CÆSPITICIA Willd.
Summit Co., Lorain Co., Franklin Co., E. E. Bogue.

CLADONIA COCCIFERA (L.) Fr. (*C. cornucopioides* L.)
"Ohio," J. L. Riddell (Synop. 1835); Fairfield Co., E. E. Bogue.

CLADONIA CORNUTA (L.) Fr.
On rotten trunks, near Cincinnati, Thos. G. Lea (Cat.)

CLADONIA CRISTATELLA Tuck.
Common on the ground.

CLADONIA DEGENERANS Floerk.
Fairfield Co., E. E. Bogue.

CLADONIA DELICATA (Ehrh.) Floerk.
Springfield, Miss H. J. Biddlecome, Mrs. E. J. Spence; Fairfield Co., E. E. Bogue.

CLADONIA FIMBRIATA (L.) Fr.
Common on the earth.

CLADONIA FIMBRIATA TUBÆFORMIS Fr. (*C. adspersa* Mont.)
On rotten wood and the earth.

CLADONIA FURCATA (Huds.) Fr.
Cedar Swamp, (Champaign Co.) Mrs. E. J. Spence, Miss H. J. Biddlecome.

CLADONIA FURCATA CRISPATA Floerk.
Cedar Swamp (Champaign Co.) Miss H. J. Biddlecome.

CLADONIA FURCATA RACEMOSA Floerk.
On the earth, very common.

CLADONIA FURCATA SUBULATA Fl.
"On the earth," near Cincinnati, Thos. G. Lea (Cat.)

CLADONIA GRACILIS (L.) Nyl.
Cedar Swamp (Champaign Co.) Mrs. E. J. Spence, Miss H. J. Biddlecome.

CLADONIA GRACILIS HYBRIDA Schaer.
On the earth, Ashtabula Co., E. E. Bogue.

CLADONIA GRACILIS VERTICILLATA Fr.
On the earth, Fairfield Co., Wm. C. Werner, E. E. Bogue; Ashtabula Co., E. E. Bogue.

CLADONIA MACILENTA (Ehrh.) Hoffm.
Rotton trunks, near Cincinnati, Thos. G. Lea (Cat.); Cedar Swamp (Champaign Co.) Mrs. E. J. Spence, Miss H. J. Biddlecome.

CLADONIA MITRULA Tuck.
Springfield, Cedar Swamp (Champaign Co.) Miss H. J. Biddlecome; Fairfield Co., E. E Bogue.

CLADONIA PAPILLARIA MOLARIFORMIS Hoffm.
Fairfield Co., E. E. Bogue.

CLADONIA PYXIDATA (L.) Fr.
On the earth, common.

CLADONIA RANGIFERINA (L.) Hoffm.
In mats on the earth, common.

CLADONIA RANGIFERINA ALPESTRIS L.
On the earth, Fairfield Co., E. E. Bogue.

CLADONIA RANGIFERINA SYLVATICA L.
"On rotten trunks," near Cincinnati, Thos. G. Lea (Cat.)

CLADONIA SQUAMOSA Hoffm.
On the earth, rocks and rotten wood, common.

CLADONIA SYMPHYCARPA EPIPHYLLA (Ach.) Nyl.
Fairfield Co., E. E. Bogue.

23. BIATORA Fr.

BIATORA CHLORANTHA Tuck.
Near Springfield, Mrs. E. J. Spence.

BIATORA FUSCO-RUBELLA (Hoffm.) Tuck.
On trunks, near Cincinnati, Thos. G. Lea (Cat.); Champaign Co., Mrs. E. J. Spence, Miss H. J. Biddlecome.

BIATORA RUBELLA (Ehrh.) Rabenh.
On Hickory bark, Painesville, W. C. Werner; on Beech, Orwell (Ashtabula Co.), on Linden, Georgesville (Franklin Co.) E. E. Bogue.

BIATORA RUSSELLII Tuck.
Springfield, Miss H. J. Biddlecome.

BIATORA RUSSULA (Ach.) Mont.
Springfield, Mrs. E. J. Spence.

BIATORA SCWEINITZII Fr.
Springfield, Miss H. J. Biddlecome; on oak bark, Sugar Grove, Fairfield Co., E. E. Bogue.

BIATORA SUFFUSA Fr.
"On trunks," near Cincinnati, Thos. G. Lea (Cat.); Springfield, Miss H. J. Biddlecome.

BIATORA VARIANS Ach. (*B. exigua* Chaub. Fr.)
On bark, Franklin Co., Wm. C. Werner.

24. HETEROTHECIUM Flot. (emend.)

HETEROTHECIUM LEUCOXANTHUM (Spreng.) Mass.
On acer saccharum, Columbus, E. E. Bogue.

25. LECIDEA (Ach.) Fr. Tuck.

LECIDEA ALBOCÆRULESCENS (Wulf.) Schaer.
On rock, Sugar Grove (Fairfield Co.) W. C. Werner, E. E. Bogue; Ashtabula Co., E. E. Bogue.

LECIDEA GRANOSA Tuck.
Ohio, Miss H. J. Biddlecome (Tuck. N. A. Lichens).

26. BUELLIA DeNot., Tuck.

BUELLIA COLLUDENS (Nyl.) Tuck.
Fairfield Co., W. A. Kellerman.

BUELLIA PARASEMA (Ach.) Th. Fr.
On trunks, common.

BUELLIA PETRÆA (Flot. Koerb.) Tuck. (*Lecidea concentrica* Dav.)
On rocks and stones, Ashtabula Co., Summit Co., E. E. Bogue; Fairfield Co., W. A. Kellerman, E. E. Bogue; Plain City (Madison Co.) Wm. C. Werner.

GRAPHIDACEI.

27. LECANACTIS (Eschw. Koerb., emend.)

LECANACTIS PREMNEA CHLOROCONIA Tuck. (*Buellia premnea chloroconia* Tuck.)
Prospect (Marion Co.) E. E. Bogue.

28. OPEGRAPHA (Humb.) Ach. Nyl.

OPEGRAPHA ATRA MACULARIS Fr.
"On trunks," near Cincinnati, Thos. G. Lea (Cat.)

OPEGRAPHA SCRIPTA LIMITATA Schaer.
"On trunks," near Cincinnati, Thos. G. Lea (Cat.)

OPEGRAPHA SCRIPTA SERPENTARIA Schaer.
"On trunks," near Cincinnati, Thos. G. Lea (Cat.)

OPEGRAPHA VARIA (Pers.) Fries.
On maple, Waynesville (Warren Co.) H. A. Surface; on old elm bark, Georgesville (Franklin Co.) W. C. Werner.

OPEGRAPHA VARIA PULICARIS Fr.
"On trunks," near Cincinnati, Thos. G. Lea (Cat.)

OPEGRAPHA VULGATA (Ach.) Nyl.
Dayton, Miss H. J. Biddlecome.

29. GRAPHIS Ach. Nyl.

GRAPHIS SCRIPTA Ach.
On trunks, very common.

30. ARTHONIA Ach. Nyl.

ARTHONIA ASTROIDES Ach.
Champaign Co., Mrs. E. J. Spence, Miss H. J. Biddlecome; Franklin Co., Wm. C. Werner.

ARTHONIA DISPERSA Nyl.
Springfield, Mrs. E. J. Spence.

ARTHONIA LECIDEELLA Nyl.
Springfield, Mrs. E. J. Spence; on Honey Locust, Columbus, W. A. Kellerman.

ARTHONIA POLYMORPHA Tuck. (*Opegrapha polymorpha* Tuck.)
"On trunks," near Cincinnati, Thos. G. Lea (Cat.); on maple, Madison Co. Wm. C. Werner.

Arthonia punctiformis Ach.
On acer rubrum, Orwell (Ashtabula Co.) E. E. Bogue.

Arthonia pyrrhuliza Nyl.
Springfield, Mrs. E. J. Spence.

Arthonia spectabilis Fl.
On trunks, common.

CALICIACEI.

31. ACOLIUM (Fee.) DeNot.

Acolium tigillare (Ach.) DeNot.
Columbus, Wm. C. Werner.

32. CALICIUM Pers. Ach. Fr.

Calicium byssaceum Fr.
On old Polyporus, Fairfield Co., W. A. Kellerman.

Calicium chrysocephalum (Turn.) Ach.
On Oak-bark, Sugar Grove (Fairfield Co.) E. E. Bogue.

VERRUCARIACEI.

33. ENDOCARPON Hedw.

Endocarpon miniatum (L.) Schaer.
Springfield, Mrs. E. J. Spence, Miss H. J. Biddlecome; on limestone rocks, Georgesville (Franklin Co.) E. E. Bogue; Fairfield Co., W. A. Kellerman.

Endocarpon pusillum Tuck.
Springfield, Miss H. J. Biddlecome.

34. TRYPETHELIUM Spreng.

Trypethelium virens Tuck.
Springfield, Mrs. E. J. Spence.

35. SAGEDIA Mass.

Sagedia oxyspora (Nyl.) Tuck.
On Beach-bark, Fairfield Co., W. A. Kellerman.

36. VERRUCARIA Pers.

VERRUCARIA MURALIS Ach.
Limestone rock, Plain City (Madison Co.) W. C. Werner.

VERRUCARIA NIGRESCENS Pers.
"On rocks," near Cincinnati, Thos. G. Lea (Cat.)

VERRUCARIA RUPESTRIS Schrad.
On limestone rocks, Muskingum Co., Wm. C. Werner; on rock, Ashtabula Co., E. E. Bogue.

37. PYRENULA.

PYRENULA GEMMATA (Ach.) Naeg.
On Beech, Oberlin, E. E. Bogue.

PYRENULA GLABRATA (Ach.) Mass.
On old bark, Rendville (Perry Co.), Fairfield Co., W. A. Kellerman; Champaign Co., Wm. C. Werner.

PYRENULA NITIDA Ach.
On bark, common.

Index

TO THE

GENERA OF LICHENS.

[The references are to the serial number, not to the page].

Fungi.*

I. AGARICACEÆ.

1. AMANITA Pers.

AMANITA CAESAREA Scop.
Miami Valley, A. P. Morgan (Fl.)

AMANITA FLAVO-RUBENS Berk.
Near Columbns, Sullivant (Sacc. Sylloge Vol. V., p, 17).

AMANITA MUSCARIA L.
Miami Valley, A. P. Morgan (Fl.)

AMANITA RUBESCENS Pers.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

AMANITA PANTHERINA DC.
Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

AMANITA VERNA Fr.
Loveland (Clermont Co.) D. L. James (Add. Cat.); Miami Valley, A. P. Morgan (Flora).

AMANITA VIROSA Fr.
Reported in Thos. G. Lea's Cat., but omitted by A. P. Morgan, who does not think it occurs in Ohio.

2. AMANITOPSIS Roz.

AMANITOPSIS VAGINATA (Bull.) Roz.
Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

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*The species, especially of the higher groups, are given for the most part on the authority of Prof. A. P. Morgan (see his various published lists); specimens of some of the others were submitted to Mr. J. B. Ellis, and the remainder were determined by the undersigned and are authenticated by herbarium specimens. This and the subsequent portions of the Catalogue make no pretentiou toward completeness Contributions of specimens from all parts of the state are earnestly solicited. [W. A. Kellerman.

Amanitopsis volvata (Peck.) Sacc.
Miami Valley, A. P. Morgan (Fl.)

3. LEPIOTA Fries.

Lepiota americana Peck.
Miami Valley, A. P. Morgan (Fl.); on sawdust in icehouse, Granville, H. L. Jones.

Lepiota acutesquamosa Weinm.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

Lepiota carcharias Pers.
Miami Valley, A. P. Morgan (Fl.)

Lepiota cristata A. & S.
Miami Valley, A. P. Morgan (Fl.)

Lepiota felina Pers.
Miami Valley, A. P. Morgan (Fl.)

Lepiota fuscosquamea Peck.
Miami Valley, A. P. Morgan (Fl.)

Lepiota granosa Morgan.
Miami Valley, A. P. Morgan (Fl.)

Lepiota mastoidea Fr.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

Lepiota miamensis Morgan.
Miami Valley, A. P. Morgan (Fl.)

Lepiota morgani Peck.
Miami Valley, A. P. Morgan (Fl.)

Lepiota naucina Fr.
Miami Valley, A. P. Morgan (Fl.)

Lepiota oblita Peck.
Miami Valley, A. P. Morgan (Fl.)

Lepiota procera Scop.
Cincinnati, Thos. G. Lea (Cat.); Loveland (Clermont Co.) D. L. James (Add. Cat.); Miami Valley, A. P. Morgan (Fl.) An edible species.

Lepiota rhacodes Vitt.
Miami Valley, A. P. Morgan (Fl.) Said to be edible.

Lepiota rubro-tincta Peck.
Miami Valley, A. P. Morgan (Fl.)

4. ARMILLARIA Fries.

ARMILLARIA MELLEA Fr.
Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.) An edible species.

5. TRICHOLOMA Fries.

TRICHOLOMA CERINUM Pers.
Miami Valley, A. P. Morgan (Fl.)

TRICHOLOMA LATERARIUM Peck.
Miami Valley, A. P. Morgan (Fl.)

TRICHOLOMA MELALEUCUM Pers.
Miami Valley, A. P. Morgan (Fl.)

TRICHOLOMA PERSONATUM Fr.
Miami Valley, A. P. Morgan (Fl.)

TRICHOLOMA SPERMATICUM Paul.
Miami Valley, A. P. Morgan (Fl.)

TRICHOLOMA TERREUM Schaeff.
Miami Valley, A. P. Morgan (Fl.)

6. CLITOCYBE Fries.

CLITOCYBE CANDICANS Pers.
Miami Valley, A. P. Morgan (Fl.)

CLITOCYBE CONNEXA Peck.
Miami Valley, A. P. Morgan (Fl.)

CLITOCYBE CYATHIFORMIS Bull.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Loveland (Clermont Co.) D. L. James (Add. Cat.); Miami Valley (A. P. Morgan (Fl.) Edible.

CLITOCYBE DEALBATA Schw.
Loveland (Clermont Co.) D. L. James (Add Cat.); Miami Valley, A. P. Morgan (Fl.) Edible.

CLITOCYBE ILLUDENS Schw.
Cincinnati, Waynesville (Warren Co.) Thos. G. Lea (Cat.); Loveland (Clermont Co.) D. L. James (add. Cat.); Miami Valley, A. P. Morgan (Fl.)

CLITOCYBE INFUNDIBULIFORMIS Schaeff.
Miami Valley, A. P. Morgan (Fl.) An edible species.

CLITOCYBE LACCATA Scop.
Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

CLITOCYBE MONADELPHA Morgan.
Miami Valley, A. P. Morgan (Fl.)

CLITOCYBE NEBULARIS Batsch.
Cincinnati, Thos. G. Lea (Cat.) Edible.

CLITOCYBE OCHRO-PURPUREA Berk.
Cincinnati, Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

CLITOCYBE PHYLLOPHILA Fr.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

CLITOCYBE PRUINOSA Lasch.
Waynesville (Warren Co.) Thos. G. Lea (Cat.)

CLITOCYBE TRUNCICOLA Peck.
Miami Valley, A. P. Morgan (Fl.)

7. COLLYBIA Fries.

COLLYBIA BUTYRACEA Bull.
Miami Valley, A. P. Morgan (Fl.)

COLLYBIA CIRRHATA Schum.
Waynesville (Warren Co.) Thos. G Lea (Cat.); Miami Valley, A. P. Morgan (Fl).

COLLYBIA COLOREA Peck.
Miami Valley, A. P. Morgan (Fl.)

COLLYBIA DRYOPHILA Bull.
Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

COLLYBIA ESTENSIS Morgan.
Maimi Valley, A. P. Morgan (Fl.)

COLLYBIA HARIOLORA DC.
Miami Valley, A. P. Morgan (Fl.)

COLLYBIA LACHNOPHYLLA Berk.
Waynesville (Warren Co.) Thos. G. Lea (Cat.)

COLLYBIA PLATYPHYLLA Pers.
Miami Valley, A. P. Morgan (Fl.)

COLLYBIA RADICATA Relh.
Cincinnati, Thos. G. Lea (Cat.); Loveland (Clermont Co.) D. L. James (Add. Cat.); Miami Valley, A. P. Morgan (Fl.) Edible.

COLLYBIA STIPITARIA Fr.
Miami Valley, A. P. Morgan (Fl.)

COLLYBIA VELUTIPES Curt.
Cincinnati, Thos. G. Lea (Cat.); Loveland (Clermont Co.) D. L. James (Add Cat.); Miami Valley, A. P. Morgan (Fl.); Columbus, W. A. Kellerman.

COLLYBIA ZONATA Peck.
Miami Valley, A. P. Morgan (Fl.)

8. MYCENA Fries.

MYCENA FILOPES Bull.
Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

MYCENA GALERICULATA Scop.
Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

MYCENA HAEMATOPA Pers.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

MYCENA LEAIANA Berk.
Cincinnati, Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

MYCENA PURA Pers.
Miami Valley, A. P. Morgan (Fl.)

9. OMPHALIA Fries.

OMPHALIA ALBOFLAVA Morgan.
On rotten wood, Miami Valley, A. P. Morgan (Fl.)

OMPHALIA CAMPANELLA Batsch.
Cincinnati, Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

OMPHALIA CHRYSEA Peck.
Miami Valley, A. P. Morgan (Fl.)

OMPHALIA EPICHYSIA Pers.
On mouldy wood, Miami Valley, A. P. Morgan (Fl.)

OMPHALIA FIBULA Bull.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

OMPHALIA INTEGRELLA Pers.
Miami Valley, A. P. Morgan (Fl.)

OMPHALIA MURALIS Sow.
Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

Omphalia rustica Fr.
Miami Valley, A. P. Morgan (Fl.)

Omphalia umbellifera L.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

10. PLEUROTUS Fries.

Pleurotus acerinus Fr.
On Acer saccharinum, Granville, H. L. Jones.

Pleurotus algidus (Fr.) Sow.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

Pleurotus applicatus (Batsch.) Sow.
Loveland (Clermont Co.) D. L. James (Add. Cat.)

Pleurotus corticatus Fr.
Miami Valley, A. P. Morgan (Fl.)

Pleurotus craspedius Fr.
Miami Valley, A. P. Morgan (Fl.)

Pleurotus lignatalis Fr.
On wood of beech and maple, Miami Valley, A. P. Morgan (Fl.)

Pleurotus mastrucatus Fr.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

Pleurotus niger Schw.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

Pleurotus pinsitus Fr.
Waynesville (Warren Co.) Thos. G. Lea (Cat.),

Pleurotus sapidus Kalch.
Miami Valley, A. P. Morgan (Fl.); on old hickory trees, Rendville (Perry Co.) Columbus, W. A. Kellerman. Edible.

Pleurotus serotinus Schrad.
Miami Valley, A. P. Morgan (Fl.); on rotten wood, Rendville (Perry Co.) W. A. Kellerman.

Pleurotus ulmarius Bull.
On trunks, especially of elms, Miami Valley, A. P. Morgan (Fl.). Edible.

11. HYGROPHORUS Fries.

Hygrophorus ceraceus Wulf.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

Hygrophorus chlorophanus Fr.
Miami Valley, A. P. Morgan (Fl.)

Hygrophorus coccineus Schaeff.
Miami Valley, A. P. Morgan (Fl.)

Hygrophorus conicus Scop.
Miami Valley, A. P. Morgan (Fl.)

Hygrophorus eburneus Bull.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.) An edible species.

Hygrophorus lauræ Morg.
Miami Valley, A. P. Morgan (Fl.)

Hygrophorus puniceus Fr.
Miami Valley, A. P. Morgan (Fl.)

12. LACTARIUS Fries.

Lactarius affinis Pk.
Miami Valley, A. P. Morgan (Fl.)

Lactarius calceolus Berkl.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

Lactarius cilicioides Fr.
Miami Valley, A. P. Morgan (Fl.)

Lactarius cinereus Pk.
Miami Valley, A. P. Morgan (Fl.)

Lactarius deliciosus L.
Miami Valley, A. P. Morgan (Fl.). Edible.

Lactarius distans Pk.
Miami Valley, A. P. Morgan (Fl.)

Lactarius pargamenus Fr.
Waynesville (Warren Co.) Thos. G. Lea (Cat); Miami Valley, A. P. Morgan (Fl.)

Lactarius piperatus Scop.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.). Edible.

Lactarius scrobiculatus Scop.
Miami Valley, A. P. Morgan (Fl.)

Lactarius subdulcis Bull.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.). An edible species.

Lactarius trivialis Fr.
Miami Valley, A. P. Morgan (Fl.)

Lactarius vellereus Fr.
Waynesville (Warren Co.) Thos. G. Lea (Cat.) ; Miami Valley, A. P. Morgan (Fl.)

Lactarius vietus Fr.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

Lactarius volemus Fr.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Loveland (Clermont Co.) D. L. James; Miami Valley, A. P. Morgan (Fl.) Edible.

Lactarius zonarius Bull.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

13. RUSSULA Persoon.

Russula decolorans Fr.
Loveland (Clermont Co.) D. L. James; Miami Valley, A. P. Morgan (Fl)

Russula foetans Pers.
Miami Valley, A. P. Morgan (Fl.)

Russula furcata Pers.
Miami Valley, A. P. Morgan (Fl.)

Russula incarnata Morgan,
Under Beech trees, Miami Valley, A. P Morgan (Fl.)

Russula lactea Pers.
In beech woods, Miami Valley, A. P. Morgan (Fl.)

Russula lepida Fr.
In beech woods, Miami Valley, A. P. Morgan (Fl.) This is said to be an edible species.

Russula lutea Vent.
In beech woods, Miami Valley, A. P. Morgan (Fl.)

Russula nitida Pers.
Waynesville (Warren Co.) Thos. G. Lea (Cat.) ; Miami Valley, A. P. Morgan (Fl.)

Russula sordida Peck.
Miami Valley, A. P. Morgan (Fl.)

Russula virescens Schaeff.
Miami Valley, A. P. Morgan (Fl.). Said to be edible.

14. CANTHARELLUS Adans.

CANTHARELLUS AURIANTIACUS Wulf.
Miami Valley, A. P. Morgan (Fl.)

CANTHARELLUS CIBARIUS Fr.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Loveland (Clermont Co.) D. L. James; Miami Valley, A. P. Morgan (Fl.) Edible.

CANTHARELLUS CINNABARINUS Schwein.
Miami Valley, A. P. Morgan (Fl.)

CANTHARELLUS MINOR Pk.
Miami Valley, A. P. Morgan (Fl.)

15. MARASMIUS Fr.

MARASMIUS ANOMALUS Pk.
Miami Valley, A. P. Morgan (Fl.)

MARASMIUS CALOPUS Pers.
Miami Valley, A. P. Morgan (Fl.)

MARASMIUS CAMPANULATUS Pk.
Miami Valley, A. P. Morgan (Fl.)

MARASMIUS CAPILLARIS Morgan.
Miami Valley, A. P. Morgan (Fl.)

MARASMIUS CLAVAEFORMIS Berk.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

MARASMIUS ERYTHROPUS Fr.
Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

MARASMIUS FAGINEUS Morgan.
Miami Valley, A. P. Morgan (Fl.)

MARASMIUS FUSCO-PURPUREUS Pers.
Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

MARASMIUS NIGRIPES Schwein.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

MARASMIUS OPACUS B. & C.
Miami Valley, A. P. Morgan (Fl.)

MARASMIUS OREADES Bolt.
Miami Valley, A. P. Morgan (Fl.); Granville, H. L. Jones. Edible.

Marasmius peronatus Bolt.
Miami Valley, A. P. Morgan (Fl.)

Marasmius plancus Fr.
Rare, Miami Valley, A. P. Morgan (Fl.)

Marasmius prasiosmus Fr.
Miami Valley, A. P. Morgan (Fl.)

Marasmius pyrrhocephalus Berk.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

Marasmius rotula Scop.
Cincinnati, Thos. G. Lea (Cat.); Loveland (Clermont Co.) D. L. James; Miami Valley, A. P. Morgan (Fl.); Granville, C. J. Herrick, E. J. Stanley.

Marasmius urens Bull.
On oak trunks and leaves, Miami Valley, A. P. Morgan (Fl.)

16. LENTINUS, Fries.

Lentinus caespitosus B. & C.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Loveland (Clermont Co.) D. L. James; Miami Valley, A. P. Morgan (Fl.)

Lentinus cochleatus Pers.
Miami Valley, A. P. Morgan (Fl.)

Lentinus lecomtei Fr.
Distributed over the whole state.

Lentinus omphalodes B. and C.
Miami Valley, A. P. Morgan (Fl.)

Lentinus pelliculosus Fr.
Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

Lentinus strigosus Fr.
Miami Valley, A. P. Morgan (Fl.)

Lentinus sulcatus Berk.
Cincinnati, Thos. G. Lea (Cat.); Loveland (Clermont Co.) D. L. James; Miami Valley, A. P. Morgan (Fl.); on rotten rails, Fairfield Co., W. A. Kellerman.

Lentinus tigrinus Bull.
Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.); Granville, H. L. Jones.

Lentinus ursinus Fr.
On rotten trunks of beech, Miami Valley, A. P. Morgan (Fl.)

LENTINUS VULPINUS Fr.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

17. PANUS Fries.

PANUS ANGUSTATUS Berkl.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

PANUS CONCHATUS Fr.
Cincinnati, Thos. G. Lea (Cat.); On trunks and branches of beech, Miami Valley, A. P. Morgan (Fl.) Edible.

PANUS DEALBATUS Berkl.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); On branches of Elm, Miami Valley, A. P. Morgan (Fl.)

PANUS DORSALUS Bosc.
Miami Valley, A. P. Morgan (Fl.)

PANUS FARINACEUS Schum.
On trunks of hickory, Miami Valley, A. P. Morgan (Fl.)

PANUS RUDIS Fr.
On beech tree, Granville, H. L. Jones.

PANUS STIPTICUS Fr.
Cincinnati, Thos. G. Lea (Cat.); Loveland (Clermont Co.) D. L. James; Miami Valley, A. P. Morgan (Fl.); on decaying wood, Fairfield Co., W. A. Kellerman.

18. TROGIA Fries.

TROGIA CRISPA Pers.
On branches of beech, etc., Miami Valley, A. P. Morgan (Fl.)

19. LENZITES Fries.

LENZITES BETULINA L.
Cincinnati, Waynesville (Warren Co.) Thos. G. Lea (Cat.); Loveland (Clermont Co.) D. L. James; Miami Valley, A. P. Morgan (Fl.); on decaying wood, Rendville (Perry Co.) Fairfield Co., W. A. Kellerman.

LENZITES SÆPIARIA Schaeff.
Miami Valley, A. P. Morgan (Fl.)

LENZITES VIALIS Peck.
Loveland (Clermont Co.) D. L. James; Miami Valley, A. P. Morgan (Fl.)

20. SCHIZOPHYLLUM Fries.

SCHIZOPHYLLUM COMMUNE Fr.
Throughout the state and over the whole earth.

21. VOLVARIA Fries.

VOLVARIA BOMBYCINA Schaeff.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Loveland (Clermont Co) D. L. James; Miami Valley, A. P. Morgan (Fl.) Edible.

12. PLUTEUS Fries.

PLUTEUS CERVINUS Schaeff.
Miami Valley, A. P. Morgan (Fl.)

PLUTEUS CHRYSOPHÆUS Schaeff.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

PLUTEUS GRANULARIS Pk.
Miami Valley, A. P. Morgan (Fl.)

PLUTEUS LEONINUS Schaeff.
Miami Valley, A. P. Morgan (Fl.)

23. ENTOLOMA Fries.

ENTOLOMA CLYPEATUM L.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

ENTOLOMA RHODOPOLIUM Fr.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

ENTOLOMA STRICTIOR Peck.
Miami Valley, A. P. Morgan (Fl.)

24. CLITOPILUS Fries.

CLITOPILUS ABORTIVUS B. & C.
Miami Valley, A. P. Morgan (Fl.)

25. LEPTONIA Fries.

LEPTONIA ASPRELLA Fr.
Miami Valley, A. P. Morgan (Fl.)

26. PHOLIOTA Fries.

PHOLIOTA ADIPOSA Fr.
Cincinnati, Waynesville (Warren Co.) Thos. G. Lea (Cat.) Miami Valley, A. P. Morgan (Fl.)

PHOLIOTA ALBOCRENULATA Pk.
Miami Valley, A. P. Morgan (Fl.)

PHOLIOTA DURA Bolt.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); in gardens, hot houses, etc., Miami Valley, A. P. Morgan (Fl.)

PHOLIOTA LIMONELLA Pk.
On trunks of beech, Miami Valley, A. P. Morgan (Fl.)

PHOLIOTA MARGINATA Batsch.
Miami Valley, A. P. Morgan (Fl.)

PHOLIOTA MUTABILIS Schaeff.
Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

PHOLIOTA PRÆCOX Pers.
Miami Valley, A. P. Morgan (Fl.)

PHOLIOTA SPECTABILIS Fr.
At base oak stumps, Miami Valley, A. P. Morgan (Fl.)

PHOLIOTA SQUARROSOIDES Peck.
Cincinnati, Thos. G. Lea (Cat.); on trunks and stumps of maple, Miami Valley, A. P. Morgan (Fl.)

PHOLIOTA TUBERCULOSA Schaeff.
Miami Valley, A. P. Morgan (Fl.)

PHOLIOTA UNICOLOR Vahl.
Miami Valley, A. P. Morgan (Fl.)

27. INOCYBE Fries.

INOCYBE DESTRICTA Fr.
Miami Valley, A. P. Morgan (Fl.)

INOCYBE DULCAMARA A. & S.
Miami Valley, A. P. Morgan (Fl.)

INOCYBE EUTHELES B. & Br.
Miami Valley, A. P. Morgan (Fl.)

INOCYBE GEOPHYLLA Sow.
Miami Valley, A. P. Morgan (Fl.)

INOCYBE LANUGINOSA Bull.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

INOCYBE LUCIFUGA Fr.
Waynesville (Warren Co.) Thos. G. Lea (Cat.)

INOCYBE PYRIODORA Pers.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

INOCYBE RIMOSA Bull.
Miami Valley, A. P. Morgan (Fl.)

28. HABELOMA Fries.

HABELOMA FASTIBILIS Fr.
Miami Valley, A. P. Morgan (Fl.)

HABELOMA ILLICITA Peck.
On rotten logs and sticks, Miami Valley, A. P. Morgan (Fl.)

29. FLAMMULA Fries.

FLAMMULA POLYCHORA Berk.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

FLAMMULA SAPINEA Fr.
On fence rails, Waynesville (Warren Co.) Thos. G. Lea (Cat.)

30. NAUCORIA Fr.

NAUCORIA SEMIORBICULARIS Fr.
Cincinnati, Thos. G. Lea (Cat.); Loveland (Clermont Co.) D. L. James; Miami Valley, A. P. Morgan (Fl.)

NAUCORIA VERVACTI Fr.
Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

31. PLUTEOLUS Fr.

PLUTEOLUS MUCIDOLENS Berk.
On a rotten trunk, Cincinnati, Thos. G. Lea, 1842.

32. GALERA Fr.

GALERA SILIGINEA Fr.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

Galera tenera Schaeff.
Miami Valley, A. P. Morgan (Fl.)

33. TUBARIA Worth. Smith.

Tubaria furfuracea Pers.
Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

Tubaria inquilina Fr.
Cincinnati, Thos. G. Lea (Cat.); Miami Falley, A. P. Morgan (Fl.)

34. CREPIDOTUS Fr.

Crepidotus crocophyllus Berk.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

Crepidotus dorsalis Peck.
Miami Valley, A. P. Morgan (Fl.)

Crepidotus mollis Schaeff.
Miami Valley, A. P. Morgan (Fl.); Clermont Co., D. L. James.

Crepidotus versutus Peck.
Miami Valley, A. P. Morgan (Fl.)

35. CORTINARIUS Fr.

Cortinarius albo-violaceus Pers.
Miami Valley, A. P. Morgan (Fl.)

Cortinarius caerulescens Fr.
Miami Valley, A. P. Morgan (Fl.); Waynesville (Warren Co,) Thos. G. Lea (Cat.) Edible.

Cortinarius calochrous Fr.
Cincinnati, Thos. G. Lea (Cat.)

Cortinarius varius Schaeff.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

Cortinarius violaceus L.
Miami Valley, A. P. Morgan (Fl.); Waynesville (Warren Co.) Thos. G. Lea (Cat.)

36. PAXILLUS Fr.

Paxillus flavidus Berk.
Miami Valley, A. P. Morgan (Fl.); Waynesville (Warren Co.) Thos. G. Lea (Cat.)

Paxillus panuoides Fr.
Miami Valley, A. P. Morgan (Fl.)

Paxillus porosus Berk.
Miami Valley, A. P. Morgan (Fl.); Waynesville (Warren Co.) Thos. G. Lea (Cat.)

37. AGARICUS Linn.

Agaricus arvensis Schaeff.
Miami Valley, A. P. Morgan (Fl.) Edible.

Agaricus campester L.
Columbus, Wm. C. Werner, W. A. Kellerman; Clermont Co., D. L. James; Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.) The common edible mushroom.

Agaricus fabaceus Berk.
Cincinnati and Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan.

Agaricus silvaticus Schaeff.
Miami Valley, A. P. Morgan (Fl.)

38. STROPHARIA Fr.

Stropharia aeruginosa Curt.
Miami Valley, A. P. Morgan (Fl.)

Stropharia semiglobata Batsch.
Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

Stropharia stercoraria Fr.
Miami Valley, A. P. Morgan (Fl.)

39. HYPHOLOMA Fr.

Hypholoma appendiculatum Bull.
Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

Hypholoma candolleanum Fr.
Miami Valley, A. P. Morgan (Fl.)

Hypholoma fasiculare Huds.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

Hypholoma lacrymabundum Fr.
Miami Valley, A. P. Morgan (Fl.)

HYPHOLOMA PYROTRICHUM Holmsk.
Miami Valley, A. P. Morgan (Fl.)

HYPHOLOMA SUBLATERITIUM Schaeff.
Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

HYPHOLOMA VELUTINUM Pers.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

40. PSILOCYBE Fr.

PSILOCYBE SPADICEA Fr.
Miami Valley, A. P. Morgan (Fl.)

41. BOLBITIUS Fr.

BOLBITIUS TITUBANS Bull.
Miami Valley, A. P. Morgan (Fl.)

42. COPRINUS Pers.

COPRINUS ATRAMENTARIUS Bull.
Miami Valley, A. P. Morgan (Fl.)

COPRINUS COMATUS Fr.
Clermont Co., D. L. James; Miami Valley, A. P. Morgan (Fl.) Edible.

COPRINUS FUSCESCENS Fr.
Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

COPRINUS INSIGNIS Peck.
Miami Valley, A. P. Morgan (Fl.)

COPRINUS MICACEUS Bull.
Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

COPRINUS NIVEUS Pers.
Miami Valley, A. P. Morgan (Fl.)

COPRINUS NYCTHEMERUS Fr.
Miami Valley, A. P. Morgan (Fl.); Waynesville (Warren Co.) Thos. G. Lea (Cat.)

COPRINUS PLICATILIS Curt.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

COPRINUS PULCHRIFOLIUS Pk.
Miami Valley, A. P. Morgan (Fl.)

COPRINUS RADIATUS Bolt.
Miami Valley, A. P. Morgan (Fl.)

COPRINUS SEMILANATUS Peck.
Miami Valley, A. P. Morgan (Fl.)

COPRINUS SQUAMOSUS Morg.
Miami Valley, A. P. Morgan (Fl.)

COPRINUS VARIEGATUS Peck.
Miami Valley, A. P. Morgan (Fl.)

43. PANAEOLUS Fr.

PANAEOLUS CAMPANULATUS L. (*Agaricus campanulatus* L.)
Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

PANAEOLUS FIMICOLUS Fr.
Miami Valley, A. P. Morgan (Fl.)

PANAEOLUS SOLIDIPES Peck.
Miami Valley, A. P. Morgan (Fl.)

44. ANELLARIA Karst.

ANELLARIA FIMIPUTRIS (Bull.) Karst. (*Agaricus fimiputris* Bolt.)
Cincinnati, Thos. G. Lea (Cat.)

45. PSATHYRELLA Fr.

PSATHYRELLA ATOMATA Fr.
Miami Valley, A. P. Morgan (Fl.)

PSATHYRELLA DISSEMINATA Pers.
Miami Valley, A. P. Morgan (Fl.)

PSATHYRELLA FALCIFOLIA Mont.
Columbus, Sullivant (Sacc. Sylloge VI. 1134.)

PSATHYRELLA GRACILIS Fr.
Miami Valley, A. P. Morgan (Fl.)

II POLYPORACEÆ.

46. BOLETUS Dill.

BOLETUS AURIPORUS Peck.
Scarce, Miami Valley, A. P. Morgan (Fl.)

BOLETUS CASTANEUS Bull.
Miami Valley, A. P. Morgan (Fl.) Said to be edible.

BOLETUS CHRYSENTERON Bull.
Miami Valley, A. P. Morgan (Fl.); Clermont Co., D. L. James.

BOLETUS EDULIS Bull.
Cincinnati, Thos. G. Lea (Cat.) An edible species.

BOLETUS FELLEUS Bull.
Miami Valley, A. P. Morgan (Fl.)

BOLETUS FLOCCOPUS Vahl.
Miami Valley, A. P. Morgan (Fl.)

BOLETUS GRACILIS Peck.
Miami Valley, A. P. Morgan (Fl.)

BOLETUS MAGNISPORUS Frost.
Rare, Miami Valley, A. P. Morgan (Fl.)

BOLETUS MUTABILIS Morgan.
Miami Valley, A. P. Morgan (Fl.)

BOLETUS PIPERATUS Bull.
Miami Valley, A. P. Morgan (Fl.)

BOLETUS RADICANS Pers.
Rare, Miami Valley, A. P. Morgan (Fl.)

BOLETUS SCABER Fr.
Rare, Miami Valley, A. P. Morgan (Fl.)

BOLETUS SORDIDUS Frost.
Miami Valley, A. P. Morgan (Fl.)

BOLETUS STROBILACEUS Scop.
Over the southern portion of the state.

BOLETUS SUBTOMENTOSUS L.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.) Said to be edible.

BOLETUS VERMICULOSUS Pk.
Miami Valley, A. P. Morgan (Fl.)

47. POLYPORUS Mich.

POLYPORUS ADUSTUS Fr.
Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.); Adams Co., W. A. Kellerman. Widely distributed.

POLYPORUS ANAX Berk.
Miami Valley, A. P. Morgan (Fl.)

POLYPORUS ARCULARIUS Batsch.
Cincinnati, Thos. G. Lea (Cat.); Clermont Co., D. L. James; Miami Valley, A. P. Morgan (Fl.)

POLYPORUS BERKLEYI Fr.
Clermont Co., D. L. James; Miami Valley, A. P. Morgan (Fl.) Edible.

POLYPORUS BRUMALIS Pers.
Miami Valley, A. P. Morgan (Fl.)

POLYPORUS CAESIUS Schrad.
Miami Valley, A. P. Morgan (Fl.)

POLYPORUS CINCINNATUS Morg.
Miami Valley, A. P. Morgan (Fl.)

POLYPORUS CUTICULARIS Bull.
Miami Valley, A. P. Morgan (Fl.)

POLYPORUS DELECTANS Peck.
Miami Valley, A. P. Morgan (Fl.)

POLYPORUS DESTRUCTOR Schrad.
Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

POLYPORUS DICHROUS Fr.
Miami Valley, A. P. Morgan (Fl.)

POLYPORUS DISTORTUS Schwein.
Miami Valley, A. P. Morgan (Fl.)

POLYPORUS DRYOPHILUS Berk.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

POLYPORUS ELEGANS Bull.
Miami Valley, A. P. Morgan (Fl.)

POLYPORUS ELEGANS NUMMULARIUS Fr.
Cincinnati, Waynesville (Warren Co.) Thos. G. Lea (Cat.)

POLYPORUS ENDOCROCINUS Berkl.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

POLYPORUS FISSUS Berk.
Waynesville (Warren Co.) Thos. G. Lea (Cat.)

POLYPORUS FLAVO-VIRENS B. & Rav.
Miami Valley, A. P. Morgan (Fl.)

POLYPORUS FRAGILIS Fr.
Miami Valley, A. P. Morgan (Fl.)

POLYPORUS FUMOSUS Pers.
Miami Valley, A. P. Morgan (Fl.)

POLYPORUS GALACTINUS Berkl.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

POLYPORUS GIGANTEUS Pers.
Miami Valley, A. P. Morgan (Fl.) An edible species.

POLYPORUS GILVUS Fr.
Cincinnati, Waynesville (Warren Co.) Thos. G. Lea (Cat.); Clermont Co., D. L. James; Miami Valley, A. P. Morgan (Fl.); Fairfield Co., W. A. Kellerman.

POLYPORUS GLOMERATUS Pk.
Miami Valley, A. P. Morgan (Fl.)

POLYPORUS HYPOCOCCINUS Berk.
Waynesville (Warren Co.) Thos. G. Lea (Cat.)

POLYPORUS INTYBACEUS Fr. (*P. giganteus*, Pers.)
Cincinnati, Thos. G. Lea (Cat.); Clermont Co., D. L. James; Miami Valley, A. P. Morgan (Fl.)

POLYPORUS LACTEUS Fr.
Miami Valley, A. P. Morgan (Fl.)

POLYPORUS LENTUS Berk.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

POLYPORUS LEUCOMELAS Pers.
Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.) This is reported as an edible species.

POLYPORUS LUTESCENS (Pers.) (*P. nidulans* Fr.)
Miami Valley, A. P. Morgan (Fl.)

POLYPORUS MOLLUSCUS Fr.
Miami Valley, A. P. Morgan (Fl.)

POLYPORUS NIVOSUS Berk.
Miami Valley, A. P. Morgan (Fl.)

POLYPORUS OVINUS Fr.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.) Said to be edible.

POLYPORUS PICIPES Fr.
Miami Valley, A. P. Morgan (Fl.); on decayed hickory log, Fairfield Co. W. A. Kellerman. Edible.

POLYPORUS PILOTÆ Schwein.
Miami Valley, A. P. Morgan (Fl.)

POLYPORUS PUBESCENS Schum.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

POLYPORUS PUBESCENS GRAYII C. & E.
Ohio, J. B. Ellis (N. A. F.)

POLYPORUS RADICATUS Schwein.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

POLYPORUS RESINOSUS Schrad.
Cincinnati, Thos. G. Lea (Cat.); Clermont Co., D. L. James; Miami Valley, A. P. Morgan (Fl.)

POLYPORUS SULPHUREUS Fr.
Cincinnati, Waynesville (Warren Co.) Thos. G. Lea (Cat.); Clermont Co., D. L. James; Miami Valley, A. P. Morgan (Fl.); Fairfield Co., W. A. Kellerman.

POLYPORUS VARIUS Fr.
Clermont Co., D. L. James; Miami Valley, A. P. Morgan (Fl.)

48. FOMES Fr. (*Polyporus.*)

FOMES APPLANATUS (Pers.) (*Polyporus applanatus* Pers.)
Found throughout the state.

FOMES CONGLOBATUS Berk. (*Polyporus conglobatus* Berk.)
Cincinnati, Waynesville (Warren Co.) Thos. G. Lea (Cat.); Wilmington, D. L. James; Fairfield Co., W. A. Kellerman.

FOMES CONNATUS Fr. (*Polyporus connatus* Fr.)
Clermont Co., D. L. James; Miami Valley, A. P. Morgan (Fl.)

FOMES FOMENTARIUS (L.) Fr. (*Polyporus fomentarius* Fr.)
Cincinnati, Thos. G. Lea (Cat.); Clermont Co., D. L. James; Miami Valley, A. P. Morgan (Fl.)

FOMES FRAXINEUS (Bull.) Fr. (*Polyporus fraxineus* Bull.)
Clermont Co., D. L. James; Miami Valley, A. P. Morgan (Fl.)

FOMES FRAXINOPHILUS Pk. (*Polyporus fraxinophilus* Pk.)
Miami Valley, A. P. Morgan (Fl.)

FOMES GRAVEOLENS Schw. (*Polyporus graveolens* Schw.; *P. conglobatus* Berk.?)
Miami Valley, A. P. Morgan (Fl.)

FOMES LUCIDUS (Leys.) Fr. (*Polyporus lucidus* Leys).
Distributed over the whole state; but not abundant.

FOMES NIGRICANS Fr. (*Polyporus nigricans* Fr.)
Southern Ohio; and doubtless distributed over the whole state.

FOMES OBLIQUUS (Pers.) Fr. (*Polyporus obliquus* Pers.)
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Clermont Co., D. L. James; Miami Valley, A. P. Morgan (Fl.)

FOMES RENIFORMIS Morg. (*Polyporus reniformis* Morg.)
Dayton, A. P. Morgan.

FOMES RIMOSUS Berk. (*Polyporus rimosus* Berk.)
Miami Valley, A. P. Morgan (Fl.)

FOMES SALICINUS (Pers.) Fr. (*Polyporus salicinus* Fr.)
Miami Valley, A. P. Morgan (Fl.)

FOMES SCUTELLATUS Schw. (*Polyporus scutellatus* Schw.)
Clermont Co., D. L. James.

FOMES VENZUELIANUS Mont. (*Polyporus supinus* Fr.)
Miami Valley, A. P. Morgan (Fl.)

49. POLYSTICTUS Fr. (*Polyporus*.)

POLYSTICTUS BIFORMIS Klotz. (*Polyporus biformis* Fr.)
Miami Valley, A. P. Morgan (Fl.)

POLYSTICTUS CINNABARINUS (Jacq.) Fr. (*Polyporus cinnabarinus* Fr.)
Everywhere throughout the state, on old cherry logs.

POLYSTICTUS CONCHIFER Schw. (*Polyporus conchifer* Schw.)
In central and southern Ohio; and perhaps over the whole state.

POLYSTICTUS FIBULA Fr. (*Polyporus fibula* Fr.)
Miami Valley, A. P. Morgan (Fl.)

POLYSTICTUS HIRSUTUS Fr. (*Polyporus hirsutus* Fr.)
Cincinnati, Thos. G. Lea (Cat.); Clermont Co., D. L. James; Miami Valley, A. P. Morgan (Fl.); Haydensville, W. A. Kellerman. Widely distributed.

POLYSTICTUS MOLLIUSCULUS Berkl. (*Polyporus molliusculus* Berkl.)
Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

POLYSTICTUS MONTAGNEI Fr. (*Polyporus montagnei* Fr.)
Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

POLYSTICTUS PARVULUS Klotsch. (*Polyporus parvulus* Koltsch).
Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

POLYSTICTUS SUBSERICEUS Peck. (*P. splendens* Pk.)
Rare, Miami Valley, A. P. Morgan (Fl.)

POLYSTICTUS PERGAMENUS Fr. (*Polyporus pergamenus* Fr.)
Cincinnati, Thos. G. Lea (Cat.); Clermont Co., D. L. James; Miami Valley, A. P. Morgan (Fl.)

POLYSTICTUS RADIATUS (Sow.) Fr. (*Polyporus radiatus* Sow.)
Cincinnati, Thos. G. Lea (Cat.); Clermont Co., D. L. James; Miami Valley, A. P. Morgan (Fl.)

POLYSTICTUS SULLIVANTII Mont. (*Polyporus sullivantii* Mont.)
Waynesville (Warren Co.) Thos. G. Lea (Cat.)

POLYSTICTUS TENUIS (Lk.) Cke. (*Polyporus tenuis* Schw.)
Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

POLYSTICTUS VELUTINUS Fr. (*Polyporus velutinus* Fr.)
Clermont Co., D. L. James; Miami Valley, A. P. Morgan (Fl.)

POLYSTICTUS VERSICOLOR (L.) Fr. (*Polyporus versicolor* L.)
Distributed throughout the state.

POLYSTICTUS VIRGINEUS Schw. (*Polyporus virgineus* Schw.)
Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

POLYSTICTUS ZONATUS Fr. (*Polyporus zonatus* Fr.)
Miami Valley, A. P. Morgan (Fl.)

50. PORIA Pers. (*Polyporus.*)

PORIA ATTENUATA Pk. (*Polyporus attenuatus* Peck.)
Miami Valley, A. P. Morgan (Fl.)

PORIA BOMBYCINA Fr. (*Polyporus bombycinus* Fr.)
Miami Valley, A. P. Morgan (Fl.)

PORIA CALLOSA Fr. (*Polyporus callosus* Fr.)
Perry Co., W. A. Kellerman; Hamilton Co, A. P. Morgan.

PORIA CANDIDISSIMA Schw. (*Polyporus candidissimus* Schw.)
Miami Valley, A. P. Morgan (Fl.)

PORIA CINEREA Schw. (*Polyporus cinereus* Schw.)
Miami Valley, A. P. Morgan (Fl.)

PORIA CONTIGUA (Pers.) Fr. (*Polyporus contiguus* Pers.)
Miami Valley, A. P. Morgan (Fl.)

PORIA CORTICOLA Fr. (*Polyporus corticola* Fr.)
Miami Valley, A. P. Morgan (Fl.)

PORIA FERRUGINOSA (Schrad.) Fr. (*Polyporus ferruginosus* Schrad.)
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

PORIA GORDONIENSIS Berk. (*Polyporus gordoniensis* B. & Br.)
Miami Valley, A. P. Morgan (Fl.)

PORIA MUCIDA (Pers.) Fr. (*Polyporus mucidus* Pers.)
Miami Valley, A. P. Morgan (Fl.)

PORIA NIGRA Berk. (*Polyporus niger* Berk.)
Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

PORIA NIGRO-PURPUREA Schw. (*Polyporus nigro-purpurascens* Schw.)
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Clermont Co., D. L. James.

PORIA OBDUCENS Pers. (*Polyporus obducens* Pers.)
Occurs in southern Ohio; and perhaps is distributed all over the state.

PORIA PURPUREA Fr. (*Polyporus purpureus* Fr.)
Miami Valley, A. P. Morgan (Fl.)

PORIA RUFA (Schrad.) Fr. (*Polyporus rufus* Schrad.)
Miami Valley, A. P. Morgan (Fl.)

PORIA SPISSA Schw. (*Polyporus spissus* Fr.)
Miami Valley, A. P. Morgan (Fl.)

PORIA UNITA Pers. (*Polyporus unitus* Pers.)
Miami Valley, A. P. Morgan (Fl.)

PORIA VAPORARIA Fr. (*Polyporus vaporarius* Pers.)
Clermont Co., D. L. James; Miami Valley, A. P. Morgan (Fl.)

PORIA VIRIDANS B. & Br. (*Polyporus viridans* B. & Br.)
Miami Valley, A. P. Morgan (Fl.)

PORIA VITELLINA Schw. (*Polyporus vitellinus* Schw.)
Miami Valley, A. P. Morgan (Fl.)

Poria vitrea Pers. (*Polyporus vitreus* Pers.)
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

Poria vulgaris Fr. (*Polyporus vulgaris* Fr.)
Common over the state.

Poria xantholoma Schw. (*Polyporus xantholoma* Schw.)
Miami Valley, A. P. Morgan (Fl.)

51. TRAMETES Fries.

Trametes mollis Smfdt.
Miami Valley, A. P. Morgan (Fl.)

Trametes pallido-fulva Berk.
Miami Valley, A. P. Morgan (Fl.)

Trametes rigida B. & Mont.
Clermont Co., D. L. James; Miami Valley, A. P. Morgan (Fl.); Perry Co, Fairfield Co., W. A. Kellerman.

Trametes scutellata Schw. (*T. ohioensis* Berk.)
Clermont Co., D. L. James; Miami Valley, A. P. Morgan (Fl.)

Trametes sepium Berk. (*Daedalea sepium* Berk.)
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Clermont Co., D. L. James; Miami Valley, A. P. Morgan (Fl.)

Trametes serialis Fr.
Miami Valley, A. P. Morgan (Fl.)

52. DAEDALEA Persoon.

Daedalea ambigua Berk. (*Trametes lactea* Berk.)
Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

Daedalea aurea Fr.
Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

Daedalea confragosa Bolt. (*Lenzites crataegi* Berk.)
Miami Valley, A. P. Morgan (Fl.); Fairfield Co., W. A. Kellerman.

Daedalea unicolor Bull.

Waynesville (Warren Co.) Thos. G. Lea (Cat.); Clermont Co., D. L. James; Miami Valley, A. P. Morgan (Fl.); Columbus, E. Mead Wilcox.

53. CYCLOMYCES Kunz.

Cyclomyces greenei Berk.
Salt-peter cave, Hocking Co., W. A. Kellerman.

54. FAVOLUS Fries,

FAVOLUS BOUCHEANUS Klotsch. (*Polyporus boucheanus* Fr.)
Cincinnati, Waynesville (Warren Co.) Thos. G. Lea (Cat.); Clermont Co. D. L. James.

FAVOLUS CANADENSIS Klotsch.
Miami Valley, A. P. Morgan (Fl.); Lima, W. A. Kellerman; Columbus, Wm. C. Werner; Granville, C. J. Herrick.

FAVOLUS OHIONIS B. & Mont.
Columbus, W. S. Sullivant (Sacc. Syl. VI., 397.)

FAVOLUS RHIPIDIUM Berk. (*Polyporus rhipidium* Berk.)
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

56. MERULIUS Hall.

MERULIUS CORIUM Fr.
Miami Valley, A. P. Morgan (Fl.)

MERULIUS HIMANTIOIDES Fr.
Miami Valley, A. P. Morgan (Fl.)

MERULIUS INCARNATUS Schwein.
Cincinnati, Thos. G. Lea (Cat.) (Prof. Morgan thinks this may be *M. rubellus* Peck.)

MERULIUS MOLLUSCUS Fr.
Miami Valley, A. P. Morgan (Fl.)

MERULIUS PORINOIDES Fr.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

MERULIUS RUBELLUS Peck.
Miami Valley, A. P. Morgan (Fl.)

MERULIUS TREMELLOSUS Schrad.
Cincinnati, Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

57. POROTHELIUM Fries.

POROTHELIUM FIMBRIATUM Pers.
Miami Valley, A. P. Morgan (Fl.)

58. SOLENIA Hoffm.

SOLENIA FASCICULATA Pers.
Miami Valley, A. P. Morgan (Fl.)

SOLENIA OCHRACEA Hoffm.
Cincinnati, Thos. G. Lea (Cat.); Clermont Co., D. L. James; Miami Valley, A. P. Morgan (Fl.)

III. HYDNACEÆ.

59. HYDNUM Linn.

HYDNUM ADUSTUM Schw.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.); Clermont Co., D. L. James.

HYDNUM ALBOVIRIDE Morg.
Miami Valley, A. P. Morgan (Fl.)

HYDNUM ALUTACEUM Fr.
Miami Valley, A. P. Morgan (Fl.)

HYDNUM BYSSINUM Schw.
Miami Valley, A. P. Morgan (Fl.)

HYDNUM CASEARIUM Morg.
Miami Valley, A. P. Morgan (Fl.)

HYDNUM CIRRHATUM Pers.
Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

HYDNUM CORALLOIDES Scop.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.); Clermont Co., D. L. James. Edible.

HYDNUM DIFFRACTUM Berk.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

HYDNUM ERINACEUS Bull.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.); Clermont Co., D. L. James.

HYDNUM FALLAX Fr.
Miami Valley, A. P. Morgan (Fl.)

HYDNUM FARINACEUM Pers.
Miami Valley, A. P. Morgan (Fl.)

HYDNUM FLABELLIFORME Berk.
Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

HYDNUM FUSCO-ATRUM Fr.
Miami Valley, A. P. Morgan (Fl.)

HYDNUM GLABRESCENS B. & Rav.
Miami Valley. A. P. Morgan (Fl.); Clermont Co., D. L. James.

HYDNUM INFUNDIBULUM Swartz.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

HYDNUM ISCHNODES Berk.
Miami Valley, A. P. Morgan (Fl.)

HYDNUM MUCIDUM Fr.
Miami Valley, A. P. Morgan (Fl.)

HYDNUM NUDUM B. & C.
Miami Valley, A. P. Morgan (Fl.)

HYDNUM NYSSAE B. & C.
Miami Valley, A. P. Morgan (Fl.)

HYDNUM OCHRACEUS Pers.
Miami Valley, A. P. Morgan (Fl.)

HYDNUM OHIENSE Berk.
Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

HYDNUM PITHYOPHITUM B. & C.
Miami Valley, A. P. Morgan (Fl.)

HYDNUM PULCHERRIMUM B. & C.
Miami Valley, A. P. Morgan (Fl.)

HYDNUM REPANDUM L.
Miami Valley, A. P. Morgan (Fl.)

HYDNUM SEPTENTRIONALE Fr.
Clermont Co., D. L. James; Miami Valley, A. P. Morgan (Fl.)

HYDNUM UDUM Fr.
Miami Valley, A. P. Morgan (Fl.)

HYDNUM XANTHUM B. & C.
Miami Valley, A. P. Morgan (Fl.)

HYDNUM ZONATUM Batsch.
Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

60. IRPEX Fr.

IRPEX CRASSUS B. & C.
Miami Valley, A. P. Morgan (Fl.)

IRPEX FUSCESCENS Schw.
Miami Valley, A. P. Morgan (Fl.)

IRPEX LACTEUS Fr.
Miami Valley, A. P. Morgan (Fl.)

IRPEX LAETICOLOR B. & C.
Miami Valley, A. P. Morgan (Fl.)

IRPEX OBLIQUUS Schrad.
Clermont Co., D. L. James; Miami Valley, A. P. Morgan (Fl.)

IRPEX TULIPIFERAE Schw.
Miami Valley, A. P. Morgan (Fl.)

61. RADULUM Fr.

RADULUM MOLARE Pers.
Miami Valley, A. P. Morgan (Fl.)

RADULUM ORBICULARE Fr.
Miami Valley, A. P. Morgan (Fl.)

RADULUM PALLIDUM B. & C.
Miami Valley, A. P. Morgan) Fl.)

62. PHLEBIA Fr.

PHLEBIA MERISMOIDES Fr.
Miami Valley, A. P. Morgan (Fl.)

PHLEBIA PILEATA Pk.
Miami Valley, A. P. Morgan (Fl.]

PHLEBIA RADIATA Fr. (*P. cinnabarina* Schw.)
Miami Valley, A. P. Morgan (Fl.); Cincinnati, Thos. G. Lea (Cat.)

63. GRANDINIA Fr.

GRANDINIA MUCIDA Fr.
Miami Valley, A. P. Morgan (Fl.)

64. ODONTIA Pers.

ODONTIA FIMBRIATA Pers.
Miami Valley, A. P. Morgan (Fl.)

ODONTIA HYDNOIDEA Schw.
Miami Valley, A. P. Morgan (Fl.)

65. KNEIFFIA Fr.

KNEIFFIA CANDIDISSIMA B. & C.
Miami Valley, A. P. Morgan (Fl.)

THELEPHORACEÆ.

66. CRATERELLUS Fr.

CRATERELLUS CANTHARELLUS Schw.
Miami Valley, A. P. Morgan (Fl.)

CRATERELLUS CORNUCOPIOIDES L.
Miami Valley, A. P. Morgan (Fl.); Clermont Co., D. L. James.

CRATERELLUS LUTESCENS Pers.
Miami Valley, A. P. Moagan (Fl.); Cincinnati, Thos. G. Lea (Cat.)

67. THELEPHORA Ehrh.

THELEPHORA ALBIDO-BRUNNEA Schwein.
Miami Valley, A. P. Morgan (Fl.)

THELEPHORA ANTHOCEPHALA Bull.
Miami Valley, A. P. Morgan (Fl.)

THELEPHORA CRISTATA Pers.
Miami Valley, A. P. Morgan (Fl.)

THELEPHORA CUTICULARIS Berk.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

THELEPHORA FILAMENTOSA B. & C.
Miami Valley, A. P. Morgan (Fl.)

THELEPHORA MICHENERI B. & C.
Miami Valley, A. P. Morgan (Fl.)

THELEPHORA MULTIPARTITA Schw.
Miami Valley, A. P. Morgan (Fl.)

THELEPHORA PALMATA Scop.
Miami Valley, A. P. Morgan (Fl.); Clermont Co., D. L. James; Cincinnati, Thos. G. Lea (Cat.)

THELEPHORA PTERULOIDES B. & C.
Miami Valley, A. P. Morgan (Fl.)

THELEPHORA RADIATA Holmok.
Miami Valley, A. P. Morgan (Fl.)

THELEPHORA SCHWEINITZII Pk. (*T. pallida* Schw.)
Miami Valley, A. P. Morgan (Fl.); Clermont Co., D. L. James; Waynesville (Warren Co.) Thos. G. Lea (Cat.); Granville, (Licking Co.), H. L. Jones.

THELOPHORA SEBACEA Pers.
Miami Valley, A. P. Morgan (Fl.); Clermont Co., D. L. James.

THELEPHORA SPICULOSA Fr.
Miami Valley, A. P. Morgan (Fl.)

THELEPHORA TEPHROLEUCA B. & C.
Miami Valley, A. P. Morgan (Fl.)

68. STEREUM Pers.

STEREUM ALBOBADIUM Schw. (*Thelphora albomarginata* Berk.)
Clermont Co., D. L. James; Hamilton Co., A. P. Morgan.

STEREUM BICOLOR Pers.
Miami Valley, A. P. Morgan (Fl.); Cincinnati, Thos. G. Lea (Cat.)

STEREUM CANDIDUM Schw.
On Quercus nigra (bark), Fairfield Co., W. A. Kellerman; Miami Valley, A. P. Morgan (Fl.)

STEREUM COMPLICATUM Fr.
Cincinnati, Thos. G. Lea (Cat.); Waynesville (Warren Co.) Thos. G. Lea (Cat.); Clermont Co., D. L. James.

STEREUM DISCIFORME DC.
Miami Valley, A. P. Morgan (Fl.)

STEREUM FASCIATUM Schw.
Ohio, Thos. G. Lea (Cat.); Clermont Co., D. L. James; Athens, Stockport (Morgan Co.) W. A. Kellerman.

STEREUM FRUSTULOSUM Pers.
Common over the state.

STEREUM HIRSUTUM Willd.
Miami Valley, A. P. Morgan (Fl.)

STEREUM LOBATUM Kunz.
Cincinnati, Thos. G. Lea (Cat.); Clermont Co., D. L. James.

STEREUM OCHRACEOFLAVUM Schw.
Miami Valley, A. P. Morgan (Fl.)

STEREUM PURPUREUM Pers.
Miami Valley, A. P. Morgan (Fl.); Clermont Co., D. L. James.

STEREUM RADIANS Fr.
Miami Valley, A. P. Morgan (Fl.)

STEREUM RUBIGINOSUM Fr.
Cincinnati, Thos. G. Lea (Cat.)

STEREUM RUGOSIUSCULUM B. & C.
Miami Valley, A. P. Morgan (Fl.)

STEREUM SERICEUM Schw.
Miami Valley, A. P. Morgan (Fl.)

STEREUM SPADICEUM Pers.
Miami Valley, A. P. Morgan (Fl.)

STEREUM SUBPILEATUM B. & C.
Miami Valley, A. P. Morgan (Fl.)

STEREUM VERSICOLOR Swartz.
Over the whole state.

69. HYMENOCHAETE Lev.

HYMENOCHAETE CINERASCENS Schw.
Miami Valley, A. P. Morgan (Fl.)

HYMENOCHAETE CORRUGATA Fr.
Miami Valley, A. P. Morgan (Fl.)

HYMENOCHAETE CURTISII Schw.
Miami Valley, A. P. Morgan (Fl.)

HYMENOCHAETE INSULARIS Berk.
Miami Valley, A. P. Morgan (Fl.)

HYMENOCHAETE PURPUREA Cke. & Morg.
Miami Valley, A. P. Morgan (Fl.)

HYMENOCHAETE RUBIGINOSA Schrad.
Miami Valley, A. P. Morgan (Fl.); Clermont Co., D. L. James.

HYMENOCHAETE SPRETA Peck.
Miami Valley, A. P. Morgan (Fl.)

HYMENOCHAETE UMBRINA B. & C.
Miami Valley, A. P. Morgan (Fl.)

70. CORTICIUM Fr.

CORTICIUM ALBIDO-CARNEUM Schw.
Miami Valley, A. P. Morgan (Fl.)

CORTICIUM AMORPHUM Pers.
Miami Valley, A. P. Morgan (Fl.)

CORTICIUM AUBERIANUM Mont.
Cincinnati, Thos. G. Lea (Cat.)

CORTICIUM CAERULEUM Schrad.
Miami Valley, A. P. Morgan (Fl.)

CORTICIUM CALCEUM Pers.
Miami Valley, A. P. Morgan (Fl.)

CORTICIUM CINEREUM Fr.
Miami Valley, A. P. Morgan (Fl.)

CORTICIUM COMEDENS Nees.
Miami Valley, A. P. Morgan (Fl.)

CORTICIUM CONFLUENS Fr.
Miami Valley, A. P. Morgan (Fl.)

CORTICIUM FILAMENTOSUM B. & C.
Miami Valley, A. P. Morgan (Fl.)

CORTICIUM INCARNATUM Fr.
Miami Valley, A. P. Morgan (Fl.)

CORTICIUM LACTEUM Fr.
Miami Valley, A. P. Morgan (Fl.); Clermont Co., D. L. James.

Corticium molle Fr.
Miami Valley, A. P. Morgan (Fl.)

Corticium ochraceum Fr.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

Corticium olivascens B. & C.
Miami Valley, A. P. Morgan (Fl.)

Corticium portentosum B. & C.
Miami Valley, A. P. Morgan (Fl.)

Corticium puberum Fr.
Miami Valley, A. P. Morgan (Fl.)

Corticium radiosum Fr.
Miami Valley, A. P. Morgan (Fl.)

Corticium subgiganteum Berk.
Miami Valley, A. P. Morgan (Fl.)

71. EXOBASIDIUM Woron.

Exobasidium vaccinii (Fckl.) Wor.
On Vaccinium vacillans and Gaylussacia resinosa, Sugar Grove, W. A. Kellerman.

72. CYPHELLA Fr.

Cyphella galeata Schum.
Miami Valley, A. P. Morgan (Fl.); Cincinnati, Thos. G. Lea (Cat.)

Cyphella griseopallida Weinm.
Miami Valley, A. P. Morgan (Fl.)

Cyphella pezizoides Zopf.
Miami Valley, A. P. Morgan (Fl.)

V. CLAVARIACEÆ.

73. CLAVARIA Vaill.

Clavaria abietina Pers.
Miami Valley, A. P. Morgan (Fl.)

Clavaria aurea Schaeff.
Miami Valley, A. P. Morgan (Fl.) Edible.

Clavaria botrytis Pers.
Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.) Edible.

Clavaria coronata Schw.
Miami Valley, A. P. Morgan (Fl.)

Clavaria crispula Fr.
Miami Valley, A. P. Morgan (Fl.)

Clavaria cristata Pers.
Miami Valley, A. P. Morgan (Fl.)

Clavaria flava Fr.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

Clavaria formosa Pers.
Miami Valley, A. P. Morgan (Fl.)

Clavaria fragilis Holmsk.
Miami Valley, A. P. Morgan (Fl.)

Clavaria fusiformis Sow.
Miami Valley, A. P. Morgan (Fl.)

Clavaria incurvata Morg.
Miami Valley, A. P. Morgan (Fl.)

Clavaria kuntzei Fr.
Miami Valley, A. P. Morgan (Fl.)

Clavaria mucida Pers.
Perry Co., W. A. Kellerman; Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

Clavaria muscoides L.
Miami Valley, A. P. Morgan (Fl.)

Clavaria pistillaris L.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

Clavaria pyxidata Pers.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

Clavaria rugosa Bull.
Miami Valley, A. P. Morgan (Fl.) An edible species.

Clavaria stricta Pers. (*C. albipes* Berk.)
Cincinnati, Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

Clavaria subtilis Pers.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Miami Valley, A. P. Morgan (Fl.)

CLAVARIA VERMICULARIS Scop.
Miami Valley, A. P. Morgan (Fl.)

74. CALOCERA Fr.

CALOCERA CORNEA Fr.
Cincinnati, Thos. G. Lea (Cat.); Clermont Co., D. L. James; Miami Valley, A. P. Morgan (Fl.)

CALOCERA FASCICULATA (Schum.) Fr.
Clermont Co., D. L. James.

CALOCERA PALMATA (Schum.) Fr.
Miami Valley, A. P. Morgan (Fl.)

CALOCERA STRICTA Fr.
Miami Valley, A. P. Morgan (Fl.)

75. LACHNOCLADIUM Lev.

LACHNOCLADIUM MERISMATOIDES Schw. (*Pterula merismatoides* Schw.)
Miami Valley, A. P. Morgan (Fl.)

LACHNOCLADIUM MICHENERI B. & C.
Miami Valley, A. P. Morgan (Fl.)

LACHNOCLADIUM SEMIRESTITUM B & C.
Miami Valley, A. P. Morgan (Fl.)

76. TYPHULA Pers.

TYPHULA MUSCICOLA (Pers.) Berk.
Miami Valley, A. P. Morgan (Fl.)

VI. TREMELLACEÆ.

77. HIRNEOLA Fr.

HIRNEOLA AURICULA-JUDAE (L.) Berk.
Over the state. Said to be edible.

HIRNEOLA AURIFORMIS (Schw.) Fr.
On trunks of walnut, Miami Valley, A. P. Morgan (Fl.)

78. EXIDIA Fr.

EXIDIA GLANDULOSA Fr.
Cincinnati, Thos. G. Lea (Cat.); on old bark, Fairfield Co., W. A. Kellerman; Miami Valley, A. P. Morgan (Fl.)

EXIDIA TRUNCATA Fr.
Miami Valley, A. P. Morgan (Fl.)

79. TREMELLA Dill.

TREMELLA ALBIDA Fr.
Clermont Co., D. L. James; Miami Valley, A. P. Morgan (Fl.)

TREMELLA INTUMESCENS Sow.
Miami Valley, A. P. Morgan (Fl.)

TREMELLA LUTESCENS Pers.
Waynesville (Warren Co.) Thos. G. Lea (Cat.)

TREMELLA MESENTERICA Retz.
Miami Valley, A. P. Morgan (Fl.)

TREMELLA VESICARIA Bull.
Miami Valley, A. P. Morgan (Fl.)

80. NAEMATELIA Fr.

NAEMATELIA NUCLEATA (Schw.) Fr.
Miami Valley, A. P. Morgan (Fl).

81. DACRYOMYCES Nees.

DACRYOMYCES CHRYSOCOMUS (Bull.) Berk.
Miami Valley, A. P. Morran (Fl.)

DACRYOMYCES DELIQUESCENS Bull.
Miami Valley, A. P. Morgan(Fl.)

DACRYOMYCES FRAGIFORMIS Nees.
Miami Valley, A. P. Morgan (Fl.)

DACRYOMYCES PELLUCIDUS Schw.
Miami Valley, A. P. Morgan (Fl.)

DACRYOMYCES STILLATUS Nees.
Miami Valley, A. P. Morgan (Fl.)

82. GUEPINIA Fr.

GUEPINIA SPATHULARIA Fr.
Cincinnati, Thos. G. Lea (Cat.)

83. HORMOMYCES, Bon.

HORMOMYCES FRAGIFORMIS Cke.
On rotten wood, Perry Co., W. A. Kellerman.

VII. PHALLACEÆ.

84. DICTYOPHORA Desv.

DICTYOPHORA DAEMONUM (Rumph.) Lev. (*Phallus daemonum* Rumph.)
Granville (Licking Co.) W. G. Tight.

DICTYOPHORA DUPLICATA (Bosc.) E. Fisch. (*Phallus duplicatus* Bosc.)
Ohio, A. P. Morgan (N. A. F.)

85. ITHYPHALLUS Fr.

ITHYPHALLUS IMPUDICUS (L.) Fr. (*Phallus impudicus* L.)
Cincinnati, Thos. G. Lea (Cat.); Clermont Co., D. L. James; A. P. Morgan (N. A. F.)

ITHYPHALLUS RETUSUS (Kalch.) E. Fisch. (*Phallus ravenelii* B. &. C.)
Ohio, A. P. Morgan (N. A. F.)

86. MUTINUS Fr.

MUTINUS BOVINUS Morg.
Ohio, A. P. Morgan (N. A. F.)

MUTINUS CANINUS (Huds.) Fr. (*Cynophallus caninus* Fr.)
Cleves (Hamilton Co.) R. M. Byrens.

87. PHYLLOGASTER Morgan.

PHYLLOGASTER SACCATUS Morg.
Hamilton Co., A. P. Morgan; Licking Co., C. J. Herrick.

VIII. NIDULARIACEÆ.

88. CRUCIBULUM Tul.

CRUCIBULUM VULGARE Tul.
Cincinnati, D. L. James (Thos. G. Lea, Cat.)

89. CYATHUS Hall.

CYATHUS STRIATUS Hall.
Cincinnati, Thos. G. Lea (Cat.); Clermont Co., D. L. James.

CYATHUS VERNICOSUS DC.
Cincinnati, Thos. G. Lea (Cat.)

IX. LYCOPERDACEÆ.

90. TYLOSTOMA Pers.

TYLOSTOMA VERRUCOSUM Morg.
Ohio, A. P. Morgan (N. A. F.)

91. GEASTER Mich.

GEASTER LAGENIFORMIS Vitt.
Ohio, A. P. Morgan (N. A F.)

GEASTER LIMBATUM Fr.
Ohio, A. P. Morgan (N. A. F.); Stockport (Morgan Co.) W. A. Kellerman.

GEASTER SACCATUS Fr.
Ohio, A. P. Morgan (N. A. F.); Clermont Co., D. L. James.

GEASTER STRIATUS D. C.
Ohio, A. P. Morgan (N. A. F.)

GEASTER TRIPLEX Jungh.
Clermont Co., D. L. James; Miami Valley, A. P. Morgan (Fl.)

92. BOVISTA Dill.

BOVISTA MINOR Morg.
Ohio, A. P. Morgan (N. A. F.)

BOVISTA PILA B. & C.
Ohio, A. P. Morgan (N. A. F.); Granville, C. J. Herrick.

BOVISTA PLUMBEA Pers.
Ohio, A. P. Morgan (N. A. F.) Said to be edible.

BOVISTA NIGRESCENS Pers.
Waynesville (Warren Co.) Thos. G. Lea (Cat.); Ohio, A. P.Morgan (N. A F.); Granville, H. L. Jones.

93. CALVATIA Fr.

CALVATIA CRANIIFORMIS Schw.
Ohio, A. P. Morgan (N. A. F.)

CALVATIA CYATHIFORMIS Bosc.
Ohio, A. P. Morgan (N. A. F.)

CALVATIA MAXIMA Schaeff.
Ohio, A. P. Morgan (N. A. F.)

94. LYCOPERDON Tourn.

LYCOPERDON ACUMINATUM Bosc.
Ohio, A. P. Morgan (N. A. F.)

LYCOPERDON ASTEROSPERMUM Dur. & Mont.
Ohio, A. P. Morgan (N. A. F.)

LYCOPERDON ATROPURPUREUM Vitt.
Ohio, A. P. Morgan (N. A. F.)

LYCOPERDON CEPAEFORME Bull.
Ohio, A. P. Morgan (N. A. F.)

LYCOPERDON COLORATUM Peck.
Ohio, A. P. Morgan (N. A. F.)

LYCOPERDON CURTISII Berk.
Ohio, A. P. Morgan (N. A. F.)

LYCOPERDON ECHINATUM Pers.
Ohio, A. P. Morgan (N. A. F.)

LYCOPERDON ELONGATUM Berk.
Ohio, A. P. Morgan (N. A. F.)

LYCOPERDON GEMMATUM Fr.
Common.

Lycoperdon giganteum Batsch.
Generally distributed. Edible.

Lycoperdon glabellum Pk.
Ohio, A. P. Morgan (N. A. F.)

Lycoperdon molle Pers.
Clermont Co., D. L. James; Ohio, A. P. Morgan (N. A. F.)

Lycoperdon peckii Morg.
Ohio, A. P. Morgan (N. A. F.)

Lycoperdon pedicellatum Peck.
Ohio, A. P. Morgan (N. A. F.)

Lycoperdon pulcherrimum B. & C.
Ohio, A. P. Morgan (N. A. F.)

Lycoperdon pusillum Batsch.
Ohio, A. P. Morgan (N. A. F.)

Lycoperdon pyriforme Schaeff.
Ohio, A. P. Morgan (N. A. F.); Clermont Co., D. L. James; Cincinnati, Thos. G. Lea (Cat.)

Lycoperdon rimulatum Pk.
Ohio, A. P. Morgan (N. A. F.)

Lycoperdon separans Pk.
Ohio, A. P. Morgan (N. A. F.)

Lycoperdon subincarnatum Pk.
Ohio, A. P. Morgan (N. A. F.)

Lycoperdon turneri E. & E.
Ohio, A. P. Morgan (N. A. F.)

Lycoperdon wrightii B. & C.
Ohio, A. P. Morgan (N. A. F.); Clermont Co., D. L. James; Licking Co., H. L. Jones. Edible.

95. SCLERODERMA Pers.

Scleroderma ohioense Ell. & Morg.
Ohio, A. P. Morgan (Jour. Mycal. I. '89.)

Scleroderma vulgare Fr.
Cincinnati, Thos. G. Lea (Cat.)

X. UREDINACEÆ.

96. UROMYCES Link. Rust.

UROMYCES APPENDICULATUS (Pers.) Fink.
On Phaseolus (cult.), Lancaster, W. A. Kellerman.

UROMYCES CALADII (Schw.) Farl.
On Arisaema throughout the state.

UROMYCES CAROPHYLLINUS (Schrank.) Schrœt.
On Carnations in greenhouses.

UROMYCES EUPHORBIÆ C. & P.
On various species of Euphorbia. Common throughout the state.

UROMYCES GRAMINICOLA Burrill.
On Andropogon virginicus, Lawrence Co., W. A. Kellerman.

UROMYCES HEDYSARI-PANICULATA (Schw.) Farl.
On species of Meibomia (Desmodium). Widely distributed.

UROMYCES HOWEI Peck.
On species of Asclepias. Common.

UROMYCES HYPERICI Schw.
On Hypericum mutilum, Fairfield Co., W. A. Kellerman.

UROMYCES LESPEDEZÆ (Schw.) Peck.
On species of Lespedeza. Common.

UROMYCES PECKII DeToni.
On Oenothera biennis, Columbus, Moses Craig.

UROMYCES POLYGONI (Pers.) Fckl.
On Polygonum, widely distributed over the state.

UROMYCES TEREBINTHI (DC.) Wint. (*Pileolaria brevipes* B. & R.)
On Rhus radicans, Fairfield Co., W. A. Kellerman.

UROMYCES TRIFOLII (A. & S.) Wint.
On species of Trifolium, widely distributed.

97. MELAMPSORA, Casts. Rust.

MELAMPSORA POPULINA Lev.
On Populus, throughout the state.

MELAMPSORA SALICINA Lev.
On Willow. Common.

98. CRONARTIUM, Fr.

CRONARTIUM ASCLEPIADEUM THESII Berk.
Cincinnati, Thos. G. Lea (Cat.)

99. PUCCINIA Persoon. RUST.

PUCCINIA ANEMONES VIRGINIANÆ Schw.
On Anemone, Lima, W. A. Kellerman; on Anemone virginiana, Scioto River, A. D. Selby; Fairfield Co., W. A. Kellerman.

PUCCINIA ANGUSTATA Peck.
On Scirpus fluviatilis, Columbns, Fairfield Co. W. A. Kellerman.

PUCCINIA ASTERIS Duby.
On Aster macrophyllus, Fairfield Co., W. A. Kellerman.

PUCCINIA CIRCAEAE Pers.
On Circaea lutetiana; common throughout the state.

PUCCINIA CORONATA Corda.
On Volunteer Oats, Perry Co., W. A. Kellerman.

PUCCINIA EMACULATA Schw.
On Panicum capillare, Columbus, Lovelann, W. A. Kellerman.

PUCCINIA HIERACII (Schum.) Mart. (*P. flosculosornm* (A. & S.) Roehl.)
On Cnicus and Taraxacum; abundant throughout the state.

PUCCINIA FUSCA Relhan. (*P. anemones* Pers.)
On Anemone nemorosa, Lima, W. A. Kellerman; Franklin Co., W. A. Kellerman, Freda Detmers.

PUCCINIA GALII Pers. (*P. galiorum* Lk.)
I. III. On Galium, Fairfield Co., W. A. Kellerman; on Galium aparine, Franklin Co., Moses Craig; Fairfield Co., Freda Detmers.

PUCCINIA GRAMINIS Pers.
On wheat, oats and other Gramineae; common.

PUCCINIA HASTATA Cke.
On Viola hastata, Fairfield Co., W. A. Kellerman.

PUCCINIA HELIANTHI Schw.
On Helianthus; doubtless over the whole state.

PUCCINIA LATERIPES B. & R.
On Ruellia sp., Columbus, C. M. Weed.

PUCCINIA MARIÆ WILSONI Clint.
On Claytonia virginica, Franklin Co., W. A. Kellerman, Freda Detmers

PUCCINIA MENTHÆ Pers.
On Mentha, Blephilia, Cunila, Pyycanthemum and Monarda; abundant over the state.

PUCCINIA NOLITANGERIS Cda. (*P. argentata* (Schultz.) Wint.)
On Impatiens fulva, Fairfield Co., W. A. Kellerman.

PUCCINIA PIMPINELLAE (Strauss.) Lk.
On Chaerophyllum procumbens, Columbus, Moses Craig.

PUCCINIA PODOPHYLLI Schw. (*P. aculeata* Schw.; *Aecidium podophylli* Schw.)
Abundant on Podophyllum peltatum throughout the state.

PUCCINIA RUBIGO-VERA (DC.) Wint.
On wheat, Central Ohio and doubtless over the whole state.

PUCCINIA SANICULA Grev.
On Sanicula, Fairfield Co., W. A. Kellerman.

PUCCINIA SAXIFRAGÆ Schl.
On Saxifraga virginiensis, Fairfield Co., Moses Craig.

PUCCINIA SILPHII Schw.
On Silphium perfoliatum, Columbus, W. A. Kellerman.

PUCCINIA SORGHI Schw. (*P. maydis* Car.)
On Indian corn throughout the state.

PUCCINIA TENUIS Burr. (*Aecidium tenue* Schw.)
I. On Eupatorium ageratoides, Fairfield Co., W. A. Kellerman.

PUCCINIA TIARELLÆ B. & C.
On Mitella diphylla, Fairfield Co., Perry Co., W. A. Kellerman.

PUCCINIA VIOLÆ DC.
On Viola; widely distributed.

PUCCINIA XANTHII Schw.
On Xanthium and Ambrosia; throughout the state.

100. GYMNOSPORANGIUM Hedw.

GYMNOSPORANGIUM GLOBOSUM Farlow.
On cedar (*Juniperus virginiana*), Fairfield Co., Clermont Co., W. A. Kellerman.

GYMNOSPORANGIUM MACROPUS Lk.
On cedar (*Juniperus virginiana*); over the whole state.

101. PHRAGMIDIUM Link.

PHRAGMIDIUM POTENTILLÆ Pers.
On Potentilla canadensis, in Central and Southern Ohio and doubtless over the whole state.

PHRAGMIDIUM SUBCORTICIUM Schrank. (*Ph. mucronatum* Cooke; *Coleosporium miniatum* (Pers.) Fckl.)
On Rose leaves and stems; common.

102. COLEOSPORIUM Lév.

COLEOSPORIUM SENECIONIS (Pers.) Fr. (*Peridermium pini* Wallr.; *Aecidium pini* Pers.)
On Pinus rigidus; Central and Southern Ohio.

COLEOSPORIUM SOLIDAGINIS Thuem.
On Solidago; common

COLEOSPORIUM SONCHI Pers. (*Uredo sonchi-arvensis* (Pers.) Lév.; *C. compositarum* Lév.)
On Helianthus and Aster; common

COLEOSPORIUM VERNONIÆ B. & C.
On Vernonia; common.

103. RAVENELIA Berk.

RAVENELIA GLANDULIFORMIS B. & C.
On Tephrosia virginica, Fairfield Co., W. A. Kellerman.

104. AECIDIUM Pers. YELLOW CLUSTER-CUPS.

AECIDIUM ACTÆÆ (Opiz.) Wallr.
On Actaea alba, Fairfield Co., Moses Craig.

AECIDIUM ASTERUM Schw. (*Ae. solidaginis* Schw.)
On Aster and Solidago in Central Ohio, and doubtless over the whole state.

AECIDIUM CIMICIFUGATUM Schw.
On Cimicifuga racemosa in Central Ohio, and doubtless wherever the host occurs.

AECIDIUM CLAYTONIATUM Schw.
On Claytonia virginica, Columbus, W. A. Kellerman.

AECIDIUM COMPOSITARUM.
On several hosts (Compositæ, Eupatorium, Helianthus, etc.); over the whole state.

AECIDIUM DICENTRÆ Trel.
On Dicentra cucullaria, Franklin Co., W. A. Kellerman.

AECIDIUM EPILOBII DC.
Cincinnati, Thos. G. Lea (Cat.)

AECIDIUM ERIGERONATUM Schw.
On Erigeron annuus, Fairfield Co., Freda Detmers; on E. bellidifolius, Fairfield Co., Moses Craig.

AECIDIUM EUPHORBIÆ Gmel.
On Euphorbia, Central Ohio.

AECIDIUM GERANII DC.
On Geranium maculatum, Franklin Co., Freda Detmers, W. A. Kellerman.

AECIDIUM GROSSULARIÆ Schum.
On Ribes; over the whole state.

AECIDIUM HOUSTONIATUM Schw.
On Houstonia cærulea, Sugar Grove, Fairfield Co., Moses Craig.

AECIDIUM HYDNOIDEUM B. & C.
On Dirca palustris, Sugar Grove, Fairfield Co., Moses Craig.

AECIDIUM IMPATIENTIS Schw.
On Impatiens; Central Ohio.

AECIDIUM NAPÆÆ Arth. and Holw.
On Napæa dioica, Sugar Grove, Fairfield Co., Moses Craig.

AECIDIUM NESÆÆ Gerard.
On Nesæa verticillatus, Licking Reservoir, W. C. Werner, Aug. D. Selby.

AECIDIUM OENOTHERÆ Pk.
On Oenthera biennis; Central Ohio.

AECIDIUM PUNCTATUM Pers.
On Hepatica acutiloba, Columbus, Moses Craig, H. A. Surface.

AECIDIUM RANUNCULI Schw.
On ranunculus abortivus; common in Central Ohio and doubtless over the whole state.

AECIDIUM SAMBUCI Schw.
On Sambucus canadensis, Central Ohio, W. A. Kellerman; no specimens seen from other parts of the state.

AECIDIUM SOMMERFELTII Johanson.
On Syndesmon thalictroides, Hocking Co, Moses Craig.

105. UREDO Persoon.

UREDO AGRIMONIÆ DC.
On Agrimonia eupatoria; Central Ohio, and perhaps wherever the host occurs.

UREDO HYDRANGEAE B & C.
On Hydrangea arborescens, Southern Ohio.

UREDO PALYPODII (Pers.) DC. (*U. filicum* Desm.)
On Cystopteris fragilis, Lancaster, W. A. Kellerman.

UREDO SMILACIS Schw.
On Smilax rotundifolia, Fairfield Co., W. A. Kellerman.

106. CÆOMA Link.

CÆOMA NITENS Schw. Bramble Rust.
On Rubus throughout the state.

XI. USTILAGINACEÆ.

107. USTILAGO Pers. SMUT.

USTILAGO AVENAE (Pers.) Jensen.
On oats; over the state.

USTILAGO CESATII Fisch. (*U. syntherismal* Schw.)
On Panicum sanguinale, Painesville, Wm. C. Werner; Columbus, W. A. Keller, man.

USTILAGO MAYDIS (DC.) Corda.
On Zea mays, everywhere.

USTILAGO TRITICI Jensen.
On wheat, generally distributed.

USTILAGO UTRICULOSA (Nees.) Tul.
On Polyganum pennsylvanicum Columbus, W. A. Kellerman; Fairfield Co, C. M. Weed.

108. TILLETIA Tul. SMUT.

TILLETIA CORONA Scribner.
On Leersia virginica; Columbus, W. A. Kellerman.

TILLETIA FOETENS Rav.
On wheat, Columbus, W. A. Kellerman.

TILLETIA STRIAEFORMIS (West) Magnus.
On Timothy, Central College, W. A. Kellerman.

109. ENTYLOMA DeBary.

ENTYLOMA PHYSALIDIS Winter.
On Physalis lanceolata; Columbus, W. A. Kellerman.

110. SOROSPORIUM Rud. SMUT.

SOROSPORIUM ELLISII Winter.
On Aristida dichotoma, Fairfield Co., W. A. Kellerman.

111. UROCYSTIS Rabenh. SMUT.

UROCYSTIS CARCINODES (B. & C.) Fisch.
On Cimicifuga racemosa, Fairfield Co., W. A. Kellerman, Aug. D. Selby; Ironton W. C. Werner.

XII. PERONOSPORACEÆ.

112. ALBUGO Kuntze. (*Cystopus* Lev.)

ALBUGO AMARANTHI (Schw.) Kuntze. (*Cystopus amaranti* (Schw.) Berk.)
On Amarantus retroflexus, Columbus, W. A. Kellerman; on A. chlorostachys hybridus, Columbus, Freda Detmers.

ALBUGO CANDIDUS (Pers.) Kuntze. (*Cystopus candidus* (Pers.) Lev.)
Cincinnati, Thos. G. Lea (Cat.); Clermont Co., D. L. James; on Brassica nigra Capsella bursa pastoris, Marion, W. A. Kellerman; on Sisymbrium officinale Columbus, W. A. Kellerman.

ALBUGO PORTULACAE (Pers.) Kuntze. (*Cystopus portulacae* Lev.).
On Portulaca oleracea, Columbus, W. A. Kellerman, Freda Detmers; Fairfield Co., W. A. Kellerman.

ALBUGO TRAGOPOGONIS (Pers.) S. F. Gray. (*Cystopus cubicus* Lev.)
On Ambrosia artemisiaefolia, Columbus, W. A. Kellerman.

113. PLASMOPARA Schroet. (*Peronospora*).

PLASMOPARA AUSTRALIS (Speg.) Swingle. (*Peronospora australis* Speg.)
On Sicyos angulata, Athens, on Micrampeles echinata, Fairfield Co., W. A. Kellerman.

PLASMOPARA HALSTEDII (Farl.) Berl. & DeTon. (*Peronospora halstedii* Forlaw).
On Erechtites hieracifolia, Columbus, W. A. Kellerman.

PLASMOPARA PYGMAEA (Ung.) Schoeter. (*Peronospora pygmaea* Ung.)
On Anemone pennsylvanica, Columbus, W. A. Kellerman.

PLASMOPARA VITICOLA (B. & C.) Berl. & DeToni. (*Peronospora viticola* DeBy.; *Botytis viticola* B. & C.)
On cultivated grapes throughout the state. On native species of Vitis also.

114. BREMIA Regel. (*Peronospora*).

BREMIA LACTUCAE Regel. (*Peronospora gangliformis* (Berk.) DeToni.)
On Lettuce (cultivated), Columbus and doubtless over the whole state.

XIII. ENTOMOPHTHORACEÆ.

115. EMPUSA Cohn.

EMPUSA APHIDIS Hoffm.
Columbus, and doubtless in all green-houses, on Aphidæ.

EMPUSA GRYLLI (Fres.) Thax. (*E. aulicæ* Reich.)
On Spilosoma virginica Fabr., Wooster, F. M. Webster.

EMPUSA MUSCAE Cohn.
On houseflies, Columbus and doubtless over whole state.

EMPUSA SPHÆROSPERMA (Fres.) Thax.
On Phytonomus punctatus, Ashtabula, F. M. Webster.

XIV. MUCORACEÆ.

116. PILOBOLUS Tode.

PILOBOLUS CHRYSTALLINUS (Wigg.) Tode.
On Horsedung, Fairfield Co., W. A. Kellerman.

117. MUCOR, Mich.

MUCOR MUCEDO L.
Common everywhere.

MUCOR RAMOSUS Bull.
Waynesville, Thos. G. Lea (Cat.)

118. FRANKIA Brunch.

FRANKIA CEANOTHI Atk.
On Ceanothus americanus, Fairfield Co., W. A. Kellerman.

XV. CHYTRIDIACEÆ.

119. SYNCHYTRIUM DeBary.

SYNCHYTRIUM DECIPIENS Farl.
On Amphicarpaea comosa, Nebraska (Pickaway Co.), Columbus, W. A. Kellerman.

XVI. PERISPORIACEÆ.

(ERYSIPHEÆ, Lèveillè. POWDERY MILDEW, WHITE MILDEW.)

120. SPHÆROTHECA Lev.

SPHÆROTHECA CASTAGNEI Lev.
On Bidens frondosa, Columbus, Aug. D. Selby; on Erechtites, Columbus, Aug. D. Selby.

SPHÆROTHECA HUMULI (DC.) Burr. Hop Mildew.
On Agrimonia eupatoria, Lancaster, W. A. Kellerman.

SPHÆROTHECA MORS-UVÆ (Schw.) B. & C. Gooseberry Mildew.
Reported over the state on cultivated gooseberries, particularly on English varieties.

SPHÆROTHECA PANNOSA (Wallr.) Lev. Rose Mildew.
On cultivated roses; Athens Co., Aug. D. Selby. Common on cultivated roses generally.

SPHÆROTHECA PHYTOPTOPHILA Kell. & Swingle. Hackberry Knot Mildew.
On Phytoptus twig-tufts of Celtis occidentalis, Lima, W. A. Kellerman; Columbus, Aug. D. Selby. Probably all over the state, wherever the host occurs.

121. ERYSIPHE (Hedw.) Lev.

ERYSIPHE CICHORACEARUM DC. (*E. lamprocarpa*) Verbena Mildew.
The commonest of all the mildews, particularly on species of Compositæ, Borraginaceæ, and Verbenaceæ; also on Parietaria pennsylvanica, Columbus, Aug. D. Selby; on Hydrophyllum macrophyllum, Pickaway Co., W. A. Kellerman; Fairfield Co., Aug. D. Selby; on Dahlia (cult) Fairfield Co., W. A. Kellerman; Columbus, Aug. D. Selby; on Phlox sp. (cult.) Fairfield Co., W. A. Kellerman.

ERYSIPHE COMMUNIS (Wallr.) Fr. Clematis Mildew.
On Aquilegia canadensis, Columbus, Freda Detmers; on Clematis virginiana and Clematis sp. (cult.) Columbus, Aug. D. Selby, Freda Detmers; on Clematis sp. (cult.) Waynesville, W. A. Kellerman; on Desmodium canescens, Columbus, Aug. D. Selby. Quite common on other species of Ranunculaceæ and Leguminosæ.

ERYSIPHE GALEOPSIDIS DC.
On Scutellaria lateriflora, Columbus, Aug. D. Selby, Wm. C. Werner; Fairfield Co., Aug. D. Selby; on Stachys aspera glabra, Columbus, W. A. Kellerman; on S. palustris, Columbus, Aug. D. Selby; on Chelone glabra, Ashtabula Co., Sara F. Goodrich.

ERYSIPHE GRAMINIS DC. Wheat Mildew.
Conidial stage only seen; on Triticum vulgare, Columbus, Freda Detmers; Lima, W. A. Kellerman; on Poa pratensis, Columbus, W. A. Kellerman; on Agropyrum, Ashtabula Co., Sara F. Goodrich.

ERYSIPHE LIRIODENDRI Schw. Tulip-tree Mildew.
On Liriodendron tulipifera, Columbus, Aug. D. Selby; Fairfield Co., Aug. D. Selby. Especially conspicuous by the dense felted mycelium.

122 UNCINULA Lev.

UNCINULA CIRCINATA C. & P.
On Acer rubrum, Fairfield Co., Aug. D. Selby; on Acer saccharum, Columbus, C. M. Weed.

UNCINULA FLEXUOSA Peck.
On Aesculus glabra, Columbus, C. M. Weed, F. M. Webster.

UNCINULA MACROSPORA Peck.
On Ulmus Americana, Fairfield Co., W. A. Kellerman, Aug. D. Selby, Freda Detmers; Columbus, Wm. C. Werner, Aug. D. Selby; on U. fulva, Columbus, C. M. Weed, Wm. C. Werner.

UNCINULA NECATOR (Schw.) Burr. (*U. ampelopsidis* Peck; *U. spiralis* B. & C.) Grape Mildew.
General throughout the state on species of Vitis and Ampelopsis.

UNCINULA SALICIS (DC.) Wint.
Common on willows.

UNCINULA COLUMBIANA Selby.
On Scutellaria lateriflora, Columbus, Aug. D. Selby.

123. PHYLLACTINIA Lev.

PHYLLACTINIA SUFFULTA (Rib.) Sacc.
Common on Oak, Beech, Chestnut, Carpinus, Catalpa; also on Phlox paniculata, Columbus, Aug. D. Selby.

124. PODOSPHÆRA Kunze.

PODOSPHÆRA OXYACANTHÆ (DC.) D. By.
Quite common on plum and cherry. On cultivated cherry, Columbus, C. M. Weed, Freda Detmers; Dayton, Joseph Potts; on Spirea tomentosa (*Podosphæra minor* Howe) Lancaster, W. A. Kellerman.

125. MICROSPHÆRA Lev.

MICROSPHÆRA ALNI (DC.) Winter. Lilac Mildew.
This species occur on a wide range of host plants. Everywhere upon Lilac: on Enonymus atropurpureus (conidial stage only); Ross Co., W. A. Kellerman; Columbus, Aug. D. Selby; on Sambucus canadensis, Columbus, Aug. D. Selby; on Platanus occidentalis (conidial stage) Columbus, Aug. D. Selby; on Castanea sativa americana, Fairfield Co., E. V. Wilcox, E. E. Bogue, C. M. Weed; Ross Co., W. A. Kellerman.

MICROSPHÆRA DIFFUSA C. & P.
On Desmodium canescens, Columbus, C. M. Weed, Freda Detmers, Aug. D. Selby.

MICROSPHÆRA ELEVATA Burrill.
On Catalpa bignonoides, Columbus, C. M. Weed.

MICROSPHÆRA EUPHORBIÆ B. & C.
On Euphorbia corollata, Columbus, E. M. Wilcox.

MICROSPHÆRA QUERCINA (Schw.) Burrill.
General on the oaks.

MICROSPHÆRA RAVENELII Berk.
On Gleditschia triacanthos, Columbus, C. M. Weed, W. A. Kellerman; Warren Co., Ross Co., Fairfield Co., W. A. Kellerman.

MICROSPHÆRA RUSSELLII Clint.
On Oxalis stricta, Columbus, W. A. Kellerman, on Oxalis recurva, E. M. Wilcox.

MICROSPHÆRA VACCINII (Schw.) C. & P. Huckleberry Mildew.
On Gaylussacia resinosa, Fairfield Co., Aug. D. Selby; on Vaccinium vacillans, Meigs Co., P. L. Pfarr; Fairfield Co., Aug. D. Selby.

XVII. PERISPORIACEÆ.

126. ASTERINA Liv.

ASTERINA GAULTHERIÆ Curtis.
On Gaultheria procumbens, Fairfield Co., Aug. D. Selby, W. A. Kellerman.

126*a*. DIMEROSPORIUM Fckl.

DIMEROSPORIUM COLLINSII (Schw.) Thuem.
On Amelanchier, Fairfield Co., W. A. Kellerman.

127. CAPNODIUM Mont.

Capnodium expansum B. & Desm.
On bark of Acer, Ohio, J. B. Ellis (N. A. P.)

127*a*. ANTENNARIA Link.

Antennaria pinophila Nees.
Cincinnati, Thos. G. Lea (Cat.)

128. SCORIAS Fries

Scorias spongiosa Fr.
Cincinnati, Thos. G. Lea (Cat.); on Beech Granville (Licking Co.) C. J. Herrick; Columbus, W. A. Kellerman.

XVIII. SPHAERIACEÆ.

129. COELOSPHÆRIA Sacc.

Coelosphæria tristis (Pers.) Sacc. (*Nitschkia tristis* Pers.)
Ohio, A. P. Morgan. (Ellis, N. A. P.)

130. QUATERNARIA Tul.

Quaternaria persooni Tul. (*Valsa quaternata* Pers.)
Cincinnati, Thos. G. Lea (Cat.)

130*a*. VALSA Fr.

Valsa leucostoma (Pers.) Fr.
Clermont Co., D. L. James.

Valsa nivea. (Hoff.) Fr.
Clermont Co., D. L. James.

131. EUTYPELLA Nits.

Eutypella leaiana (Berk.) Sacc. (*Valsa leaiana* Berk.)
Cincinnati, Thos. G. Lea (Cat.)

131*a*. EUTYPA Tul.

Eutypa spinosa (Pers.) Tul. (*E. limaeformis* Schw.)
Cincinnati, Thos. G. Lea (Cat.); Clermont Co., D. L. James; Fairfield Co., W. A. Kellerman.

132. DIATRYPE Fr.

DIATRYPE DISCIFORMIS Hoffm.
Cincinnati, Thos. G. Lea (Cat.)

DIATRYPE PLATYSTOMA Schw.
Clermont Co., D. L. James.

DIATRYPE TINCTOR Berk.
Cincinnati, Thos. G. Lea (Cat.)

133. CERATOSTOMA Fr.

CERATOSTOMA SETIGERUM E. & E.
Ohio, A. P. Morgan (Fl.)

134. ROSELLINIA DeNot.

ROSELLINIA MAMMIFORMIS (Pers.) Ces. DeNot. (*Hypoxylon mammiformis* Berk.)
On old wood, Fairfield Co., W. A. Kellerman.

135. BOMBARDIA Fr.

BOMBARDIA FASCICULATA Fr. (*Sphaeria bombarda* Batsch.)
Cincinnati, Thos. G. Lea (Cat.)

136. ANTHOSTOMA Nits.

ANTHOSTOMA ATRO-PUN TATUM (Schw.) Sacc. (*Diatrype atropunctata* Schw.)
Cincinnati, Thos. G. Lea (Cat.)

137. XYLARIA Hill.

XYLARIA CASTOREA Berk.
Ohio, A. P. Morgan (Ellis, N. A. P.)

XYLARIA CARPOPHILA Fr.
Cincinnati, Thos. G. Lea (Cat.)

XYLARIA CONOCEPHALA B. & C.
Ohio, A. P. Morgan (Ellis N. A. P.)

XYLARIA DIGITATA Ehrh.
Cincinnati, Thos. G. Lea (Cat.)

XYLARIA HYPOXYLON Grev.
Cincinnati, Thos. G. Lea (Cat.); Fairfield Co., W. A. Kellerman; Clermont Co., D. L. James.

Xylaria polymorpha Pers.
Clermont Co., D. L. James; Waynesville (Warren Co.) Thos. G. Lea (Cat.); Columbus, W. C. Werner.

138. PORONIA Willd.

Poronia pocula Schw.
Cincinnati, Thos. G. Lea (Cat.)

139. USTULINA Tul.

Ustulina vulgaris Tul.
Cincinnati, Thos. G. Lea (Cat.)

140. HYPOXYLON Bull.

Hypoxylon albocinctum E. & E.
Hamilton Co., A. P. Morgan (Ellis, N. A. P.)

Hypoxylon annulatum Schw.
Fairfield Co., W. A. Kellerman.

Hypoxylon atropunctatum Schw.
Fairfield Co., W. A. Kellerman.

Hypoxylon coccineum Bull.
Cincinnati, Thos. G. Lea (Cat.)

Hypoxylon cohaerens Pers.
Cincinnati, Thos. G. Lea (Cat.)

Hypoxylon concentricum Grev.
Cincinnati, Thos. G. Lea (Cat.); Clermont Co., D. L. James.

Hypoxylon howeianum Pk.
Ohio, A. P. Morgan (Ellis, N. A. P.)

Hypoxylon marginatum Schw.
Ohio, A. P. Morgan, (Ellis, N. A. P.)

Hypoxylon morgani E. & E.
Ohio, A. P. Morgan (Ellis, N. A. P.)

Hypoxylon ohioense E. & E.
Ohio, A. P. Morgan (Ellis, N. A. P.)

Hypoxylon petersii B. & C.
Ohio, A. P. Morgan (Ellis, N. A. P.)

Hypoxylon rubiginosum Fr.
Fairfield Co., W. A. Kellerman.

HYPOXYLON SASSAFRAS Schw.
Fairfield Co., W. A. Kellerman.

HYPOXYLON TURBINULATUM Schw.
Ohio, A. P. Morgan (Ellis, N. A. P.)

140*a*. NUMMULARIA Tul.

NUMMULARIA BULLIARDI Tul.
On old Oak bark, Fairfield Co., W. A. Kellerman.

NUMMULARIA GLYCYRRHIZA B. & C.
Ohio, A. P. Morgan (Ellis, N. A. P.)

NUMMULARIA MICROPLACA B. & C.
Fairfield Co., W. A. Kellerman.

NUMMULARIA DISCRETA Schw.
Fairfield Co., W. A. Kellerman.

141. GNOMONIELLA Sacc.

GNOMONIELLA CORYLI (Batsch.) Sacc. (*Gnomonia coryli* Batsch.)
On Corylus americana, Fairfield Co., W. A. Kellerman.

142. LAESTADIA Auersw.

LAESTADIA ACERIFERA (Cke.) Sacc. (*Sphaerella acerifera* Cke.)
On Acer saccharinum, Fairfield Co., W. A. Kellerman.

143. PHOMATOSPORA Sacc.

PHOMATOSPORA ARGYROSTIGMA Berk.
Cincinnati, Thos. G. Lea (Cat.)

144. BOTRYOSPHAERIA Ces. & DeN.

BOTRYOSPHAERIA QUERCUUM (Schw.) Sacc. (*Melogramma fuliginosum* Ell.)
On old leaves of Sassafras, Fairfield Co., W. A. Kellerman.

BOTRYOSPHAERIA RHIZOGENA (Berk.) Sacc. (*Sphaeria rhizogena* Berk.)
Cincinnati, Thos. G. Lea (Cat.)

145. SPHAERELLA Ces. & DeNot.

SPHAERELLA ASIMINAE E. & K.
Fairfield Co., W. A. Kellerman.

SPHAERELLA CONVEXULA Schw.
Ohio, J. B. Ellis (N. A. P.)

SPHAERELLA FRAGARIAE (Tul.) Sacc.
On Fragaria (cult.) Columbus, Freda Detmers.

SPHAERELLA FRAXINICOLA (Schw.) Cke.
Fairfield Co., W. A. Kellerman.

SPHAERELLA GAULTHERIA C. & E.
On Gaultheria procumbens, Fairfield Co., W. A. Kellerman.

SPHAERELLA LIRIODENDRI Ellis.
On Liriodendron tuliperfera, Fairfield Co., W. A. Kellerman.

SPHAERELLA MACULAEFORMIS Pers.
On Quercus macrocarpa, Q. rubra, Q. alba and Celtis occidentalis, Fairfield Co., W. A. Kellerman.

SPHAERELLA POLYSTIGMA Ellis.
On Quercus coccinea, Fairfield Co., W. A. Kellerman.

SPHAERELLA PRAECOX Pass.
On Lactuca canadensis, Fairfield Co., W. A. Kellerman.

SPHAERELLA SASSAFRAS E. & E.
On Sassafras, Fairfield Co., W. A. Kellerman.

SPHAERELLA SPARSA Pers.
On Tilia americana, old Chestnut leaves, Fairfield Co., W. A. Kellerman.

146. DIDYMELLA Sacc.

DIDYMELLA LOPHOSPORA Sacc. & Speg.
Ohio, J. B. Ellis (N. A. P.)

147. GNOMONIA Ces. & DeNot.

GNOMONIA ULMEA (Sacc.) Thuem. (*Sphaeria ulmea* Schw.)
On Ulmus americana, Fairfield Co., W. A. Kellerman.

GNOMONIA SASSAFRAS E. & E.
On Sassafras leaves, Fairfield Co., W. A. Kellerman.

GNOMONIA SETACEA Pers.
On Chestnut leaves, Fairfield Co., W. A. Kellerman.

148. VENTURIA DeNot.

VENTURIA ORBICULA Schw.
On Quercus prinus, Fairfield Co., W. A. Kellerman.

149. DIAPORTHE Nits.

DIAPORTHE MAYDIS Berk.
Ohio, Thos. G. Lea (Cat.)

150. VALSARIA Ces. & DeNot.

VALSARIA FULVO-PRUINATA (Berk.) Sacc. (*Valsa fulvopruinata* Berk.)
Cincinnati, Thos. G. Lea (Cat.)

151. LEPTOSPHAERIA Ces. & DeNot.

LEPTOSPHAERIA OGILVIENSIS Berk.
On Achillea millefolium, Fairfield Co., W. A. Kellerman.

152. CARYOSPORA DeNot.

CARYOSPORA PUTAMIUM Schw. (*Sphaeria putamium* Schw.)
Cincinnati, Thos. G. Lea (Cat.)

153. PSEUDOVALSA Ces. & DeNot.

PSEUDOVALSA CONVERGENS (Tode) Sacc. (*Valsa convergens* Tode.)
Cincinnati, Thos. G. Lea (Cat.)

154. LASIOSPHAERIA Ces. & DeNot.

LASIOSPHAERIA CRINITA (Pers.) Sacc. (*Sphaeria crinita* Pers.)
Cincinnati, Waynesville, Thos. G. Lea (Cat.)

155. HERPOTRICHIA Fckl.

HERPOTRICHIA DIFFUSA Schw.
Ohio, A. P. Morgan (Ellis, N. A. P.)

HERPOTRICHIA RHODOMPHALA (Berk.) Sacc. (*Sphaeria rhodomphala* Berk.)
Cincinnati, Thos. G. Lea (Cat.)

156. CALOSPORA Sacc.

CALOSPORA ACULEANS (Schw.) Sacc. (*Valsa aculeans* Schw.)
Clermont Co., D. L. James.

157. PLEOSPORA Rabh.

PLEOSPORA HERBARUM (Pers.) Rabh. (*Sphaeria herbarum* Pers.)
Cincinnati, Thos. G. Lea (Cat.)

158. PYRENOPHORA Fr.

PYRENOPHORA TRICHOSTOMA (Fr.) Sacc.
On old wheat stems, Columbus, W. A. Kellerman.

160. OPHIOBOLUS Riess.

OPHIOBOLUS FULGIDUS (C. & P.) Sacc. (*Sphaeria fulgida* C. & P.)
On Ambrosia trifida, Fairfield Co., W. A. Kellerman.

161. OPHIOCERAS Sacc.

OPHIOCERAS OHIOENSE E. & E.
Ohio, A. P. Morgan (Ellis, N. A. P.)

162. SPHAERIA.

SPHAERIA MAYDIS Berk.
On Zea mays, Cincinnati, Thos. G. Lea (Cat.)

SPHAERIA VERBASCICOLA Schw.
On Verbascum thapsus, Fairfield Co., W. A. Kellerman.

SPHAERIA VIRESCENS Schw. (*Diatrype virescens* Schw.)
Clermont Co., D. L. James.

XIX. HYPOCREACEÆ.

163. HYPOMYCES Fr.

HYPOMYCES LACTIFLUORUM Schw.
Waynesville (Warren Co.) Thos. G. Lea (Cat.)

HYPOMYCES XYLOPHILUS Pk.
Ohio, A. P. Morgan (Ellis, N. A. P.)

164. NECTRIA Fr.

NECTRIA COCCINEA (Pers.) Fr. (*Sphaeria coccinea* Pers.)
Cincinnati, Thos. G. Lea (Cat.)

NECTRIA LACTEA Ell. & Morgan.
On old Polyporus, Ohio, A. P. Morgan (Ellis, N. A. P.)

165. HYPOCREA Fr.

HYPOCREA PAPYRACEA Ell. & Hol.
Ohio, A. P. Morgan (Ellis, N. A. P.)

166. PLEONECTRIA Sacc.

PLEONECTRIA DENIGRATA Winter.
Ohio, A. P. Morgan (Ellis, N. A. P)

167. CLAVICEPS Tul.

CLAVICEPS PURPUREA (Fr.) Tul.
On Elymus canadensis, E. virginicus, Festuca elatior, Glyceria fluitans; Columbus, W. A. Kellerman.

168. CORDYCEPS Fr.

CORDYCEPS HERCULEA (Schw.)
Ohio, A. P. Morgan (Ellis, N. A. P.)

169. EPICHLOE Fr.

EPICHLOE TYPHINA (Pers.) Tul.
On Grass sheaths; Fairfield Co., W. A. Kellerman; Ironton, W. C. Werner.

XX. DOTHIDEACEÆ.

170. PHYLLACHORA Nits.

PHYLLACHORA GRAMINIS Pers.
On various grasses; widely distributed.

PHYLLACHORA TRIFOLII (Pers.)
On Trifolium repens; Fairfield Co., W. A. Kellerman.

171. PLOWRIGHTIA Sacc. BLACK-KNOT.

PLOWRIGHTIA MORBOSA (Schw.) Sacc. (*Sphaeria morbosa.*)
On Plum and cultivated cherry, apparently over the whole state.

172. DOTHIDEA Fr.

DOTHIDEA GRAMINIS Pers.
On Panicum latifolium, Fairfield Co., W. A. Kellerman.

DOTHIDEA POTENTILLAE Fr.
On Potentilla canadensis, Fairfield Co., W. A. Kellerman.

DOTHIDEA SOLIDAGINIS Schw.
On Solidago canadensis, Fairfield Co., W. A. Kellerman.

DOTHIDEA TETRASPORA.
On old stems of Osage Orange, Columbus, E. M. Wilcox.

XXI. HYSTERIACEÆ.

173. GLONIUM Muhl.

GLONIUM SIMULANS Gerard.
Ohio, J. B. Ellis (N. A. P.)

GLONIUM STELLATUM Muhl.
On rotten wood, Fairfield Co., W. A. Kellerman; Cincinnati, Thos. G. Lea (Cat.)

174. HYSTERIUM Tode.

HYSTERIUM ELONGATUM Wahl.
Cincinnati, Thos. G. Lea (Cat.)

HYSTERIUM PULICARE ANGUSTATUM Fr.
Cincinnati, Thos. G. Lea (Cat.)

HYSTERIUM PROSTII Duby.
Ohio, A. P. Morgan (Ellis, N. A. P.)

174. DICHAENA Fr.

DICHAENA FAGINEA Fr.
Cincinnati, Thos. G. Lea (Cat.)

176. HYSTEROGRAPHIUM Corda.

HYSTEROGRAPHIUM COOKEIANUM Ger.
Ohio, A. P. Morgan (Ellis, N. A. P.)

HYSTEROGRAPHIUM LESQUEREUXII (Duby.)
Ohio, Leo Lesquereux, A. P. Morgan (Ellis, N. A. P.)

HYSTEROGRAPHIUM PRAELONGUM Schw.
Ohio, A. P. Morgan (Ellis, N. A. P.)

177. LOPHODERMIUM Chev.

LOPHODERMIUM ARUNDINACEUM CULMIGENUM (Fr.) Fckl.
On old wheat stubble, Fairfield Co., W. A. Kellerman.

178. ACROSPERMUM.

ACROSPERMUM COMPRESSUM Tode.
On Verbena urticifolia, Fairfield Co., W. A. Kellerman.

XXII. HELVELLACEÆ.

179. MORCHELLA Dill.

MORCHELLA ESCULENTA Pers.
Common.

MORCHELLA HYBRIDA Pers. (*M. rimosipes* DC.)
Columbus, Wm. C. Werner & W. A. Kellerman; Granville, E. G. Stanley.

180. GYROMITRA Fr.

GYROMITRA ESCULENTA Pers.
Cincinnati, Thos. G. Lea (Cat.)

GYROMITRA GIGAS Knab.
Granville, C. J. Herrick.

XXIII. PEZIZACEÆ.

181. PEZIZA Dill.

PEZIZA AURANTIA Pers.
Cincinnati, Thos. G. Lea (Cat.)

PEZIZA COCCINEA Jacq.
Cincinnati, D. L. James.

PEZIZA PUSTULATA (Hedw.) Pers.
Cincinnati, Thos. G. Lea (Cat.)

182. LACHNEA Fr.

LACHNEA SCUTELLATA L. (*Peziza scutellata.*)
Common.

183. PSILOPEZIZA Berk.

PSILOPEZIZA NUMMULARIA Berk.
Cincinnati, Thos. G. Lea (Cat.)

184. SARCOSCYPHA Fr.

SARCOSCYPHA FLOCCOSA (Schw.) (*Peziza floccosa* Schw.)
Cincinnati, Thos. G. Lea (Cat.); Fairfield Co., W. A. Kellerman.

SARCOSCYPHA OCCIDENTALIS Schw. (*Peziza occidentalis.*)
Cincinnati, Thos. G. Lea (Cat.); Clermont Co., D. L. James.

185. HELOTIUM Fr.

HELOTIUM AERUGINOSUM Fr.
Cincinnati, Thos. G. Lea (Cat.)

HELOTIUM CITRINUM Batsch.
Cincinnati, Thos. G. Lea (Cat.); Rendville (Perry Co.) W. A. Kellerman.

HELOTIUM PALLESCENS Fr.
On rotten wood, Fairfield Co., W. A. Kellerman.

186. PHIALEA Fr.

PHIALEA SCUTULA (Pers) Gill.
Granville, H. L. Jones.

187. PEZIZELLA Fckl.

PEZIZELLA LEUCOSTIGMA (Fckl.) Sacc. (*Peziza leucostigma* Fr.)
Cincinnati, Thos. G. Lea (Cat.)

188. MOLLISIA Fr.

MOLLISIA DEHNII (Rabh.) Karst. (*Peziza dehnii* Rabh.)
On Potentilla norvegica, widely distributed.

189. TRICHOPEZIZA Fckl.

TRICHOPEZIZA CAPITULA (Pk.) Sacc. (*Peziza capitata* Pk.; *P. echinulata.*)
On Quercus alba, old leaves, Fairfield Co., W. A. Kellerman.

190. DASYSCYPHA Fr.

DASYSCYPHA NIVEA (Hedw.) Sacc. (*Peziza nivea* Fr.)
On old rails, Fairfield Co., W. A. Kellerman.

XXIV. DERMATEACEÆ.

191. URNULA Fr.

URNULA CRATERIUM (Schw.) Fr. (*Peziza craterium* Schw.)
Fairfield Co., W. A. Kellerman; Columbus, W. A. Kellerman, E. E. Bogue.

192. CENANGIUM Fr.

CENANGIUM CRATERIUM Fr.
Cincinnati, Thos. G. Lea (Cat.)

CENANGIUM TRIANGULARE Fr.
On rotten stems of Quercus, Fairfield Co., W. A. Kellerman; Cincinnati, Thos. G. Lea (Cat.)

XXV. BULGARIACEÆ.

193. LEOTIA Hill.

LEOTIA LUBRICA (Scop.) Pers.
Clermont Co., D. L. James.

194. BULGARIA Fr.

Bulgaria ophiobolus Ell.
Perry Co., W. A. Kellerman.

Bulgaria rufa Schw.
Clermont Co., D. L. James.

195. CORYNE Tul.

Coryne ellisii Berk.
Perry Co., W. A. Kellerman.

Coryne urnalis Aul. (*Coryne purpurea* Fckl.; *Bulgaria purpurea* Cke.)
Perry Co., W. C. Kellerman.

XXVI. STICTACEÆ.

196. STICTIS Pers.

Stictis sterei B. & C.
On Stereum frustulosum, Fairfield Co., W. A. Kellerman.

Stictis stereicola B. & C.
Clermont Co., D. L. James.

XXVII. PHACIDIACEÆ.

197. RHYTISMA Fr.

Rhytisma acerinum (Pers.) Fr.
On Acer rubrum, Sugar Grove, W. A. Kellerman; A. saccharinum, Bainbridge (Ross Co.) W. A. Kellerman.

Rhytisma punctatum Fr.
Cincinnati, Thos. G. Lea (Cat.)

XXVIII. PATELLARIACEÆ.

198. PATELLARIA Wahl.

Patellaria carpinea Berk.
Cincinnati, Thos. G. Lea (Cat.)

XXIX. GYMNOASCACEÆ.

199. EXOASCUS Fckl.

EXOASCUS ALNITORQUUS (Tul.) Sadeb.
On Alnus serrulata, Fairfield Co., Hocking Co., W. A. Kellerman.

EXOASCUS DEFORMANS Fckl. (*Taphrina deformans* Tul.; *Ascomyces deformans.*)
Widely distributed and usually abundant on peach leaves.

EXOASCUS PRUNI Fckl. (*Taphrina pruni* Tul.)
Probably over the whole state.

XXX. SPHÆRIOIDACEÆ.

200. PHYLLOSTICTA Pers.

PHYLLOSTICTA AMPELOPSIDIS E. & M.
On Ampelopsis quinquefolia, Athens, Fairfield Co., W. A. Kellerman.

PHYLLOSTICTA ASIMINAE E. & K.
On Asimina, Southern Ohio, and doubtless wherever the host occurs.

PHYLLOSTICTA CHENOPODII West.
On Chenopodium album, Fairfield Co., W. A. Kellerman.

PHYLLOSTICTA DECIDUA E. & K.
On Nepeta cataria, Peppermint leaves, Leornus cardiaca, Fairfield Co., W. A. Kellerman.

PHYLLOSTICTA DEUTZIAE E. &. E.
On Deutzia gracilis and D. scabra (cult.), Columbus, W. A. Klellerman.

PHYLLOSTICTA LABRUSCAE Thuem.
On Vitis, Orwell (Ashtabula Co.) E. E. Bogue; on Vitis aestivalis bicolor, Fairfield Co., W. A. Kellerman.

PHYLLOSTICTA LAPPAE E. & K.
On Lappa major, Fairfield Co., W. A. Kellerman.

PHYLLOSTICTA LYCII E. & K.
On Lycium vulgare, Fairfield Co., W. A. Kellerman.

PHYLLOSTICTA PERSICAE Sacc.
On Peach leaves, Fairfield Co., W. A. Kellerman.

PHYLLOSTICTA PODOPHYLLI Winter.
On Podophyllum peltatum, Fairfield Co., W. A. Kellerman.

PHYLLOSTICTA VERBENAE Sacc.
On Scutellaria. Fairfield Co., W. A. Kellerman.

201. PHOMA Fr.

PHOMA GLANDICOLA Desm.
On old cupules of Quercus rubra; over the whole state.

PHOMA LONGISSIMUM Berk.
Clermont Co., D. L. James.

PHOMA UVICOLA Arc.
On cultivated grapes, common.

PHOMA PHYTOLACCAE B. & C.
On Phytolacca decandra, Fairfield Co., W. A. Kellerman.

202. SPHAERONEMA Fr.

SPHAERONEMA MACROSPORA B. & C.
On Robinia viscosa, Fairfield Co., W. A. Kellerman.

SPHAERONEMA OXYSPORUM Berk.
Waynesville (Warren Co.) Thos. G. Lea (Cat.)

SPHAERONEMA PERSICAE Schw.
On old Peach limbs, Fairfield Co., W. A. Kellerman.

203. VERMICULARIA Fr.

VERMICULARIA DEMATIUM Fr.
On Xanthium strumarium, Fairfield Co., W. A. Kellerman; Cincinnati, Thos. G. Lea (Cat.)

VERMICULARIA LILIACEARUM West.
On Pardanthus (cult.) Fairfield Co., W. A. Kellerman.

VERMICULARIA TRICHILLA Fr.
On European Ivy (cult.) Lake Co., Sara F. Goodrich.

204. CYTOSPORA Ehrh.

CYTOSPORA CARBONACEA Fr.
Cincinnati, Thos. G. Lea (Cat.)

205. SPHAEROPSIS Lev.

SPHAEROPSIS PERICARPII Pk.
On old Walnut hulls, Fairfield Co., W. A. Kellerman.

SPHAEROPSIS SPHAEROIDES Ellis.
On Platanus occidentalis, Fairfield Co., W. A. Kellerman.

SPHAEROPSIS VINCA Cav.
On Vinca minor (cult.) Fairfield Co., W. A. Kellerman.

206. DIPLODIA Fr.

Diplodia mori Berk.
Cincinnati, Thos. G. Lea (Cat.)

207. DARLUCA Cast.

Darluca filum Cast.
On Lespedeza violacea (*uromyces*) Fairfield Co., E. V. Wilcox.

208. SEPTORIA Fr.

Septoria aesculi (Lib.) Westd.
On Aesculus glabra, Franklin Co., Freda Detmers.

Septoria anemones aquilegiae E. & K.
On Aquilegia vulgaris, Fairfield Co., W. A. Kellerman.

Septoria cacaliae Ell. & Kell.
On Cacalia atriplicifolia, Central and Southern Ohio.

Septoria consimilis E. & M.
On Lactuca sativa (cult.), Lactuca scariola, Franklin Co., Freda Detmers.

Septoria destruens auct. Amer.
On Malva rotundifolia, Franklin Co., Freda Detmers.

Septoria erigerontis Pk.
On Erigeron, Fairfield Co., W. A. Kellerman.

Septoria gei Desm.
On Geum, Fairfield Co., W. A. Kellerman.

Septoria graminum Desm.
On wheat, Bromus ciliatus, Franklin Co., Freda Detmers.

Septoria kalmaecola (Schw.) B. & C.
On Kalmia latifolia, wherever the host occurs.

Septoria lophanthi Ellis.
On Lophanthus nepetoides, Fairfield Co., W. A. Kellerman.

Septoria ochroleuca B. & C.
On Castanea sativa americana, Fairfield Co., W. A. Kellerman.

Septoria oenotherae West.
On Oenothera, common, W. A. Kellerman.

Septoria phlyctaenoides B. & C.
On Phytolacca decandra, Fairfield Co., W. A. Kellerman.

Septoria podophyllina Pk.
On Podophyllum peltatum, Fairfield Co., Franklin Co., Lima, W. A. Kellerman.

SEPTORIA POLYGONORUM Desm.
On Polygonum, perhaps over the whole state.

SEPTORIA RIBIS Desm.
On Cherry, Currant (cult.), Fairfield Co., W. A. Kellerman.

SEPTORIA RUBI West.
On the species of Rubus, common.

SEPTORIA SCROPHULARIAE West.
On Scrophularia nodosa marylandica, Franklin Co., and doubtless over the state.

SEPTORIA SPECULARIAE B. & C.
On Specularia perfoliata, Pickaway Co., W. A. Kellerman.

SEPTORIA SPHAERELLOIDES E. & K.
On Hypericum corymbosum, Fairfield Co., W. A. Kellerman.

SEPTORIA TRITICI B. & C.
On wheat leaves, Fairfield Co., Columbus, W. A. Kellerman.

SEPTORIA ULMI Fr.
On Ulmus fulva, Hocking Co., W. A. Kellerman.

SEPTORIA VERBASCICOLA B. & C.
On Verbascum blattaria, Franklin Co., W. A. Kellerman.

SEPTORIA VERBENAE Desm.
On Verbena, Central Ohio, W. A. Kellerman.

SEPTORIA VESTITA B. & C.
On Squash, Franklin Co., W. A. Kellerman.

SEPTORIA VIOLAE West.
On Viola hastata, Fairfield Co., W. A. Kellerman.

SEPTORIA WALDSTEINIAE P. & C.
On Waldsteinia fragarioides, Franklin Co., Freda Detmers, W. A. Kellerman.

XXXI. LEPTOSTROMACEÆ.

209. MELASMIA Lev.

MELASMIA GLEDITSCHIAE E. & M.
On Gleditschia triacanthos, common.

210. LEPTOSTROMA Fr.

LEPTOSTROMA ACTAEAE C. & E.
On Cimicifuga racemosa, Fairfield Co., W. A. Kellerman.

Leptostroma petiolarum C. & E.
On Ailanthus glandulosa (petioles), Fairfield Co., W. A. Kellerman.

Leptostroma vulgare Fr.
On Eupatorium purpureum, Fairfield Co., W. A. Kellerman.

211. ENTOMOSPORIUM Lev.

Entomosporium mespili (DC.) Sacc.
On Quince and Pear, over the state.

XXXII. MELANCOMACEÆ.

212. GLOEOSPORIUM Desm.

Gloeosporium lindemuthianum Sacc. & Mag.
On bean pods, Columbus.

Gloeosporium nervisequum Sacc.
Ohio, T. B. Galloway (1888).

Gloesporium venetum Speg.
On Raspberry (cult.) Columbus, Freda Detmers.

213. LIbERTELLA Desm.

Libertella faginea Desm.
On Beech bark, Central Ohio, W. A. Kellerman.

214. PESTALOZZIA DeNot.

Pestalozzia aquatica E. & E.
On Sarracenia sp. cult. (in green house) Columbus, W. A. Kellerman.

XXXIII. MUCEDINACEÆ.

215. MONILIA Pers.

Monilia fructigena.
On fruits over the whole state.

Monilia aureofulva C. & E. (*Oidium simile* Berk.)
On rotten wood, Fairfield Co., W. A. Kellerman.

216. OIDIUM Link.

Oidium monilioides Sh.
On Agropyrum repens, Lake Co., Sara F. Goodrich.

OIDIUM SIMILE Berk.
Cincinnati, Thos. G. Lea (Cat.)

217. BOTRYTIS Mich.

BOTRYTIS GENICULATA Corda.
Clermont Co., D. L. James.

BOTRYTIS VULGARE.
On cultivated Pæonia, old leaves and stems, Fairfield Co., W. A. Kellerman.

218. OVULARIA Sacc.

OVULARIA VERONICAE (Fckl.) Sacc. (*Ramularia veronicae* Fckl.)
On Veronica peregrina, Columbus, W. A. Kellerman.

219. MICROSTROMA Niessl.

MICROSTROMA JUGLANDIS (Ber.) Sacc. (*M. leucosperma* Nees.)
On walnut leaves, Hocking Co., W. A. Kellerman.

221. DIDYMARIA Corda.

DIDYMARIA UNGERI Corda.
On Ranunculus recurvatus, Fairfield Co., W. A. Kellerman.

222. CYLINDROCLADIUM Morgan.

CYLINDROCLADIUM SCOPARIUM Morgan.
On old pod of Gleditschia triacanthos, Preston (Hamilton Co.) A. P. Morgan.

223. DACTYLIUM Lk.

DACTYLIUM ROSEUM Lk.
Cincinnati, Thos. G. Lea (Cat.)

224. RAMULARIA Ung.

RAMULARIA ARVENSIS Sacc.
On Potentilla norvegica, Central Ohio.

RAMULARIA EPIGAEAE Ellis.
On Epigaea repens, Fairfield Co., W. A. Kellerman.

RAMULARIA LINEOLA Pk.
On Taraxacum officinale, Columbus, W. A. Kellerman.

RAMULARIA MITELLAE Pk.
On Mitella diphylla, Fairfield Co., Aug. D. Selby.

RAMULARIA OBOVATA Fckl.
On Rumex crispus, Fairfield Co., W. A. Kellerman.

RAMULARIA PLANTAGINIS E. & M.
On Plantago rugelii, Fairfield Co., Columbus, Freda Detmers, W. A. Kellerman.

RAMULARIA TULASNEI Sacc.
On Fragaria virginiana, Lima, W. A. Kellerman.

225. SYNTHETOSPORA Morgan.

SYNTHETOSPORA ELECTA Morgan.
On the hymenial surface of some Peziza, presumably P. semitosta, Preston, (Hamilton Co) A. P. Morgan (Bot. Gaz.)

XXXIV. DEMATIACEÆ.

226. TORULA Pers.

TORULA HERBARUM Lk.
On old stems of Alternanthera, in green house, Columbus, W. C. Werner.

227. STACHYBOTRYS Corda.

STACHYBOTRYS LOBULATA Berk.
On old valise in cellar, Columbus, W. C. Werner.

228. MENISPORA Pers.

MENISPORA APICALIS B. & C.
Hamilton Co., A. P. Morgan (Bot. Gaz.)

MENISPORA CILIATA Corda.
Hamilton Co., A. P. Morgan (Bot. Gaz.)

MENISPORA COBALTINA Sacc.
Hamilton Co., A. P. Morgan (Bot. Gaz.)

MENISPORA GLAUCA (Link.) Pers.
Hamilton Co., A. P. Morgan (Bot. Gaz.)

MENISPORA LIBERTIANA Sacc. & Roum.
Hamilton Co., A. P. Morgan (Bot. Gaz.)

229. FUSICLADIUM Bon.

FUSICLADIUM DENTRITICUM Fckl.
On Pyrus malus, Columbus, Freda Detmers.

230. POLYTHRINCIUM Kunze & Schum.

POLYTHRINCIUM TRIFOLII Kunze.
On Trifolium pratense and Trifolium repens, Columbus, Freda Detmers.

231. CLADOSPORIUM Link.

CLADOSPORIUM EPIPHYLLUM Link.
On Sassafras leaves, Fairfield Co., W. A. Kellerman.

CLADOSPORIUM FULVUM Cke.
On Tomato vines (cultivated) Columbus, Freda Detmers W. A. Kellerman.

CLADOSPORIUM HERBARUM Link.
On cultivated Pæonia, old stems and leaves, and Vinca minor, Fairfield Co., W. A. Kellerman; Cincinnati, Thos. G. Lea (Cat.)

232. SEPTONEMA Corda.

SEPTONEMA SPILOMEUM Berk.
Cincinnati and Waynesville (Warren Co.) Thos. G. Lea (Cat.)

233. HELMINTHOSPORIUM Link.

HELMINTHOSPORIUM GRACILE Wallr.
On Iris (cult.), Fairfield Co., W. A. Kellerman.

HELMINTHOSPORIUM PERSISTENS Cke.
On dead leaves, Fairfield Co., W. A. Kellerman.

234. CERCOSPORA Fr.

CERCOSPORA ACALYPHA Peck.
On Acalypha virginica, Franklin Co., W. C. Werner.

CERCOSPORA ALTHAEINA Sacc.
On Hollyhock leaves, Ashtabula Co., Sara F. Goodrich.

CERCOSPORA APII PASTINACAE Fres.
On Celery and wild Parsnip, Central Ohio, Freda Detmers, W A. Kellerman.

CERCOSPORA ASIMINAE Ell. & Kell.
On Asimina triloba, Fairfield Co., W. A. Kellerman; Franklin Co., Freda Detmers.

CERCOSPORA BETAECOLA Sacc.
On Beet, Columbus, Freda Detmers, W. A. Kellerman.

CERCOSPORA CANA Sacc.
On Erigeron, Franklin Co., and Columbus, Freda Detmers, W. A. Kellerman

CERCOSPORA DATURAE Peck.
On Datura stramonium, Franklin Co. and Fairfield Co., Freda Detmers and W. A. Kellerman.

CERCOSPORA DESMODII Ell & Kell.
On Desmodium acuminatum, Adams Co., W. A. Kellerman.

CERCOSPORA DIANTHERAE E & K.
On Dianthera americana, Columbus, Warren Co., W. A. Kellerman.

CERCOSPORA ELONGATA Peck.
On Dipsacus sylvestris, Franklin Co., Freda Detmers, W. A. Kellerman.

CERCOSPORA EFFUSA (B. & C.) Ellis.
On Lobelia inflata and L. syphilitica, Central and Southern Ohio, W. A. Kellerman.

CERCOSPORA FERRUGINEA Fckl.
On Ambrosia trifida, Athens, W. A. Kellerman.

CERCOSPORA GYMNOCLADI E. & K.
On Gymnocladus dioicus, Columbus, E. E. Bogue.

CERCOSPORA LIRIODENDRI Ell. & Hark.
On Liriodendron tulipifera, Fairfield Co., W. A. Kellerman.

CERCOSPORA POLYGONACEA Ell. & Ev.
On Polygonum convolvulus, Columbus, Freda Detmers.

CERCOSPORA SABBATIAE E. &E.
On Sabbatia angularis, Fairfield Co., W. A. Kellerman.

CERCOSPORA SAGITTARIAE E. & K.
On Sagittaria sagittaefolia, Scioto Co. and Franklin Co., W. A. Kellerman.

CERCOSPORA SMILACINA Pk. (*Helminthosporium petersii* B. & C.)
On Smilax, Fairfield Co., W. A. Kellerman.

CERCOSPORA SYMPLOCARPI Pk.
On Symplocarpus foetidus, Orwell (Ashtabula Co.) E. E. Bogue.

CERCOSPORA VIOLAE Sacc.
On Viola palmata, Columbus, Freda Detmers.

235. SPORODESMIUM Link.

SPORODESMIUM CONCINNUM Berk.
Cincinnati, Thos. G. Lea (Cat.)

SPORODESMIUM CELLULOSUM Fr.
Cincinnati, Thos. G. Lea (Cat.)

236. MACROSPORIUM Fr.

MACROSPORIUM PINGUEDINIS Berk.
Cincinnati, Thos. G. Lea (Cat.)

MACROSPORIUM PLEOSPOROIDES E. & K.
On Lappa major, Fairfield Co., W. A. Kellerman.

MACROSPORIUM PUNCTIFORME Berk.
Cincinnati, Thos. G. Lea (Cat.)

XXXV. STILBACEÆ.

236. CERATIUM A. & S.

CERATIUM HYNOIDES A. & S.
On rotten wood, Fairfield Co., W. A. Kellerman; Granville, W. G. Tight, H. L. Jones.

237. SPOROCYBE Fries.

SPOROCYBE BYSSOIDES Fr.
On Papaw and on Rumex (old leaves), Fairfield Co., W. A. Kellerman.

SPOROCYBE PERSICAE Fr.
Clermont Co., D. L. James.

XXXVI. TUBERCULARIACEÆ.

238. TUBERCULARIA Tode.

TUBERCULARIA VULGARIS Tode.
Cincinnati, Thos. G. Lea (Cat.)

239. BACTRIDIUM Kunze.

BACTRIDIUM FLAVUM K. & S. (*B. clavatum* B. & Br.; *B. ellisii* Berk.)
Hamilton Co., A. P. Morgan (Bot. Gaz.)

240. FUSARIUM Link.

FUSARIUM LATERITIUM Nees.
Cincinnati, Thos. G. Lea (Cat.); Clermont Co., D. L. James.

FUSARIUM OXYSPORUM AURANTIACUM Cda.
On Squash (fruit), Columbus, W. A. Kellerman.

241. EPICOCCUM Link.

Epicoccum purpurascens Ehr.
On old paper, Fairfield Co., W. A. Kellerman.

Epicoccum sphærospermum Berk.
On Carex, Fairfield Co., W. A. Kellerman.

242. EXOSPORIUM Link.

Exosporium tiliæ.
Clermont Co., D. L. James.

Alphabetical List

OF

HOST-PLANTS OF THE PARASITIC FUNGI.

Acalypha virginica (Cercospora acalyphae).
Acer rubrum (Rhytisma acerinum, Uncinula circinata).
Acer saccharinum (Rhytisma acerinum, Uncinula circinata).
Achillea millefolium (Leptosphaeria ogilviensis).
Actaea alba (Aecidium actaeae).
Aesculus glabra (Septoria aesculi, Uncinula flexuosa).
Agrimonia eupatoria (Ureo agrimoniæ, Sphaerotheca humuli).
Agropyrum (Erysiphe graminis, Oidium monilioides).
Ailanthus glandulosa (Leptostroma petiolarum).
Alnus serrulata (Exoascus alnitorquus).
Amarantus chlorostachys (Albugo amaranthi).
Amelanchier (Dinemasporium collinsii.)
Ambrosia artemisiaefolia (Albugo tragopoginis, Puccinia xanthi).
Ambrosia trifida (Cercospora ferruginea).
Ampelopsis quinquefolia (Phyllosticta ampelopsidis, Uncinula necator).
Amphicarpaea comosa (Synchytrium decipiens).
Anemone (Puccinia anemones virginianæ).
Anemone quinquefolia (Puccinia fusca).
Anemone pennsylvanica (Plasmopara pygmaea).
Andropogon virginicus (Uromyces graminicola).
Aquilegia canadensis (Erysiphe communis).
Aquilegia vulgaris (Septoria anemones).
Arisaema (Uromyces caladii).
Aristida dichotoma (Sorosporium ellisii).
Asclepias (Uromyces howei).
Asimina triloba (Cercospora asiminae, Phyllosticta asiminae, Sporocybe byssoides).
Aster (Coleosporium sonchi, Aecidium asterum).
Aster macrophyllus (Puccinia asteris).
Beech (Scorias spongiosa, Phyllactinia suffulta, Libertella faginea).
Beet (Cercospora betaecola).
Bidens frondosa (Sphaerotheca castagnéi).
Blephilia (Puccinia menthae).
Borraginaceae (Erysiphe cichoracearum).
Brassica nigra (Albugo candidus).
Bromus ciliatus (Septoria graminum).
Cacalia atriplicifolia (Septoria cacaliae).
Capsella bursa pastoris (Albugo candidus).

Carex (Epicoccum sphaerospermum).
Carpinus (Phyllactinia suffulta).
Castanea sativa americana (Microsphaera alni, Gnomonia setacea, Sphaerella sparsa, Septoria ochroleuca).
Catalpa bignonioides (Microsphaera elevata, Phyllactinia suffulta).
Ceanothus americanus (Frankia ceanothi).
Cedar (Gymnosporangium macropus, G. globosum).
Celery (Cercospora apii pastinacae).
Celtis occidentalis (Sphaerotheca phytoptophila, Sphaerella maculaeformis).
Chaerophyllum procumbens (Puccinia pimpinellae).
Chenopodium album (Phyllosticta chenopodii).
Cherry (cult.) (Septoria ribis, Plowrightia morbosa, Podosphaera oxyacantha).
Chestnut (Phyllactinia suffulta, Gnomonia sectacea; Sphaerella sparsa, Septoria ochroleuca).
Cimicifuga racemosa (Aecidium cimicifugatum, Leptostroma actaeae, Uromyces carcinodes).
Circaea lutetiana (Puccinia circaeae).
Claytonia virginica (Aecidium claytoniatum, Puccinia mariæ-wilsoni).
Clematis (cult.) (Erysiphe communis).
Clematis virginiana (Erysiphe communis).
Cnicus (Puccinia hieracii).
Compositae (Aecidium compositarum, Erysiphe cichoracearum).
Cunila (Puccinia menthae).
Currant (Septoria ribis).
Dahlia (cult.) (Erysiphe cichoracearum).
Datura stramonium (Cercospora daturae).
Dead leaves (Helminthosporium persistens).
Desmodium (Meibomia) (Uromyces hedysari-paniculata).
Desmodium accuminatum (Cercospora desmodii).
Desmodium canescens (Erysiphe communis, Microsphaera diffusa).
Deutzia gracilis (Phyllosticta deutziae).
Dianthera americana (Cercospora diantherae).
Dicentra cucullaria (Aecidium dicentræ).
Dipsacus sylvestris (Cercospora elongata).
Dirca palustris (Aecidium hydnoideum).
Elymus canadensis (Claviceps purpurea).
Elymus virginicus (Claviceps purpurea).
Epigaea repens (Ramularia epigaeae).
Erechtites hieracifolia (Plasmopara halstedii).
Erigeron (Cercospora cana, Septoria erigerontis).
Erigeron annuus (Aecidium erigeronatum).
Erigeron bellidifolius (Aecidium erigeronatum).
Euonymus atropurpureus (Microsphaera alni).
Eupatorium ageratoides (Puccinia tenuis, Aecidium tenue).
Eupatorium perfoliatum (Aecidium compositarum).
Eupatorium purpureum (Leptostroma vulgare).
Euphorbia (Uromyces euphorbiae, Aecidium euphorbiae).
European Ivy (Vermicularia trichilla).
Fagus (Scorias spongiosa, Phyllactinia suffulta, Libertella faginae).
Festuca elatior (Claviceps purpurea).
Flies (Empusa muscae).
Fragaria virginiana (Ramularia tulasnei).

Fruits (Monilia fructigena).
Galium (Puccinia galii).
Gaultheria procumbens (Asterina gaultheriae, Sphaerella gaultheriæ).
Gaylussacia resinosa (Microsphaera vaccinii, Exobasidium vaccinii).
Geranium maculatum (Aecidium geranii).
Geum (Septoria gei).
Gleditschia triacanthos (Melasmia gleditschia, Microsphaera ravenelii).
Gleditschia triacanthos (old pods) (Cylindrocladium scoparium).
Glyceria fluitans (Claviceps purpurea).
Goose berries (cult.) (Sphaerotheca mors uvæ).
Gramineae, wheat, oats, etc. (Puccinia graminis).
Grapes (cult.) (Plasmopara viticola, Phoma uvicola).
Grasses (Phyllachora graminis, Epichloe typhina).
Gymnocladus dioicus (Cercospora gymnocladi).
Helianthus (Coleosporium sonchi, Puccinia helianthus, Aecidium compositarum).
Hepatica acutiloba (Aecidium punctatum).
Hollyhock leaves (Cercospora althaeina).
Horse dung (Pilobolus crystallinus).
House flies (Empusa muscae).
Houstonia caerulea (Aecidium houstoniatum).
Hydrangea arborescens (Uredo hydrangeae).
Hydrophyllum macrophyllum (Erysiphe cichoracearum).
Hypericum corymbosum (Septoria sphaerelloides).
Hypericum mutilum (Uromyces hyperici).
Impatiens (Aecidium impatientis).
Impatiens fulva (Puccinia nolitangeris.)
Iris (cult.) (Helminthosporium gracile).
Indian corn (Puccinia sorghi, Ustilago maydis).
Juniperus virginiana (Gymnosporangium macropus, G. globosum).
Kalmia latifolia (Septoria kalmaecola).
Lactuca canadensis (Sphaerella praecox).
Lactuca sativa (cult.) (Septoria consimilis).
Lactuca scariola (Septoria consimilis).
Lappa major (Phyllosticta lappae, Macrosporium pleosporoides).
Leersia virginica (Tilletia corona).
Leguminosae (several species) (Erysiphe communis).
Lespedeza (Uromyces lespedezae).
Lespedeza violacea (Darluca filum).
Lettuce (cult.) (Bremia lactucæ).
Lilac (Microsphaera alni).
Liriodendron tulipifera (Cercospora liriodendri, Erysiphe liriodendri, Sphaerella liriodendri).
Lobelia inflata (Cercospora effusa).
Lobelia syphilitica (Cercospora effusa).
Lophanthus nepetoides (Septoria lophanthi).
Lycium vulgare (Phyllosticta lycii).
Malva rotundifolia (Septoria destruens).
Meibomia (Uromyces hedysari-paniculata, Erysiphe communis, Microsphaera diffusa).
Mentha (Puccinia menthae).
Micrampeles echinata (Plasmopara australis).
Mitella diphylla (Puccinia tiarellae, Ramularia mitellæ).
Monarda (Puccinia menthæ).
Napæa dioica (Aecidium napææ).

Nepeta cataria (Phyllosticta decidua).
Nesæa verticillata (Aecidium nesææ).
Oaks (Microsphæra quercina, Phyllactinia suffulta).
Oak bark (Nummularia bulliardi).
Oats (Ustilago avenæ, Puccinia graminis, P. coronata).
Oenotherae (Septoria oenotheræ).
Oenotherae biennis (Aecidium œnothera, Uromyces peckii).
Old wood (Rosellinia mammiformis).
Pæonia (cult.) (Botrytis vulgare, Cladosporium herbarum).
Panicum capillare (Puccinia emaculata).
Panicum latifolium (Dothidea graminis).
Panicum sanguinale (Ustilago cesatii).
Paper (old) Epicoccum purpurascens).
Pardanthus (Vermicularia liliacearum).
Parietaria pennsylvanica (Erysiphe cichoracearum).
Parsnip (Cercospora apii pastinacae).
Peach leaves (Exoascus deformans, Phyllosticta persicae).
Peach limbs (old) (Sphaeronema persicae).
Pear (Entomosporium mespili).
Phaseolus (cult.) (Uromyces appendiculatus).
Phlox (cult.) (Erysiphe cichoracearum).
Phlox paniculata (Phyllactinia suffulta).
Physalis lanceolata (Entyloma physalidis).
Phytolacca decandra (Phoma phytolaccae, Septoria phlyctaenoides).
Pinus rigidus (Coleosporium senecionis).
Plantago rugelii (Ramularia plantaginis).
Platanus occidentalis (Sphaeropsis sphaeroides, Microsphaera alni).
Plum (cult.) (Plowrightia morbosa, Podosphaera oxycanthae).
Poa pratensis (Erysiphe graminis).
Podophyllum peltatum (Phyllosticta podophylli, Puccinia podophylli, Septoria podophyllina).
Polygonum (Uromyces polygoni, Septoria polygonorum).
Polygonum convolvulus (Cercospora polygonacea).
Polygonum pennsylvanicum (Ustilago utriculosa).
Populus (Melampsora populina).
Portulaca oleracea (Albugo portulacae).
Potentilla canadensis (Dothidea potentillae, Phragmidium potentillae).
Potentilla norvegica (Mollisia dehenii, Ramularia arvensis).
Pycnanthemum (Puccinia menthae).
Pyrus malus (Fusicladium dendriticum).
Quercus (rotten stems) (Cenangium triangulare).
Quercus alba (Trichopeziza capitula, Sphaerella maculaeformis).
Quercus coccinea (Sphaerella polystigma).
Quercus macrocarpa (Sphaerella maculaeformis).
Quercus prinus (Venturia orbicula).
Quercus rubra, (Sphaerella maculaeformis, Phoma glandicola).
Quince (Entomosporium mespili).
Ranunculaceæ (various species) (Erysiphe communis).
Ranunculus abortivus (Aecidium ranunculi).
Ranunculus recurvatus (Didymaria ungeri).
Raspberry (cult.) (Glœosporium venetum).
Rhus radicans (Uromyces terebinthi).
Ribes (Aecidium grossulariæ).

Robinia viscosa (Sphaeronema macrospora).
Rose (leaves and stems) (Phragmidium subcorticium).
Roses (cult.) (Sphaerotheca pannosa).
Rubus (Caeoma nitens, Septoria rubi).
Ruellia (Puccinia lateripes).
Rumex (old leaves) (Sporocybe byssoides).
Rumex crispus (Ramularia obovata).
Sabbatia angularis (Cercospora sabbatiae).
Sagittaria sagittaefolia (Cercospora sagittariae).
Sambucus canadensis (Microsphaera alni, Aecidium sambuci).
Sanicula (Puccinia saniculæ).
Sarracenia (sp. cult.) (Pestalozzia aquatica).
Sassafras (Sphaerella sassafras, Cladosporium epiphyllum, Gnomonia sassafras, Melogramma fuliginosum).
Saxifraga virginiensis (Puccinia saxifragae).
Scirpus fluviatilis (Puccinia angustata).
Scrophularia nodosa marilandica (Septoria scrophulariae).
Scutellaria (Phyllosticta verbaenae).
Scutellaria lateriflora (Erysiphe galeopsidis), Uncinula columbiana.
Sicyos angulata (Plasmopara australis).
Silphium perfoliatum (Puccinia silphii).
Sisymbrium officinale (Albugo candidus).
Smilax (Cercospora smilacina).
Smilax rotundifolia (Uredo smilacis).
Solidago (Aecidium asterum, Aeisolidaginis, Coleosporium solidaginis).
Specularia perfoliata (Septoria speculariae).
Spilosoma virginica (Empusa grylli).
Spiraea tomentosa (Podosphaera minor).
Squash (fruit) (Fusarium oxysporum).
Stachys aspera glabra (Erysiphe galeopsidis).
Stachys palustris (Erysiphe galeopsidis).
Stereum frustulosum (Stictis sterei).
Symplocarpus foetidus (Cercospora symplocarpi).
Syndesmon thalictroides (Aecidium sommerfeltii).
Taraxacum officinale (Ramularia lineola, Puccinia hieracii).
Tephrosia virginica (Ravenelia glanduliformis).
Tilia americana (Sphaerella sparsa).
Timothy (Tilletia striaeformis).
Tomato vines (Cladosporium fulvum).
Trifolium (Uromyces trifolii.)
Trifolium pratense (Polythrincium trifolii).
Trifolium repens (Polythrincium trifolii, Phyllachora trifolii.)
Triticum vulgare (Erysiphe graminis, Ustilago tritici, Tilletia foetens, Septoria tritici).
Ulmus americana (Uncinula macrospora, Gnomonia ulmea).
Ulmus fulva (Uncinula macrospora, Septoria ulmi).
Vaccinium vacillans (Exobasidium vaccinii, Microsphaera vacinii).
Verbascum blattaria (Septoria verbascicola).
Verbascum thapsus (Spheria verbascicola).
Verbena (Septoria verbenae).
Verbenaceae (Erysiphe cichoracearum).
Vernonia (Coleosporium vernoniae).
Veronica peregrina (Ovularia veronicae).
Vinca minor (Cladosporium herbarum, Sphaeropsis vinca).

Viola (Puccinia violae).
Viola hastata (Puccinia hastata Septoria violae).
Viola palmata (Cercospora violae).
Vitis (Phyllosticta labruscae, Uncinula necator).
Vitis aestivalis bicolor (Phyllosticta labruscae).
Waldsteinia fragarioides (Septoria waldsteiniae).
Walnut hulls (old) (Sphaeropsis pericarpii).
Walnut leaves (Microstroma juglandis).
Wheat (Puccinia rubigovera, Puccinia graminis, Tilletia foetans, Septoria graminum, Ustilago tritici, Septoria tritici, Pyrenophora trichostoma).
Willow (Melampsora salicina, Uncinula salicis).
Wood (rotten) (Ceratium hynoides, Monilia aureofulva).
Xanthium strumarium (Vermicularia dematium, Puccinia xanthii).
Zea mays (Sphaeria maydis, Ustilago maydis, Puccinia sorghi).

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ALGÆ.

1. NITELLA Ag.

NITELLA TENUISSIMA (Desv.) Ktz.
Painesville, Wm. C. Werner.

1*a*. CHARA L.

CHARA CONTRARIA A. Br.
Cedar Swamp (Champaign Co.) Wm. C. Werner; Columbus, E. M. Wilcox.

CHARA CORONATA Ziz.
Clermont Co., J. F. James (Cat.) Painesville, Wm. C. Werner.

CHARA FLEXILIS Wiild.
Cincinnati, Jos. Clark (Cat.); Painesville, Wm. C. Werner.

CHARA FRAGILIS Desv.
Painesville, Wm. C. Werner.

CHARA FŒTIDA A. Br.
Cedar Swamp (Champaign Co.) Wm. C. Werner.

CHARA GYMNOPUS MICHAUXII A. Br.
Painesville, Wm. C. Werner.

CHARA INTERMEDIA A. Br.
Champaign Co., Wm. C. Werner; Springfield, E. M. Wilcox.

2. LEMANEA Bery.

LEMANEA TORULOSA (Roth.) Ag.
Painesville, H. C. Beardslee.

3. BATRACHOSPERMUM Roth.

BATRACHOSPERMUM MONILIFORME Roth.
Painesville, H. C. Beardslee.

4. THOREA Bory.

THOREA RAMOSSISSIMA Bory.
Ohio river, Cincinnati, G. B. Twitchell.

5. CHANTRANSIA Fr.

CHANTRANSIA PYGMAEA Kg.
Ohio river, Cincinnati, G. B. Twitchell.

Chantransia violacea Kg.
Painesville, H. C. Beardslee.

Chantransia violacea beardsleei Wolle.
Painesville, H. C. Beardslee.

6. COLEOCHAETE Breb.

Coleochaete scutata Breb.
Ponds, Delhi, G. B. Twitchell.

Coleochaete soluta Pringsh.
Ponds, Delhi, G. B. Twitchell.

7. 'OEDOGONIUM Lk.

Oedogonium borisianum (LeCl.) Wittr.
Ponds and ditches, Delhi, G. B. Twitchell.

Oedogonium capillare (L.) Kg.
Painesville, H. C. Beardslee.

Oedogonium crispum (Hass.) Wittr.
Ponds and ditches, Delhi, G. B. Twitchell.

Oedogonium cryptoporum Wittr.
Ponds and ditches, Delhi, G. B. Twitchell.

Oedogonium fonticola A. Br.
Painesville, H. C. Beardslee.

Oedogonium fragile Wittr.
Granville, C. L. Payne (Bull. Den. U.)

Oedogonium gracillimum Wittr. & Lund.
Ponds and ditches, G. B. Twitchell.

Oedogonium polymorphum Wittr. & Lund.
Granville, C. L. Payne (Bull. Den. U.)

Oedogonium wolleanum Wittr.
Painesville, H. C. Beadslee.

8. BULBOCHÆTE Ag.

Bulbochæte crenulata Pringsh.
Muddy Creek, Delhi, G. B. Twitchell.

9. CYLINDROCAPSA.

Cylindrocapsa amoena Wolle.
Muddy Creek, Delhi, G. B. Twitchell.

10. DRAPARNALDIA Ag.

DRAPARNALDIA GLOMERATA Ag.
Painesville, H. C. Beardslee; Ponds, Delhi, G. B. Twitchell; Columbus, W. A. Kellerman; Ironton, W. C. Werner.

DRAPARNALDIA PLUMOSA Ag.
Ponds, Delhi, G. B. Twitchell.

DRAPARNALDIA RAVENELII Wolle.
Columbus, W. A. Kellerman.

11. STIGEOCLONIUM Kg.

STIGEOCLONIUM NANUM (Dillw.) Kg.
Ponds, Cincinnati, G. B. Twitchell.

STIGEOCLONIUM RADIANS Kg.
Ponds, Cincinnati, G. B. Twitchell.

STIGEOCLONIUM TENUE Kg.
Ponds, Cincinnati, G. B. Twitchell.

12. CHAETOPHORA Schrank.

CHAETOPHORA ELEGANS Ag.
Ponds, Delhi, G. B. Twitchell.

CHAETOPHORA ENDIVIAEFOLIA Ag.
Painesville, H. C. Beardslee; Ponds, Delhi, G. B. Twitchell.

CHAETOPHORA ENDIVIAEFOLIA LINEARIS Rab.
Columbus, W. A. Kellerman.

CHAETOPHORA PISIFORMIS (Roth.) Ag.
Columbus, W. A. Kellerman; Delhi, G. B. Twitchell.

13. APHANOCHAETE A. Br.

APHANOCHAETE REPENS A. Br.
Columbus, Mrs. W. A. Kellerman.

14. CLADOPHORA.

CLADOPHORA AEGAGROPILA (L.) Kg.
Springs, Price Hill, Cincinnati, G. B. Twitchell.

CLADOPHORA CRISPATA Kg.
Near Cincinnati, G. B. Twitchell; Granville, C. J. Herrick.

CLADOPHORA FRACTA Kg.
Painesville, H. C. Beardslee; Cincinnati, G. B. Twitchell.

CLADOPHORA GLOMERATA Kg.
Painesville, H. C. Beardslee, Cincinnati, G. B. Twitchell; Georgesville, E. E. Bogue.

15. ULOTHRIX Kg.

ULOTHRIX FLACCIDA Kg.
Painesville, H. C. Beardslee.

ULOTHRIX SUBTILIS Kg.
Cincinnati, G. B. Twitchell.

ULOTHRIX SUBTILIS VABIABILIS Kg.
Columbus, F. B. Eldridge.

ULOTHRIX ZONATA (W. & M.) Aresch.
Cincinnati, G. B. Twitchell; Columbus, W. A. Kellerman.

16. CONFERVA Lk.

CONFERVA BOMBYCINA Ag.
Granville, C. J. Herrick.

CONFERVA GLACIALIOIDES Wolle.
Painesville. H. C. Beardslee.

CONFERVA RHYPOPHILA Kg.
Granville, C. L. Payne, (Bull Den. U.)

CONFERVA VULGARIS Rabh. (*Microspora vulgaris* Rab.)
Painesville, H. C. Beardslee; Columbus, E. E. Bogue.

CONFERVA VULGARIS FARLOWII Wolle.
Painesville, H. C. Beardslee.

17. VAUCHERIA DC.

VAUCHERIA DICHOTOMA Lyngb.
Cincinnati, G. B. Twitchell.

VAUCHERIA DILLWYNII Ag.
Painesville, H. C. Beardslee.

VAUCHERIA GEMINATA (Vauch.) DC.
Painesville, H. C. Beardslee; Columbus, W. A. Kellerman.

VAUCHERIA GEMINATA RACEMOSA Walz.
Columbus, F. B. Eldridge.

VAUCHERIA SESSILIS (Vauch.) DC.
Logan Co., Cedar Swamp (Urbana), Painesville, H. C. Beardslee; Cincinnati, G. B. Twitchell.

Vaucheria terrestris Lyngb.
Cincinnati, G. B. Twitchell.

18. BOTRYDIUM Wallr.

Botrydium granulatum L.
Cincinnati, G. B. Twitchell.

19. VOLVOX Ehrb.

Volvox globator L.
Ponds, Delhi, G. B. Twitchell.

20. EUDORINA Ehrb.

Eudorina stagnale Wolle.
Cincinnati, G. B. Twitchell.

21. PANDORINA Ehrb.

Pandorina morum Bory.
Delhi, G. B. Twitchell.

22. EUGLENA Ehrb.

Euglena viridis Ehrb.
Cincinnati, G. B. Twitchell; Columbus, W. C. Werner.

23. CLAMYDOCOCCUS A. Br.

Clamydoccus pluvialis A. Br.
Cincinnati, G. B. Twitchell.

24. HYDRODICTYON Roth.

Hydrodictyon utriculatum Roth.
Painesville, H. C. Beardslee; Cincinnati, G. B. Twitchell; Granville, F. B. Eldridge; Columbus, W. C. Werner.

25. SCENEDESMUS Meyer.

Scenedesmus caudatus Corda.
Cincinnati, G. B. Twitchell.

Scenedesmus polymorphus Wood.
Granville, H. L. Jones (Bull. Den. U.)

26. CHARACIUM A. Br.

Characium sessile Herm.
Cincinnati, G. B. Twitchell.

27. PROTOCOCCUS Ag.

PROTOCOCCUS VIRIDIS Ag.
Cincinnati, G. B. Twitchell.

PROTOCOCCUS VIRIDIS GIGAS Kg.
Fairfield Co. (in gelatinous mass around frogs eggs) W. A. Kellerman.

28. TETRASPORA Ag.

TETRASPORA BULLOSA (Roth.) Ag.
Delhi, G. B. Twitchell.

TETRASPORA EXPLANATA Kg. Kirch.
Delhi, G. B. Twitchell.

TETRASPORA LUBRICA (Roth.) Ag.
Columbus, Mrs. W. A. Kellerman; E. E. Bogue.

29. GLEOCYSTIS Naeg.

GLOEOCYSTIS AMPHA Kg.
Columbus, W. A. Kellerman.

30. RAPHIDIUM Kg.

RAPHIDIUM POLYMORPHUM Fres.
Delhi, G. B. Twitchell.

31. SPIROGYRA Link.

SPIROGYRA ADNATA Kg.
Granville, C. L. Payne (Bull. Den. U.)

SPIROGYRA CRASSA Kg.
Painesville, H. C. Beardslee; Ponds, Delhi, G. B. Twitchell.

SPIROGYRA DECIMA (Muhl.) Kg.
Georgesville (Franklin Co.) E. E. Bogue; Columbus, F. B. Eldridge.

SPIROGYRA DUBIA Kg.
Granville, C. L. Payne (Bull. Den. U.)

SPIROGYRA FLUVIATILIS Hilse.
Granville, C. L. Payne (Bull. Den. U.)

SPIROGYRA GREVILLEANA (Hass.) Kg.
Delhi, G. B. Twitchell.

SPIROGYRA HERRICKI Payne.
Granville, C. L. Payne (Bull. Den. U. IV. 132.)

SPIROGYRA INFLATA (Vauch.) Rab.
Delhi, G. B. Twitchell.

Spirogyra insignis (Hass.) Kg.
Granville, H. L. Jones (Bull. Den. U.)

Spirogyra longata (Vauch.) Kg.
Delhi, G. B. Twitchell.

Spirogyra nitida (Dill.) Link.
Delhi, G. B. Twitchell.

Spirogyra quinina (Ag.) Kg.
Painesville, Logan county, H. C. Beardslee; Fairfield Co. W. A. Kellerman.

Spirogyra rivularis Rab.
Painesville, Logan Co., H. C. Beardslee.

Spirogyra tenuissima (Hass.) Kg.
Delhi, G. B. Twitchell.

Spirogyra varians (Hass.) Kg.
Painesville, H. C. Beardslee; Pickaway Co., W. A. Kellerman.

Spirogyra weberi Kg.
Granville, H. L. Jones (Bull. Den. U.)

32. ZYGNEMA Kg.

Zygnema cruciatum Ag.
Granville, C. L. Payne (Bull. Den. U.)

Zygnema insigne Kg.
Painesville, H. C. Beardslee.

Zygnema stellium Ag.
Painesville, H. C. Beardslee; Delhi, G. B. Twitchell.

Zygnema stellium genuinum Kirch.
Granville, C. L. Payne (Bull. Den. U.)

33. PLEUROCARPUS A. Br.

Pleurocarpus columbianus minor Wolle.
Painesville, H. C. Beardslee.

Pleurocarpus mirabilis A. Br.
Painesville, H. C. Beardslee; Columbus, Mrs. W. A. Kellerman.

34. HYALOTHECA Ehrb.

Hyalotheca mucosa (Mert.) Ralfs.
Granville, C. L. Payne (Bull. Den. U.)

35. DESMIDIUM Ag.

DESMIDIUM SWARTZII Ag.
Granville, C. L. Payne (Bull. Den. U.)

36. SPHAEROZOSMA Corda.

SPHAEROZOSMA FILIFORME Rab.
Granville, H. L. Jones (Bull. Den. U.)

37. CLOSTERIUM Nitsch.

CLOSTERIUM ACEROSUM (Schrank) Ehrb.
Granville, C. L. Payne (Bull. Den. U.)

CLOSTERIUM DIANAE Ehrb.
Granville, H. L. Jones (Bull. Den. U.)

CLOSTERIUM LINEATUM Ehrb.
Granville, H. L. Jones (Bull. Den. U.)

CLOSTERIUM MONILIFERUM Ehrb.
Granville, H. L. Jones (Bull. Den. U.)

CLOSTERIUM PARVULUM Naeg.
Granville, H. L. Jones (Bull. Den. U.)

CLOSTERIUM STRIGOSUM Ehrb.
Granville, H. L. Jones (Bull. Den. U.)

38. DOCIDIUM Breb.

DOCIDIUM TRABECULA (Ehrb.) Naeg.
Granville, H. L. Jones (Bull. Den. U.)

39. COSMARIUM Corda.

COSMARIUM BIRETUM Breb.
Granville, H. L. Jones (Bull. Den. U.)

COSMARIUM BOTRYTIS Menegh.
Granville, H. L. Jones (Bull. Den. U.)

COSMARIUM BREBISSONII Menegh.
Granville, H. L. Jones (Bull. Den. U.)

COSMARIUM BROOMEI Thwaites.
Granville, H. L. Jones (Bull. Den. U.)

COSMARIUM CONTRACTUM Kirch.
Granville, H. L. Jones (Bull. Den. U.)

Cosmarium intermedium Delp.
Granville, H. L. Jones (Bull. Den. U.)

Cosmarium latum Breb.
Granville, H. L. Jones (Bull. Den. U.)

Cosmarium orbiculatum Ralfs.
Granville, H. L. Jones (Bull. Den. U.)

Cosmarium ralfsii Breb.
Granville, H. L. Jones (Bull. Den. U.)

Cosmarium seelyanum Wolle.
Granville, H. L. Jones (Bull. Den. U.)

Cosmarium tinctum Ralfs.
Granville, H. L. Jones (Bull. Den. U.)

40. EUASTRUM Ehrh.

Euastrum elegans Breb.
Granville, H. L. Jones (Bull. Den. U.)

Euastrum rostratum Ralfs.
Granville, H. L. Jones (Bull. Den. U.)

41. MICRASTERIAS Ag.

Micrasterias truncata (Corda) Ralfs.
Granville, C. L. Payne, H. L. Jones (Bull. Den. U.)

42. STAURASTRUM Meyen.

Staurastrum anatinum Cooke & Wills.
Granville, H. L. Jones (Bull. Den. U.)

Staurastrum inconspicuum Nord.
Granville, H. L. Jones (Bull. Den. U.)

Staurastrum polymorphum Breb.
Granville, H. L. Jones (Bull. Den. U.)

Staurastrum pseudopachyrynchum Wolle.
Granville, H. L. Jones (Bull. Den. U.)

43. PEDIASTRUM Meyen.

Pediastrum angulosum Menegh.
Granville, H. L. Jones (Bull. Den. U.)

Pediastrum boryanum (Turpin.) Menegh.
Granville, H. L. Jones (Bull. Den. U.); Delhi, G. B. Twitchell.

PEDIASTRUM EHRENBERGII A. Br.
Granville, H. L. Jones (Bull. Den. U.)

PEDIASTRUM SIMPLEX Meyen.
Granville, H. L. Jones (Bull. Den. U).

PEDIASTRUM TETRAS Ehrb.
Delhi, G. B. Twitchell.

44. GLOEOTRICHIA Ag.

GLOEOTRICHIA NATANS Thur.
Ross Lake, G. B. Twitchell.

GLOEOTRICHIA PISUM Thur.
Delhi, G. B. Twitchell.

45. NOSTOC Vauch.

NOSTOC COMMUNE Vauch.
Delhi, G. B. Twitchell.

NOSTOC MUSCORUM Ag.
Delhi, G. B. Twitchell.

NOSTOC RUPESTRE Kg.
Granville, C. L. Payne (Bull. Den. U.)

NOSTOC SPHAERICUM Vauch.
Delhi, G. B. Twitchell.

46. ANABAENA Bory.

ANABAENA OSCILLARIOIDES Bory.
Delhi, G. B. Twitchell.

ANABAENA STAGNALIS Kg.
Delhi, G. B. Twitchell.

47. CYLINDROSPERMUM Kg.

CYLINDROSPERMUM MACROSPERMUM Kg.
Delhi, G. B. Twitchell; Columbus (green house) W. A. Kellerman.

48. LYNGBYA Ag. & Thur.

LYNGBYA PALLIDA (Naeg.) Kg.
Delhi, G. B. Twitchell.

LYNGBYA VULGARIS (Kg.) Kirch. (*Phormidium vulgare* Kg.)
Painesville, H. C. Beardslee; Delhi, G. B. Twitchell.

49. MICROCOLEUS Desm. et. Thur.

Microcoleus gracilis Hass.
Columbus (green house) F. B. Eldridge.

50. OSCILLARIA Bosc.

Oscillaria elegans Ag.
Cincinnati, G. B. Twitchell.

Oscillaria froelichii Kg.
Columbus (green house) W. A. Kellerman, F. B. Eldridge.

Oscillaria froelichii fusca Kirch.
Columbus, E. E. Bogue.

Oscillaria imperator Wood.
Cincinnati, G. B. Twitchell.

Oscillaria major Vauch.
Cincinnati, G. B. Twitchell.

Oscillaria nigra Vauch.
Painesville, H. C. Beardslee; Cincinnati, G. B. Twitchell; Lima, W. A. Kellerman.

Oscillaria princeps Vauch.
Columbus, E. E. Bogue.

Oscillaria subtilissima Kg.
Cincinnati, G. B. Twitchell.

Oscillaria tenerrima Kg.
Columbus, W. A. Kellerman.

Oscillaria tenuis Gg.
Granville, C. L. Payne (Bull. Den. U.); Columbus, E. E. Bogue.

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MYXOMYCETES. Slime-Moulds.

1. PHYSARUM Pers.

Physarum cinereum (Batsch.) Pers.
On grass, clover etc., Central Ohio.

Physarum polymorphum Rostf.
Granville, W. G. Tight, H. L. Jones.

Paysarum simile Rostf.
Granville, W. G. Tight, H. L. Jones.

Physarum sinuosum Rostf.
Granville, W. G. Tight, H. L. Jones.

2. FULIGO Hall.

Fuligo septica (Link.) Gmel.
On apple tree, Granville, H. L. Jones.

Fuligo varians Sommf.
Cincinnati, Thos. G. Lea (Cat.)

3. CRATERIUM Trent.

Craterium leucocephalum Rost.
Granville, W. G. Tight, H. L. Jones.

Craterium rubiginosum Mass.
Granville, W. G. Tight, H. L. Jones.

4. LEOCARPUS Link.

Leocarpus fragilis (Dicks.) Rostf.
Cincinnati, Thos. G. Lea (Cat.)

5. TILMADOCHE Fr.

Tilmadoche compacta Wing.
Granville, W. G. Tight, H. L. Jones.

Tilmadoche mutabilis Rostf.
Granville, W. G. Tight, H. L. Jones.

Tilmadoche gyrocephala Rostf.
Granville, W. G. Tight, H. L. Jones.

Tilmadoche nutans Rostf.
Granville, W. G. Tight, H. L. Jones.

6. CHONDRIODERMA Rostf.

CHONDRIODERMA RETICULATUM Rostf.
Granville, W. G. Tight, H. L. Jones.

CHONDRIODERMA TESTACEUM Rostf.
Granville, W. G. Tight, H. L. Jones.

7. DIDYMIUM Schrad.

DIDYMIUM FARINACEUM Schrad.
Granville, W. G. Tight, H. L. Jones.

DIDYMIUM RUGULOSUM Berk.
Cincinnati, Thos. G. Lea (Cat.)

DIDYMIUM SQUAMULOSUM A. & S.
On old oak leaves, Fairfield Co., W. A. Kellerman; Granville, W. G. Tight, H. L. Jones.

8. LEPIDODERMA DeBary.

LEPIDODERMA TIGRINUM (Schrad.) Rostf.
Cincinnati, Thos. G. Lea (Cat.)

9. DIACHAEA Fr.

DIACHAEA LEUCOPODA Rostf.
Granville, W. G. Tight, H. L. Jones.

10. LAMPRODERMA Rostf.

LAMPRODERMA PHYSARIOIDES (A. & S.) Rostf.
Cincinnati, Thos. G. Lea (Cat.)

LAMPRODERMA VIOLACEUM Rostf.
Granville, W. G. Tight, H. L. Jones.

11. COMATRICHA Preuss.

COMATRICHA FRIESIANA DeBy.
Cincinnati, Thos. G. Lea (Cat.); Granville, W. G. Tight, H. L. Jones.

COMATRICHA TYPHINA Roth.
Rendville (Perry Co.) W. A. Kellerman; Granville, W. G. Tight, H. L. Jones.

12. STEMONITES Gled.

STEMONITES FUSCA Roth.
Cincinnati, Thos. G. Lea (Cat.); Hocking Co., W. A. Kellerman; Granville, W. G. Tight, H. L. Jones.

STEMONITES FERRUGINEA Rostf.
Granville, W. G. Tight, H. L. Jones.

STEMONITES MAXIMA Schw.
Granville, W. G. Tight, H. L. Jones.

STEMONITES MORGANI Peck.
Granville, W. G. Tight, H. L. Jones.

STEMONITES TENERRIMA B. & C.
Granville, W. G. Tight, H. L. Jones.

STEMONITES VIRGINIENSIS Rex.
Granville, W. G. Tight, H. L. Jones.

STEMONITES WEBBERII Rex.
Granville, W. G. Tight, H. L. Jones.

12*a*. LICEA Schrad.

LICEA BIFORIS Morgan.
On inside bark of Liriodendron, Miami Valley, A. P. Morgan (Myx.)

LICEA PUSILLA Schrad.
On old wood, Miami Valley, A. P. Morgan (Myx.)

LICEA VARIABILIS Schrad.
On old wood, Miami Valley, A. P. Morgan (Myx.)

13. TUBULINA Pers.

TUBULINA CAESPITOSA Peck.
On old wood, Miami Valley, A. P. Morgan (Myx.)

TUBULINA CYLINDRICA Bull.
Granville, W. G. Tight, H. L. Jones.

TUBULINA SPERMOIDES Mass.
Granville, W. G. Tight, H. L. Jones.

TUBULINA STIPATA Rostf.
Granville, W. G. Tight, H. L. Jones.

14. CLATHROPTYCHIUM Rostf.

CLATHROPTYCHIUM RUGULOSUM Wallr.
On old wood, Miami Valley, A. P. Morgan (Myx.)

15. DICTYDIUM Schrad.

DICTYDIUM CERNUUM Pers.
On old wood, Miami Valley, A. P. Morgan (Myx.)

DICTYDIUM LONGIPES Morgan.
Granville, W. G. Tight, H. L. Jones.

16. CRIBRARIA Pers.

CRIBRARIA ARGILLACEA Pers.
On rotten trunks, Miami Valley, A. P. Morgan (Myx.)

CRIBRARIA CUPREA Morgan.
On old wood, Miami Valley, A. P. Morgan (Myx.)

CRIBRARIA DICDYDIOIDES C. & B.
Granville, W. G. Tight, H. L. Jones.

CRIBRARIA ELEGANS B. & C.
On old wood, Miami Valley, A. P. Morgan (Myx.)

CRIBRARIA TENELLA Schrad.
Granville, W. G. Tight, H. L. Jones.

CRIBRARIA VULGARIS Schrad.
On old wood, Miami Valley, A. P. Morgan (Myx.)

17. RETICULARIA Bull.

RETICULARIA ATRA A. & S.
On wood and bark, especially pine, Miami Valley, A. P. Morgan (Myx.)

RETICULARIA SPLENDENS Morgan.
On old wood, Miami Valley, A. P. Morgan (Myx.)

RETICULARIA UMBRINA Fr.
Granville, W. G. Tight, H. L. Jones.

18. PERICHAENA Fr.

PERICHAENA DEPRESSA Lib.
On inside of bark of Juglans Acer, etc., Miami Valley, A. P. Morgan (Myx.)

PERICHAENA MARGINATA Schw.
Outer surface of bark of Acer, Fagus, etc., Miami Valley, A. P. Morgan (Myx.)

PERICHAENA IRREGULARIS B. & C.
On outer bark of Acer, etc., Miami Valley, A. P. Morgan (Myx.)

19. OPIOTHECA Currey (*Cornuvia* Rostf.)

OPIOTHECA CHRYSOSPERMA Currey (*Cornuvia circumscissa* Rostf.)
On inner surface of old bark of Quercus, etc., Miami Valley, A. P. Morgan (Myx.)

OPIOTHECA PALLIDA B. & C.
On dead stems of herbaceous plants, Miami Valley, A. P. Morgan (Myx.)

OPIOTHECA VERMICULARIS Schw.
On inside of old bark, Miami Valley, A. P. Morgan (Myx.)

OPIOTHECA WRIGHTII B. & C. (*Hemiarcyria melanopeziza* Speg.)
On inner bark of Acer, Hicoria, etc., Miami Valley, A. P. Morgan (Myx.)

20. ARCYRIA Hall.

ARCYRIA ADNATA (Batsch.) Rost.
On old wood, Miami Valley, A. P. Morgan (Myx.)

ARCYRIA CINEREA (Bull.) Schum.
Cincinnati, Thos. G. Lea (Cat.); Loveland, D. L. James.

ARCYRIA COOKEI Mass.
On old wood, moss, etc., Miami Valley, A. P. Morgan (Myx.)

ARCYRIA DIGITATA Schw. (*A. bicolor* B. & C.)
Granville, W. G. Tight, H. L. Jones.

ARCYRIA MINOR Schw.
On old wood, bark, Polyporus, etc., Miami Valley, A. P. Morgan (Myx.)

ARCYRIA NUTANS.
Granville, W. G. Tight, H. L. Jones.

ARCYRIA PUNICEA Pers.
Cincinnati, Thos. G. Lea (Cat.); Loveland, D. L. James.

21. LACHNOBOLUS Fr.

LACHNOBOLUS GLOBOSUS Schw.
Granville, W. G. Tight, H. L. Jones.

22. LYCOGOLA Mich.

LYCOGOLA CONICUM Pers.
On old wood, Miami Valley, A. P. Morgan (Myx.)

LYCOGOLA EPIDENDRON Buxb.
Cincinnati, Thos. G. Lea (Cat.); Rendville (Perry Co.) W. A. Kellerman; Granville, C. J. Herrick.

LYCOGOLA EXIGUUM Morgan.
On old wood, Miami Valley, A. P. Morgan (Myx.)

LYCOGOLA FLAVO-FUSCUM Ehrh.
On Apple tree, Granville, W. G. Tight, H. L. Jones.

23. OLIGONEMA Rostf.

OLIGONEMA BREVIFOLIA Peck.
On old wood and mosses, Miami Valley, A. P. Morgan (Myx.)

OLIGONEMA FLAVIDUM Peck.
Granville, W. G. Tight, H. L. Jones.

OLIGONEMA FULVUM Morgan.
On old effused Sphaeria, Miami Valley, A. P. Morgan (Myx)

OLIGNEMA NITENS Lib. (*Trichia nitens* Libert.)
On and within rotten wood, Miami Valley, A. P. Morgan (Myx.)

OLIGONEMA PUSILLA Schw. (*Trichia pusilla* Schroet.)
Granville, W. G. Tight, H. L. Jones.

24. TRICHIA Hall.

TRICHIA AFFINIS DeBy. (*T. jackii* Rost.)
Granville, W. G. Tight, H. L. Jones.

TRICHIA ANDERSONI Rex.
Inside of bark of Acer, Miami Valley, A. P. Morgan (Myx.)

TRICHIA CHRYSOSPERMA DC.
Cincinnati, Thos. G. Lea (Cat.); Granville, W. G. Tight, H. L. Jones.

TRICHIA FALLAX Pers.
On old wood, Miami Valley, A. P. Morgan (Myx.)

TRICHIA FRAGILIS Sow.
On old wood, Miami Valley, A. P. Morgan (Myx.)

TRICHIA SCABRA Rost.
Granville, W. G. Tight, H. L. Jones.

TRICHIA VARIA Pers.
Cincinnati, Thos. G. Lea (Cat); Granville, W. G. Tight, H. L. Jones.

25. HEMIARCYRIA Rostf.

HEMIARCYRIA ABLATA Morgan.
Granville, W. G. Tight, H. L. Jones.

HEMIARCYRIA CLAVATA Pers.
Cincinnati, Thos. G. Lea (Cat.); Fairfield Co., Perry Co., W. A. Kellerman.

HEMIARCYRIA FUNALIS Morgan.
On old wood, Miami Valley, A. P. Morgan (Myx.)

HEMIARCYRIA LONGIPILA Rex.
On old wood of Oak, etc., Miami Valley, A. P. Morgan (Myx.)

HEMIARCYRIA PLUMOSA Morgan.
Granville, W. G. Tight, H. L. Jones.

HEMIARCYRIA RUBIFORMIS Pers.
Cincinnati, Thos. G. Lea (Cat.); Granville, W. G. Tight, H. L. Jones.

HEMIARCYRIA SERPULA Scop.
Granville, W. G. Tight, H. L. Jones.

HEMIACYRIA STIPATA Schw.
Granville, W. G. Tight, H. L. Jones.

26. CALONEMA Morgan.

CALONEMA AUREUM Morgan.
On and within rotten wood, Miami Valley, A. P. Morgan (Myx.)

Index

TO THE

SLIME MOULD (MYXOMYCETES).

[The references are to the serial number, not to the page.]

Additions and Corrections.

Page 81, add VERNONIA ALTISSIMA GRANDIFLORA, Nutt., Ashtabula Co., Sara F. Goodrich.

Page 83, for "SOLIDAGO ARGUTA Ait," read SOLIDAGO JUNCEA Ait.

Page 84, add SOLIDAGO TENUIFLORA Pursh, Toledo, J. A. Sanford; Franklin Co., E. M. Wilcox.

Page 85, add ASTER DRUMMONDII Lindb., Franklin Co., Wm. C. Werner.

Page 85, add ASTER DUMOSUS CORDIFOLIUS T. & G., Franklin Co. W. S. Sullivant (Cat.)

Page 85, add ASTER LATERIFLORUS BIFRONS Gray, Painesville, Wm. C. Werner

Page 85, add ASTER LATERIFLORUS THYRSOIDEUS Gray, Painesville, Wm. C. Werner.

Page 87, add ASTER NOVI-BELGII LAEVIGATUS Gray, Ironton, Wm. C. Werner.

Page 91, under HELIANTHUS TRACHELIIFOLIUS, insert Ashtabula Co., Sara F. Goodrich.

Page 92, add BIDENS CONNATA COMOSA Gray, Painesville, Wm. C. Werner.

Page 103, add LONICERA JAPONICA Thunb., near Ironton, Wm. C. Werner.

Page 104, under HOUSTONIA PURPUREA, insert Loveland, Jos. F. James.

Page 100, add VALERIANA SYLVATICA Banks, "Northern Ohio," J. S. Newberry (Cat.)

Page 121, add CONVOLVULUS SEPIUM AMERICANUS Sims, Richland Co., E. Wilkinson.

Page 122, add ASCLEPIAS TUBEROSA DECUMBENS Pursh, "Ohio," Gray (Man.)

Page 158, under FRAGARIA AMERICANA, strike out "Painesville, Wm. C. Werner;" for "Springfield" read Clifton (Green Co.)

Page 159, transfer "Painesville, Wm. C. Werner," from POTENTILLA ARGUTA to P. ARGENTEA.

Page 161, under AMELANCHIER CANADENSIS add A form toward var. ROTUNDIFOLIA T. & G., Georgesville (Franklin Co.) Aug. D. Selby.

Page 161, add AMELANCHIER CANADENSIS OBOVALIS (Mx.) B. S. P. (*A. can. oblongifolia* T. & G.), Painesville, a large leaved form, Wm. C. Werner; Lorain Co., A. A. Wright (Cat.); Toledo, J. A. Sanford.

Page 166, add ARABIS CONFINIS Watson, Painesville, Wm. C. Werner; Lorain Co., A. A. Wright (Cat.); Licking Co., H. L. Jones (Cat.); Franklin Co., W. S. Devol.

Page 166, under ARABIS HIRSUTA insert Cuyahoga Falls (Summit Co.) Wm. C. Werner; Put-in-Bay Island (Lake Erie) H. C. Beardslee (Cat.)

Page 166, strike out "CARDAMINE FLEXUOSA (*C. hirsuta sylvatica*), Lorain Co., A. A. Wright (Cat.)"

Page 167, after CARDAMINE PENNSYLVANICA Muh'. (*C. hirsuta*), change "L" to Gray, Man. not L.

Page 173, under RANUNCULUS CIRCINATUS strike out Toledo, J. A. Sanford.

Page 176, JEFFERSONIA DIPHYLLA AND PODOPHYLLUM PELTATUM should be placed under BERBERIDACEAE page 171.

Page 186, under ULMUS RACEMOSA, read Chagrin Falls (Cuyahoga Co.) instead of "Ashtabula Co."

Page 209, add CAREX GRAYI HISPIDULA Gray, Ashtabula Co., Sara F. Goodrich.

Page 213, strike out CAREX LAXIFLORA STYLOFLEXA, Licking Co., H. L. Jones.

Page 224, for "AGROSTIS EXARATA" read A. ALTISSIMA (Walt.) Tuck. (*A. elata* Trin.), slender forms.

CHAPTER III.

CONTRIBUTIONS TO THE PALEONTOLOGY OF OHIO.

By R. P. Whitfield.

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I. Descriptions of Fossils from the Palæozoic Rocks of Ohio.

In submitting for publication the following descriptions and observations of Ohio fossils I feel it due to myself to account for its detached and apparently incomplete character, to state that this arises from the fact, that it is essentially a report on certain groups of fossils submitted to me, partially for the purpose of ascertaining their horizons or for determining their relations to other beds the horizons of which were supposed to be already known. In the effort to carry out these objects, besides the specimens and information which I have received from Dr. Newberry, I have been aided by the loan of specimens and by other assistance from President Edward Orton, of the Ohio State University, and by the Hyatt Brothers, students in that institution, who have furnished me much information in regard to localities and horizons of different species, as well as lists of those known to occur in particular beds in the vicinity of Columbus; and also with specimens from their private collections. To the late Rev. E. B. Andrews, of Lancaster, Ohio, I am also indebted for the use of many of the specimens illustrating the Maxville limestones.

The fossils illustrated on Plate I, represent forms that are found exclusively in the hydraulic cement beds of the State,[1] which represent the lower part of the Lower Helderberg and Waterline groups of New York. The character of the fossils is such that no comments are necessary in regard to the horizon they represent. Plates II to VI inclusive, contain figures of species from the limestones below the horizon known as the "Bone bed" in the vicinity of Columbus, Ohio, and are to a great extent illustrations of heretofore undescribed forms. The forms represented on Plate VII are, with one exception, known species; they represent horizons not hitherto recognized within the limits of the State, and require something more than a passing notice; I have there-

[1] The beds of this horizon in Ohio are magnesian limestone, of the ordinary type, and are burned into common lime, on the large scale.—E. O.

fore made some remarks upon them, preceding their descriptions, more extended than would be convenient in this place.

The species illustrated on Plate VIII are from the Huron and Erie Shales with one exception (*Aristozoe canadensis*), and the remarks preceding their description will sufficiently explain their grouping.

Those illustrated on the two following Plates, Nos. IX and X, are all from the limestone layers known as the Maxville limestones, and although several are of previously undescribed species, enough of them are recognized forms to fully establish their geological horizon, which appears to be equivalent to the St. Louis and Chester beds of Illinois and the surrounding States. This conclusion, I believe, had been reached by Mr. F. B. Meek during his work on the Ohio fossils, at least his labels on some specimens of *Spirifera contracta* in the State Cabinet at Columbus would indicate this conclusion. The possibility of fully and satisfactorily identifying any of the divisions of the Lower Carboniferous formations of the more western States among the beds represented beneath the true Coal Measures of Ohio, must certainly be considered as an advantage in the study of these formations. Not only is this true from a stratigraphical point of view as enabling us to identify a stratum or formation over a much greater extent of country and thereby trace out and locate its history in time; but also palæontologically, as enabling us to satisfactorily identify many of the slightly varying forms of fossils represented in these beds with those from other localities, instead of having them described as distinct species, founded upon minute or imaginary differences resulting principally from a change in the state of preservation or of the conditions of life under which they may have existed during the deposition of the sediments in which they are now found. There seems to be a constantly growing tendency to describe as new species forms which vary in the slightest particular from the established species, and it often arises from the inability to satisfactorily identify the beds in which they are found with those from other localities where the stratigraphical relations are already known, and I cannot but regret that it is not practicable to work out the fossils of other of the Ohio formations, as I am fully persuaded there are several of these which could be positively identified with well-known formations in other States, were this done. This is shown by the fossils from the red Iron-stone beds of the Waverly at Sciotoville, Ohio, among which are forms which indicate the Burlington or Burlington and Keokuk beds of Iowa and Illinois. On Plate X, fig. 4 a–c, of Vol. II, Pal. Ohio, is represented a Productus in the condition of an internal cast, which when studied in numbers in connection with *Productus flemingi* var. *burlingtonensis* Hall, from Burlington, Iowa, and Quincy, Illinois, cannot fail to be identified as the same species, while the *Hemipronites crenistria* of the same plate scarcely differs from *Orthis keokuk* of the same beds; and on Plate XIV of the same volume, fig. 6, is already identified with the *Athyris lamellosa* of the Iowa locality. Although there may be many entirely new forms embraced within the vertical limits occupied by these same shells at the localities from which they are derived, I do not think this is a sufficient reason why they should be considered as other than equivalents of the Burlington and Keokuk beds of the western States above mentioned.[1]

Plate XI is occupied principally by new forms from the Coal Measures, while Plate XII contains many previously described species. The smaller forms represented being mostly illustrations of species found in two separated layers of chert, within the limits of the Coal Measures, near Webb Summit and at Mrs. Banks's Farm, Falls township, Hocking county, which were particularly examined for determining their horizons, and the figured specimens were obtained from them in place. These species sufficiently mark their places as within the true coal bearing series.

For the interesting new forms illustrated on Plate XI, I am indebted to H. Moores, Esqr., of Columbus, Ohio, and to Mr. Somers, of the same place, who have taken pains to collect and send to me for examination much of the well developed fauna of Carbon Hill, Hocking county, Ohio. On this same plate is represented a new genus and species of air breathing Mollusk, the discovery of which in the Coal Measures of Marietta, Ohio, is an exceedingly interesting fact, as showing the wide distribution over the American coal region during its formation, the conditions of climate and terrestrial circumstances which permitted the existence of this form of life to extend over Ohio, Indiana, and Nova Scotia.

[1] It may be well to state in this connection that these remarks were written in 1880.—R. P. W.

DESCRIPTIONS OF SPECIES.

SPECIES FROM THE HYDRAULIC LIMESTONES OF THE LOWER HELDERBERG GROUP.

MOLLUSCOIDEA.

BRACHIOPODA.

Genus STREPTORHYNCHUS King.

Streptorhynchus hydraulicum.

PLATE I, figs. 1—3.

Streptorhynchus hydraulicum Whitf., Ann. N. Y. Acad. Sci., 1882, p. 193.

Shell small to minute, the largest individuals yet observed not exceeding five-eighths of an inch in greatest diameter, while the most of those observed are not more than two-thirds as great. Valves depressed convex, or, more commonly, appearing very flat, as seen on the surface of the stone. Hinge-line straight, nearly as long as the width of the shell below, and the latter usually more than the length, frequently nearly once and a half as great. Ventral valve characterized by a very narrow and nearly vertical cardinal area, and a usually more or less twisted or otherwise distorted beak. Dorsal valve slightly more convex than the ventral, with a perceptible mesial depression extending from beak to base, becoming broad and undefined below the middle of the length. Surface of the shell marked by coarse and somewhat rigid radiating striæ, which are distinctly alternating in size; the principal ones proportionally very strong.

The small size of the shell, with the strong radiating and alternate striæ, are distinguishing features of the species. There is no species resembling it, to any degree, among the fossils of New York rocks of a corresponding age. It presents much more the features of forms of the genus from the Coal Measures than any heretofore described from Silurian rocks of America, and will not be readily confounded with any known species.

Formation and Locality.—In the hydraulic beds of the Lower Helderberg group, at Belleville, Sandusky county, and at Greenfield, Ohio; associated with *Meristella bella*, *Nucleospira rotundata* and *Leperditia alta*, occurring sometimes in great numbers, almost covering the surfaces of slabs.

Genus SPIRIFERA Sowerby.

Spirifera Vanuxemi.

PLATE I, figs. 4 and 5.

Orthis plicata Vanuxem, Geol. Rept. 3d Dist. N. Y., 1842, p. 112, fig. 1.
Spirifera Vanuxemi Hall.

The shells of this species are abundantly scattered over the surface of certain layers of the Waterlime rock, at Peach-Point, Put-in-Bay Island; associated with *Leperditia alta* of Conrad, and occur of all sizes from those of not more than an eight of an inch in transverse diameter to those of about five-eighths of an inch, and present all the features of those of the Tentaculite limestone of eastern New York. The form is transversely oval in outline and convex in profile, on each side; the ventral being the most rotund; cardinal angles rounded and cardinal line short; ventral beak strongly incurved. The shell is marked on each side of the mesial fold or sinus by about four strong, rounded plications and are separated by concave spaces, which on the ventral valve appear of about equal width with the plications, but on the dorsal are narrower and somewhat sharper in the bottom. The mesial fold is fully twice as wide as the strongest plication, is somewhat regularly rounded or depressed convex, while the mesial sinus of the ventral valve appears narrower and deeply concave. The surface of the shell is marked by fine transverse or concentric striæ which are strongly undulated in crossing the plications and fold, and under a magnifier are seen to present considerable regularity in size and arrangement.

The species presents many similarities to *S. crispus* Hisinger; as it occurs in the Niagara group of New York and other places in America, as well as to those of European localities. In fact it is quite difficult to see wherein they differ, but as the Lower Helderberg forms are nearly always found only as separated valves and more or less exfoliated, there is some difficulty in instituting satisfactory comparisons.

Formation and Locality.—In hydraulic limestone of the Lower Helderberg group, at Peach Point, Put-in-Bay, Lake Erie.

Genus MERISTELLA Hall.

Meristella lævis.

PLATE I, figs. 6—7.

Atrypa lævis Vanuxem, 1842, Geol. Rept. 3d Dist. N. Y., p. 120, fig. 2.
Merista lævis (Vanux.) Hall, 10th Rep. State Cab., p. 94.
Merista (= *Meristella*) *lævis* (Vanux.) Hall, Pal. N. Y., vol. 3, p. 247, pl. 39, fig. 3.

Shell below a medium size, longitudinally ovate in form, and very ventricose; ventral valve much longer than the dorsal, with a strong incurved beak, from which the shell constantly widens to below the middle of the length; body of the valve flattened along the centre in the upper part, and gradually becoming more and more depressed until it becomes concave toward the front, forming a very distinct mesial sinus; front slightly prolonged and bent upward. Dorsal valve very convex in the upper part, approaching gibbous on the umbo, the beak small but strongly incurved; front of the valve truncate or slightly emarginate to accommodate the front extension of the ventral, but no distinctly defined mesial fold exists. Surface of the shell marked only by numerous concentric lines of growth, some of which are strongly defined.

The specimens of this species noticed from Ohio are smaller than the usual size of individuals from New York, but present the usual features of the species as shown on the specimens figured by Prof. Hall, on Plate XXXIX, Pal. N. Y., vol. 3, fig. 3, f and k, which is by far the most common and characteristic form among those from that State. The Ohio specimens are internal casts, and show the slit in the dorsal valve caused by the removal of the median septum very distinctly. The casts of the ventral side show the characteristic form of muscular impression but it is small and faintly marked.

Formation and Locality.—In the hydraulic beds of the Lower Helderberg group, at Greenfield, Ohio.

Meristella bella.

PLATE I, figs. 8–10.

Merista bella Hall, 10th Rept. State Cab., 1857, p. 92.
Meristella bella Hall, Pal. N. Y., vol. 3, p. 248, pl. xl, fig. 1.

Shell rather below a medium size, somewhat oblate in form, at least as wide as long, the narrowing of the beak giving an oblate appearance to the shell. Valves usually ventricose and sometimes highly convex, generally a little more full above than below the middle; margins of the shell regularly curved except near the beak, which is slightly projecting and moderately incurved. Surface of the valves smooth, but each characterized by a slightly impressed mesial sinus along the centre, more strongly marked on the ventral than on the dorsal side, and which not unfrequently causes an emargination of the front border of the shell.

The specimens of this species from Ohio are mostly in the conditions of internal casts, but a few among them retain the substance of the shell in the condition of a white chalky coating, sufficiently well preserved to afford material for description and illustration. They vary much among themselves in the form of the outline and in the degree of convexity of the valves, a few of them presenting a globular form, while others are but moderately convex. They sufficiently resemble the New York forms to be readily identified where the shell is retained, but in condition of internal casts are not so easily recognized. The muscular imprints as seen on them are small and faint, those of the dorsal valve narrow and elongated, and that of the ventral is quite small, though deep, and is confined to the rostral portion of the valve.

Formation and Locality.—In a soft drab-colored hydraulic limestone referred to the Lower Helderberg group, at Greenfield, Ohio, associated with forms which appear to represent *Nucleospira.*

Genus NUCLEOSPIRA Hall.

Nucleospira rotundata.

PLATE I, figs. 11–14.

Nucleospira rotundata Whitf., Ann. N. Y. Acad. Sci., 1882, p. 194.

Shell attaining a rather large size for the genus, being often more than half an inch in transverse diameter, and when of medium or large size, strongly ventricose or rotund. The younger individuals, however, are depressed-convex or lenticular in profile. Length of the shell as great or greater than the transverse diameter. Beaks small and incurved, not at all conspicuous. Valves marked by a slight depression along the median line, strongest on the ventral side.

This species, like all those of this formation yet obtained in Ohio, are mostly internal casts and impressions; consequently the true features of the shell are not readily obtained. The general features of the species, however, are preserved sufficiently for identification and comparison, when good individuals are selected. The shell bears much resemblance to *N. ventricosa*, Con., from the Lower Helderberg group of New York, in its general form, except the much greater size and more elongated form of the adult individuals. There is more difficulty in separating them satisfactorily from the casts of *Meristella bella* Hall, with which they are associated. In fact, it is all but impossible to do this with certainty, unless they are in a good state of preservation, as the difference in the form of the muscular imprint of the ventral valve, and the more strongly incurved beaks, are the only features that can be relied upon.

Formation and Locality.—In the hydraulic limestone of the Lower Helderberg group, at Greenfield, Ohio.

Genus RETZIA King.

Retzia formosa.

PLATE I, figs. 15 and 16.

Waldheimia formosa Hall, 10th Rep. State Cab., 1857, p. 88.
Trematospira formosa Hall, Pal. N. Y., vol. 3, p. 215, pl. 36, fig. 2.
Rhynchospira formosa Hall, Pal. N. Y., vol. 3, p. 485, pl. 95 A, figs. 7–11.

Shell small, the specimens observed not exceeding five-sixteenths of an inch in length, by about one-fourth of an inch or less in width; elongate-ovate in form, widest below the middle and narrowing at the beak on the ventral side, the apex being slightly incurved. Valves highly convex, with a slight depression along the middle. Surface of the shell marked by about twenty-two simple, round, radiating plications, two of which in the middle of the valves are more slender than the others and depressed below their level, forming a slight mesial sinus on each valve.

The shell, or rather the impression of the shell of this species as left in the rock, appears to represent an adult specimen, but is very much smaller than those of the Lower Helderberg group of New York, or those of *R. evax* in the Niagara group at Waldron, Indiana, but possesses all the essential specific characters of the species except in this one particular. The species as recognized in the Silurian rocks of Perry county, Tenn., resemble exactly this from Ohio, both in size and general characters. It has proven hitherto quite rare, but might possibly be found in greater abundance were it sought for; the specimens noticed occurring on blocks of stone selected for other fossils.

Formation and Locality.—Lower Helderberg group (Waterlime beds), at Greenfield, Ohio.

Genus RHYNCHONELLA Fischer.

Rhynchonella hydraulica.

PLATE I, fig. 17.

Rhynchonella hydraulica Whitf., Ann. N. Y. Acad. Sci., March, 1882, p. 194.

Shell rather smaller than medium size, transversely oval in outline and ventricose in profile; the dorsal valve being highly convex, and the ventral somewhat depressed convex. Beaks small, not prominent or conspicuous; that of the ventral valve moderately incurved, and the other rather strongly incurved. Surface of the shell marked by from sixteen to eighteen simple plications, four of which are strongly elevated on the front half of the dorsal valve to form the mesial elevation, which does not extend beyond the middle of the valve, and six or seven may be counted on each side of the valve. The plications are but slightly elevated, are round on the summit, and do not extend beyond the middle of the shell, the upper part of which is smooth, and marked only by concentric lines of growth. The interior of the dorsal valve is marked by a moderately strong mesial, extending from the apex of the valve to about one-third of its length. The shell appears to have been also marked by fine concentric lines of growth, some of which form distinct varices.

This species belongs to the semi-plicated group of the genus, of which there are many species having close resemblance to it, but none in rocks of corresponding age or position having very close affinities.

Formation and Locality.—In the hydraulic limestone of the Lower Helderberg group, at Greenfield, Ohio.

Genus PENTAMERUS Sowerby.

Pentamerus pes-ovis.

PLATE I, figs. 11–22.

Pentamerus pes-ovis Whitf., Ann. N. Y. Acad. Sci., March, 1882, p. 195.

Shell quite small, and of a somewhat broadly triangular form, with depressed convex valves, the ventral side being nearly twice as deep as the dorsal, and more elongated at the beak, giving it the triangular character; cardinal slopes straightened and rapidly diverging; front broadly rounded.

The species is known only in the condition of internal casts, and as thus seen, the ventral valve is deeply cleft along the median line by the removal of the central septum, the slit often extending more than three-fourths of the length of the valve. The filling of the spoon-shaped cavity is proportionally large, being long and narrow, and not strongly arched. Cast of the dorsal valve characterized by a proportionally large and broad cardinal plate, from which project two long and strongly divergent and distant crural processes, reaching far along the surface of the cast in some cases, while in others they are quite short. The surface of the valves has been destitute of plications, but is usually marked in the larger individuals by several strong varices of growth near the front margin, which give to the shell a prematurely old appearance for so small a species; the individuals seldom exceed five-eighths of an inch in length on the ventral side.

This species is unlike any known form of a similar size, in the shallowness of the valves, in the erect character of the ventral beak, and in the deeply divided feature of the cast of this valve. The dorsal valve is much less marked, and is often destitute of any distinguishing feature.

Formation and Locality.—In the hydraulic limestone of the Lower Helderberg group, in Adams county, Ohio, occurring in numbers densely packed together, but having the shelly substance entirely removed.

MOLLUSCA.

LAMELLIBRANCHIATA.

Genus PTERINEA Goldfuss.

Pterinea aviculoidea.

PLATE I, fig. 23.

Megambonia aviculoidea Hall, Pal. N. Y., vol. 3, p. 274, pl. 49, figs. 7 and 8.
Pterinea aviculoidea (Hall) Whitf., Geol. Rept. Wis., vol. iv, p. 322, pl. 25, figs. 6–7.

Shell of proportionally small size, obliquely rhomboidal in outline, with a moderately long, straight hinge-line, but little shorter than the length of the body of the shell below. Left valve depressed convex, with a small, slightly incurved beak, scarcely extending above the cardinal line. Anterior end short, and the anterior projection scarcely defined; posterior wing concave and the posterior margin nearly at right angles to the hinge-line for a short distance below, then gently curving backward to the rounded postero-basal extremity; basal line rounded and on the anterior side of the umbonal ridge curving rapidly upward to the anterior extremity. Body of the valve convex and oblique to the hinge, the umbonal ridge broadly rounded. Surface of the shell marked only by lines of growth some of which are stronger and form slight varices.

The species is poorly represented in individuals, but the specimens seen are so precisely like those of the Tentaculite limestones of New York as to be not readily mistaken.

Formation and Locality.—In the hydraulic limestone of the Lower Helderberg group on Put-in-Bay Island, Lake Erie.

Genus GONIOPHORA Phillips.

Goniophora dubia.

PLATE I, figs. 24–26.

Modiolopsis? dubius Hall, Pal. N. Y., vol. 3, p. 264, pl. 49, fig. 2.

Shell small, transversely elongate, nearly twice and a half as long as high. Valves ventricose, most highly convex on the anterior half, becoming more depressed toward the posterior; beaks small, very slightly incurved but not elevated above the cardinal border and rather inconspicuous, situated about half or rather less than half the height of the shell from the anterior extremity, proportionally more distant on the larger specimens than on those of small size. Hinge-line long and straight, extending four-fifths of the length of the shell behind the beaks and characterized by a narrow but distinct escutcheon. Anterior end short and full, very obtusely pointed at the longest part, which is at about the middle of the height, above which point there is a very distinct but narrow lunule extending to the extremity of the hinge-line. Basal margin of the valve very broadly curved, slightly emarginate just anterior to the middle and the whole subparallel to the cardinal line. Posterior extremity sharply rounded below and the upper margin very obliquely truncated; body of the valve marked by a broad, distinct, mesial sulcus extending from behind the beak to the broad sinus of the basal margin. The umbonal ridge is rather sharply marked and angular in the upper portion, but becomes less distinctly marked posteriorly; postero-cardinal slope of moderate width, very slightly concave in the younger stages of growth but less strongly marked as the growth advances. Surface of the valves marked by strong, sublamellose, concentric lines of growth parallel to the outer margin of the valves.

The shell undergoes considerable change in form and in the strength of the surface characters between the younger and more advanced stages of growth; the sharpness of the features being much reduced on the older portions, by the rounding of the unbonal ridge and of the angularity of both the anterior and posterior extremities of the shell. The shell differs in several of its external features from the genus *Modiolopsis*, possessing a distinct lunule and escutcheon as well as the angular unbonal ridge, in all of which features it corresponds with *Goniophora*.

Formation and Locality.—In the hydraulic limestone of the Lower Helderberg group at Peach Point, Put-in-Bay Island, Lake Erie, and at Middletown, Marion Co., Ohio.

ARTICULATA.

CRUSTACEA.

MEROSTOMATA.

Genus EURYPTERUS DeKay.

Eurypterus Eriensis.

PLATE I, figs. 31, 32.

Eurypterus Eriensis, Whitf., Ann. N. Y., Acad. Sci., March, 1882, p. 196.

Among the fossils from the hydraulic limestones of Peach Point, Put-in-Bay Island, Lake Erie, there are several detached cephalic shields and one body, of a species of *Eurypterus*, which is so distinctly different from any of those described, that it seems necessary to class it as a separate species. The differences, so far as seen on the parts preserved, consist in the form of the cephalic plate, in the size and position of the eye-tubercles, and in the proportions of the body as compared with the known forms. There are undoubtedly other and more important differences in the appendages, but as these are not preserved on any of the individuals examined, comparison is impossible.

The cephalic shield is proportionally broader than that of *E. remipes* or *E. lacustris*, and is more regularly rounded or arched on the anterior border, lacking that subquadrate form characteristic of those species. The eyes are proportionally smaller, and situated near each other, and also farther forward, as well as being somewhat more oblique to the longitudinal axis of the body. The minute ocular points are somewhat larger than in *E. remipes*, are situated close together, and are nearly opposite the posterior end of the real eye-tubercles; they consist of a pair of distinctly elevated rings surrounding rather deep, although minute, central depressions; the inner margins of the rings being almost in contact. The head does not show evidence of having been margined by an elevated or thickened rim, as in those species, but as the specimens are rather impressions of the inner surface of the external crust than actual external surfaces (being more properly internal casts, the substance of the carapace having been entirely removed), this feature may not be properly shown. The head-plate more closely resembles that of *E. microphthalmus* Hall (Pal. N. Y., vol. iii, p. 407,* pl. 80 A, fig. 7), from the Tentaculite limestone near Cazenovia, N. Y., than of any other described species; it differs, however in being proportionately much shorter, which gives it a more semi-circular form. The eye-tubercles are also more nearly of the size of those of that species and similarly situated.

The thorax closely resembles that of *E. remipes* in its general form, but the lower three or four segments are proportionally shorter, giving the posterior extremity a much more compact character. The principal distinction between the two species, as shown by the thorax, exists in a difference of the ornamentation of the surface, as seen on the specimen used. This consists in the minute spine-like pustules or pointed granules, marking the surface of the crust, being arranged in irregular transverse lines across the body, and parallel to the anterior and posterior margins of the segments, instead of being irregularly disposed, as in all other species described. No indication of the longitudinal rows of larger pustules, marking the median line of the thoracic segments can be traced. Caudal spine not observed.

OSTRACODA.

Genus LEPERDITIA Ronault.

Leperditia alta.

PLATE I, fig. 27.

Cytherina alta (Con.) Vanuxem, Geol. Rept., 3d Dist. N. Y., 1843, p. 112, fig. 6.
Leperditia alta (Conrad) Jones, Ann. and Mag. Nat. Hist., vol. 17, 2d series, p. 88; Hall, Pal. N. Y., vol. 3, p. 373; Meek, Pal. Ohio, vol. 1, p. 187, pl. 17, fig. 2.

Valves of the carapace transversely sub-ovate, widest posterior to the middle and narrowed in front, the proportional height and length being somewhat variable, but are usually about as two and three. Hinge-line straight nearly two-thirds as long as the entire valve, extremities salient. Anterior end of the valves narrowly rounded and the posterior extremity broadly curved; basal-line curved but with a scarcely perceptible angularity just posterior to the middle of the length. Surface prominently convex and a little the fullest anterior to the middle; ocular tubercle small, situated a little below and just behind the anterior extremity of the hinge-line. Lower margin of the valves slightly inflected, and in some cases the posterior margin appears to have been bordered by a slightly thickened rim.

The individuals examined are either internal casts or impressions of the exterior, owing to which fact the finer surface features of the crust cannot be definitely ascertained; enough is seen however to show its identity with those from the Tentaculite limestones of New York. The species as described by Mr. F. B. Meek includes this and the following one, which are very distinct species, the differences being very strongly marked in the great prominence of the lower part of the valves of that one, and its strongly sub-angular form as well as in its greater size. The principal variation noticed among the individuals of this species, is in the greater proportional length of some of them, producing a cylindrical form. This feature is however seen occasionally among those from Schoharie, N. Y., but does not appear to be worthy of specific consideration.

Formation and Locality.—In the hydraulic limestone of the Lower Helderberg group, at Bellevue, Sandusky Co., Ohio.

Leperditia angulifera.

PLATE I, figs. 28–30.

Leperditia angulifera Whitf., Ann. N. Y., Acad. Sci., March, 1882, 196.

Carapace of medium size, having a length, in adult individuals, of about three-eighths of an inch, by a height of one-fourth of an inch in the broadest part. General form of the outline broadly sub-ovate and widest posteriorly; hinge-line straight, equal in length to two-thirds that of the entire valve; anterior end a little the shortest, narrowly rounding into the broadly curved basal line; posterior end broadly rounded. Surface of the carapace highly elevated and prominent, forming a strong, somewhat angular, longitudinal node just within the basal margin, and near the middle of the length. From this point, the surface slopes somewhat gradually upward to the hinge-line, with a barely perceptible convexity, except on the anterior end, where it is more strongly convex, and characterized by a rather prominent and well-marked ocular tubercle. From the angular node near the lower margin, there is, on well-preserved individuals, a perceptible angulation, extending along the surface to the point of greatest length on the anterior end, and a similar one, but less strongly marked, on the posterior side. There is no perceptible difference in form between the right and left valves, each showing the features about equally developed. No appearance of striations radiating from the ocular tubercle can be detected, either on the internal casts or in the matrices; still the nature of the rock in which they are imbedded is such that very obscure markings would scarcely be preserved.

This species differs from *Leperditia alta* Conrad, of the same formation, in its larger size, and in the larger and more distinct eye-tubercle, as well as in its slightly different position; but most distinctly in the sub-angular ridge-like node, and greater convexity of the lower border of the valves. This projecting node being situated near the lower margin, and also being the most prominent point of the valve, causes the rock to adhere to the more abrupt sides when fractured, and gives to the valves as they appear upon the fractured surface a very decidedly triangular aspect, entirely unknown in *L. alta*.

Formation and Locality.—In the hydraulic limestone of the Lower Helderberg group, at Greenfield, Ohio, where it occurs in great numbers, forming distinct layers through the rock, as does the *L. alta* in the Tentaculite limestone of New York.

SPECIES FROM THE LIMESTONES OF THE UPPER HELDERBERG GROUP.

PROTOZOA.

Genus RECEPTACULITES DeFrance.

Receptaculites devonicus.

PLATE II, fig. 10.

Receptaculites devonicus Whitf., An. N. Y. Acad. Sci., March, 1882, p. 198.

A very decidedly marked and characteristic specimen of the genus *Receptaculites*, DeFrance, has been obtained from the limestones of the Upper Helderberg group, by Mr. Edward Hyatt, of the Ohio State University, from a quarry at Fishinger's mills, about eleven miles north of Columbus, Ohio. The specimen is about two and a half inches in diameter, is broadly concave across the disk, and slightly recurved at the outer margin. The concentric lines of pores or cells are strongly marked, and increase rapidly in size as they recede from the centre of the disk, but the surface has been so much weathered that the grooves left by the removal of the stolons at the foot of the cells are not distinguishable, so that the entire specific characters are not recognized; enough, however, remains to show the general form and proportions. It has much the appearance of specimens of a corresponding size of *R. Oweni* Hall, from the lead-bearing limestones of the West, both in its general form and in the concavity of the disk, as well as in the proportions and rate of increase of the cell-openings as seen exposed on the surface of the limestone.

The occurrence of a species of this genus at this horizon, is a rather unexpected feature in its history. The highest horizon of its occurrence hitherto recorded, is in the shaly limestone of the Lower Helderberg group of New York, from which the type of the species *Receptaculites infundibuliformis* (*Coscinium infundibuliformis* Eaton, Geol. Text-book, 2d ed., 1833, p. 132, fol. 5, figs. 64, 65), was derived. The figure and description, as given by Prof. Eaton, are both poor, but the specimen is still in the cabinet of the Rensselaer Polytechnic Institute, bearing the original label, and I have seen several specimens of the species from the same formation. *R. dactyloides* (*Dictyocrinus dactyloides* Conrad) is also from about the same horizon. Both of these species, however, are in the Silurian, while the present species brings the genus up to the Devonian; so that we now know of its existence from the base of the Lower Silurian to the Lower Devonian.

RADIATA.

Genus STYLASTREA Lonsdale.

Stylastrea Anna.

PLATE II, figs. 1–5.

Stylastrea Anna[1] Whitf., Ann. N. Y. Acad. Sci., March, 1882, p. 199.

Corallum compound, growing in irregular or more or less hemispherical masses of several inches in diameter, which are formed of a large number of closely aggregated polygonal cell-tubes or polyps, of rather small size, divided by intercellular walls of considerable thickness, as in most forms of the compound *Cyathophyllidæ.* Full-grown polyps, measuring about half an inch in diameter, but usually somewhat smaller; the prevailing size being about three-eighths of an inch. Calyces deep, abruptly declining from the intercellular walls to a depth nearly equaling the tranverse diameter. Longitudinal septa or rays well developed, extending about one-third, or less of the diameter of the tube from the outer wall, and averaging about forty in number in adult individuals; some containing thirty-six, and one large one counted gives forty-two. Crest of the rays strongly denticulate, the denticles being thickened and knot-like at their junction with the rays. Central chamber within the limits of the longitudinal rays, equal to one-third of the entire diameter of the polyp, and divided by numerous distinct transverse tabulæ, which are variously bent or interrupted by contact with the adjoining ones, leaving irregular cavities of considerable size between them. Interseptal spaces occupied by a series of horizontal plates, which originate at the outer wall, and extend upward and inward with increased growth to the edge of the rays, where they form the denticulation of the crest. Between the latter plates, the spaces are occupied by the smaller irregular vesicular structure.

The species, in its general features, resembles *Cyathophyllum rugosum* Hall, sp., from this formation, and may be easily mistaken for that one, in obscure or imperfect specimens; but where the internal structure is observable, especially in longitudinal sections of the polyps, can be very readily distinguished by the large central space in each polyp, and by the strongly developed transverse tabulæ; also by the rays not extending to the centre, as in that species and in those of the genus *Acervularia.* When the coral is weathered, or the substance becomes chalky, so that the polyps are readily separable from each other longitudinally, the appearance very closely resembles that of *Cyathophyllum rugosum* when in a similar condition, but the interruption of the rays before reaching the centre, and the great extent of the tabulæ, will then serve to distinguish them.

Formation and Locality.—In the Upper Helderberg group, in Paulding county, Ohio.

[1] Named in honor of Mrs. Orton, wife of President Edward Orton, of the State University, Columbus, Ohio.

MOLLUSCOIDEA.

BRACHIOPODA.

Genus STREPTORHYNCHUS King.

Streptorhynchus flabellum.

PLATE II, figs. 7 and 9.

Streptorhynchus flabellum Whitf., Ann. N. Y. Acad. Sci., March, 1882, p. 200.

Shell below a medium size, semi-circular or semi-ovate in outline, with a straight hinge-line of variable length; the lateral and front margins are somewhat regularly rounded and, in a profile view, irregularly bi-convex. Ventral valve depressed convex, with a more or less elevated and projecting but twisted or distorted beak, overhanging a nearly vertical cardinal area of irregular form and width, which is divided in the middle by a narrowly triangular convex deltidium. The dorsal valve is almost regularly semi-circular, very depressed convex, with a slightly more prominent umbo, and is destitute of cardinal area. Surface of the valves marked by from twenty-two to twenty-four strong, rather sharply elevated, radiating plications, which are entirely simple, and separated by broad, concave interspaces. The shell is also further marked by fine, regular, concentric striæ of growth, which arch backward in crossing the radii, and may have been sub-lamellose on the external surface, but the examples seen are all exfoliated.

The species is of a somewhat unusual type, especially in Devonian rocks. The dorsal valve seen alone presents so much the appearance of a strongly-marked *Aviculopecten*, that when first observed it was thought to belong to that genus; but the ventral valve, similarly marked, and possessing the characteristically twisted cardinal area and beak with its covered fissure, at once indicates its true position. It is entirely unlike any species hitherto described from American rocks, and will not easily be mistaken. It resembles, in the features of the dorsal valve, specimens of *Orthis flabellum* from the shales of the Niagara group of New York and elsewhere; but it is more coarsely marked, with wider and more deeply concave interspaces.

Formation and Locality.—In the limestone of the Upper Helderberg group, at Smith and Price's quarries, near Columbus, Ohio. Collected by Mr. Hyatt.

Genus RHYNCHONELLA Fischer.

Rhynchonella? raricosta.

PLATE II, fig. 6.

Rhynchonella raricosta Whitf., Ann. N. Y. Acad. Sci., March, 1882, p. 201.

Shell of moderate size, and somewhat transversely sub-triangular in outline, when seen upon the ventral side. Ventral valve flattened and very shallow, with a short, obtuse, and not at all incurved beak; cardinal slopes incurved, and the margins straight from the beak to near the point of greatest width of the valve, the angles of divergence being nearly or quite 120 degrees. Front of the valve broadly curved, and marked by several deep indentations corresponding to the number of plications marking the surface. Middle of the valve marked by a broad, shallow, slightly angular mesial sinus, which is more than one-third as wide at the front of the valve as the length from beak to base. Surface of the valve marked on each side of the sinus, by two low, angular, but distinct plications, besides those bordering the sinus; no other markings are traceable on the surface of the shell. The margin of the valve between the plications is extended, forming rounded projections similar to that of the mesial sinus, and probably corresponding to low rounded plications which have characterized the dorsal valve, which has not been observed.

The broad sub triangular form of the shell, with the shallow ventral valve and the small number of low, angular plications, will readily distinguish this from any species hereto known. There may possibly be some doubt as to the generic reference of the species; but this cannot be positively determined until more perfect individuals are obtained.

Formation and Locality.—In limestone of the Upper Helderberg group, at Smith and Price's quarries, near Columbus, Ohio. Collected by the Hyatt brothers, of the State University.

MOLLUSCA.

LAMELLIBRANCHIATA.

Genus MYTILARCA H. and W.

Prelim. Notice Lamellibranchiate Shells, Up. Held., Ham. and Chemung Groups etc. State Cab. Nat. Hist., Dec. 1869.

Mytilarca percarinata.

PLATE VI, figs. 1 and 2.

Mytilarca percarinata Whitf., Ann. N. Y. Acad. Sci., March, 1882, p. 202.

Shell less than medium size, the specimen used for description and illustration measuring but one and three-fourths inches in extreme height; and the distance from the anterior to the posterior margins across the point of greatest diameter, only a trifle over one inch; the depth of the valve being nearly half an inch. Form of the shell elongate triangular-ovate, rather acutely pointed at the beak, which is small and incurved; anterior, or byssal, margin straight and absolutely vertical in the example mentioned; basal margin broadly rounded from the anterior line nearly to the point of greatest length of the valve, where it is more rapidly curved, and finally passes abruptly into the rapidly ascending posterior margin; the lower part of which is nearly parallel to the anterior side, but above inclines more rapidly toward the short and very oblique hinge-line. The surface of the valve is most elevated along the anterior umbonal ridge, where it is at right angles to the anterior surface, but slopes gently backward for two-thirds of the distance toward the posterior margin, and on the other third much more abruptly. Near the beak, the surface rounds rapidly from the anterior ridge to the posterior border. Surface of the shell marked by numerous concentric ridges, parallel to the margin of the valve, many of which are strongly marked and form varices of growth. On the anterior surface, these varices and the concentric striæ are well marked. Cardinal area not observed.

The example used is a right valve, and bears evidence in its characters of being an adult shell. It is associated in the same layers of cherty material with *M. ponderosa*, H. & W. (Prelim. Notice Lamell. Shells, etc., p. 21), but may be readily distinguished by the vertical anterior surface and the angular umbonal ridge. From the young of that species, it is readily distinguished by these characters, as those are distinctly round and ventricose. The only known species approaching this in the angularity of the ridge, is *M. attenuata*, H. & W., of the Chemung group; but this is quite distinct in other respects.

Formation and Locality.—In the white chalky chert-beds of the Upper Helderberg Group, near Dublin, Ohio.

GASTEROPODA.

Genus PLATYCERAS Conrad.

Platyceras squalodens.

PLATE III, figs. 6 and 8.

Platyceras squalodens Whitf., Ann. N. Y. Acad. Sci., March, 1882, p. 202.

Shell small, sharply conical when viewed in a lateral direction, with the apex gently curved anteriorly; but in a posterior view, the form is narrowly lanceolate, with the dorsal portion rising into a thin, sharp crest or ridge; anterior side rounded and the anterior slope conclave. Aperture narrowly ovate, rounded on the anterior side, widest just above the middle, and extending backward into a narrow point. Surface of the shell marked by fine, hair-like, concentric lines of growth parallel to the margin of the aperture, which is a little bent down anteriorly and posteriorly, and also by a rather faintly marked, but still distinct sulcus, which passes from the apex on the left anterior slope, and over which the striæ are slightly undulated, indicating a slight notch in the margin at this point.

In the narrow and curved lanceolate form of the shell, this species differs very materially from any of the numerous species of this very monotonous genus, and may be readily distinguished by the sharp dorsal ridge.

Formation and Locality.—In the Upper Helderberg limestone, at Columbus, Ohio. Collection of Columbia College.

Genus DENTALIUM Linnæus.

Dentalium Martini.

PLATE III, fig. 10.

Dentalium Martini Whitf., Ann. N. Y. Acad. Sci., March, 1882, p. 203.

Shell somewhat larger than medium size, rather rapidly expanding from the apex to the aperture for a species of this genus, and moderately curving throughout the length; cylindrico-conical in form, and circular in a transverse section. Surface marked only by encircling striæ, which form rather broad undulations on the shell, and are strongly arched forward on the inner side of the curvature, showing that the lip of the shell has been somewhat extended on this side of the aperture. Shell-substance thick.

This species attains a rather large size, and expands more rapidly than most species of the genus, reaching a diameter of one-fourth of an inch in a length of less than two inches. The curvature is also considerable, being deflected fully an eighth of an inch from a straight line within the length of the specimen when tested on the inner face. There is no species of similar character from rocks of Devonian age, so far as can be ascertained. On some of the internal casts, there occurs a longitudinal ridge, as if there had been a slit or interruption of some kind at that point, which gives rise to a supposition that it may have belonged to the genus *Coleoprion* Sandberger, though no positive interruption of the striæ of the surface is seen on any specimen examined. This fact may suggest its belonging to the recently formed genus *Coleolus* Hall; but its perfect resemblance to *Dentalium* more strongly indicates its affinities as in that relation, rather than with the Pteropoda. Nor does there appear any sufficient reason among the species referred to *Coleolus* by its author, for a generic separation from *Dentalium*, other than their more strictly straight form. But there are straight or nearly straight Dentalia, and also curved forms which he has referred to the new genus. The generic feature "shells thick" would also be opposed to pteropodous affinities. In its more rapid taper and greater curvature, it is sufficiently distinct from described forms of that genus.

Formation and Locality.—In the cherty layers of the Upper Helderberg limestones, near Dublin, Ohio.

Genus MACROCHEILUS Phillips.

Macrocheilus priscus.

PLATE III, figs. 3 and 4.

Machrocheilus priscus Whitf., Ann. N. Y. Acad. Sci., March, 1882, p. 204.

Shell small and very ventricose, the height but little greater than the diameter of the body volution; the former in the figured example being three-eighths of an inch, and the latter only about one-sixteenth of an inch less. Shell composed of about four volutions, which are very ventricose and rapidly increase in diameter, the last one forming the great bulk of the shell, equaling fully two-thirds of the entire height. Suture line distinct, but not strongly marked. Apical angle about eighty degrees. Aperture somewhat semilunate, strongly modified on the inner side by the body of the preceding volution, which occupies fully one-half its height. Columella strong, straight and rounded, and the twisted ridge obsolete. Surface of the shell apparently smooth; at least no striæ are perceptible.

This pretty little species reminds one strongly of *M. ventricosus* Hall, from the Coal-measures, but is somewhat shorter in the spire, although resembling it in most other respects. The substance of the shell is soft and chalky, and might not retain minute surface striæ if they had ever existed; but no remains of them are visible at present.

Formation and Locality.—In the white cherty layers of the Upper Helderberg group, near Dublin, Ohio.

Genus LOXONEMA Phillips.

Loxonema parvulum.

PLATE III, fig. 5.

Loxonema parvulum Whitf., Ann. N. Y. Acad. Sci., March, 1882, p. 204.

Shell minute, scarcely exceeding a fourth of an inch in length, and proportionally slender, with a rapidly ascending spire, which is slightly more rapidly tapering in the upper than in the lower part. Volutions six or six and a half, moderately convex on the outer surface, and more strongly rounded on the lower part of the exposed portion than on the upper; suture-line distinct, but not margined by a flattening of the upper edge of the succeeding volution. Aperture elongate, slightly angular at the base, and pointed above. Surface of the volutions marked by a large number of distinct vertical striæ, which are more numerous and slightly finer on the body volution than above, and are so nearly destitute of sigmoid curvature as to appear vertical until closely examined.

The small size of the shell, the nearly vertical lines, and the unequally expanding volutions, are distinguishing features; the latter character, however, appears to vary a little in degree on some of the specimens. It will be readily distinguished from the young shells of *L. Hamiltoniæ*, which occurs in the same rock, by the number of volutions and the slender form.

Formation and Locality.—In the white cherty layers of the Upper Helderberg limestone, near Dublin, Ohio.

CEPHALOPODA.

Genus ORTHOCERAS Breyn.

Orthoceras nuntium.

PLATE III, figs. 1 and 2.

Orthoceras nuntium Hall, 15th Rept. State Cab., p. 79. pl. 8, figs. 3 and 4. Pal. N. Y., I lust. Dev. Foss., p. 43, figs. 4 and 15.

Comp. O. *subulatum* Hall, Geol. Rept. 4th Dist. N. Y., p. 180, fig., and Pal. N. Y. Illust. Dev. Foss., pl. 38; also *O. Thoas* and *O. Hyas* Hall of same work.

Shell attaining considerable size, the specimen used for description and figured having a length of nine inches, and still imperfect at both extremities, retains only about an inch of the outer chamber, and has a diameter of half an inch at the lower extremity. Section circular; tube moderately increasing in diameter with increased length, slightly curved throughout, and marked by regular encircling annulations, which are elevated, round on the crest, separated by deeply concave interspaces, which regularly increase in distance and also in strength from below upwards. Those of the lower part where the shell is uncompressed and is half an inch in diameter, are about one-tenth of an inch distant from each other; and at the upper end where the diameter is about one and three-fourths of an inch are about three-eighths of an inch from crest to crest. Surface of the shell marked by fine, closely arranged and sharply elevated concentric striæ, and also by longitudinal striæ of similar character, but more or less alternating in strength, the two sets giving a finely cancellated structure just discernable to the unassisted eye. Septa very deeply concave and regularly curved, uniting with the shell a little above the crest of each annulation. Siphuncle small and centrally situated.

The species is of the ordinary annulated type differing from other species of the group only in the strength and comparative distance of the annulations; in the rate of increase in diameter, and in the nature of the surface markings. The shell, like many of the annulated forms of any considerable size from the upper Helderberg and Hamilton groups, shows a slight curvature of the tube, a little more perceptible in the lower part than above. The Ohio specimens correspond more nearly to the one from the Hamilton group of N. Y., figured by Prof. Hall (Pal. N. Y., Illust. Dev. Foss., Pl. 43, fig. 14), in the rate of increase in the diameter, and in the form and relative strength of the annulations than with the original specimens to which the name was first applied, or to most of those figured under the same name on the same plate. The specimen from Ohio figured on Pl. 41, fig. 9, Illust. Dev. Foss., Pal. N. Y., under the name *O. Thoas*, is identical with the one here described, but does not retain the shell nor show surface markings, but corresponds in the form of the annulations and in its slight curvature and rate of increase in diameter, in which particulars it differs materially from those from New York, given on the same plate. It is barely possible the Ohio specimens may represent a species distinct from any of those from New York, but it seems totally impossible to detect characters sufficient to distinguish it as such. *O. subulatum* Hall, from the Marcellus shell is a very closely allied if not identical form.

Formation and Locality.—In the cherty layers of the Upper Helderberg group, near Dublin; and in the limestone of the same formation near Delaware and Columbus, Ohio.

CEPHALOPODA.

Genus TREMATOCERAS Whitf.

Ann. N. Y. Acad. Sci., March, 1882, p. 205.

A straight, obconical, cephalopodous shell, presenting the characteristics of an *Orthoceras*, so far as the appearance of the tube, septa and siphuncle is concerned; but with the additional feature of a line of elongated, raised tubercles along one side of the shell, which have formed perforations at certain stages of growth, probably confined to the outer chamber as openings, which were closed as the animal extended the shell, and before the septa opposite them were formed. Type, *T. Ohioense*.

The shell for which the above generic name is proposed offers an entirely novel feature among the Orthoceratidæ. The line of nodes seen on the cast of the shell is entirely different from anything pertaining to the ornamentation of the shell, and presents the same appearance as would the partially filled perforations of a *Haliotis*, or like those shown on the back of species of *Bucania*, and those on which the genus *Tremanotus* was founded; neither is it a feature at all dependent upon the position of the siphon or directly connected with it; for in the specimen used the siphon is slightly eccentric, on the opposite side of the tube from the nodes. Its position would thus indicate that it was a feature pertaining to the dorsal lip of the shell, corresponding to the sinus seen in the lip of many other genera. Taking this view of it, it would appear to indicate the existence of a deep, narrow notch, with raised margins, in the lip of the shell at stated periods, beyond which the shell was again united for a time, leaving a perforation to be closed by a deposit of shell from the mantle as it approached the lower part of the chamber of habitation. Many species of Orthoceras have been observed, having a raised line, or rather markings, along the dorsal side; but none, so far as I am aware, presenting these evidences of a series of separate openings, which I consider a feature worthy of generic distinction.

Trematoceras Ohioense.

PLATE VI, figs. 3 and 4.

Trematospira Ohioense Whitf., Ann. N. Y. Sci., March, 1882, p. 206.

Shell of medium size, straight, and somewhat rapidly tapering from below upward; the rate of increase being equal to nearly one-sixth of the increase in length. Septa moderately concave, rather closely arranged; five of the chambers about equaling the diameter of the uppermost of the five counted. Siphon of moderate size, and in the specimen used slightly eccentric. The surface of the shell, so far as can be determined from the internal cast, has been smooth. Perforations, or nodes representing them, large and elevated, two to three times as long as wide, and occurring at every third septum below, and at every second in the upper part of the specimen.

Formation and Locality.—In limestone of the Upper Helderberg group, at Smith and Price's quarry, near Columbus Ohio. The discovery and preservation of this peculiar specimen are due to the careful observation of Mr. Edward Hyatt, of the State University, at Columbus, Ohio.

Genus GOMPHOCERAS Sowerby.

Gomphoceras Hyatti.

PLATE IV, fig. 1, and PLATE I, fig 1.

Gomphoceras Hyatti Whitf., Ann. N. Y. Acad. Sci., March, 1882, p. 206.

Shell large and robust, slightly arcuate throughout, but more strongly curved below than in the upper part; somewhat rapidly expanding from below upward to near the middle of the outer chamber, where it is suddenly contracted to the aperture, and on the lateral margins again slightly expanding. The rate of increase in diameter, as compared with the increased length, is about as one and two, when measured on the inside curvature. Transverse section of the shell obtusely subtriangular, flattened or but slightly convex on the inner surface, rounded on the lateral surfaces, and obtusely rounded on the back; the dorso-ventral and lateral diameters are about as four and five, and the triangular form is more perceptible in the earlier stages of growth, owing to the greater convexity of the inner face in the upper portion and on the outer chamber. Outer chamber comparatively short, being about two-thirds as high as wide. Aperture large, irregularly tri-lobed, straight on the inner face, and about four-fifths as wide as the entire width of the shell, and apparently about two-thirds as wide in a dorso-ventral direction as laterally. The exact form of the aperture on the outer side cannot be ascertained, owing to the imperfection of the specimen in this part. Septa moderately concave, very closely arranged in the lower part, but more distinctly disposed above; the rate of increase in distance somewhat gradual to near the upper portion, where two or three of the septa are slightly more crowded. In the more distant portions, three chambers occupy the space of one inch, but in the lower part of the specimen, where the transverse diameter is a little more than one and a half inches, they are less than one-twelfth of an inch apart. Siphuncle of moderate size and sub-centrally situated. Surface of the shell unknown.

The specimen from which the description is taken is an internal cast, not retaining any portion of the shelly structure; but it appears to have been destitute of strong surface markings. It measures about seven inches in length by nearly four inches in transverse diameter at the widest part, which is near the lower part of the outer chamber. The lower end is imperfect, and measures one and a half inches in transverse diameter. It is with some hesitation that I place the species under the genus *Gomphoceras*, owing to the strong curvature of the shell and the structure of the aperture, which is reversed in its relation to the curvature of the shell as compared with most species of the genus; the widest portion being on the inside curvature, instead of on the outer side. The general triangular or tri-lobed form of the aperture, together with the greater lateral diameter, would seem to overbalance the fact of the curvature.

Formation and Locality.—In limestone of the Upper Helderberg group, at Smith and Price's quarries, near Columbus, Ohio. Named in honor of Mr. E. Hyatt, from whose collection it was obtained.

Gomphoceras amphora.

PLATE III, fig. 9.

Gomphoceras amphora Whitf., Ann. N. Y. Acad. Sci., March, 1882, p. 207.

Shell of large size, elongate-ovate or short sub-fusiform, somewhat rapidly expanding from below upward to within a short distance of the base of the outer chamber; from which point it again contracts more rapidly to about one-half the height of the outer chamber, and is then drawn out into a narrow neck, resembling the neck of a bottle, of a width but little exceeding one-third of the diameter of the larger portion of the shell. Aperture not distinctly traced, but on the side figured, there is an appearance of a deep, rather narrow sinus, extending nearly one-half the depth of the outer chamber. The shell bears the appearance, also, of having been curved, as indicated principally by the obliquity of the septa, which are numerous, rather deeply concave, and arranged at a distance of about one-fourth of an inch in the largest part of the specimen, and decreasing in distance below and above; while near the base of the outer chamber there about six septa closely crowded together. Position of the siphuncle not determined.

The species resembles *G. eximium* Hall, of the same formation, in the lower part of its length, although more rapidly expanding, but in the upper part, and especially near the aperture, differs entirely from any other species known.

Formation and Locality.—In the limestone of the Upper Helderberg group, in Marion county, Ohio. Collection of Columbia College, New York.

Gomphoceras Sciotense.

PLATE IV, fig. 4; PLATE V, fig. 2; PLATE VI, figs. 6 and 7.

Gomphoceras Sciotense Whitf., Ann. N. Y. Acad. Sci., March, 1882, p. 208.

Shell of medium size or smaller, short obconical in form, or rapidly expanding from the apex upward; slightly flattened in a dorso-ventral direction, giving a broadly oval transverse section, which is a little more flattened on the dorsal than on the opposite side, in the more perfect specimen, but may not be constantly so in all individuals. Septa shallow, arranged at nearly equal distances from each other in the larger parts, and numbering about seven in an inch, except near the outer chamber, where there are usually one or two more closely arranged. The outer chamber is proportionally short, and rapidly contracted in the upper part to about one-half the diameter below, to form the transversely sub-triangular or obscurely trilobed aperture, which is rounded at the lateral extremities, straightened on the dorsal side, and provided with a moderately deep but rather narrow sinus on the ventral margin. Siphuncle proportionally small, and situated close to the dorsal side.

Only two individuals have thus far been observed, and these show some slight variation in the form of transverse section and in the proportional length of the outer chamber; the one retaining the chambers being shorter above, and more flattened on the dorsal side than the other. In this specimen, the septa are somewhat obliquely arranged, being highest on the dorsal side, which may, however, be owing to oblique compression in the matrix. The individuals, being both internal casts, have afforded no opportunity of observing the surface structure.

Formation and Locality.—In the limestone of the Upper Helderberg group, at Smith and Price's quarries, near Columbus, Ohio. Collected by Mr. Hyatt.

Genus CYRTOCERAS Goldf.

Cyrtoceras cretaceum.

PLATE IV, figs. 2 and 3.

Cyrtoceras cretaceum Whitf., Ann. N. Y. Acad. Sci., March, 1882, p. 209.

Shell of medium size, somewhat moderately expanding in its upward growth to the base of the outer chamber, from which point it again contracts to the aperture; the increase not always regular, but in some individuals more abruptly expanding above than below. Shell slightly curving throughout its length, appearing less arcuate in the upper portion, owing to the contraction of the outer chamber toward the aperture. Transverse section oval, widest in a lateral direction, and with the inner surface much less arcuate than the outer or dorsal surface. Outer chamber proportionally short, the length not exceeding the dorso-ventral diameter of the lower end; margin simple, so far as can be determined from any of the specimens, showing only a broad, shallow sinuosity on each side. Septa somewhat closely arranged and deeply concave, but slightly increasing in distance in the upper part, the average length of the chambers being about one-tenth of an inch, but somewhat more crowded just below the outer one. Siphuncle of moderate size, situated a little within the dorsal surface, and very slightly expanded within the chambers. Surface of the shell marked only by transverse lines of growth parallel to the margin of the aperture.

The shells are moderately abundant, and show slight variations in form among individuals, especially in the rate of increase in dimensions or in the regularity of the expansion, as well as in the comparative distance between the septa; a single individual showing a much greater distance between them in the upper part of its length. The shell would probably be considered by some as belonging to the genus *Oncoceras*, as the decrease in diameter in the upper part of the outer chamber gives to the shell, below, the peculiar bulging appearance supposed to be characteristic of that genus; but the transverse form and elliptical section, together with the form of the siphuncle and other features, present characters common to the genus *Cyrtoceras*. It is most nearly related, in general form, to *C. Conradi* Hall, from the Marcellus shales of New York, but attains a much greater size, has a shorter outer chamber, and is destitute of the small lip-like sinus on the ventral side, as seen in that one. The upper portion of *Gomphoceras oviforme* Hall, from the limestone of the Marcellus shale, bears considerable resemblance, except in the closing of the aperture, which constitutes a generic difference.

Formation and Locality.—In the cherty layers of the Upper Helderberg limestone, near Dublin, and at Bellenaris quarry at Georgesville, Franklin county, Ohio.

Genus GYROCERAS DeKoninck.

Gyroceras Columbiense.

PLATE VI, fig. 8.

Gyroceras Columbiense Whitf., Ann. N. Y. Acad. Sci., March, 1882, p. 210.

Shell of about a medium size, often attaining a diameter across the disk of about six inches, although the majority of the specimens seen will not measure more than five. The shell is closely coiled, the volutions being in absolute contact and about one and a half or two in number. Volutions nearly circular in a transverse section, being a very little greater in the lateral direction than in the dorso-ventral, and the back of the volution barely perceptibly flattened on the outer portion of the larger one, but not perceptibly so on the inner portions. Septa deeply concave and distantly arranged; the chambers measuring about half an inch each, on the outer two-thirds of the body volution of a specimen where the vertical, or largest, diameter of the disk is five inches. Position of the siphuncle not absolutely determined. Surface of the shell unknown.

All the individuals of this species observed are internal casts, and occur in a rather rotten limestone, under conditions very unfavorable for the preservation of the shelly substance; consequently the surface characters have not been observed. It is an abundant species, but owing to the conditions of preservation, is not often found in collections. It will be readily distinguished from the other described species by the closely coiled volutions and the nearly circular section. It is perhaps more nearly related to *G. cyclops* Hall, 15th Rept. N. Y. State Cab. Nat. Hist., than to any other described species; but it differs from that one in its smaller size, and more rapidly increasing as well as more closely coiled volutions, and does not appear to have been provided with the broadly expanding and foliated varices which are so characteristic of that species. It might be objected, that as the shell of this species is unknown, the determination of the absence of these foliated expansions is not well authenticated; but it may be answered, that as the two species are associated in the same layers in the quarries where they are both rather common, if they were really one and the same, the shell would be preserved on these as well as on the *G. cyclops*, and the expansions readily detected.

Formation and Locality.—In the limestone of the Upper Helderberg group, near the lower part, at Smith and Price's and at other quarries near Columbus, Ohio.

Gyroceras seminodosum.

PLATE IV, fig. 5.

Gyroceras seminodosum Whitf., Ann. N. Y. Acad. Sci., March, 1882, p. 211.

Shell small, compactly coiled, and consisting, in the specimen used, of a little more than two volutions, which increase rather rapidly in diameter with increased age; they are somewhat wider transversely than in a dorso-ventral direction, and are slightly triangularly elliptical in a transverse section; the greatest transverse diameter being very slightly outside of the middle of the dorso-ventral diameter. The inner one and a half coils are smooth on the exterior, but the outer volution, for a little more than the larger half, is ornamented by a single series of comparatively large, transverse, triangularly elliptical nodes on each lateral surface, having the angular side of the node placed anteriorly and the opposite side nearly straight. The nodes are placed at distances from each other about equal to one-half the dorso-ventral diameter of the tube at the node indicated. The septa are not clearly defined and cannot be given with certainty; but they appear to be distantly placed on the inner portions of the shell, while on the nodose portion they seem to be placed at about half the distance of the nodes apart. The siphuncle has not been observed. The surface of the shell, as seen on a fragment of the substance remaining on the dorsum of the outer volution, is marked with rather close, distinct, revolving lines or ridges, crossed by more closely arranged transverse lines, which make a shallow retral bend in crossing the back of the shell.

The specimen is probably an immature shell, but is a distinctly marked species, differing strongly in its form and nodose character from any of those associated with it. It most nearly resembles *G.* (*Hercoceras?*) *paucinodus* Hall, from the Upper Helderberg group of New York (see Illust. Dev. Foss., pl. 55, figs. 1 and 2), but is less distinctly triangular in a transverse section, that one being widest near the outer portion of the volution, with a nearly regular sloping surface on the side of the whorl to its junction with the preceding one, while this species is rounded. The form of the nodes is also different—those being situated near the dorsal margin. The triangular form of these nodes is peculiar in having the two short sides of the triangle directed forward. It also differs in having a greater number of volutions for a given diameter.

Formation and Locality.—In limestone of the Upper Helderberg group, near Dublin, Ohio. Collected by Mr. Hyatt, of the State University, at Columbus, Ohio.

NOTE ON THE MARCELLUS SHALE AND OTHER MEMBERS OF THE HAMILTON GROUP IN OHIO, AS DETERMINED FROM PALÆONTOLOGICAL EVIDENCE.

During the early summer of 1878, President Edward Orton wrote, asking if I could spend a few days with him in central and southern Ohio, in an effort to ascertain from palæontological evidence, the true horizon of certain layers of rock which had been somewhat of a difficulty to him; and in the month of August I spent several days with him for that purpose. While making these somewhat hurried observations at a locality about six miles N. W. of Columbus, in Perry township, on the east bank of the Scioto river, we accidentally discovered a thin bed of dark brown shale, somewhat fissile and bituminous in character, in what Prof. Orton had considered as a representative of the Delaware limestone of Delaware, Ohio. The peculiar texture of the shales, occurring where I had expected only a light-colored limestone, excited my interest; and after a few minutes' examination, I discovered that they contain numerous flattened shells of *Leiorhynchus limitaris*, Vanuxem. I also obtained from them two specimens of *Discina minuta*, and examples of *Lingula Manni* Hall; the two former being well-known and characteristic forms of the Marcellus shales of New York. On examination, we found that these shells, especially the *Leiorhynchus*, extended through a thickness of several feet of the rock, and that the peculiar bituminous character of the shale accompanied them, but with intercalations of thin layers of less bituminous and light-colored limestones. Subsequently, at a point nearly opposite Dublin, Ohio, some miles north of the above-mentioned locality, the same shale was again recognized in a corresponding horizon, accompanied by the same species, the *Leiorhynchus* being quite numerous. At a subsequent visit, Mr. Edward Hyatt obtained *Discina Lodensis* Hall, another New York Marcellus species. At this second locality, immediately above the shale, and while the limestone layers retain much of the bituminous character, the layers become thicker and more calcareous, and their surfaces are covered with the shells of *Spirifera gregaria* Clapp, and *Tentaculites scalariformis* Hall, both of which are likewise common in the blue limestone layers at Delaware, Ohio.

A section of the rocks at the first-mentioned locality, six miles N. W. of Columbus, on the east bank of the Scioto, subsequently furnished by Prof. Orton, is as follows:

The lower bed, No. 1 of section, is a heavy-bedded limestone about thirty feet thick, representing the Columbus quarries, including the coral beds and those containing the large cephalopods. (Lower Corniferous of the Ohio Geol. Rept.)

No. 2, a thin layer of limestone, four to six inches thick densely filled with teeth, plates and bones of fishes, locally known as the "Bone-bed."

No. 3, about thirty feet of thin-bedded shaly limestone, the "Delaware bed" of Prof. Orton. The upper part of this is supposed to represent the beds of similar character at Delaware, Ohio, which contain the large fish-remains.

No. 4, about fifteen feet of bluish, somewhat marly shales, the "Olentangy shales" of N. H. Winchell. This is followed above by the Huron shales, the supposed equivalents of the Genesee slates and Portage shales of New York.

Near the lower part of No. 3, only a few feet above the "Bone-bed," occurs the dark brown shale in question, with the peculiar fossils, which I have no hesitation in pronouncing the equivalent of the Marcellus shales of New York. Admitting this—and there certainly appears to be no alternative—the rocks found above this limit should represent the Hamilton group of the New York system; and we ought to find some fossils here, characteristic of that formation, which would not pass below this line. To ascertain if this was so, I requested Mr. Edward Hyatt, who has collected carefully the fossils around Columbus, to furnish me a list[1] of the species known, with their horizons indicated; and also requested the use of specimens of species not known to occur below the horizon of the "Bone-bed," that being the most easily recognized limit, and the one most generally studied in connection with the vertical distribution. Contrary to my expectations, the species yet known not to pass below the "Bone-bed" are very few. These, with the exception of the *Tentaculites scalariformis*, have been illustrated on Plate III, and are, with two exceptions, known Marcellus and Hamilton types, one being a new species, and the other (*Spirifera Maia* Bill.), occurring in the Upper Helderberg limestone in Canada. The examination of the upper layers for characteristic fossils was not carried far enough to make it perfect, owing to Mr. Hyatt's absence from Columbus; but the few forms found above these bituminous layers will readily be recognized as characteristic of the Hamilton group, and warrant one in considering the Black shales and other beds coming above these thin limestones in central Ohio, as equivalent to the Genesee slates and succeeding formations of New York.[2]

The following lists, prepared by E. and H. Hyatt, of Columbus, Ohio, are from the limestones within twenty-four miles of that place. Those of the first list are from below the horizon of the "Bone-bed," and the next from above; *Strophomena rhomboidalis* being the only species fully recognized from both horizons. All species have been collected by them from known horizons, or have been seen from the beds by myself.

[1] Names given by Mr. Hyatt, which I cannot verify.—R. P. W.

[2] These lists will be found appended at the end of the present article.

Species from below the "Bone-Bed."

PROTOZOA.

Stromatopora DeBlainville.

S. granulosa Nich.

S. nodulata Nich.

S. ponderosa Nich.

S. Sanduskyensis Rominger.

S. substriatella Nich.

Cannopora Phillips.

C. columnaris Nich.[1]

C. densa Nich.[1]

Receptaculites DeFrance.

R. Devonicus Whitf.

RADIATA.

Favosites Lamark.

F. basalticus Goldf.

F. Gothlandic Lamarck. (?)

F. hemispheric Yand. and Shumard.

F. invaginat Nich.

F. pleurodictyoides Nich.

F. polymorph Goldf. ?

F. turbinat Billings.

Michelinia DeKoninck.

M. convexa Emmons.

M. maxima Troost.

Emmonsia Ed. and Haime.

E. Emmonsi Hall.

Trachypora Ed. and Haime.

T. elegantula Billings.

[1] Since writing the above remarks, Vol. V. of the Palæont. of New York has been published. In it the author has, on p. 139, some remarks on the limestones at the Falls of the Ohio, and their relations to the Hamilton group of New York. After showing that the Hydraulic-cement beds of the Falls of the Ohio are the equivalents of the Hamilton group of New York (which had already been stated in the Geol. Rept. Ind., 1875, pp. 147, 148, and also shown in sections on page 157), the author remarks, "In the State of Ohio, similar conditions may be inferred, from the fact that certain known species of Hamilton fossils are published in the Ohio Geological Reports as from the Corniferous group." At the meeting of the Am. Assoc. for the Advancement of Science, at Saratoga, August, 1879 (see Proc. A. A. A. Sci., vol. xxviii, p. 297), I read a notice of the occurrence in Ohio of rocks representing the Marcellus shales of New York, embracing most of the substance of this note, and in which it was shown that a considerable thickness of the limestones previously recognized as "Corniferous" in Ohio, were above the horizon of the beds which I had recognized, from palæontological and lithological evidence, as of the age of the Marcellus shale, and would be of necessity equivalents of the Hamilton group. This was in August, 1879. The volume above-mentioned is dated, in the letter of transmissal, Dec. 15, 1879.

AULOPORA Goldfuss.
A. cornuta Bill.
A. filiformis Bill.
A. tubæformis Gold. ?
SYRINGOPORA Goldf. ?
S. Hisingeri Bill.
S. Maclurei Bill.
S. tabulata Ed. and Haime.
ERIDOPHYLLUM Ed. and Haime.
E. Simcoense Bill.
E. strictum E. and H.
E. Verneuilanum E. and H.
STYLASTREA Lonsdale.
S. Anna Whitf.
ZAPHRENTIS Rafinesque.
Z. cornicula Ed. and H.
Z. Edwardsi Nich.
Z. gigantea Ed. and H.
Z. prolifica Bill.
Z. Wortheni Nich.
CYATHOPHYLLUM Goldf.
C. rugosum Hall.
C. Zenkeri Bill.
HADRIOPHYLLUM Ed. and H.
H. D'Orbignyi Ed. and H.
HELIOPHYLLUM Ed. and H.
H. confluens Hall.
H. Halli Ed. and H.
AULACOPHYLLUM Ed. and H.
A. sulcatum Ed. and H.
CYSTIPHYLLUM Lonsdale.
C. Americanum Ed. and H.
C. Ohioense Nich.

CRINOIDEA.

MEGISTOCRINUS O. and S.
M. spinulosus Lyon.
DOLATOCRINUS Lyon.
D. multiradiatus Hall.
D. radiatus Hall.

BLASTOIDEA.

NUCLEOCRINUS Conrad.
N. Verneuili Troost.
CODASTER McCoy.
C. pyramidatus Shumard.

ANCYROCRINUS Hall.
A. spinosus Hall.

MOLLUSCA.

BRYOZOA Emmerich.

STICTOPORA Hall.
S. Gilberti Meek.

LICHENALIA Hall.
L. lichenoides Meek.

BRACHIOPODA.

DISCINA Lamarck.
D. grandis Vanux.?

CRANIA Retzius.
C. crenistriata Hall.
C. Hamiltoniæ Hall.

ORTHIS Dalman.
O. Livia Bill.
O. propinqua Hall.
O. Vanuxemi Hall.

STREPTORHYNCHUS King.
S. flabellum Whitf.
S. pandora Bill.

STROPHODONTA Hall.
S. ampla Hall.
S. demissa Conrad.
S. hemispherica Hall.
S. inequiradiata Hall.
S. nacrea Hall.
S. Patersoni Hall.
S. perplana Conrad.
S. subdemissa Hall.?

STROPHOMENA Rafinesque.
S. rhomboidalis Wilck.

CHONETES Fischer.
C. acutiradiata Hall.
C. arcuata Hall.
C. deflecta Hall.
C. mucronata Hall.?
C. Yandellana Hall.

PRODUCTELLA Hall.
P. spinulicosta Hall.

SPIRIFERA Sowerby.
S. acuminata Con.
S. duodenaria Hall.
S. euruteines Owen.
S. fimbria'a Con.

S. Grieri Hall.
S. macra Hall.
S. macrothyris Hall.
S. Manni Hall.
S. Marcyi Hall.
S. Oweni Hall.
S. segmenta Hall.
S. varicosa Hall.

Spiriferina D'Orb.
S. raricosta Conrad's sp.

Cyrtina Davidson.
C. Hamiltoniæ Hall.

Meristella Hall.
M. nasuta Conrad's sp.
M. scitula Hall.

Nucleospira Hall.
N. concinna Hall.

Atrypa Dalman.
A. reticularis Linn.

Rhynchonella Fischer.
R. Billingsi Hall.
R. Carolina Hall.
R. Dotis Hall.
R. Thetis Billings.
R.? raricosta Whitf.

Pentamerella Hall.
P. arata Hall.

Terebratula Schlotheim.
T. Sullivanti Hall.

Tropidoleptus Hall.
T. carinatus Conrad.

LAMELLIBRANCHIATA.

Aviculopecten McCoy.
A. crassicostatus H. and W.
A. parilis Conrad.

Pterinea Goldf.
P. flabella Conrad? The specimens referred to this species are very doubtfully identified. They are large, coarse forms, very unlike any of those in the higher beds.

Mytilarca H. and W.
M. ponderosa H. and W.
M. percarinata Whitf.

Conocardium Brown.
C. trigonale Hall. *C. Ohioense* Meek, is the young of the above.

Goniophora Phillips.

G. perangulata H. and W.

Paracyclas Hall.

P. lirata Conrad.

P. Ohioensis Meek=*P. lirata* Conrad. *P. occidentalis* H. and W.

Modiomorpha H. and W.

M. elliptica?

M. perovata Meek.

Sanguinolites McCoy.

S. Sanduskyensis Meek.

GASTEROPODA.

Platyceras Conrad.

P. attenuatum Meek.

P. bucculentum Hall.

P. carinatum Hall.

P. conicum Hall.

P. dumosum Conrad.

P. multispinosum Meek.

P. squalodens Whitf.

Platyostoma Conrad.

P. lichas Hall.

Euomphalus Sowerby.

E. Decewi Billings=*Pleuronotus Decewi* Hall.

Turbo Klein?

T. Kearneyi Hall=*Palæotrochus Kearneyi.*

T. Shumardi D'Vern.

Isonema M. and W.

I. bellatula Hall=*Callonema bellatula* Hall.

I. depressum M. and W.

I. humile Meek.

Xenophora Fischer.

X. antiqua Meek.

Naticopsis McCoy.

N. æquistriata Meek.

N. cretacea H. and W.

N. levis Meek.

Loxonema Phillips.

L. Leda Hall.

L. Hamiltoniæ Hall.

L. pa vulum Whitf.

L. pexatum Hall.

Orthonema M. and W.

O. Newberryi Meek.

MACROCHEILUS Phillips.
M. priscus Whitf.
PLEUROTOMARIA DeFrance.
P. adjutor Hall.
P. Doris Hall=*Cyclonema Doris* Hall.
P. Hebe Hall.
P. Lucina Hall.
MURCHISONIA De Verneuil.
M. desiderata Hall.
M. Maia Hall.
M. obsoleta Meek.
DENTALIUM Linnæus.
D. Martini Whitf.
BELLEROPHON Montfort.
B. Newberryi Meek.
B. Pelops Hall.
B. propinquus Meek.

PTEROPODA.

CONULARIA Miller.
C. elegantula Meek.
TENTACULITES Schloth.
T. scalariformis Hall.

CEPHALOPODA.

ORTHOCERAS Breynius.
O. nuntium Hall.
O. Ohioense Hall.
O. profundum Hall.
TREMATOCERAS Whitf.
T. Ohioense Whitf.
GOMPHOCERAS Sowerby.
G. amphora Whitf.
G. eximium Hall.
G. Hyatti Whitf.
G. sciotense Whitf.
CYRTOCERAS Goldfuss.
C. cretaceum Whitf.
C. Ohioense Meek.
C. undulatum Vanuxem?
GYROCERAS Meyer.
G. Columbiense Whitf.
G. Cyclops Hall.
G. inelegans Meek.
G. Ohioense Meek.
G. seminodosum Whitf.

CRUSTACEA.

Dalmania Emmerich.
D. Calypso Hall.
D. Helena Hall=*D. Ohioense* Meek.
D. selenurus Green.

Phacops Emmerich.
P. rana Green.

Proetus Steininger.
P. crassimarginatus Hall.

Species from above the Bone-Bed.

CRINOIDEA.

Goniasteroidocrinus Lyon.
G. spinigerus Hall.

BRACHIOPODA.

Lingula Brugiere.
L. Manni Hall.
L. ligea Hall.

Discina Lamarck.
D. Lodensis Hall.
D. minuta Hall.

Strophomena Rafinesque.
S. rhomboidalis Wilck.

Chonetes Fischer.
C. scitula Hall.
C. reversa Whitf.

Spirifera Sowerby.
S. Maia Billings.
S. zic-zac Hall.

Leiorhynchus Hall.
L. limitaris Vanuxem.

LAMELLIBRANCHIATA.

Aviculopecten McCoy.
A. equilaterus Hall.

Pterinea Goldfuss.
P. similis Whitf.

Actinodesma Sandberger.
A. subrectum Whitf.

Grammysia DeVern.
G. bisulcata Conrad.

Nyassa H. and W.
N. arguta H. and W.

RECOGNIZED SPECIES FROM THE MARCELLUS SHALES OF OHIO.

MOLLUSCOIDEA.

BRACHIOPODA.

Genus LINGULA Brug.

Lingula Manni.

PLATE VII, figs. 1 and 2.

Lingula Manni Hall.; 16th Rept. State Cab N. Y., p. 24; Pal. N. Y., vol. 4, No. 6, pl. 2. fig. 3.

Shell of medium size, longitudinally subovate, somewhat more than half as wide as long, very obtusely pointed at the upper end, with subparallel lateral margins, and often rather squarely truncate in front, with rounded basal angles. Substance of the shell thin and polished, with irregular concentric lines of growth which do not produce any marked surface character. Interior of the valves sometimes characterized by a thin, hair-like, median ridge, which extends to below the middle of the valve, leaving a distinct median depression on the cast where the substance of the shell has been removed.

The specimens of this species are usually about three-fourths of an inch in length by a little less than half an inch in width. They vary considerable in outline, the variation being principally in the form of the front, some of them being much more round on the front margin than others, or than the type specimens. This variation also causes a difference in the form of the lateral margins producing a more rounded or oval form, and giving the shells an appearance approaching that of *L. Delia* Hall, Pal. N. Y., vol. iv, p. 12, pl. 2, fig. 9. The two forms are associated in the shales and can scarcely be considered as distinct species. Many of the specimens are so distinctly like *L Manni*, that it seems impossible the others having so slight a difference in form could be distinct, that I have not thought it advisable to attempt their separation.

Lingula ligea?

PLATE VII, figs. 3 and 4.

? Lingula ligea Hall; Pal. N. Y., vol. 4, part 1, p. 7, pl. 1, fig. 2.

Shell elongate elliptical in general outline, being about twice as long as wide, rounded on the anterior end, and slightly more pointed at the beak in full grown forms; but in young or partly grown shells the extremities appear nearly equal. Valve moderately convex, and sometimes a very little flattened along the middle. Surface marked by fine concentric lines of growth.

The examples referred with some slight doubt to this species are quite numerous in the thin bedded layers of bituminous limestones from above the "Bone-bed," at Smith and Price's quarries, near Columbus, Ohio. The young shells have much the appearance of *L. spatulata* Hall, but when fully grown are almost exactly of the character of *L. ligea.*

Genus DISCINA Lamarck.

Discina minuta.

PLATE VII, figs. 5 and 6.

Orbicula minuta Hall, Geol. Rept. 4th Dist. N. Y., p. 180.
Discina minuta Hall, Pal. N. Y., vol. 4, p. 16, pl. 1, fig. 16.

Shell minute, subcircular. Dorsal valve moderately convex or flattened as occurring in the shales, the apex situated a little nearest the posterior margin, often about one-third of the diameter from the border, pointed and directed toward the posterior or peduncular margin. Ventral valve not observed. Surface of the shell marked only by closely arranged, very fine concentric striæ.

The shells of this species usually occur of about three-sixteenths of an inch in diameter, and are usually very much flattened by compression in the shales. They closely resemble those from the black Marcellus shales of New York, but lack that convexity and finely polished surface usually present on the Avon specimens.

Formation and Locality.—In the brown shale capping of the Upper Helderberg limestone near Dublin, Ohio.

Discina Lodensis.

PLATE VII, fig. 7.

Orbicula Lodensis Hall, Geol. Rept. 4th Dist. N. Y., p. 223.
Orbicula Lodensis Vanuxem, Geol. Rept. 3d Dist. N. Y., p 168.
Discina Lodensis Hall, Pal. N. Y., vol. 4, p. 22, pl. 1, fig. 14.
Discina media Hall, Pal. N. Y., vol. 4, p. 20, pl. 2, figs. 25–29.

A single lower valve, referable to this species, was obtained from the black shales. The form is subcircular and discoid, a little narrowed toward the peduncular margin, and broadest forward of the middle. Foramen comparatively small, narrowly elliptical, not extending quite to the margin, the inner end not reaching to the centre of the disk; the point of origin on the valve being slightly eccentric. Surface marked by fine, not closely arranged, elevated, concentric lines.

The specimen described and figured very closely resembles the New York species above cited; so nearly so in fact as to preclude the possibility of detecting specific differences. The specimens from New York differ greatly among themselves in the general form and outline of the valves; so that on this character alone it would not be safe to rely; and the general features of the shell, so far as can be determined from a single valve, are not the same in both cases.

Formation and Locality.—In the brown shales at the top of the Upper Helderberg limestone near Dublin, Ohio.

Genus CHONETES Fischer.

Chonetes scitula.

PLATE VII, fig. 10.

Chonetes scitula Hall, Pal. N. Y., vol. 4, pt. 1, p. 130, pl. 21, fig. 4.

Shell small and semicircular in outline, or in some cases semi-ovate being a little more than half of a circle. Hinge-line as long or a little longer than the shell below, and but slightly mucronate at the extremities. Ventral valve nearly equally convex or a little depressed just within the cardinal extremities. Dorsal valve flattened or slightly concave. Surface marked with about sixty, fine, even striæ in the larger specimens, as counted on the ventral valve, and the hinge-line bears three short spines on each side of the beak.

The specimens being in limestone are all much exfoliated, so that the surface striæ are not distinctly shown toward the cardinal borders. The shells are perhaps a little longer than the more typical forms of *C. scitula* as they occur in the Hamilton shales near Cayuga Lake, N. Y., and are somewhat intermediate in this respect between those and *C. Yandelli* Hall, from the hydraulic limestones from near Louisville, Ky.

Formation and Locality.—In thin-bedded bituminous limestones of the Marcellus shale, above the "Bone-bed" at Smith and Price's quarries, near Columbus, Ohio.

Chonetes reversa.

PLATE VII, figs. 8 and 9.

Chonetes reversa Whitf., Ann. N. Y. Acad. Sci., 1882, 213.

Shell of about medium size, semicircular in outline, with a long, straight hinge-line exceeding the width of the shell below. Valves resupinate, or reversed in their curvature; the ventral being very slightly convex in the earlier stages of growth, and subsequently recurved so as to appear concave; the entire deflection from a plane being very little, so that the general appearance of this valve may be said to be nearly flat. Area linear. Hinge-line ornamented by four, long, very slender spines on each side of the centre, which are projected from the hinge-line at an angle of about 65 degrees, measured on the outside; or 115 degrees as counted on the inside of the spine. Surface of the ventral valve marked by exceedingly fine striæ, which are slightly alternating in size; there being from two to five finer ones between the coarser kind. Interior of the valve characterized by fine pustules, arranged in indistinct lines, presenting the usual characteristics of the genus. Dorsal valve not positively known; but there is associated with it, in the same layers, a slightly convex valve with similar striæ, but more distinctly alternating, which may possibly represent this valve. Its form is similar, and the convexity correspondingly great.

This species is peculiar in its resupinate character, so far as the genus is known in American Devonian rocks, and this character, together with its form, its fine striæ, and its nearly erect slender spines, will readily distinguish it from any other species. The dorsal valve above spoken of was at first supposed to be the young of *Strophodonta perplana* Conrad's sp., but the similarity in size and character of striæ to this species renders it doubtful

Formation and Locality.—In thin-bedded bituminous limestone, from above the "Bone-bed" at Smith and Price's quarries, near Columbus, Ohio.

Genus SPIRIFERA Sowerby.

Spirifera Maia.

PLATE VII, fig. 14.

Athyris Maia Billings, Can. Jour. Ind. Sci. and Arts, May, 1860, p. 276.
Sperifera Maia (Bill.) Hall, Pal. N. Y. vol. 4, pt. 1, p. 416, pl. 63, figs. 6–13.

Several single valves of this species have been obtained from the thin-bedded limestones, associated with the Discina and Leiorhynchus bearing shales, on W. Meeteer's farm, two and a half miles south of Dublin, Ohio; but in too imperfect a condition for illustration; still, however, sufficiently distinct to leave no reasonable doubt of their identity. They are smaller in size than those from the Upper Helderberg limestone of Canada, but otherwise not different so far as can be discovered from the imperfect material on hand.

Genus LEIORHYNCHUS Hall.

Leiorhynchus limitaris.

PLATE VII, fig. 11.

Orthis limitaris Vanuxm, Geol. Rept. 3d Dist. N. Y., 1842, p. 146, fig. 3.
Atrypa limitaris Hall, Geol. Rept. 4th Dist. N. Y., 1843, p. 182, fig. 11.
Leiorhynchus limitaris Hall, 13th Rept. State Cab., p. 85, 1860.
Leiorhynchus limitaris Hall, Pal. N. Y. vol. 4, p. 356, pl. 56, figs. 6–21.

Shell small in size, seldom exceeding five-eighths of an inch in width and usually not more than three-eighths; form orbicular in outline and lenticular in profile when not compressed. Valves subequal in depth and rotundity, the ventral beak slightly extending beyond that of the dorsal and the middle third or more of the width of the valve depressed, forming a broad but shallow sinus which extends to within a short distance of the beak. Dorsal valve elevated in the middle to form the fold which corresponds to the sinus of the ventral, but which does not continue much beyond the middle of the valve. Surface of the shell marked by from ten to twelve or more low, angular plications, four or five of which are seen in the sinus of the ventral, and a corresponding number elevated on the fold of the dorsal valve, and from three to four or even five marks each side of the shell beyond the limit of the fold and sinus. The specimens are usually marked also by several strong concentric lines of growth which form strong varices on the larger specimens, and the plications are not unfrequently divided by slighter depressions along their surfaces, which gives the appearance of being bifurcated, and the plications themselves are very unequal in strength and seldom extend entirely to the apex of the valves.

This shell is a very well-marked species and cannot well be mistaken for any other of the several species, which, so far as is yet known, are limited to certain horizons; this one characterizing the horizon of the Marcellus shale in New York, wherever the species has been found. Its occurrence in Ohio has not heretofore been known or suspected, and its presence in numbers, flattened and compressed in a dark brown, somewhat fossil shale, presenting so exactly the characters and appearance that it does in the shales of New York, and also associated with other characteristic forms of the Marcellus shale, is a somewhat significant fact, and one of considerable importance in its stratigraphical relations.

MOLLUSCA.

LAMELLIBRANCHIATA.

Genus AVICULOPECTEN McCoy.

Aviculopecten? equilatera.

PLATE VII, fig. 16.

Avicula equilatera Hall, Rept. 4th Dist. Geol. Surv. N. Y., 1843, p. 180, Table 71, fig. 7[1].

Shell small and slightly oblique, somewhat trapezoidal in outline, hinge-line straight and as long as the greatest length of the shell; beaks nearly central on the hinge; anterior cardinal angle mucronate, and the anterior border gradually sloping backward from the point; basal broader broadly rounded; posterior margin slightly extended at the lower third beyond the extremity of the hinge, and also slightly sinuate above to form the sulcus of the posterior wing, which is small and rounded. Surface of the valves very depressed convex, and marked by numerous fine bifurcating radii, and also by several concentric undulations which give to the shell a strongly corrugated appearance.

The species is, in New York, a very characteristic form of the Marcellus shales, and is readily distinguished from any of those of the Hamilton or other formations by its fine striæ and corrugated surface. The striæ, although somewhat increasing in strength toward the margin, are frequently bifurcated so that the increase in strength is not equal to that of simple radii.

Formation and Locality.—In the bituminous shale from above the "Bone-bed" at Smith and Price's quarries, near Columbus, Ohio, associated with *Discina minuta* and *Leiorhynchus limitaris.*

Pterinea similis.

PLATE VII, fig. 15.

Pterinea similes Whitf., Ann. N. Y. Acad. Sci., 1882, p. 214.

Shell small, oblique; the body, exclusive of the wings, being almost regularly although obliquely ovate in outline, the anterior part being the larger; hinge-line about two-thirds as long as the entire length of the valve; anterior wing small, distinctly rounded on the end, and separated from the body of the shell, on the left valve, by a distinct sulcus along the surface, and which constricts the margin of the shell; posterior wing one-third longer than the anterior side, pointed at the extremity and sinuate below. Body of the valve ventricose, strongly so on the umbone, with a strong, tumid beak, which projects distinctly beyond the hinge. Surface of the left valve marked by distinct radii, which plainly alternate in strength over the body of the valve, but less distinctly so toward and on the wings; also, by less strong concentric lines, and varices of growth. Right valve unknown.

The shell is of the type of *Pterinea decussata* Hall, which occurs abundantly in the Hamilton group in New York, but is of extremely small size, and very ventricose; the proportionally strong varices of growth

[1] *This is probably the A. (Pterinopecten) invalidus* Hall, *of* Pal. N. Y., vol. 5, part I, pl. 1, fig. 18.

showing its adult character. The type is one represented in the Devonian rocks, from the Hamilton to the top of the Chemung, inclusive, in New York, by several distinct species, but which is seldom recognized below this horizon. We may, therefore, consider it as an additional evidence of the age of the beds in which it is found.

Formation and Locality.—In the thin shaly layers of bituminous limestone, from above the "Bone-bed" at Smith and Price's quarries, near Columbus, Ohio.

SPECIES FROM THE LIMESTONES ABOVE THE "BONE-BED," IN THE VICINITY OF COLUMBUS, OHIO, AND NOT KNOWN TO OCCUR BELOW THAT HORIZON.

ECHINODERMATA.

CRINOIDEA.

Genus GILBERTSOCRINUS Phillips.

Gilbertsocrinus spinigerus.

PLATE VII, fig. 12.

Trematocrinus spinigerus Hall, 15th Rept. State Cab., p. 128.
Gilbertsocrinus (*Trematocrinus*) *spinigerus* Hall, Descript. of New Species of Grinoidea from the Carboniferous rocks of the Mississippi valley, Plate I, fig 9.

Body small, of nearly equal height and width, broadly truncated at the base, slightly rounded and expanded in the lower half of the height, but generally contracted above to the base of the arms. The base of the cup is deeply impressed, including the basal and sub-radial plates; the first radials form the lowest part of the cup, the second radials are placed at the point of its greatest diameter, and the third at about one-half the entire height. The first and second radials are comparatively large, the first being heptagonal, the second hexagonal, and the third which are smaller than the second are heptagonal, obtusely cuneiform above, and support on each sloping face two proportionately large supra-radial plates, one above the other, the upper face of the second one of which is excavated and its surface cicatrized for the attachment of the true arms, while the summit arms arise from above and are formed by the junction of the plates from the two adjacent rays. The first interradial plates are moderately large, are truncated below the rest on the upper truncated ends of the subradials, thereby separating the first radials of the adjacent rays from each other. Above the first interradials the plates are in arches of three plates each for two or three transverse ranges with two and then one at the top, except in a single lateral area where there is but two plates transversely.

The anal area is somewhat larger than the other areas, but the arrangement of plates cannot be determined from excess of silicification. The inter-supraradial areas are marked by two plates in each, situated one above the other, the second one having its upper end forming a part of the summit or dome of the crinoid. The summit arms have been small but proportionately strong at the base, the earlier series of plates only being reserved.

The surface of the plates has been elevated in the middle and perhaps ridged in a stellate manner, but they are too small and too much weathered to allow of a perfect determination of this feature. The centre of the radial series is elevated so as to form a distinctly marked ridge traversing the series from and above the third radial; while the first and second radials bear short obtusely rounded spines, of a length somewhat greater than the diameter of the plate. The spines of the first radials project outward and downward at an angle of nearly forty-five degrees to the line of the base, while those of the second radials are a little inclined below a horizontal.

I had at first described this as a distinct species from the New York form, on account of the less depressed interradial areas, but on more critical comparison have decided that this may be only an individual difference. It agrees so nearly in all the details of structure in the permanent features of the crinoid, that it does not seem possible to point out any distinguishing features that can be called specific. It is true that in the details of the true and the summit arms there may have been distinguishing characteristics, but in their absence I should prefer not to name it as a different species from that one.

Formation and Locality.—In limestone above the "Bone-bed," at Smith and Price's quarries, near Columbus, Ohio. Hyatt Brothers, collectors.

MOLLUSCOIDEA.

BRACHIOPODA.

Genus SPIRIFERA Sowerby.

Spirifera ziczac.

PLATE VII, fig. 13.

Dethyris ziczac Hall, Geol. Rept. 4th Dist. N. Y., 1843, p. 200, fig. 5.
Spirifera ziczac Hall, Pal. N. Y., vol. 4, p. 222, pl. 35, figs. 15–23.

The specimens of this species recognized in Ohio are in a very imperfect condition, being single valves preserved in a limestone matrix, and consequently much exfoliated when detached from the rock. Enough, however, remains to show the strongly lamellose structure of the surface, which together with the form of the shell and the mesial rib in the bottom of the sinus of the ventral valve is sufficient to fully characterize them as belonging to this species.

The form of the ventral valve is somewhat triangular, much wider than high, the beak somewhat prominent and extended beyond the line of the hinge; body of the valve ventricose and strongly arcuate, with a deep, moderately wide mesial sinus, the bottom of which is occupied by a slightly elevated rib, corresponding to the depression in the fold of the dorsal side; from eight to ten angular ribs occupy each side of the valve; cardinal area moderately high and incurved, foramen nearly as wide as high. Surface of the shell marked by strong, concentric, lamellose lines.

Formation and Locality.—In the blue limestone layers above the "fish-beds" at Delaware, Ohio.

MOLLUSCA.

LAMELLIBRANCHIATA.

Genus PTERINEA Goldfuss.

Pterinea flabella.

PLATE VII, fig. 17.

Avicula flabella Conrad, Jour. Acad, Nat. Sci. Phila., 1st series, vol. 8, p. 238, pl. 12, fig. 8.

Avicula flabella (Conrad), Vanux., Geol. Rept. 3d Dist. N. Y., 1842, p. 152, fig. 3.

Shell obliquely subrhombic including the wings, or the body of the valves alone obliquely ovate, largest below. Hinge line straight, generally pretty long, especially on the posterior side, the wing on this side usually extending backward as far as the posterior extremity of the body of the shell, and sometimes even beyond that point; but always distinctly separated from it by a broad, more or less deep, rounded sinus; leaving the wing of a triangular form, with the extremity sometimes rounded but often pointed or even mucronate. Anterior wing on the left valve much smaller, but still well developed, rounded on the margin, sloping on the cardinal border, and separated from the body of the shell by a broad, often deep, rounded channel, which gradually widens with the growth of the shell. Body of the left valves highly convex, and often with an abrupt cardinal slope much straightened beyond the middle of the length. Beak large, tumid, projecting somewhat beyond the cardinal border, and placed at about one-third or less than one-third of the entire length of the cardinal line from the anterior extremity; anterior border of the valve rounding backward from a little below the sinus of the anterior wing, and usually forming a nearly regular curve to beyond the middle of the valve before beginning the upward curvature of the posterior portion. Posterior extremity of the valve subangular at the point of greatest length. Surface of the left valve marked by several strong, distinct, radiating costæ, varying in number on different individuals but usually ten or twelve; those making the centre of the valve and on the umbonal slope being nearly straight in their direction from the beak to the base of the shell; while those nearer the anterior end become more and more curved in their direction as they approach the margin. From three to five intermediate costæ occupy the usually slightly concave but often flattened interspaces. The entire surface of the valve is often marked by more or less strongly marked concentric lines of growth, which in crossing the stronger radii often form lamellose projections on their surface when perfectly preserved, but are usually represented by small knotty prominences as commonly seen. The posterior wing is often marked by indistinct radiating lines, though not uncommonly these are entirely obsolete, and the concentric lines are strongly marked. The right valve of this shell is very slightly concave, proportionately smaller than the left, with the radiating lines much subdued, and the concentric lines not so elevated or knotty.

The specimens of this species observed from the rocks above the "Bone-bed," in Ohio, have been left valves mostly. I have a recollection, however, of having seen one slab in the Ohio State Collection, at Columbus, which contained the impression of one right and one left valve, possessing the usual features of the species common in the Hamilton rocks of New York; and which was said to be from layers above the "Bone-bed." The specimen figured on Plate XII, fig. 17, is from this horizon, and presents all the features common to the New York Hamilton forms, including the great gibbosity of the left valve. In the Upper Helderberg limestones of New York few representatives of this species have been recognized, and those present a coarser, ruder form than the Hamilton group specimens; and specimens from the limestones from below the "Bone-bed," near Columbus, are not uncommon, but are very large, very coarse, and rude in character, having but a distant resemblance to the typical forms of the species. These I strongly suspect are properly a distinct species, but the examples thus far obtained have been of so imperfect a character as not to furnish characters sufficiently marked to determine this question.

Formation and Locality.—In rocks above the "Bone-bed;" horizon known as the "Petroleum Rock," in Tully township, Marion county, Ohio, The specimen figured is from the State collection at Columbus, and was collected by Rev. Mr. Herzer.

Genus ACTINODESMA Sandb.

Actinodesma subrecta.

PLATE VII, fig. 20.

Actinodesma subrecta Whitf., Ann. N. Y. Acad. Sci., 1882, p. 215.

Shell of moderate size; the body of the shell, exclusive of the wings and hinge extensions, ovate in outline, and slighly oblique to the cardinal line. Hinge-line extended in the form of strong articulations or wings on the sides of the shell; the upper margin straight, or a little declining on each side of the beak; anterior wing short, triangular and divided from the body of the shell by a deep and wide sub-triangular notch; posterior side long and sub-mucronate at the extremity, three to three and a half times long as the anterior side, and its area much greater, extending along the body of the valve to nearly half its length from the beak. Body of the left valve more than moderately convex, and strongly arcuate or bent between the beak and base of the shell; so that when placed on a flat surface, the margin, especially on the posterior side, would be much elevated above the plane. Beak of the valve large, sub-tumid, and slightly extended above the cardinal line. Length of the body of the shell, from the cardinal line to the base, about one-fifth greater than across it in the opposite direction. Anterior border broadly rounded, the basal margin more sharply so, with a slight angularity at its junction with the nearly direct posterior border. Surface of the shell marked by irregular, concentric, strongly lamellose lines, resembling those of the oyster. Right valve not yet observed from Ohio.

The species is allied to *A. recta*—*Avicula recta* Conrad, but is shorter, more ventricose on the left side, more arcuate or bent, and with less extended wings. It is not an uncommon species in the soft shales of the Hamilton group of New York, where it is readily recognized from *A. recta* by the above mentioned characters. The *A. recta* is most common in the arenaceous beds of eastern New York, while this is the prevailing form among the soft shales further west. The right valve is there recognized as being shorter than the left, concave instead of convex, with an appressed beak or umbo not extending beyond the cardinal line, and the valve is much thinner in its substance.

Formation and Locality.—In layers of brownish limestone above the "Bone-bed," at Fishinger's mill, Franklin County, Ohio. Collected by the Hyatt brothers, of the S ate University at Columbus.

Genus NYASSA H. & W.

Preliminary Notice of Lamellibranchiata shells of the Upper Helderberg Hamilton and Chemung Groups, etc., Albany, N. Y. 1869, p. 28 (generic description omitted):—Whitf. Ann. N. Y. Acad. Sci., 1882, p. 216.

Shells bivalve, very oblique and transversely ovate in form. Posterior hinge-plate narrow, bearing from one to four long, slender, ridge-like teeth. Anterior plate broad, marked by numerous small point-like teeth with intermediate depressions, arranged somewhat radiating from the middle of its inner border. Adductor muscles two, one at each extremity. Pallial line entire. Ligament internal. Type, *N. arguta.* Name, mythological. Geological range, so far as known, Devonian. Family relations apparently near *Megalomus* Hall, and *Megalodon* Sowerby.

Nyassa arguta.

PLATE VII, fig. 18.

Nyassa arguta H. and W. Prelim. Notice of the Lamellib. Shells of the Upper Held., Hamilton and Chemung Groups, etc., Albany, N. Y., Dec. 1869, p. 28;—Whitf., Ann. N. Y. Acad. Sci., 1882, p. 216.

Shell of medium size, transversely sub-ovate or sub-trapezodial, much longer than high. Valves moderately ventricose, most prominent along the umbonal ridge, which is stronly arcuate and sub-angular. Beaks rather small and appressed, slightly incurved, and situated near the anterior end. Surface of the valve generally declining from the umbonal ridge to the basal line, and with a slight sinus or sulcus below the ridge, which gradually widens toward the margin of the shell, where it causes a broad, but not marked, emargination in the border of the shell. Cardinal slope narrow and abrupt; hinge-line arcuate; posterior end of the shell narrowed; anterior end broad, rounded, and slightly excavated below the beaks.

Surface of the shell marked by concentric lines of growth parallel to the margin of the valve, and often forming rather strong, irregular varices, most distinctly marked on the anterior half of the shell.

The Ohio specimens, although preserved in an entirely different matrix, are yet such exact counterparts of the New York shells that no question can exist of their positive identity.

Formation and Locality.—In limestone above the "Bone-bed" in Tully township, Marion County, Ohio. The specimen figured is from the State Cabinet at the State University, Columbus, Ohio.

Genus GRAMMYSIA DeVern.

Grammysia bisulcata.

PLATE VII, fig. 19.

Pholadomya anomala Goldf. Pet. Germanica, p. 272, pl. 157, fig. 9.

Pterinea bisulcata Conrad, Ann. Rept. Geol. Surv. N. Y., 1838, p. 16.

Cypricardites bisculcata Conrad, Ann. Rept. Geol. Surv. N. Y., 1841, p. 52.

Grammysia Hamiltonensis DeVern., Bul. Geol. Soc., France, 2d Series, vol. 4, p. 696, 1847.

Cardinia Hamiltonensis DeOrb., Prod. Palæon., vol. 1, p. 76, 1850.

Grammysia bisculcata Conrad, H. and W. Prelim. Notice Lamellib. Shell of the Up. Held. Hamilton and Chemung Groups. Published as ext. from Rept. State Cab., Dec. 1869. (Anonymously.)

Specimens of this species, presenting all the specific features of the typical forms from the Hamilton beds of New York, are found at Fishinger's Mills, and at Scioto Station, in beds of limestone above the "Bone-bed."

The general form is transversely elliptical, a little more than half as long again as high, the valves usually compressed somewhat in the direction of bedding, but still moderately convex and extremely Unio-like in their general expression. The body of the valves is marked by the characteristic oblique rib and furrow passing from the beak to the postero-basal margin, somewhat modifying its border; also by numerous concentric folds or wrinkles parallel to the margin of the shell, and marking stages of growth. These wrinkles are usually well marked on the anterior end of the shells, and become faintly marked or obsolete posterior to the oblique furrow, and on the rather wide posterior cardinal slope. The hinge-line is nearly straight and shorter than the length of the shell behind the beaks, causing an oblique truncation of the posterior end above the longest point of the valve. Beaks large, tumid, situated well forward on the valves and enrolled. The oblique ridge is generally more or less nodose from the crossing of the concentric folds of the shell.

This species has always been considered a very characteristic and well-marked Hamilton type; and its occurrence in layers above the horizon of the "Bone-bed," and not below, is very significant.

FOSSILS OF THE ERIE SHALES.

There appears to be no question regarding the equivalence of the Erie shales of Ohio with the Portage and Chemung groups of New York, and the palæontological features of these latter formations are so well known, and so marked, that there ought to be no doubt as to their geological position. Their stratigraphical relations also to the Catskill group, the American equivalents of the Old Red Sandstone of England, which is considered as typical Devonian, would apparently leave no doubt as to their place in the geological record, or to the zoölogical age to which they should be referred. From these considerations I have considered the following fossils from the Erie shales, as of Devonian age, an opinion for which I alone may be held responsible. The group, taken as a whole, are of special interest on account of the Crustaceans; while the other forms associated with them are sufficiently characteristic to show their stratigraphical relations.

MOLLUSCOIDA.

Genus DISCINA Lamarck.

Discina humilis.

PLATE VIII, figs. 1 and 2.

Discina humilis Hall, Pal. N. Y., vol. 4, p. 16, pl. 2, fig. 18.

A crushed and fragmentary specimen of this species, but quite too imperfect for illustration, has been detected in one of the nodules from the Erie shale at Leroy, Lake county, Ohio. The shell shows it to have been circular, nearly discoid in form, with the surface covered by distant elevated lides or ridges, and corresponds in all respects, as far as can be seen on the specimen, to those from the Marcellus shale and Hamilton beds of New York.

Genus ORTHIS Dalman.

Orthis tioga.

PLATE VIII, fig. 3.

Orthis tioga Hall, Pal. N. Y., vol. 4, p. 59, pl. 8, figs. 20–29.

Among the concretionary nodules of the Erie shale from Leroy, Lake county, there is one which contains impressions, or casts, of several valves of the above named species. The specimens are somewhat smaller than the general run of the New York Chemung specimens, but otherwise cannot be distinguished from them. The most entire ones are dorsal valves, and are moderately convex, with a decided mesial sinus. The form is transversely oval or elliptical, with a short cardinal area and small depressed beak; the striæ are rather coarse, frequently bifurcated and much recurved on the cardinal margins and slopes, many of them running off on the cardinal border. Muscular scars large and sub-flabellate, all the features being the same as the typical forms of the species, modified only in size.

Genus PALÆONEILO H. and W.

Preliminary Notice of Lamellib. Shells of the Upper Held., Hamilton and Chemung groups, etc., N. Y. State Cab. Nat. Hist., Dec., 1869, p. 6.

Palæoneilo similis.

PLATE VIII, figs. 4 and 5.

Palæoneilo similis Whitf., Ann. N. Y. Acad. Sci., 1882, p. 217.

Shell oblong, with nearly equally rounded extremities, and almost parallel dorsal and ventral margins. Anterior end short, a little narrower than the body of the shell, resulting from the constriction below the beaks. Posterior end rounded with a slight oblique truncation below the middle of the height, corresponding to the very shallow umbonal sulcus of the valves. Beaks situated within the anterior third of the length of the shell, small and unrolled. Valves ventricose, most prominent just below the umbones, and slightly sulcated along the posterior slope. The surface of the shell, so far as can be determined from the matrix, has been smooth or without visible markings. On the internal cast, the condition in which specimens are found, the muscular imprints are faintly marked—the pedal muscles being the most distinct.

The species is closely related to *P.* (*Leda*) *Barrisi* White and Whitf., Proc. Bost. Soc. Nat. Hist., vol. 8, p. 298 (*Palæoneilo Barrisi* (W. and W.), H. & W., Prelim. Notice of Lam. Shells of the Up. Held., Hamilton and Chemung groups, etc.), but has been somewhat more nearly parallel on the margins, and has a smoother shell.

Formation and Locality.—In calcareous concretions of the Erie shale, at Leroy, Lake county, Ohio, accompanying the fossil entomostracan from the same locality (next described.)

CRUSTACAEA.

PHYLLOPODA.

In the 16th Rept. State Cab. New York there is represented a peculiar bivalve crustacean from the Hamilton group of that State, under the name of *Ceratiocaris punctata;* and in the Illustrations of Devonian Fossils, Plate, XXIII, fig. 7, Section Crustacea, it is repeated under the name *Ceratiocaris* (*Aristozoe*) *punctata*. Among the fossils of the Erie shales of Leroy, Lake county, Ohio, similar forms have been detected, but specifically distinct from the New York forms: Others, not yet described, have been observed from the Hamilton and Chemung groups of New York. The Ohio species here given, together with the Macrurian decapod and the following observations on the genera with but slight modifications, were published in the Am. Jour. Sci. and Arts for January, 1880, as preliminary to this report.

The fossils in question differ from the true types of *Ceratiocaris* in so many particulars, and to so great an extent, that it is quite impossible to include them under that genus. The reference to *Aristozoe* Barr, is however, still more erroneous, as the forms to which that name is applied by its author are true Ostracods, having all their parts concealed within the carapace, as in *Leperditia* and its allies; while the forms under consideration are provided with a bivalve, or at least a two-sided carapace, which incloses the thoracic portions; while the abdomen and caudal parts are naked, or not inclosed within this covering, and are more properly classed among the Phyllopods.

That this latter character, the naked abdomen and caudal plate, pertains to these organisms, is abundantly proven by the Ohio specimens now under consideration. The fossils are found inclosed in small concretions; and there would be but little chance for specimens or parts of specimens of different species, or less likely of parts of individuals of distinctly related generic forms, to be inclosed in the same small concretion; so we may safely conclude, that, where parts or fragments of individuals of corresponding size are found in the same concretion, they are parts of one individual or at most, of the same species. In the concretions in question, there are two examples where parts of the naked abdomen and caudal plate with its accompanying spines, are imbedded in the concretion together with the carapace which I have classed as of the same species. This I consider as ample proof that the parts belong to the one individual; and that the animal of which they are the remains, was provided with a naked body and spinose caudal appendage as in *Ceratiocaris*. It is also, stated in the Illust. Dev. Foss., that one specimen resembling *C. punctata*, has been found with a body similar to that called *C. armata* attached to the carapace, showing their individual relations.

The several species above mentioned, while differing greatly from *Ceratiocaris*, possess features in common which at once characterize them as a natural group, sufficiently marked to be readily distinguished. I therefore propose to recognize them as a distinct genus under the generic name ECHINOCARIS, possessing the following characters:

Genus ECHINOCARIS Whitf.

Echinocaris Whitfield, Am. Jour. Sci. and Arts, 3d series, vol. 19, p. 34, 1880.

Carapace bivalve, valves subovate in outline; united on the dorsal margin by a straight hinge; the anterior, basal and posterior margins rounded, and generally more or less produced posteriorly. Surface of the valves marked by a more or less distinctly elevated, curved, longitudinal ridge, centrally or subcentrally situated; also by one or more (usually three) vertical ridges, or ridge-like nodes, extending from the hinge-line on the body of the valve, and usually situated anterior to the middle of the length. Abdomen naked, composed of several segments (four known) and a caudal plate, which is produced into an elongated spine with a lateral, movable spine on each side. Posterior margin of the abdominal segments bearing spines on the now known species.

Type *Echinocaris sublevis* Whitf.

Among the genera now known and referred to of the *Ceratiocaridæ* there are several distinct types of structure, indicated by the features of the carapace alone, independent of the changes which take place in the abdominal segments and in the caudal spine and appendages. The following synopsis of some of their characters may serve to illustrate their peculiarities and to show more distinctly the relations which ECHINOCARIS bears to other known genera:

1st Section: Carapace more or less elongated, with a straight or slightly arched dorsal line; anterior end sharply rounded or pointed (rostrate); posterior end truncate; sides convex, smooth or simply striate, sometimes marked by a simple ocular node near the antero-dorsal margin; no ridges or other nodes. *Ceratiocaris* McCoy, 1849; *Caryocaris* Salter, 1862; *Hymenocaris* Salter, 1852; *Solenocaris* Meek, 1872; (?) *Colpocaris* Meek, 1872. The last somewhat questionable in char. acter.

2d Section: Carapace similar in form to that of Sect. 1, with the posterio-basal angles produced into spines, and the surface with longitudinal ridges- *Dithyrocaris* Scouler (= *Argas* Scouler).

3d Section: Carapace rounded at both extremities, elongate-elliptical or elongate-ovate in form with a straight dorsal margin; surface concentrically striate, no nodes or ridges. *Lingulocaris* Salter, 1866.

4th Section: Carapace triangular, dorsal margin straight; surface punctate or reticulate, and concentrically striated (growth lines ?). *Dictyocaris* Salter, 1860.

5th Section: Carapace suboval or subovate with a straight hinge-line; surface marked with longitudinal ridges or representative nodes and ridges. Surface of parts smooth, punctate or pustulose. *Echinocaris* new gen.

6th Section: Carapace broadly oval or ovate, no straight cardinal line, consequently no hinge, anterior end rostrated or beaked, surface destitute of nodes or ridges. *Physocaris* Salter, 1860.

7th Section: Carapace composed of three pieces, or apparently of three; two of which are semi-circular, with the anterior end of each obliquely truncate, forming when the two are united, an anterior triangular notch into which the third or rostral plate is inserted. Surface concentrically marked by growth lines; no nodes or ridges. *Peltocaris* Salter, 1866; *Discinocaris* Woodward, 1866; *Aptichopsis* Barrande, 1872; *Pterocaris* Barrande, 1872 (not Heller, 1862).

It will be readily seen from the above synopsis that *Echinocaris* differs materially in the features of the carapace from all the other genera enumerated. The features of the abdomen and caudal parts are not as reliable, but are somewhat distinctive as may be seen by the following table of comparison. (A mark of interrogation indicates that the parts are unknown or only partially known.)

Genus	Ceratiocaris,	abdominal	segments	5 or 6,	smooth,	caudal	spines	3.
"	Dithyrocaris,	"	"	1,	"	"	"	3.
"	Hymenocaris,	"	"	8,	"	"	"	6.
"	Dictyocaris,	"	"	6,	"	"	"	3 ?.
"	Physocaris,	"	"	5,	"	"	"	3.
"	Echinocaris,	"	"	4,	spiny,	"	"	3.
"	Discinocaris,	"	"	4,	?	"	"	3 ?.
"	Peltocaris,	"	"	3,	smooth,	"	"	3.
"	Caryocaris,	"	"	1,	?	"	"	3.
"	Lingulocaris,	"	"	?		"	"	?.
"	Colpocaris,	"	"	?		"	"	3.
"	Solenocaris,	"	"	?		"	"	?.
"	Aptychopsis,	"	"	?		"	"	?.

The number of segments here allotted to any given genus indicates the maximum number of naked segments known; some of them contain species having a smaller number, and in some a much greater number exists, some of which are concealed within the carapace. Thus *Ceratiocaris* is known to possess in one species fourteen segments in the abdomen, only six of which are naked.

The genus *Dithyrocaris* McCoy, is described as having three longitudinal ridges. This feature is seen only when the two valves are pressed open as in McCoy's example, so as to present the appearance of one large plate; in which case the hinge line forms the middle ridge.

The third or rostral plate in *Peltocaris*, *Caryocaris*, *Discinocaris* and *Aptychopsis* would appear to be quite analogous to the small rostral plate seen in *Ceratiocaris*, and supposed to exist in *Dithyrocaris*, and perhaps some others, but which is usually absent. It is possible many of the forms may have possessed this rostral plate, at least among those that are deeply notched in front when the valves are spread open. In this case they would as properly be considered as having three plates in the carapace as those grouped under section 7. The forms of this section are usually found with the carapace spread open on the rock, and are then circular and discoid, but when in their natural position would have been more or less roof-shaped.

Colpocaris Meek presents some features that raise a question as to its true affinities. The longitudinal crenulated line and the inflection of the supposed ventral border do not seem to be properly understood; and I am of the opinion they may belong to a different group of Crustaceans.

Echinocaris sublevis.

PLATE VIII, figs. 12–14.

Echinocaris sublevis Whitfield, Am. Jour. Sci. and Arts, 3d series, vol. 19, p. 36, 1880.

Carapace obliquely subovate in general outline, the height equal to two-thirds the length, widest and deepest behind the middle, the posterior portion projecting obliquely backwards and downwards beyond the extremity of the hinge-line; dorsal-line straight, forming a hinge-line two-thirds the length of the valve; outer margin of the valves, except on the dorsum, bordered by a narrow, slightly raised and thickened rim; anterior border nearly vertical from the extremity of the dorsal line, for about one-half the width of the valve, except a very slight rounding backward to the hinge-line above; below it slopes abruptly backward to and along the basal line, and again more abruptly curving around the posterior end of the valve and forward to the extremity of the cardinal line; below which it is distinctly excavated. The portion of the valve which projects beyond the hinge is nearly or quite equal to one-third the length of the valve. Surface of the valves convex, and marked by ridges and tubercles. The principal ridge commences at about the anterior third of the valve, and just above the middle, as an elevated, rounded, and nearly vertical ridge; but soon bends somewhat abruptly, and is directed backward in a broad, sweeping curve, at less than one-third of the height of the valve from the lower margin, and gradually decreasing in strength terminates a little within the margin opposite the longest part of the valve. A second and slightly stronger ridge rises from just behind the middle of the length of the hinge, and descends with a gentle forward curvature, terminates near the upper anterior end of the first one. The anterior or principal tubercle is large and distinct, and situated near the antero-dorsal angle of the valve, occupying the greater part of the space between the front margin and the two ridges just described. Between this and the second ridge the surface is elevated, forming a low tubercle. The surface of the anterior tubercle is occupied by several small but distinct pustules, and the entire surface of the valve covered by a minutely granulose structure.

Abdomen apparently consisting of four free segments; the first one being short and much thicker than the others on the anterior end, but rapidly narrowed posteriorly; the posterior margin being armed with several small spine-like tubercles. The other three segments are shorter than wide, gradually decreasing in strength and increasing in length backwards, the first of the three being apparently less than half as long as wide, their posterior margins all spine bearing; a long curved lateral spine on each side, with three short ones between, and all increasing in length backwards from the first or anterior segment.

Telson proportionally large, of a general triangular form, but slightly protruding at the origin of the movable spines, and projecting behind into a long, slender, and apparently cylindrical spine, making the telson with its spine about as long as the four free segments together. Lateral spines cylindrical, very gently curved, and standing at an angle of about forty-five degrees to the central spine. Surface of the telson highly convex and somewhat angular at the origin of the spine. Surface of the crust of the abdomen smooth.

This species is closely allied in the form of the carapace to *E. punctata* Hall (16th Rep. State Cab. N. Y., p. 74, plate 8, fig. 1); but differs in the form of the nodes and ridges, and in the surface structure, also in wanting the projection at the posterior end of the hinge; if this feature is natural on that specimen. It is probable that the abdomen and telson figured on the same plate under the name *Ceratiocaris armata*, belong to the same species as the carapace of *E. punctata*, as suggested by Prof.

Hall in the explanation of plate 23, section Crustacea, Illust. Dev. Fossils, and if so, the distinction between these parts of the two species is much more marked than between the carapaces.

Formation and Locali y.—In small calcareous concretions in the Erie shales (Portage and Chemung) at Leroy, Lake county, Ohio.

Echinocaris pustulosa.

Plate VIII, fig. 15.

Echinocaris pustulosa Whitefield, Am. Jour. Sci. and Arts, 3d series, vol. 19, p. 38, 1880.

Carapace ovate, widest anterior to the middle, the greatest height equal to three-fourths of the length, hinge-line straight, rather more than half as long as the valve, while nearly one-third the length of the valve projects behind its extremity. Margin of the valve bordered by a narrow, thickened rim. Anterior end of the valve slightly excavated below the hinge extremity, and the margin broadly rounded in front; posterior end more pointed, while the basal line is broadly and evenly curved. At the posterior end of the hinge the margin is also slightly constricted as in front. Surface of the valve convex and marked by the characteristic nodes or ridges. The principal ridge commences in an oval node, which is situated just within the anterior third of the length of the valve; is placed vertically, just above the middle of the height; and the horizontal position, which is sharply elevated and slightly curved, is situated almost in the middle of the width, and terminates a little less than one-fourth of the length from the posterior extremity. The second ridge commences at the hinge-line near the middle of its length, and descends with a slightly forward direction to within a very short distance of the top of the vertical portion of the principal ridge. The anterior ridge, corresponding to the anterior node or tubercle of *E. sublevis*, is narrow and vertical; of a slightly sigmoid form, and originates near the anterior extremity of the hinge-line; the lower end reaching more than one-third the depth of the valve. The surface of the ridges and of the valve in the postero-dorsal field, as also of the space be ow the principal horizontal ridge, is marked by correspondingly large and distinct pustules. Abdomen and telson unknown.

This species differs from *C. sublevis* in its slightly broader form, and in the want of the obliquity of the axis of the valve with the hinge; in the narrower posterior extremity, the pustulose surface, and in the form of the su face ridges; most notably in the anterior one being ridge-like and vertically sigmoid instead of round. The individual used in description is half an inch in length and three-eighths of an inch in its greatest height.

Formation and Locality.—In calcareous concretions in the Erie shales, at Leroy, Lake county, Ohio.

Echinocaris multinodosa.

Plate VIII, fig. 16.

Echinocaris multinodosa Whitefield, Am. Jour. Sci. and Arts, 3d series, vol, 19, p. 38, 1880.

Carapace elongate-subovate, about twice as long as high, rounded in front and somewhat pointed behind; the basal-line straightened along the middle portion and parallel to the hinge-line; cardinal line straight and nearly half as long as the length of the valve, and a little nearer the anterior than to the posterior end of the carapace. Margin of the valves bordered by a narrow, elevated, thickened rim, which is expanded considerably in width around the anterior end of the valve, and terminates in a rounded, elongated ridge at the posterior extremity of the hinge; from which point the ridge is directed obliquely forward and slightly downward from the caudal line. The surface of each valve is divided into three slightly elevated areas, with depressed sulci between; an anterior, a central, and a posterior one. The first is situated in the middle of the anterior end of the shell; the central one unites with the anterior one below, and extends along the basal margin behind, in a narrow curved point below the posterior one, and projects upward near the centre of the valve in a triangular form, terminating in an elevated point just above the median line. The posterior and largest area is ovate in form, and occupies a little less than one-half the length of the shell, is narrowed in front and pointed behind, taking the form of the extremity of the shell. The centre of the anterior area is slightly tumid. Along the hinge-line and just below its margin there are three sub-angular tubercles or nodes, at nearly equal distances and of nearly equal strength, except that the posterior one is prolonged at its base into a low, rounded, and slightly curved elevation, which extends to near the point of the central raised area before mentioned. These three nodes, together with the oblique ridge-like one terminating the marginal rim, border the hinge-line on each valve. General surface of the valve finely punctate, but most distinctly so on the posterior field.

The elongated form of the carapace readily distinguished this from any of the other species described, while the number of node-like ridges is a very marked feature. The abdomen and telson of this species have not been observed, although several imperfect carapaces, mostly showing parts of both valves, have been obtained.

Formation and Locality.—In calcareous concretions in the Erie Shales, at Leroy, Lake county, Ohio.

DECAPODA.

Associated with the specimens of Entomostraca, described from the concretions of the Erie shales of Ohio, are the remains of a Macrouran Decapod, which appears to differ so much from any described genus as to make undesirable to refer it to any of them. One of the peculiarities consists in the possession of a pair of very strong antennal appendages, which projects from beneath the anterior end of the thoracic carapace, and are of such size and strength as to raise considerable doubt as to their true nature. The existence of five thoracic limbs, exclusive of these, projecting from beneath the carapace on one side would seem to place their pedal nature out of the question; while their great development as seen on the specimen would indicate that they had served some purpose other than simple antennæ, and to raise the question as to the possibility of their having been chelate at their extremities. As only the basal portions of these organs are represented, however, this question cannot be satisfactorily determined. Having had an opportunity of consulting Dr. A. S. Packard, Jr., in regard to them, he gave as his opinion, that from their position and the representation of the other five pairs of thoracic members without them, they could not be other than antennal in their functions, notwithstanding their great size and anomalous character. Taking this view of their nature, the specimen would conform strictly to the type of Macrouran Decapods.

In its generic relations, as well as in its general expression, the specimen resembles most nearly the genus *Pygocephalus* of Prof. Huxley, first given in the Quart. Jour. Geol. Soc. London, vol. 13, p. 363, 1857, with figures and descriptions of three specimens, under the name *P. Cooperi.* Neither the genus or the species were well characterized at that time. It is however again referred to in vol. 18, p. 420, of the same journal, with a figure of a specimen supposed to be of the same species, much better preserved, from the coal shales at Paisley. There are however, too many limbs represented as originating from the thorax for a Decapod, and the antennæ, although represented as of large size are not like those of the Ohio specimen, while there is a second pair shown. In other parts the figure is indistinct, and in the description the parts are not defined sufficiently for close comparison. The differences, however, are so great that I shall propose for this form the new generic name PALÆOPALÆMON, with the following diagnosis:

Genus PALÆOPALÆMON Whitfield.

Am. Jour. Arts and Sci., 3d series, vol. 19, p. 40, 1880.

A marouran decapod crustacean, having a shrimp-like body, with a thoracic carapace narrowed but not rostrate in front, and keeled on the back and sides. Abdomen of six segments terminated by an elongated triangular and pointed telson; segments arched, pleura smooth, not expanded nor lobed, their extremities rounded. Sixth segment bearing caudal flaps, one on each side, composed of five visible elements, the outer four apparently anchylosed to form a single large triangular plate on each side of the telson. Thoracic ambulatory appendages elongated, smooth, and filiform, except the upper (second) joint, which is laterally compressed. Abdominal appendages short, the upper joints flattened or convex anteriorly, as if for the attachment of plates or fimbriæ. Antennæ with the basal joints strong and well developed, of large size, much exceeding in strength any of the thoracic limbs. Eye peduncles short.

This is so far as I am aware the most ancient decapod crustacean yet recognized, and on that account alone is of great interest. The character of the caudal plates, in having the parts combined to form a solid plate on each side of the telson, is also an interesting feature, if rightly understood. From the impression of the plate as seen on the ventral side, it was at first supposed to be a simple element only, but on obtaining an impression in the fragment of rock, chipped from the top or dorsal surface, the obscure lines of the first and second joints were detected, while the outer three are only traceable from the very slight difference in the surface character of two of them, and the thickened substance of the third or marginal one. Of the thoracic limbs only parts have been seen, and of the abdominal members the three anterior ones on one side; the others being concealed by the rock. The eye-stalks appear to have been very short, judging from the spherical cavities beneath the anterior extremity of the carapace, which are small, close together, and shallow.

The earliest form of decapod crustacean previously described, so far as I can ascertain, is given by Mr. Salter in the Quart. Jour. Geol. Soc. London, vol. 17, p. 531, 1861, as *Palæocrangon sociale*; said to be from the Lower Carboniferous limestone of Fifeshire, Scotland. There is another supposed decapod, *Gitocrangon*, noticed by Richter (Beiträge Palæont. Thiring.) from the Upper Devonian which is mentioned by Salter; but of which he says he is doubtful if it be a crustacean at all. I have not seen the work in which the original description occurs, and can only judge of its nature from Mr. Salter's remarks.

Palæopalæmon Newberryi.

PLATE VIII, figs. 19–21.

Palæopalemon Newberryi Whitfield, Am. Jour. Sci. and Arts, 3d series, vol. 19, p. 41, 1880.

Body slender, the carapace forming a little more than one-third of the entire length, higher than wide, narrowed anteriorly and truncate behind; being longer below than above; median line carinate, with a second carina on each side a little below the crest; anterior end not rostrate but obliquely truncate, and sloping rapidly backward above the truncation, forming when looked upon in front, a narrow elongated shield shaped and slightly depressed area, obtusely pointed above and rapidly widening at the base, the lateral carine rising from the lower angles; lower posterior angles rounded, basal margins gently curved thoroughout and bordered by a narrow thread-like band with a narrow groove within it. Abdomen moderately robust, highly arched along the dorsal line, the pleura curving inward below, giving a cylindrical form. Pleura broadly rounded at their extremities on the anterior face, but slightly angular on the posterior corners; posterior margin of the segments strongly arching forward on the back. Telson elongate-triangular, a little less than twice as long as wide, somewhat angular above and marked by a central ridge below, and by a backward curving transverse ridge across the widest part. Caudal flap large, forming a triangular plate on each side, the first and second joints short, subtriangular; marginal plate of the flap thickened, narrow, and elongate, central plate narrowly triangular, a little longer than wide; third or inner plate of equal length with the second, and a little wider than the marginal one; the three combined as one, being apparently anchylosed at their margins to form a solid piece. Antennæ very strong, the first joint half as long as the thorax, slightly swollen in their lower half, and flattened on the under side; the other portions unknown. Thoracic limbs very slender and only of moderate length, the second joint laterally compressed, making the height nearly double the width; other joints apparently cylindrical. Abdominal limbs known only by their second (?) joints, which appear to be triangular in form, widening below, flattened and plate-like in character or slightly convex on the anterior face. (In one case only a single thread-like appendage can be seen as if projecting from the outer lower angle.)

Surface of the carapace marked by very fine tortuous and interrupted, raised lines, strongest anteriorly and running obliquely upward and backward; also by a single, slender, distinct, raised ridge, extending more than one-fourth the length of the carapace, orignating at the lower anterior angle, and passing upward and backward, with a bifurcation at the anterior third of its length. Surface of the abdomen essentially smooth. Caudal flaps marked by impressed lines, increased in number and fineness from above downwards.

The following species is introduced for comparison with *Echinocaris:*

ENTOMOSTRACA.

Genus ARISTOZOE Barrande.

Aristozoe Canadensis n. sp.

PLATE VIII, figs. 17 and 18.

Carapace of large size, being more than one and a half inches in extreme length, and nearly one inch in height. Form subovate, widest at the anterior end and straightened on the dorsal margin. Hinge-line straight nearly five-sixths of the entire length of the valve, and reaching nearer to the anterior than to the posterior extremity. Valves very ventricose, but more especially so anterior to the middle. Margin strong and rounded, separated from the body of the valve by a distinct furrow, border narrow in front and along the base, but rapidly widening at the posterior end, and again narrowed toward the posterior extremity of the hinge. Anterior (occular?) tubercle large, more than one-fourth of an inch in diameter, ovate in form, and narrowest in front, situated close in the antero-cardinal angle; its surface smooth, but capped by a smaller sub-central, nipple-like tubercle. Behind the tubercle, and nearly two-fifths of the length from the anterior end, there is a sharp vertical constriction of the surface, which extends from the hinge to about one-half the width of the valve, where it becomes obsolete. Posterior to this there are two other slight sulci, the anterior of which appears to be slightly curved. Surface of the crust, so far as can be ascertained from the specimen, smooth, except near the lower margin, where it is covered with distant, rounded tubercles of about a twentieth of an inch in diameter each, arranged in three horizontal rows, which decrease rapidly in length from below upward; the upper one containing not more than one-half as many tubercles as the lower or marginal line.

Formation and Locality.—The specimen is an internal cast, in a rather coarse, slightly ferrugineous sandstone. It is said to have come from the Trenton formation in the Ottawa basin of Canada, the exact locality unknown. I introduced it here for comparison with the species of *Echinocaris*, under the impression that it had been described by the late Mr. Billings, of the Canadian survey; but the strictest search has failed to reveal any such description, and I have been obliged to give it a name, notwithstanding the uncertainty of its origin.

SPECIES FROM THE HURON SHALES.

MOLLUSCOIDA.

BRACHIOPODA.

Genus LINGULA Brugiere.

Lingula ligea.

PLATE VII, figs. 3 and 4.

Lingula ligea Hall, Pal., N. Y., vol. 4, pp. 7 and 8, pl. 1, fig. 2.

Shell elongate-oval, widest in the middle, and nearly twice as long as wide, very slightly pointed at the upper end and neatly rounded in front, surface of the valve regularly and evenly convex, and marked only by very fine concentric lines of growth.

In the interior of the shell the median line is marked by an elevated ridge, representing muscular scars, which reaches fully two-thirds the length of the valve. The impression contains four elements, two above and two below, the upper pair inclosing the upper half of the lower. Near the rostral extremity another widely diverging pair of scars are seen, which also appear double.

The specimen is undistinguishable from examples of *L.* (*D.*) *ligea* Hall, from New York, where it occurs in the Hamilton and Portage groups. The median line of muscular scars and the diverging rostal scars show that it belongs to the section of Lingulidæ for which Prof. Hall proposed the generic name *Dignomia*.

Formation and Locality.—In the calcareous nodules from the Huron shales at Delaware, and also from the Erie shales, at Leroy, Lake county, Ohio, with *Echinocaris*, etc.

Plumulites Newberryi.

PLATE VIII, figs. 6–11.

Plumulites Newberryi, Whitf., Ann. N. Y. Acad. Sci., 1882, p. 217.

The specimens for which the above specific name is proposed, consist of several detached plates, and of one of several plates, irregularly folded together in such a manner as to be difficult of interpretation. The several plates vary considerably in form among themselves, and probably represent those from different parts of the body.

The general form of the plates is triangular, with the apex, or initial point of growth, a little inclined to one side; the base, or margin of accretion, is usually the longest side, but not in all cases. One set of plates has the shorter sides diverging at nearly right angles. On this form, the basal line is convex for more than two-thirds its length, and concave on the remaining portion, giving a sigmoidal outline; of the shorter sides, one is straight to near the apex, where it becomes rounded, and the other is slightly concave. Another form has the shorter sides diverging at an angle of about 105 degrees, one slightly convex and the other concave; while the basal margin is convex in two sections, with a constriction or interruption between the two sections, or at about one-third of its length from the straight margin. The plates of this and the preceding form have the surface regularly annulated transversely, parallel to the basal margin, the annulations very fine, and regularly increasing in size and strength from the apex to the base, except in aged specimens, where they are again crowded near the border: five undulations may be counted in an eighth of an inch where strongest. These forms, also, have the straight margin often fractured and bent, as if they had been broken along that side; indicating that two such plates may have been united along this line; and on the only individual showing several plates together, this would appear to be the case. A third form of plate is narrowly triangular or conical, the basal border being the shortest, and simply convex; the other sides being slightly curved thoroughout, but more distinctly so near the apex, which is obtusely rounded; the lateral margins are of unequal length, and the annulations of the surface finer and more closely arranged than on the other forms.

The individual specimens are much too few in number to give any very satisfactory idea of the general form of the complete body, or of the number of ranges of plates of which it may have been composed. There appears to be no reason however, to doubt the correctness of the reference of these plates to the genus *Plumulites* Barrande, as their general form and surface structure are exactly like those given by Dr. Barrande, and also to those given in Vol. II, Pal. Ohio, pl. 4, figs. 1 and 2 (*P. Jamesi*), as occurring in the rocks of the Hudson river group, at Cincinnati; while some idea may be obtained of the probable form of the entire body from the outline figure of a European species, represented in fig. 3 of the same plate. These Devonian specimens, however, have been of very much greater size than the above, as the plates here figured are all represented of natural size, the larger individual plates being more than an inch in transverse diameter, while the species above referred to is minute. The occurrence of forms of this genus in rocks of Devonian age is also a new feature in its history; as those of Europe are confined to the Lower Silurian formations and the lower beds of the Upper Silurian; while these occur above the middle Devonian.

Formation and Locality.—In the Cleveland shale at Sheffield and Birmingham, Erie county, Ohio.

SPECIES FROM THE MAXVILLE LIMESTONE, THE EQUIVALENT OF THE ST. LOUIS AND CHESTER LIMESTONES OF THE MISSISSIPPI VALLEY.

CŒLENTERATA, RUGOSA.

CYATHOPHYLLIDÆ.

Genus ZAPHRENTIS Rafinesque.

Zaphrentis Cliffordana.

PLATE IX, figs. 1–3.

Zaphrentis Cliffordana Edwards and Haime, Polyp. Foss. Terrains Palæoz., p. 329. pl. 3, fig. 5.

Corallum small, measuring from an inch to one inch and a half in height, with a transverse diameter at the summit of from five-eighths to three-fourths of an inch; somewhat regularly tapering and distinctly curved, without distinct varices of growth, but showing slight corrugations of the surface in most individuals. Rays well developed, numbering from thirty to thirty-six in the primary series, with an equal, number of secondaries which are much less strongly developed; the primary series extending nearly or quite to the centre of the rather deep calyx. Transverse plates strongly developed. Fosset situated on the inner side, strong, deep, and extending to the middle of the calyx in the specimens seen. Epitheca thin, frequently showing the lines of the rays impressed on its surface.

The species does not attain a very large size, but is a very common form on the surface of the limestone, and is somewhat persistent in character, the greatest variation being in the somewhat more rapid expansion of some examples. The specimens from Ohio accord quite closely with that figured by the authors of the species as cited, and also with specimens from the Chester limestone from several localities in the western States, especially from Chester, Ills.

Formation and Locality.—In the Maxville limestone, at Maxville and Newtonville, Ohio. I found them quite plentiful on the surfaces of blocks of limestone, at Winona Furnace, obtained at Culver's quarry, near Maxville. The originals of the species are cited from Button-mold Knobs, near Louisville (Keokuk limestones); and from Mammoth Cave, Ky. (Chester limestone).

Cyathocrinus Maxvillensis, n. sp.

PLATE IX, figs. 5–8.

Cyathocrinus inequidactylus Whitf., Ann. N. Y. Acad. Sci., 1882, p. 219.
Not C. *inequidactylus* (McCoy) W. and Sp.

Body of rather small size. Calyx deep cyathiform, being nearly hemispherical in one example, and somewhat broad obconical in another, and composed of smooth plates, which have only the general convexity of the body, or very slightly tuberose.

Basal plates minute to moderate size, higher than wide. Subradials large; height and width nearly equal; two of them heptagonal and the others hexagonal, the lower sides barely divergiug from a straight line. First radials wider than high,and about two-thirds as high as the subradials. Anals visible, three in number; the first elongate pentagonal, nearly twice as high as wide, and situated a little obliquely on the right side of the area; the other two are small and pentagonal. Second radials, or first arm-plates, smaller than the first radials and narrowing upward, wedge-formed above, and each supporting two arms. On the postero-lateral rays they are long and cylindrical, with the arms slender. On the anterior ray, it is short and supports two slender arms; while on the antero-lateral rays they support a slender arm similar to those of the other rays on the anterior side, and on the outer side an arm several times larger and stronger than the others, and composed of larger and stronger plates.

Plates of the arms short and unequal-sided, and giving origin to jointed tentaculæ from the longer side of each plate, which is upon the alternate sides of the arm, or on the same side from every second plate. Surface of the plates smooth. Length of the arms and subsequent bifurcations not known. Column small, round, and composed of unequal-sized plates alternating with each other.

The slender arms are preserved on two individuals to the length of about one inch, and the strong antero-lateral arm on one, to more than an inch; but no evidence of bifurcation appears.

The inequality of the antero-lateral arms will be the distinctive feature of the species, as the form of calyx is similar to many other species of the group.

Formation and Locality.—In the Maxville limestone (shaly portion), at Newtonville, Ohio.

BLASTOIDEA.

Genus PENTREMITES Say.

Pentremites elegans.

PLATE IX, fig. 4.

Pentremites elegans Lyon, trans. Acad. Sci. St. Louis, vol. 1, p. 632, pl. 20, fig. 4.

Body small, broadly subpyriform, the length equal to about once and a half the height, but somewhat variable with age; the greatest width being at the base of the ambulacral areas, or considerable below the middle of the height; the outline of the lower portion being nearly straight lines, or a little concave between the base of the ambulacral areas and the lower extremities of the basal plates; while above the form is generally rounding or convex. In a basal view the form is pentangular, and viewed from above somewhat pentalobate; the ambulacral areas being slightly sul cated. Basal plates small, extending to rather less than half the height of the body below the base of the areas, and in their lower half are somewhat more attenuate than above, the cicatrix for the attachment of the column being very small. Forked plates elongated, and the sinus very broad and deep; the length of the plates being equal to more than once and a half their greatest width, and their summits slightly truncated for the reception of the small-pointed interambulacral plates, which are in length about equal to one-fourth of the entire length of the areas. Ambulacral areas proportionally wide, distinctly depressed along their middle and composed, in the specimen figured, of about twenty-six pairs of transverse poral-plates, from ten to eleven of which occupy the space of an eighth of an inch in length, in the lower and middle portions, but become shorter above. Summit openings rather large, surface smooth.

The examples observed vary considerable in form according to their relative age, the smaller ones being shorter above than figured, with narrower areas and shorter poral plates, while the diameter is somewhat less. The species is proportionally broader and shorter than *P. pyriformis* Say, although somewhat resembling it, but is sufficiently distinct to be readily recognized.

Formation and Locality.—In the Maxville limestone (Chester group), at Newtonville, Ohio. Collection of Columbia College.

MOLLUSCOIDA.

BRYOZOA.

Genus POLYPORA McCoy.

Polypora Varsouviensis?

?*Polypora tarsouviensis* Prout, Trans. St. Louis Acad. Nat. Sci., vol. i, p. 237, pl. 15, fig. 3.

Some macerated fragments of *Polypora*, very closely resembling this species, have been examined on the surface of thin shaly layers of the Maxville limestones, from Newtonville, Ohio. But the examples are too much worn and too fragmentary for description or illustration. A species of *Fenestella* has also been detected showing only the nonporiferous surfaces of fragments. The rays are very fine and slender, with slightly elongated, quadrangular fenestrules. The rays are finely striate longitudinally, but too imperfect for use or identification.

Synocladia rectistyla.

Plate IX, figs. 9 and 10.

Synocladia rectistyla Whitf., Ann. N. Y. Acad. Sci., 1882, p. 220.

Bryozoum growing in spreading funnel-formed fronds, rising from a rooted base and widely diverging in their upward growth; the inner surface of the cup bearing pores. Rays straight and somewhat rigid in their upward direction, with frequent bifurcations, which are not abrupt with rapidly diverging branches, but rise gradually from a thickened space, and gradually diverge as slender but constantly thickened rays until the normal strength is attained.

The rays are slender, rather closely arranged; about six of them occupying the space of a fourth of an inch in the widest parts, and from eleven to twelve may be counted in the same space in the most crowded parts.

Transverse dissepiments nearly as strong as the longitudinal rays, and often slightly arched upwards between them in the wider parts, but more frequently directed obliquely upward in passing in one ray to the next and very often directed upward to the right from one side of a ray, and to the left on the opposite side; but they are generally direct in the more crowded portions. The middle of the ray on the poriferous surface is elevated or roof-like, with a central crest or ridge bearing distant nodes; a single row of large pores is arranged on each side, which are usually less than their own diameter apart, and more or less alternating with those of the opposite side. From two to three pores occupy each side of each fenestrule, and the pores are margined by an elevated lip, which on unworn spaces are very prominent. From one to three similar pores, although sometimes of smaller size, occupy the surface of each dissepiment. Non-poriferous surface not observed.

This species is somewhat similar to *S. biserialis* Swallow (Trans. St. Louis Acad. Sci., vol. i, p. 179), as identified and figured by Mr. F. B. Meek (Final Rept. of U. S. Geol. Surv. Neb., pl. 7, fig. 5), but differs in wanting the longitudinal nodose ridge between the pores of the dissepiments, and in having only a single row of pores on those parts occupying the middle of the dissepiment as well as in the more slender, finer, and more direct, and much more crowded rays, also in having a larger number of somewhat smaller pores on the rays. Mr. Meek, *loc. cit.*, identifies the above species with *Synocladia Cestriensis* (*Septipora Cestriensis* Prout, Trans. St. Louis Acad. Sci., vol. i, p. 448, pl. 18, fig. 2), which differs from the Ohio specimens in the stronger and thicker, as well as more flexuose rays; in the rounded fenestrules, and smaller-sized pores, which are also more abundant, often showing three ranges on parts below bifurcations. On direct comparison of the Newtonville specimens with specimens from Chester, Ill., these differences, especially those pertaining to the mode of growth, are very marked and characteristic.

Formation and Locality—In the Maxville limestone (Chester), at Newtonville, Ohio. Collected by Prof. E. B. Andrews.

BRACHIOPODA.

Genus STREPTORHYNCHUS King.

Streptorhynchus crassum.

PLATE IX, figs. 11 and 12.

Hemipronites crassum M. and W.
Orthis Lasellensis McChesney, New Pal. Foss., 1859, p. 32, pl. i, fig. 6.

Shell very variable in size and form, but usually more or less plano-convex as seen in profile, somewhat semi-oval in outline, but usually a little too long from beak to base to be strictly so considered. Ventral valve more or less flattened, a little prominent on the umbo, but usually becoming slightly concave toward the front of the shell; cardinal area of moderate height with a covered deltidium; beak more or less distorted. Dorsal valve convex, often quite rotund, but usually depressed convex, with a slightly prominent umbo. Surface of the shell marked by radiating striæ of considerable strength, which are sometimes sharply elevated and uniform, but on other specimens may be distinctly alternating in strength or arranged in fascicles; these are crossed by fine concentric striæ which give a finely crenulated surface when viewed through a lens. Coarser concentric undulations of growth also mark the shell at irregular distances.

The individuals referred to this species are so extremely variable in all their characters that it becomes next to impossible to properly characterize the species by any kind of verbal description. There are, however, two distinct types of shell included among them, which possess characters sufficiently distinct to indicate. One of these is strongly plano-convex in profile, the dorsal valve being very highly convex, with a large and strong beak, incurved; the ventral valve usually being distinctly concave toward the front margin, and the beak usually more or less distorted and twisted. This form generally attains a considerable size, occurring of a diameter of two and a half or three inches. The other form is much smaller, seldom exceeding one and a half inches in its transverse diameter; the shell is less convex, in fact never very highly rounded, the cardinal area much narrower and the beak less liable to distortion. These forms usually characterize different beds, and are easily recognized from each other, but among them there are usually intermediate forms associated, which tend to destroy the line of specific distinction, on which account they are usually considered as varieties of the one species; although there is not the least trouble in recognizing the different types in well-marked specimens, still many individuals occur which cannot be satisfactorily referred to either, rendering it impossible to strictly classify hem, except as one species.

In placing this species under the genus *Streptorhynchus* King, I do so with the belief that *S. crenistria*, the shell upon which the genus was founded, is generally distinct from *orthis adspectans* and its congeners which formed the types of Pander's genus *Hemipronites;* as, besides the strong internal differences, the entire absence of a cardinal area on the dorsal valve of the former shell and those of that group, and the presence of a very well-developed area on that of the latter, together with the difference in the general form of the shell, offer good grounds for generic separation.

Genus PRODUCTUS Sowerby.

Productus elegans.

PLATE IX, figs. 15 and 16.

Productus elegans N. and P., Jour. Acad. Nat. Sci. Phila., vol. iii, 2d series, p. 13, pl 1, fig. 7.

Productus elegans of Authors.

Productus fasciculatus McChesney, New Pal. Foss., 1859, p. 38.

Shell small, rather below a medium size, highly arcuate, and often much produced in older specimens; hinge-line short, frequently not more than half as long as the width of the shell below. Body of the shell somewhat quadrangular in the upper part, being flattened or even slightly sinuate along the median line, and also flattened on the sides; beak proportionally large and obtuse, not projecting much beyond the line of the hinge when viewed from above; auriculations very small. Visceral cavity proportionally small, the distance between the valves as seen when the front extension of the valves is removed being not more and generally less than half the width of the shell. Dorsal valve slightly concave. Surface of the shell marked by strong fasciculating striæ, strongest near the front, often showing some stronger ones with scattered spine bases; spines often most numerous on the sides of the shell near the hinge extremities. The upper portion of the ventral and the surface of the dorsal valve are marked by strong concentric wrinkles, generally distinct, but sometimes quite obscure.

The Ohio specimens of the species are of very characteristic form, so closely resembling those from the limestone at Chester, Ill., that there is scarcely a chance of mistaking them. They are also usually of about the same size with the western specimens, only occasionally an individual occurring of large size; in which case they present the characters of the form described by Mr. McChesney as *P. fasciculatus*. A few individuals have been noticed from the harder and more compact limestone, which are less quadrangular in the upper part, and the striæ appear a little finer and smoother, and the front of the shell in its extension somewhat rounder than the usual form. Some of these peculiarities, especially the smooth finer appearing striæ and apparent absence of spines, are the result of excessive exfoliation, but the difference of form is probably of other origin.

Productus pileiformis.

PLATE IX, figs. 13 and 14.

Productus pileiformis McChesney, New Pal. Foss., 1859, p. 40.
Com. *Productus cora* D'Orb.

Shell of medium size, pileiform, highly arcuate from beak to front and rounded from side to side, beak small, somewhat pointed, and the body of the shell somewhat gradually expanding toward the front. Hinge-line usually quite short and inconspicuous; auriculations small or obsolete. Surface of the shell marked by very fine radiating striæ which are even and usually quite smooth or free from spine-bases; increased by implantation on the ventral valve, the added ones at first very small, presenting a strongly alternating character, soon becoming of full size. The striæ of the dorsal valve do not present this feature on any of the specimens examined. Body of the shell marked in the upper part by numerous strong, irregular and unequal, transverse undulations, a portion of which only are projected entirely across the shell on the ventral side.

There is some question as to the propriety of separating these forms from *P. cora* D'Orb. of the Coal Measures; there are, however, many points of difference as well as many of resemblance, although none of them on either side are very constant beyond limited localities; except perhaps the general form and usually fine striæ. There is perhaps equal reason for uniting with *P. cora*, *P. tenuicosta* Hall, *P. coriformis* Swallow, and some others; but these names seem useful and convenient in designating forms of different horizons and geographical areas; as there are differences between them readily recognized and appreciated by those accustomed to examining them, which cannot be portrayed in a figure or described verbally, but which often serve to detect, or at least aid in detecting the true horizon of beds of rock which would otherwise be left in doubt, and it appears necessary to have some means of referring to or designating such forms when speaking of beds characterized by them. The form under consideration resembles those from the Chester limestone of Illinois, used in the description given by Mr. McChesney, more closely than they do those from the St. Louis limestone, given under the name *P. tenuicosta* by Prof. Hall, which have a larger and more rounded beak and much longer hinge-line; the striæ, however, in their extreme fineness resembles those of the St. Louis limestone specimens.

Genus SPIRIFERA Sowerby.

Spirifera (*Martinia*) *contracta.*

PLATE IX, figs. 17–19.

Spirifera (*Martinia*) *glaber* var. *contractus* M. and W., Geol. Rept. Ill., vol. 2, p. 298, pl. 23, fig. 5.

Shell of medium size, broad ovate or globular in general form with highly ventricose or gibbous valves, and a short hinge-line with rounded cardinal extremities. Ventral valve the most gibbous, with a large and strong incurved beak; cardinal area small, one-third or less than one-third as high as long, divided in the centre by a rather wide fissure; hinge-line less than half the width of the shell below, the cardinal slopes strongly and abruptly rounded; centre of the valve deeply impressed by a moderately wide, subangular mesial sinus. Dorsal valve nearly orbicular, moderately convex from side to side; beak small, slightly tumid, projecting slightly beyond the cardinal line; mesial portion somewhat strongly defined at the margins, and does not extend above the middle of the shell. Surface of the valves smooth to the naked eye, but under a magnifier is seen to be marked by fine, obscure, radiating lines and by transverse lines of growth.

All the specimens seen are exfoliated to a greater or less degree, so that the real surface has not been seen. The surface striæ, seen by the aid of a lens, are too strong and distinct not to be a surface character, as they are readily felt by the hand, although not readily visible to the unassisted eye. The shell does not attain a very large size, no specimens examined exceeding one and three-eighths inches in length, by a transverse diameter of about one and one-fourth inches. The shells are somewhat variable in form, being proportionally more or less elongate than the measurements above given. They also differ much in the size and strength of the mesial elevation and sinus, and in the length of the hinge-line. I have much doubt as to the absolute identity of this shell with the Illinois shells described and figured by Messrs. Meek and Worthen, from the fact that these appear distinctly marked by the radiating striæ, while those from the west are said to be smooth, except for the concentric lines of growth, though occasionally showing faint evidences of obscure radiating lines. The fact that the authors of that species refer it to *Sp. glaber*, which is entirely destitute of radiating lines, would seem to indicate it as different from the Ohio forms.

Spirifera Rockymontana?

PLATE IX, fig. 20.

Spirifera Rockymontana Murcou, Geol. N. Amer., p. 50, pl. 7, fig. 4; Feb., 1858.
Spirifera Keokuk Hall, Geol. Rept. Iowa, vol. 1, pt. 2, p. 642, pl. 20, fig. 3; Sept., 1858.
Spirifera Keokuk var. Hall, Ibid., p. 672, pl. 24, fig. 4.
Spirifera opima Hall, Ibid., p. 711, pl. 28, fig. 1.

Several specimens of a *Spirifera*, of the form referred to *S. Keokuk* var. Prof. Hall, have been obtained from Newtonville, Ohio, which are so entirely similar to those from the St. Louis and Chester limestones of Iowa, as to be absolutely undistinguishable; the form of the shell, the form and number of the plications, and the minute surface structure being exactly as in those.

The form of the shell will vary from longer than wide to much wider than long, dependent on the extension of the hinge-line. In profile the shell is extremely ventricose, with a strongly enrolled beak; a moderate cardinal area, vertically striated; a well-marked mesial fold and sinus; from seven to ten simple, rounded, or sub-angular plications on each side, and from four to six bifurcating or dividing plications on the fold and sinus. The plications and intervening spaces, when the surface is well preserved, are marked by fine longitudinal lines, showing even on partially exfoliated specimens, and are also crossed by still finer transverse striæ which undulate in crossing the plications, and on perfectly preserved surfaces appear to be minutely setose on their edges.

The species is extremely variable in its general outline, as exhibited among the collections from all of the many localities from which I have examined specimens, especially in the extension of the hinge-line, and the proportional width of the shell below, and also in the prominence of the mesial fold; but the form of the plications and the character of those marking the fold and sinus are usually the same in all; while the most constant and persistent character, and one I have have been able to detect on specimens from almost every locality noticed, consists of the minute structure of the surface. I have lately examined a large number of examples from the limestones and sandstones of the Coal Measures of New Mexico, which correspond exactly with those figured by Prof. Marcou under the name *S. Rockymontana*, and find them showing all the variations in form noticed among the Keokuk, St. Louis, Chester, and Coal Measure limestones of Ohio and the West, and am thoroughly convinced they cannot be separated, even as local varieties, with any degree of safety or satisfaction.

Formation and Locality.—The specimen figured is from the Maxville limestone (Chester), at Newtonville, Ohio.

Genus ATHYRIS McCoy.

Athyris subquadrata.

PLATE X, figs. 1–3.

Athyris subquadrata Hall, Geol. Iowa, vol. i, pt. 2, p. 703, pl. 27, fig. 2, and p. 708, fig. 118.

Shell small or of medium size, subquadrate in outline and strongly trilobate, very variable in its proportional length and breadth, varying from longer than wide to much wider than long. Valves ventricose, the ventral the most rotund, with the beak more or less prolonged and incurved, the extremity distinctly and rather strongly truncated and perforated by a round foramen of considerable size; the middle of the valve is marked by a rather deep, more or less angular mesial sinus, which extends to the beak, but is faintly marked in the upper third of its length becoming strong and distinct toward the front where the shell is prolonged and bent upward in a lingulate extension. Dorsal valve most rotund on the umbo, the beak obtuse and incurved; middle of the valve strongly elevated in front, forming an abrupt, rounded, mesial fold, which is not strongly marked posterior to the middle of the length, and scarcely defined in the upper part. On the sides the shell is bent downward, forming on each side of the fold a deep sulcus, outside of which the shell is again inflated or elevated, giving a strongly trilobed form to the front half of the valve. Surface of the shell marked only by concentric lines of growth, which are mostly confined to the anterior portion, and are often very numerous and crowded, giving the shell a much thickened appearance on the margin.

The species is a well-known type of the Chester limestones of Illinois and Kentucky, and is often identified with *Athyris* (*Terebratula*) *ambigua*, of the European Carboniferous rock. The Ohio specimens are equally characteristic in form with any of those from the West, and may be readily distinguished by its strongly trilobate form.

Locality.—Newtonville and Maxville, Ohio.

Genus TEREBRATULA Llhwyd.

Terebratula turgida.

PLATE IX, figs. 21 and 22.

Terebratula turgida Hall, Trans. Albany Inst. vol. IV, p. 6, extract page 6, 1856.

Shell rather smaller than medium size, ovate in general form, the point of greatest width usually below the middle of the length, and the length nearly one-third greater than the transverse diameter; base truncate and slightly emarginate. Valves moderately to highly ventricose, the ventral generally the deepest and sinuate below the middle of the length, often deeply so; beak strong, incurved, obliquely and very distinctly truncate, and perforated by a proportionally large foramen. Dorsal valve highly convex, with an abruptly incurved beak, which passes within the deltidial opening of the opposite valve; front of the valve sometimes convex and sometimes slightly sulcated, causing the emargination or truncation of the base. Shell structure finely punctate, and the surface often ornamented by concentric varies of growth.

The specimens from Ohio are larger than those from the typical locality (Spergen Hill, Ind.), usually are, but not so large as they are sometimes found. They correspond closely in form and general characters, but are not so generally sulcated on the dorsal valve. They are, however, altogether too similar to afford means for specific distinction. The most of the specimens which I have examined from Ohio have been slightly distorted by compression and in this condition may not afford as many points of difference as more perfect individuals would have done.

Formation and Locality.—In the Maxville limestone at Maxville and Newtonville, Ohio.

MOLLUSCA.

LAMELLIBRANCHIATA.

Pinna Maxvillensis.

PLATE X, fig. 5.

Pinna Maxvillensis Whitf., Ann. N. Y., Acad. Sci., 1882. p. 221.

Shell of about a medium size, very acutely triangular in outline, with highly convex valves; the length along the hinge equal to nearly three times the greatest width. Hinge-line straight, not quite as long as the shell below; anterior end acute; basal margin very slightly arcuate, and the posterior extremity rather broadly rounded; the point of greatest length being at about one-third of the width below the hinge-line. Surface of the shell, except for a short distance within the basal margin, marked by moderately strong, simple radiating plications, about eighteen in number, as counted at the posterior end of the specimen figured, but increasing in number with increased growth; the additions being near the hinge. There are also numerous strong concentric lines of growth parallel to the margin, often forming undulations of the surface.

I find no American species described that closely resembles this one; but *P. flexicostata* McCoy, from the English Carboniferous rocks (British Pal. Foss., p. 499, pl. 3, E, figs. 11–13), is very similar, but has slightly stronger radii, is somewhat broader, and differs in having a longitudinal depression just below the hinge-line, which this species does not possess.

Formation and Locality.—In the Maxville limestone, at Maxville, Ohio. Collection of Prof. E. B. Andrews.

Genus SCHIZODUS King.

SCHIZODUS CHESTERENSIS.

PLATE X, fig. 4.

Schizodus Chesterensis M. and W., Geol. Rept. Ills., vol. 2, p. 301. pl. 23, fig. 6.

Shell of medium size, transversely subovate, with moderately convex valves and large, strong, incurved, and projecting beaks. Anterior end forming one-third the length of the shell, inflated, and rapidly sloping from the beaks to the longest point, which is near the middle of the height, and rounding backward below; posterior end elongated and narrowed, obtusely pointed at the extremity; basal margin irregularly convex, most strongly arcuate opposite the beaks; posterio-cardinal margin sloping somewhat rapidly from the beaks backward, and the cardinal slope rather abrupt. Surface of the shell smooth, except for the fine lines of growth.

The specimen used in the above description was identified by Mr. F. B. Meek, and labeled by him with the name here applied to it. The specimen is slightly distorted and otherwise injured, but in its present condition very closely resembles those described in the Illinois Report. Still on one valve which preserves nearly all of the posterio-cardinal slope, the lines of growth would indicate a shell with a much higher posterior end than those above cited; and when better material is obtained it may be necessary to give it another specific name.

Formation and Locality.—In the Maxville limestone, at Maxville, Ohio. Collection of Columbia College.

Genus ALLORISMA King.

ALLORISMA ANDREWSI.

PLATE X, fig. 6.

Allorisma Andrewsi Whitf., Ann. N. Y. Acad. Sci., 1882, p. 222.

Shell of medium size or smaller, transversely elliptical in outline; the length being about twice the height, and the thickness a little more than two-thirds the height. Valves ventricose, most rotund a little in advance of the middle and along the umbonal ridge, and wedge-shaped posteriorly, as seen in a cardinal view; beaks of moderate size slightly projecting above the hinge-line, incurved, directed anteriorly, and situated at about one-sixth of the entire length from the anterior end. Cardinal line straight or appearing slightly concave, extending about three-fourths of the length of the shell from the beaks backward, and bordered by a proportionally large and wide escutcheon. Anterior end short, sloping forward from between the beaks, at about an angle of forty-five degrees to the hinge-line, to near the middle of the height of the shell, and then abruptly rounding backward into the somewhat regularly convex basal margin. Posterior end broadly rounded from the point of the umbonal ridge to the extremity of the cardinal line. Anterior end of the shell characterized by a very small lunule. Surface of the shell marked by several strong concentric undulations or folds, which are simple, and regularly increase in size and strength to near the full size of the shell; but near the outer margin of the valves, in the specimen figured, they are smaller and doubled by the interpolation of an intermediate rib. The undulations are crossed obliquely from the beak to the basal margin, just posterior to the middle, by a narrow, almost imperceptible sulcus, and along the crest of the umbonal ridge by a line of low-convex and faintly-marked nodes, one on the surface of each undulation; the posterior umbonal slope is also marked, immediately below the margin of the escutcheon, by a slightly concave sulcus, across which the undulations are more faintly marked than below.

The species is closely allied to *Allorisma clavata* McChesney, and was at first supposed to be identical; but on comparison, it shows so many points of difference that it became necessary to consider it as a distinct species.

Formation and Locality.—In limestone of the age of the Chester group (or Chester and St. Louis combined), at Newtonville, Ohio. Collected by E. B. Andrews, to whom the species is dedicated.

ALLORISMA MAXVILLENSIS.

PLATE X, figs. 7 and 8.

Allorisma Maxvillensis Whitf., Ann. N. Y. Acad. Sci., 1882, p. 222.

Shell small, the specimen used being a little less than one inch in length, and the height less than half the length. Form of the shell transversely elongate, and cylindrically oval, the cardinal and basal margins parallel and very slightly curved, and the extremities very nearly equally rounded; beaks small, inrolled, barely projecting above the cardinal line, and situated at about one-fourth of the entire length from the anterior end. Body of the shell very evenly and highly rounded from the cardinal to the basal margins, and almost as convex posteriorly as in front. Umbonal ridge scarcely perceptible, and the umbonal slope convex; escutcheon and lunule not defined; anterior slope abruptly rounded. Surface of the shell marked by faint concentric undulations of unequal strength, but most strongly marked on the posterior end and on the umbonal slope.

The evenly convex and regularly cylindrical form of the shell, together with the inconspicuous beaks and the equal-sized anterior and posterior extremities, are distinguishing features of the species. The shell shows evidence in its form and curvature, in a profile view, of having been slightly gaping behind.

Formation and Locality.—In limestone of the age of the Chester group of Illinois, at Newtonville, Ohio.

GASTEROPODA.

Genus STRAPAROLLUS Montfort.

STRAPAROLLUS SIMILIS.

PLATE X, figs. 9–11.

Straparollus similis M. and W., Geol. Surv. Ill., vol 3, p. 285, pl. 19, figs. 4 and 5.

Shell about a medium size, helicoid, with a slightly elevated spire, and a broad, open umbilicus in which are exposed portions of several of the volutions. Volutions from four to four and a half in number, moderately increasing in size, flattened on the upper surface, sharply carinate on the upper peripheral angle, and rounded on the periphery and on the basal and umbilical surfaces. Besides the carination on the upper lateral angle of the volution, the larger one often bears a second ridge, of considerable strength, on the middle portion of the lower surface; which, on many of the larger specimens, is developed into a sharply elevated ridge; while on other specimens of similar size it is entirely obsolete. Aperture circular. Surface of the shell marked by fine, closely crowded, transverse lines of growth, presenting a slightly roughened surface under a lens.

A number of the specimens on hand, of both small and large size, are marked on the centre of the periphery by an irregular fringed expansion of considerable width, presenting an appearance similar to what might result from a vertical crushing of the volution and spreading out of this portion of the shell laterally; but as many of them do not possess this character to any extent, it can scarcely be considered as an organic feature of the species. A single individual among them shows this feature existing on all of the volutions, the outer whorls reaching to just below the expansion.

The shell is of a form common to the Lower Carboniferous formations, and also to those referred to the Waverly group and to the Chemung of New York; species occurring both with and without the revolving carinæ, *E. Hecale* Hall (Illust. Dev. Foss., pl. 16, fig. 12), of the Chemung group, is usually destitute of the ridges, as is also *S. cyclostomus*, of the Burlington sandstones of Iowa and other States. There are forms in the Lower Carboniferous of Illinois, in the St. Louis and Chester groups, showing the carinæ, as does also *Euomphalus* (*Strap.*) *laxus* White, and *Euomph.* (*Strap.*) *Utahensis* H. and W., from the Waverly group as represented in the far West. The different species described present slight differences from each other, but are all so closely allied in form as to be not readily distinguishable.

Formation and Locality.—In the Maxville limestone, Chester group, at Newtonville, and near Maxville, Ohio. Collected by Prof. Andrews.

Genus NATICOPSIS McCoy.

NATICOPSIS ZICZAC.

PLATE X, figs. 15 and 16.

Naticopsis ziczac Whitf., Ann. Sci., 1882, p. 223.

Shell small, the greatest diameter of the body-volution, in the only individual seen, being about nine-sixteenths of an inch; and the entire vertical height of the shell only half an inch. The shell is very obliquely ovate in form, and consists of about two and a half ventricose volutions, which increase somewhat rapidly in size to the last one, which forms nearly the entire bulk of the shell. The surface of the shell is ornamented by a series of strong and raised transverse lines, which, on the upper volutions, are simple as far as the suture below, and are directed strongly backward in their passage; but on the body-volution they appear more distant and conspicuous, and are directed strongly backward in their passage for about one-third the vertical diameter of the volution, where they are bent forward at an acute angle, and after continuing for a distance nearly equal to their length above, are again bent backward. Across the middle of the volution, they make two or more zig-zagging bends in vertical lines, forming a revolving band of vertical ridges on the periphery; below this band, the lines are directed forward obliquely, running nearly parallel to the base of the shell.

The peculiarity of this shell consists entirely in the structure of the surface ornamentation, as the general form of the species is similar to that of many others, but the peculiar zig-zag feature of the ornamenting ridges will at once distinguish it from all other described species. Several ornamented forms of the genus are known from the Coal Measures, but their markings consist of nodes, either promiscuously scattered or arranged in patterns.

Formation and Locality.—In the limestone of the age of the St. Louis and Chester beds of Illinois (Maxville limestone), at Newtonville, Ohio.

Genus HOLOPEA Hall.

Holopea Newtonensis.

PLATE X, fig. 12.

Holopea Newtonensis Whitf., Ann. N. Y. Acad. Sci., 1882, p. 224.

Shell of medium size, ovate in outline and ventricose, with a moderately elevated spire and extremely ventricose volutions, which increase very rapidly in bulk from the apex. Volutions three and a half to four in number, with strongly rounded surfaces and moderate sutures. Apical angle about seventy degrees. Aperture broad ovate, modified on the inner side by the preceding volution, pointed at the upper end and broadly rounded at the base. Surface of the shell smooth and substance very thin.

The form of the shell is much like that of a *Macrocheilus*, but the substance is much thinner than those usually are, and the base of the columella is not prolonged, nor is there a solid axis; but specimens show satisfactory evidence of having been distinctly and largely umbilicated.

Formation and Locality.—In the Maxville limestone (Chester), at Newtonville, Ohio. Collection of Columbia College, New York.

Genus MACROCHEILUS Phillips.

Macrocheilus subcorpulentus.

PLATE X, fig. 14.

Macrocheilus subcorpulentus Whitf., Ann. N. Y. Acad. Sci., 1882, p. 224.

Shell small, the specimens observed not exceeding five-eighths of an inch in length, and the diameter rather exceeding half the length; spire conical, the apical angle being about fifty degrees. Volutions about three or three and a half, rapidly increasing in diameter and very ventricose, the last one forming more than half the length and much the greater bulk of the shell; suture deep and well marked. Aperture ovate, short, and oblique. Surface of the shell smooth. Columella not seen.

This species is rather closely related to several forms which have been described from the Coal Measures of the Western States, but differs in the form of the volutions somewhat from any, and in the more regular tapering spire—those mostly having the body-volutions proportionally enlarged.

Formation and Locality.—In the Maxville limestone (Chester and St. Louis groups), at Newtonville, Ohio. Collected by Prof. E. B. Andrews.

Genus POLYPHEMOPSIS Portlock.

Polyphemopsis melanoides.

PLATE X, fig. 13.

Polyphemopsis melanoides Whitf., Ann. N. Y. Acad. Sci., 1882, p. 225.

Shell rather below a medium size, elongate-fusiform; the length nearly twice and a half the greatest diameter, when not compressed; spire elevated, pointed at the apex, the apical angle being about thirty-five degrees when uncompressed. The specimen figured gives on measurement thirty degrees in the line of compression, and forty degrees in the opposite direction. Volutions about five and a half, gradually increasing in size, moderately and evenly convex, with distinct sutures. Aperture elongate ovate, widest across the middle, rounded and effuse below and pointed above. Columella not observed. Surface apparently smooth.

This species nearly of the form of *M. fusiforme* Hall (Geol. Rept, Iowa, vol. i, part 2), from the Coal Measures of Iowa, but is considerably more slender. It is possible it may not properly belong to the genus, as the columella has not been closely observed; but so far as can be determined, it appears to be twisted.

Formation and Locality.—In the Maxville limestone, at Newtonville, Ohio. Collected by Prof. E. B. Andrews.

HETEROPODA.

Genus BELLEROPHON Montfort.

Bellerophon sublævis?

PLATE X, figs. 20 and 21.

? Bellerophon sublævis Hall, Trans. Albany Institute, vol. iv, p. 32.

Shell of a medium size or smaller, subglobose in general form, with a moderately expanded lip around the sides of the aperture. Umbilicus closed, the axis being solid and the auriculations thickened at their junction with the body of the shell, covering the central or axis portion. Volutions round and globular within the auriculations, the inner ones projecting into and strongly modifying the forms of the aperture, which is transversely reniform and expanded at the sides. Surface of the shell not known from Ohio specimens.

The Ohio specimens referred to this species are all quite imperfect; being imbedded in compact limestone and the shell replaced with crystals of carbonate of lime, they do not give the entire characters, so their correct reference to *B. lævis* Hall is somewhat doubtful. The species as seen on entire individuals from the original locality is slightly keeled on the outer volution, and marked, rather faintly, by curved transverse striæ parallel to the margin of the aperture, and indicates a rather shallow but broad notch in the margin of the aperture.

Formation and Locality.—The originals of the species are from Spergen Hill and Bloomington, Indiana; and the Ohio specimens are known from Newtonville and Maxville, Ohio, in the Maxville limestone.

Bellerophon alternodosus.

PLATE X, figs. 17-19.

Bellerophon alternodosus Whitf., Ann. N. Y. Acad. Sci., 1882, p. 225.

Shell of about a medium size, and somewhat subglobose in general form, with an appearance of being slightly flattened on the dorsum in immature specimens; while on the adult forms, the dorsum is marked on the outer half of the body-volution by a double series of rounded nodes, those on one side of the center alternating with those of the other side, and the inner margins of the two series interlocking with each other. Aperture broadly elliptical, strongly modified by the projection of the preceding volution, on the inner margin. Auriculations largely developed and slightly reflected. Axis very distinctly perforate. Inner lip somewhat callous on the protruding inner volution. Surface of the shell, so far as can be ascertained, marked only by lines of growth, beyond the nodes mentioned.

This species is somewhat similar in general form to *B. Montfortianus* N. and P., from the Coal Measures, in its general form, but does not possess the strong transverse folds nor the carina between the lines of nodes marking the dorsum. It also differs in the alternating positions of the nodes.

Formation and Locality.—In the Maxville limestone at Newtonville, Ohio. Collection of Columbia College, New York.

CEPHALOPODA.

Genus NAUTILUS Breynius.

Nautilus (Temnocheilus) spectabilis.

PLATE X, fig. 22.

Nautilus spectabilis M. and W., Proc. A. N. S. Phila., 1860, p. 469.
N. (Endolobus) speetabilis Geol. Rept., Ill., vol. ii, p. 308, pl. 25, fig. 1.

Shell of medium to large size, composed of several volutions, which increase rapidly in size, and are transversely elliptical in a transverse section; the diameter from side to side being about one-third greater than the dorso-ventral diameter at the same point; the lateral edges being obtusely angular, and the dorsal portion of the section larger and more convex than the inner part, strongly convex and subangular on the back. Inner surface of the volution strongly impressed by the one preceding, which it embraces to near the point of greatest diameter. Umbilicus very broad and deep, exposing each of the inner volutions to just beyond the point of greatest transverse diameter, the umbilical surface of the volutions being moderately convex but quite abrupt. The sides of the volutions are marked by a series of nodes of considerable strength and size, arranged at regularly increasing distances, and occurring, as nearly as can be determined from the example on hand, at about every second septum. The nodes are situated on the crest of the side, and are obtusely rounded and prominent. Septa moderately distant and but slightly bent downward on the dorsum. On a specimen measuring about three inches in its greatest diameter, the whole of which is septate, they are arranged at about one-third of an inch apart, near the outer extremity of the last volution. Siphuncle not observed, and the depth of the septa not ascertained. The surface of a portion of the specimen bears marks of a series of strong varices of growth, which have crossed the dorsum and show a strong retral sinus or notch in the margin of the lip at this point. The varices are seen on the inner portion of the last volution and appear to have been arranged at distances nearly corresponding to the septa at the same place. No other markings of the surface are retained.

The specimen from the Maxville limestone is somewhat smaller than that from the Chester limestone figured by Meek and Worthen (Geol. Ill., vol. ii, plate 25, fig. 1), and varies slightly in having the larger bulk of the volution outside of the line of nodes that occur on the lateral angles; or in other words the dorsal portion is larger than the ventral, though on the inner volutions of the specimen this character is not so distinct. Beyond this slight difference they appear to agree as far as the characters are preserved. The difference between this species and *Nautilus Forbesanus* McChes. (New Pal. Foss., page 63, and accompanying plate 3, fig. 4 a and b), from the Coal Measures, Mercer county, Ill., are almost too slight for specific distinctions, where all the examples are internal casts. In the last-named species the bulk of the volution is on the inner side of the line of nodes instead of on the outside as in the one now under consideration, while in the one now figured by M. and W. it is very nearly or quite equally divided. Where all other features are the same in all, these would scarcely seem to be of specific importance.

From the strong sinus in the lip on the back of the shell the species has been referred to McCoy's genus *Temnocheilus*, and would be so classed if that division should be retained.

Formation and locality.—In the Maxville limestone (Chester), near Rushville, Ohio, from the collection of Prof. E. B. Andrews.

NAUTILUS PAUPER.

PLATE X, fig. 23.

Nautilus pauper Whitf., Ann. N. Y. Acad. Sci., 1882, p. 226.

Shell somewhat below the medium size, and consisting of about two and a half volutions, which increase rather rapidly in size, and are so coiled as to expose almost the entire diameter of the inner coils in the umbilical cavity; the outer one embracing only the dorsal surface of the inner volution. Volutions quadrangular in form, with the lateral diameter only about two-thirds as great as the dorso-ventral diameter; while the dorsal and ventral surfaces are nearly vertical to the plane of the sides, so far as can be determined from the specimen on hand; or possib y the dorsal surface may be slightly rounded. The sides of the shell are marked by a faint, narrow, revolving sulcus bordering the margin of the umbilicus, and by a correspondingly faint ridge close to the dorsal margin; while a much stronger rounded ridge occurs on the surface at about one-third of the width of the volution from the dorsal border. Internal features of the shell not known.

A single individual only of the species has been observed, and is altogether too imperfect to reveal all the features. It consists of the non-septate portion of the shell, in the condition of an internal cast, with the impression of one side of the entire shell; but gives no indications of the septa themselves. The only features indicating its cephalopodous nature, upon which one can rely, are its symmetrical form, and the evidence of a similar ornamentation on the opposite sides; otherwise it might have been supposed to represent a form of *Euomphalus*.

Formation and Locality.—In the Maxville limestone (Chester), near Rushville, Ohio. Collection of Prof. E. B. Andrews.

FOSSILS FROM THE COAL MEASURES.

ECHINODERMATA.

CRINOIDEA.

Genus CYATHOCRINUS Miller.

Cyathocrinus Somersi

PLATE XI, figs. 4 and 5.

Cyathocrinus Somersi Whitf., Ann. N. Y. Acad. Sci., 1882, p. 226.

Calyx very shallow, being low and spreading; the extreme height to the top of the first radial plates not exceeding one-fourth of the diameter; the sides, above the middle of the subradial plates, gradually and almost evenly curving. Centre of the calyx below deeply impressed, the cavity embracing the basal and inner half of the subradial plates. Basal plates very small, extending but little beyond the circumference of the proportionally small column, and forming by their union a somewhat regular pentagon. Subradial plates of medium size, four of them being equal, and pointed at their upper ends, the upper edges being convex; the fifth plate is larger than the others, and is truncated above by the very small first anal plate, which rests between the adjacent first radials, and has apparently joined three other plates above. The surface of this plate bears a single round granulose tubercle. First radial plates nearly twice as wide as high; their lateral faces being short and uniting with those of the adjacent plate, except on the anal side, where they are separated by the first anal plate. Articulating face for the second radials nearly straight, but deeply grooved. Second radial plates short; that of the anterior ray being cuneiform above, and has supported an arm-plate on each upper sloping surface. The second radials of the other rays have not been fully determined; but on the antero-lateral rays, where partially detached plates remain, they have been quadrangular, as if for the support of other radial plates in a direct series. Surface of the inner half of the subradial plates smooth, while the outer half and the entire surface of the other plates are covered with proportionally large, distinct, irregular tubercles, which are flattened on their surfaces and covered with numerous small, distinct granules. The granules also extend to parts of the intermediate surface. The upper margin of the first radial is bounded by an elevated transverse ridge, which is also granulose.

This species bears considerable resemblance in its general surface-markings to *Eupachycrinus tuberculatus* M. and W. (Geol. Surv. Ill., vol. v, pl. 24, figs. a, b), but the tubercles are very distinctly granulose. It, however, does not possess the structure of *Eupachycrinus*, having only one small anal plate, the upper end of which projects above the line of the first radials. The only specimen yet obtained of the species measures about three-fourths of an inch in diameter, and is about three-sixteenths of an inch high to the top of the first radial plates.

Formation and Locality.—In the Coal Measures at Carbon Hill, Hocking county, Ohio. Collected by Mr. Somers, of Columbus, Ohio.

Genus ZEACRINUS Troost.

Zeacrinus Mooresi.

PLATE XI, figs. 6–10.

Zeacrinus Mooresi Whitf., Ann. N. Y. Sci., 1882, p. 227.

Form of entire body unknown. Calyx of moderate size and pentagonal in outline, very broadly cyathiform or shallow cup-shaped; the region of the basal plates being impressed, and the radials but moderately curving upward at their outer edges. Basal plates small, forming by their combination a nearly regular pentagon. Subradials proportionally large, wider than high, four hexagonal and one on the anal side heptagonal. Subradials short, but not very broad, twice to twice and a half as wide as long; the cicatrix for the second radials very large and nearly straight. The anal plates, three of which are preserved, are longer than wide. Column small, round, composed near the calyx of alternately small and large plates, with very coarse radiating lines of articulation. Surface of calyx smooth, except a line of granules just within the margin of the subradial plates.

The second radial plates present the strong specific feature of the species, and are large and spine-bearing, as in *Zeacrinus mucro-spinus* McChesney. The spines are long, much thickened, and bulbous in the lower part, presenting in this respect a strong contrast with those of that species. The cicatrix for the attachment of the arm-plates is very large, showing that the plates above were of large size. Arms and dome unknown.

The species has been quite abundant, as the spines are found in great numbers, and vary considerably in size, according to the width of the first radial plates upon which they have rested. But all are thickened and bulbous, and many of them are more than an inch in length. They are seldom found attached to the calyx, but are scattered through the shale in the bed where found.

Formation and Locality.—In shale of the Coal Measures at Carbon Hill, Hocking county, Ohio. Named in honor of H. Moores, Esq., of Columbus, Ohio, their discoverer.

MOLLUSCOIDEA.

BRACHIOPODA.

Genus DISCINA Lamarck.

Discina Meekana.

PLATE XI, figs. 1–3.

Discina nitida? (Phil.) M. and W., Geol. Ill., vol. v, p. 572, pl. 25, fig. 1.
Not *Discina nitida* Phillips, Geol. Yorkshire, vol. ii, p. 221, pl. 11, figs. 10–13.
Discina Meekana Whitf., Ann. N. Y. Acad. Sci., 1882, p. 228.

Shell of moderate size or larger, circular or subcircular in outline. Dorsal valve convex with an elevated beak which is directed backward and situated at about one-third of the length of the shell from the posterior margin. Posterior slope slightly concave just below the apex; anterior slope convex. Surface of the shell, when preserved, marked by fine, even, but elevated and regular concentric lines, with flattened interspaces; about ten or eleven of the elevated lines occupy at space of an eighth of an inch on the middle of a shell, being finer within and coarser beyond that point. On the partially exfoliated shell, fine radiating vascular lines are perceptible. Ventral valve flat, discoidal, circular in outline, or perceptibly elongated in some cases; the apex a little more than one-third the length of the shell from the posterior margin. Foramen small, elongate-elliptical, narrow, not extending more than one-fourth of the distance from the apex toward the margin, and the depression somewhat further. Surface marked as in the other valve.

This shell would appear to be identical with the one described and figured by Messrs. Meek and Worthen as *D. nitida?* under the supposition that it was the same as that figured by Prof. Phillips, in the Geol. Yorkshire Coast, vol. ii, pl. 11, figs. 10–13; but it differs very much in outline from those figures, as well as those given by other authors, in its circular form; those being ovate, narrowed behind and widened in front; also, in having the apex much more distant from the margin. They also cite *D. Missouriensis* Shumard, as a synonym of the European species. That author indicates his shell as parabolic in outline; from which statement I should consider it as distinct from the present species.

Formation and Locality.—In the Coal Measures at Carbon Hill and Flint Ridge, Ohio; also in Illinois and Iowa.

Genus CRANIA Retzius.

Crania carbonaria.

PLATE XI, figs 11 and 12.

Crania carbonaria Whitf., Ann. N. Y. Acad. Sci., 1882, p. 229.

Shell small, none of the specimens observed exceeding three-eighths of an inch in diameter; subcircular in outline, or varied in form by the outline of the object to which they are attached. Free valve depressed convex, marked by a few concentric lines of growth; attached valve thin, but with a slightly thickened margin. Posterior muscular impressions large and submarginal, the others being nearly central and forming a small elevation just posterior to the middle of the valve.

The shells of this species are found attached to the spines of *Zeacrinus* and other bodies, one of those figured being upon the operculum of *Naticopsis.* They are very thin, and not easily detected in the roughened condition caused by the adhering material in which most of the fossils from these beds are found. Species of this genus are rather rare in the Coal Measures, but very few having been described. *Crania permiana* Shumard, from the white limestones of the Guadalupe Mts., Texas, is a large form, and probably not a *Crania*, according to the description given. *C. modesta* White and St. John, from the Coal Measures of Iowa, is described as "rather small, finely punctate, smooth, except somewhat strong concentric lines of growth toward the margins. Upper valve moderately convex, umbo oblique, nearly central. Lower valve moderately concave." There would appear to be some similarity between the upper valves of this and the Ohio species; but the remark concerning the lower valve being "moderately concave" throws considerable doubt on their identity, as the lower valve of this species is attached over its entire surface, while that one would appear to be free or partially free, if it is a *Crania*.

Formation and Locality.—In the Coal Measures of Carbon Hill, Hocking county, Ohio. Collected by H. Moores, Esq., of Columbus, Ohio.

MOLLUSCA.

GASTEROPODA.

Genus MACROCHEILUS Phillips.

Macrocheilus regularis.

PLATE XI, fig. 13.

Loxonema regularis Cox, Geol. Rept. Ky., vol. iii, p. 566, pl. 8, fig. 2, 1857.

Shell of moderate size, fusiform, with an elevated, rapidly ascending spire, which is composed of about nine volutions, and has an apical angle of from twenty to twenty-five degrees, in different individuals when not compressed. Spire, when viewed in front, forming considerable more than half the length of the shell, but when measured on the opposite side forms a little less than one-half the entire length. Volutions slightly convex and in some individuals presenting a slightly shouldered aspect caused by a very slight, almost imperceptible augularity at about the upper third of the exposed part. Greatest diameter of the body-whorl situated a little below the suture and decreasing below. Suture close and not strongly marked. Aperture narrow, elongated, the outer lip sharp and compressed in the upper part. Columella twisted and marked in the lower part by a single, but very strong twisted fold; anterior end of the lip rimate. Surface of the shell marked only by obscure lines of growth.

The species is one of the most elongated forms of the genus yet recognized from the American Coal Measure strata, and will be readily recognized by the great length of the spine, especially as seen in a front view; while the unusually strong columellar fold will also distinguish it. In most of the specimens observed the body volution appears to contract more abruptly above in its outer half than before, giving a somewhat unsymmetrical feature to this part of the shell. All the examples seen are compressed in the direction of bedding, usually to the extent of one-third of their original diameter or more, and some of them are entirely flattened. This gives them in appearance a much greater apical angle than the living shell really possessed, which may easily mislead one in making a hasty comparison. The longest individual observed measures two inches and five-eighths in length, and has a diameter of the body-whorl of one inch. The shell is considerably flattened except in the upper part of the spire, which shows the diameter of the lower part to have been increased fully one-third. The species was originally described by Prof. T. C. Cox, loc. cit., as a *Loxonema*, and his figure would indicate a shell like *Polyphemopsis*, but feeling uncertain of its accuracy in consequence of the great similarity, I procured the loan of the type specimen, which with but little cleaning shows the columellar fold as strongly developed as any of the Ohio specimens.

Formation and Locality.—In the Coal Measure strata at Carbon Hill, Hocking county, Ohio. Collected and presented by Mr. H. Moores, of Columbus, Ohio.

Genus LOXONEMA Phillips.

Loxonema plicatum.

PLATE XI, figs. 14 and 15.

Loxonema plicatum Whitf., Ann. N. Y. Acad. Sci., 1882, p. 231.

Shell small and slender, spire elevated, presenting an apical angle of about fifteen degrees; composed of about eleven volutions, in the example used and illustrated, which are flattened on the surface in the direction of the spire, and marked by strong vertical plicæ, which are directed a little forward in their passage across the volution from above downward. The body or largest volution, counting from the lip backward, contains fifteen of these plications, and the volutions above contain nearly the same number; those of the several volutions being in line with those on the one below, but set enough back of it to be in line with the slope of the plication. This gives them a somewhat spiral arrangement on the shell, the whole having a twist of about one-fourth of one turn in the length of the shell. On the last volution the plicæ are not distinct much below the bulge of the whorl. Aperture elongate and pointed below. Suture distinct, but not grooved or banded. Columella straight, about half as long as the aperture, solid, and terebra-like; shell without umbilicus.

The species belongs to a group of the genus which has but few representatives in our Coal Measures; and even those that are nearest allied to it appear to differ in the form of the columella, which is somewhat peculiar; and if other species should appear presenting these same characters, it may be necessary to separate them generically from the true *Loxonema.*

Formation and Locality.—In the Coal Measures of Carbon Hill, Hocking county, Ohio. Collected by H. Moores, Esq.

CEPHALOPODA.

Genus NAUTILUS Breyn.

Nautilus Ortoni.

PLATE XII, fig. 20.

Nautilus Ortoni Whitf., Ann. N. Y. Acad. Sci., 1882, p. 231.

Shell of medium size, and consisting of about two and a half or three closely coiled volutions, but which are not at all embracing; the outer one being simply in close contact with the medio-dorsal portion of the next within, and exposing nearly the entire dorso-ventral diameter of the shell. Volutions transversely subpentangular, being angularly convex on the back, strongly subangular on the sides, and concave on the abrupt umbilical slope, which forms a somewhat sigmoidal curve resembling an ogee moulding, while the slightly concave ventral surface is quite narrow, and forms a fifth surface. Lateral angles obtuse or round subangular, and ornamented by a series of nodes which are strong and very distinct on the inner coil, broad and rounded on the first part of the last volution, and become obsolete on the outer third. The substance of the shell has been very thick and strong, and the surface shows no evidence of growth-markings or striæ. Septa and other internal features unknown.

The shell resembles somewhat *N. spectabilis* M. and W., but has a smaller number of coils in a shell of corresponding size, while the concavity of the umbilical slope and the subangular back are strong distinguishing features.

Formation and Locality.—In the Coal Measures at Springfield, Summit county, Ohio. Cabinet of the School of Mines, N. Y. City.

Nautilus (*Gyroceras?*) *subquadrangularis.*

PLATE XI, fig. 16.

Nautilus (*Gyroceras?*) *subquadrangularis* Whitf., Ann. N. Y. Acad. Sci., 1882, p. 232.

Shell of about medium size, consisting of two volutions, as seen on the specimen used, which increase somewhat rapidly in size with increased length, and are closely coiled so as to bring them in close contact, but not to be in any degree embracing. The inner volution, however, is coiled in so large a circle that it leaves an opening within it of about one inch in diameter. The shell is at first circular in section, but before the completion of the first coil the form has become modified so as to produce a subquadrangular section, narrowest on the dorsal side, and the second volution becomes distinctly quadrangular, being nearly as wide on the dorsum as across the lateral face; but the angles are all distinctly rounded, and the inner or umbilical margins most particularly so. The inner part of the shell has a line of strong node-like undulations on each dorsal angle, which becomes obsolete at about the first third of the second volution. Margin of the aperture greatly extended on the sides beyond the line of the inner edge, and apparently sinuate on the back. Septa deeply concave and numerous; those at the base of the outer chamber showing about three chambers in the space of one inch, and gradually decreasing in distance toward the earlier part of the shell. On the quadrangular parts, they are deeply receding on the sides and back, and correspondingly advanced on the angles; a consequence of the quadrangular form on a deeply concave septum. Surface of the shell apparently smooth and the substance thin. Siphon unknown.

The species is peculiar in its quadrangular form, and in the wide opening through the centre: in these characters it differs from any previously described species. It is of a form that is with difficulty placed in the genus *Nautilus*—its characters, so far as the external features are concerned, nearly resembling those of *Gyroceras*—and in the absence of a knowledge of the position of the siphuncle, must remain doubtful.

Formation and Locality.—In limestone of the Coal Measures, at Canfield, Ohio. Collected by H. C. Bowman, and now in the cabinet of the School of Mines, New York City.

The following species are forms which characterize two different beds of chert in the Coal Measures in the Hocking Valley, and are sufficiently pronounced to leave no doubt of their true horizon. These beds have been used as horizons from which to determine the position of the rocks in that vicinity.

MOLLUSCOIDEA.

BRACHIOPODA.

Genus DISCINA Lamarck.

Discina Meekana Whitf.

For references and synonym see page 483.

Specimens of this species are not uncommon in both of these chert beds, the imprints only remaining.

Genus SPIRIFERA Sowerby.

Spirifera (Martinia) lineata.

PLATE XII, fig. 3-5.

Spirifera lineata Martin.

Internal casts, of small size, of this shell are quite common in the upper chert layers of the Coal Measures in Hocking county, bearing all the features of the species so far as the casts are concerned, but the matrix was not obtained in a sufficiently perfect condition to yield the external form of the shell. In the black or lower cherts some of the individuals have obtained a larger size, one specimen measuring about five-eighths of an inch in transverse diameter. A small individual of the species was obtained in the lower black chert, at Webb Summit, retaining all the fimbriæ of the surface in a most perfect manner, an enlarged figure of which is given on Plate XII, fig 6.

Genus ATHYRIS McCoy.

Athyris subtilita.

PLATE XII, figs. 7–9.

Terebratula subtilita Hall, Stansbury's Rept. Great Salt Lake, 1852, p. 409, pl. iv (by error in text pl. ii), fig. 1 a, b, and 2 a, b. *Terebratula subtilita*, *Athyris subtilita*, and *Spirigera subtilita* of various authors.

Internal casts of specimens of this species, of small size, are common in the upper chert beds of the Coal Measures in Hocking county, Ohio. Individuals have been observed varying in size from less than one-eighth of an inch to more then half an inch in diameter, but all in the condition of casts. The larger specimens, although much smaller than those usually found in the shaly limestones at Greentown and elsewhere, nevertheless show distinctly by their markings and the distinctness of the musculars scars that they were adult shells, but probably stunted in growth by unfavorable conditions, as they are perfect in form and markings. The specimen illustrated on Plate XII, figs. 7–9, is from the cherty layers at Mrs. Banks, in the railroad cutting, Falls township. The individuals from the black cherts, at Webb Summit, Hocking county, are of larger size, and correspond more nearly with the ordinary forms of the species.

MOLLUSCA.

LAMELLIBRANCHIATA.

Genus AVICULOPECTEN McCoy.

Aviculopecten interlineatus.

PLATE XII, figs. 10 and 11.

Aviculopecten interlineatus M. and W., Proc. Acad. Nat. Sci. Phila., 1860, p. 454; Geol. Rept. Ill., vol. 3, p. 229, pl. 26, fig. 7.

Shell small, subcircular in outline, hinge-line straight, nearly as long as the width of the shell below, and with sharp angular auriculations. Valves very gently convex. Surface of the left valves marked by fine, even, lamellose, concentric striæ; several of which are more strongly and highly elevated, forming varices at regularly increasing distances. Right valve also marked by similar fine striæ, but with the varices very indistincly marked, or barely perceptible under a lens.

The species is a very strongly marked one, and very characteristic of the Coal Measures. Mr. Meek describes indications of faint radii between the varices on the examples from Illinois, but which do not appear on specimens from Ohio so far as observed. The right valve figured occurs close by the other, and is evidently of the same individual; the features are very similar, differing only in the absence of the strong concentric varices.

Formation and Locality.—In a thin layer of chert of the Coal Measures, near the farm of Mrs. Banks, Falls township, Hocking county, Ohio.

GASTEROPDA.

Genus NATICOPSIS McCoy.

Naticopsis Ortoni.

PLATE XII, figs. 12 and 13.

Naticopsis Ortoni Whitf., Ann. N. Y. Acad. Sci., 1885. p. 230.

Shell small, with a somewhat depressed conical spire, which forms an angle of about 105 degrees, and the two and a half to three volutions are obliquely flattened on their upper side, in the direction of the spire; the outer one being marked just below the suture by a barely perceptible concave channel of considerable width, which produces a very slight angularity of the upper part of the volution. Suture-line slightly grooved. Lower side of the volution rounded; umbilicus closed; callus slight; aperture obliquely ovate at the outer margin, but rounded within from the excessive thickening of the shell. Surface of the shell marked by fine, rather equal and somewhat regular transverse striæ of growth, most distinctly marked on the lower half of the volution. On the outer half of the last volution, there occur lines of nodes, very faintly indicated, having a direction opposite to the growth-lines, and becoming faintly and finally imperceptible toward the lower side.

The species resembles *N. nana* M. and W. (Geol. Rept. Ill., vol iii, p. 365, pl. 32, fig. 4), in size and general form, but differs from it in the greater flattening of the volution in the direction of the spire and in the faintly nodose surface.

Formation and Locality.—In a thin cherty band of the Coal Measures in the railroad cutting at Mrs. Banks' farm, Falls township, Hocking county, Ohio.

PULMONIFERA.

The existence of shells of terrestrial air-breathing Mollusca in the Coal Measures of this country was first made known in the year 1851, when Sir Charles Lyell and Prof. J. W. Dawson made known their discovery of *Pupa vetusta* in the coal-beds of the South Joggins, Nova Scotia. Since that time there have been several additional species discovered in the same region, and others in the Coal Measures of Indiana. In the Am. Jour. Sci. for November, 1880, Prof. Dawson has given a summary of the species known from the coal formations up to that time, and also described what he supposes to be a similar form from the Devonian plant-beds of St. John, New Brunswick. At the time Prof. Dawson's memoir appeared I was working on the form herein described, from the Upper Coal Measures at Marietta, Ohio, which has proved to be so entirely distinct from any of those previously known that it became necessary to found a new genus (*Anthracopupa*) for its reception, which was published in the above-mentioned journal, February, 1881.

All the species known up to the time of Prof. Dawson's paper were supposed to belong to the inoperculate division of the terrestrial Gasteropods, and had been referred to the HELICIDÆ and PUPINEÆ. In making the studies of the Ohio shell I had obtained, through the kindness of John Collett, Esq., State Geologist of Indiana, specimens of the two forms from that State, and in freeing them from the matrix I discovered that the species *Dawsonella Meeki* Brad. possessed not only the reflected and slightly thickened lip described by its author, but that the inner lip and much of the umbilical region were covered by a thickened and flattened callus closely resembling that of *Helicina*, furnishing strong presumptive evidence that it had been provided with an operculum, like the shells of that genus. If this view of its nature is correct, it would place it with the HELICINIDÆ in the operculate section of the Pulmonifera. The Ohio shell has also some peculiar features that are not recognized among any of the Pupa-form species heretofore described from this formation. It is of small size, and the general form is similar to that of the group of the Pupæ usually referred to the genus *Vertigo*; minute shells with a nearly vertical aperture, armed with several projecting tooth-like points within its cavity. This shell not only presents these same features, but the additional one of having a small, nearly circular notch in the peristome near the upper end of the outer lip, very closely resembling the minute pore-like notch occurring near the upper angle of the aperture in the genus *Pupina* Vignard; or that seen in *Anaulus* Pfieffer. This latter feature is not present so far as I am aware in any genus of operculated pulmoniferous shells; at least not in the same degree nor with the same apparent purpose that it occurs in the operculated genera above mentioned. The last volution is also flattened or contracted on the back in a very similar manner to that of *Pupina*, as well as of many of the Pupæ. It would therefore almost seem as if in this little shell, of this early age, there were foreshadowed features that afterwards pertained to these two groups of a later time; although the projecting teeth within the aperture as hereafter described would preclude the possibility of an operculum in this case.

Genus ANTHRACOPUPA Whitf.

Am. Jour. Sci., vol. xxi, February, 1881, page 1:6.

Shell minute, pupaform, with few volutions, the last one unsymmetrical; axis imperforate; aperture large, nearly vertical; peristome thickened, united above by a thin callus on which may occur one or more palatal teeth; other tooth-like projections occur on the inner margin of the lip, and a small, nearly circular notch, resembling that in *Pupina*, deeply indents the inner edge of the outer limb near its junction with the body-whorl. Surface of the shell marked by fine, nearly vertical lines.

Type *A. Ohioensis.*

Anthracopupa Ohioensis.

PLATE XII, figs. 15–17.

Anthracopupa Ohioensis Whitf., Am. Jour. Sci., Feb. 1881, vol. xxi, p. 126.

Shell small and robust, having a length of about three and one-third mm. with a transverse diameter of about two mm., and consisting of about four volutions, the last one extremely ventricose, except on the outer half, where it is obliquely flattened and contracted, and with the aperture, forms about three-fourths of the entire length of the shell. Aperture large, longer than wide, and broadly rounded at the base; lip thickened, rounded within and forming a flattened thickened rim on the outside; particularly on the lower part. Labial notch situated very near the upper extremity of the lip, regular in shape, and forming nearly two-thirds of a circle. A single tooth-like ridge of moderate size extends inward from the lip at about the middle of the columellar side, and another of greater size projects nearly vertically from the middle of the callus which coats the body of the volution within the aperture. Umbilical chink small. Surface of the shell marked by fine, nearly vertical, even striæ or lines. Apex apparently mamillated.

Formation and Locality.—In the higher beds of the Coal Measures, near Marietta, Ohio. The specimen figured is in the collection of the Schools of Mines, Columbia College.

Pupa vetusta and *P. Vermilionensis* are both associated in the material in which they are found with small helicoid shells (*Zonites* and *Dawsonella*), also pulmoniferous in character; but the Ohio shell up to the present time is not known to have any such associate; on the contrary, like the first individuals of *P. vetusta* discovered, it is accompanied in one of the layers in which it occurs, by immense numbers of what appears to be a species of *Spirorbis*, which is so abundant that small hand specimens from which two of the Anthracopupas were obtained appear to be nearly half composed of these shells. The form of the shell is similar to most species of the genus, and has a diameter of nearly one line. Although it occurs packed together in such immense numbers in the rock it has one surface generally more or less flattened as though for attachment to some foreign body, and has I presume during life been attached to marine plants, from which it has fallen as they were decomposed, and thus been amassed on the muddy bottom.

ANNELIDA.

Spirorbis anthracosia.

PLATE XII, figs. 18 and 19.

Spirorbis anthracosia Whitf., Am. Jour. Sci., Feb., 1881.

Shell minute, planorbiform, composed of from one to two and a half volutions, tube slender, and very gradually increasing in diameter, marked by very fine, irregular encircling striæ, which are often gathered into little knots or points near the border of the open umbilicus. Lower side of the shell more or less flattened as if for the attachment to some foreign substance. Diameter seldom exceeding one line, generally less.

Formation and Locality.—In the higher strata of the Coal Measures, near Marietta, Ohio.

NEW GENUS AND SPECIES OF BURROWING FOSSIL BIVALVE SHELL.

Several years ago Prof. Edward Orton of the Ohio Geological Survey, called my attention to a mass of Tetradium from the Hudson river group, Brown County, Ohio, which was filled with perforations or burrows like those often seen in living corals, made and occupied by species of Lithodomus. On close examination several of the burrows were seen to have shells, occupying them, which at the time were thought to be examples of *Sedgewickia? divaricata*, described in Vol. II, Pal. Ohio, p. 89, Plate 2, fig. 3. More recently, on closer examination, and by removing one of the shells from the burrow, it proves to be a very distinct species and to present some of the general appearance of a *Modiolopsis*.

That the shells now occupying the burrows in this coral were the original excavators of the perforations, there can be no question, I think; as there are remains of no less than twelve individuals to be seen in the burrows, all of the one form, while no other shell is present. Moreover, they are each suited in size to the burrows they occupy. So far as I am aware no shell resembling *Modiolopsis* and possessing burrowing habits, is known to occur in Silurian or Devonian rocks; these therefore present a new feature in the molluscan life of this period that is highly interesting.

The perforations or burrows in this coral are of various sizes from very small ones to those more than an inch in length as seen in section and of a diameter of more than a fourth of an inch, and where shells are seen in them they appear of a size suited to the burrow they occupy. The shells when fully grown, or what appear to be adult, are nearly or quite three-fourths of an inch in length, and of nearly three-eighths of an inch in height from base to cardinal margin. The burrows are not uniform in direction as seen in the coral, but are vertical, lateral or oblique in direction indiscriminately; but are confined principally to the lower side and margins of the mass; which is about seven by four and a half inches in diameter and nearly three inches thick, of an elongated oval and sub-hemispherical form.

Although the shells have much the form of *Modiolopsis* in general outline, and have large anterior and posterior muscular scars, with an entire pallial line, they differ much in surface characters, being strongly marked by regular, elevated, concentric ridges, parallel to the margin of the valves. This structure is so markedly different from that of *Modiolopsis*, that, when taken in connection with the burrowing habit, I think it necessary to place them under a distinct generic head, and therefore propose for them the name *Corallidomus*, in allusion to their habitat, and designate them as *Corallidomus concentricus*, from the concentric surface markings, with the following diagnosis of generic and specific characters.

Genus CORALLIDOMUS, New Genus.

Korallion, a Coral and Domos, a House.

A bivalve mollusk having anterior and posterior muscular scars, and an integral pallial line; shell oblong, with an external ligament and somewhat modioliform outline, coupled with a burrowing habit of life. Type *C. concentricus.*

Corallidomus concentricus, New sp.

PLATE XIII.

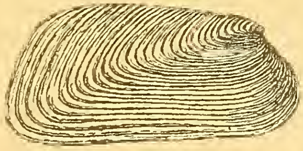

Fig. 2.

FIG. 1.* View enlarged of a shell restored, the measurements taken from the two best specimens.

FIG. 2. Enlarged view, two diameters, of the right side of the shell indicated by the cross on the large figure. The shell is exfoliated and reveals the muscular markings.

Shell small, twice as long as high, and moderately ventricose; cardinal and basal margins subparallel, generally converging slightly anteriorly; valves subangular along the umbonal ridge; beaks small, rather pointed anteriorly, situated at about one-fourth of the entire length of the shell from the anterior end; anterior end rounded below the median line of the valve, posterior end obliquely truncated and broad; surface of valves marked by even, sharply elevated, concentric ridges or lamellæ, which are abruptly curved in crossing the umbonal ridge, presenting or rather accentuating the slight angularity of the ridge.

Formation and Locality.—In the Cincinnati Shales of the Hudson River group, Brown County, found in its native burrows in *Labechia Ohioensis* Nich.

*I regret that the cut for figure 1 has been lost since it came into my possession. E. O.

Appendix.

Leiorhynchus Newberryi.

LEIORHYNCHUS NEWBERRYI H. and W., 23d Rept. State Cab., N. Y. In the descriptions of this species it is correctly referred to the Chemung group, but improperly to the Waverly group on the plate.

Genus PHOLADELLA H. and W.

Preliminary Notice of Lamellibranchiate Shells of the Upper Helderberg, Hamilton, and Chemung groups, etc. (State Cab. Nat. Hist., Dec., 1869, p. 63). The name ("Hall, n. g.") incorrectly inserted without my knowledge.—R. P. W.

Pholadella Newberryi.

PHOLADELLA NEWBERRYI H. and W. Prelim. Notice, cited above, p. 65.

Allorisma (*Sedgwickia?*) *pleuropistha* Meek, Pal. Ohio, vol. i, p. 309, plate 13, Figs. 4*a* and 4*b*.

Pleurotomaria Mississippiensis.

PLEUROTOMARIA MISSISSIPPIENSIS White and Whitf., Proc. Bost. Soc. Nat. Hist., 1862, p. 203, vol. 8.

Pleurotomaria textiligera Meek, Pal. Ohio, vol. i, p. 314, plate 13, figs. 7*a* and *b*.

NOTE.

The material embodied in the foregoing paper, with the accompanying plates, was originally prepared for, and was expected to form a part of Volume III. of the Palæontology of Ohio, and to be published as a part of the work of the geological survey of that State, then under the directorship of Prof. John S. Newberry; but owing to a change of policy of the State authorities, the volume was never published. Subsequently, a part of the matter was published in the Annals of the Academy of Sciences in March, 1882, under the title of "Descriptions of New Species of Fossils from Ohio," and references made to the volume and plates as prepared for the survey report. Consequently the new genera and species will date from that publication, except a few of the Crustaceans which had been previously published in the Am. Jour. Science for January, 1880, pp. 33 to 42, in conjunction with one hundred and twenty-five copies of an artotype plate distributed with author's copies. In preparing the matter for republication in the Annals at the present time it became necessary to alter the numbering of the plates[1] from one to twelve, as at first made, to five to sixteen; otherwise the matter stands essentially as originally prepared.—R. P. W.

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[1] The original numbering is restored in the present volume. E. O.

CHAPTER IV.

OBSERVATIONS UPON THE SO-CALLED WAVERLY GROUP OF OHIO.

By Prof. C. L. Herrick, Denison University, Granville, O.

Introduction.

It is proper to say that the following pages were prepared, at the request of Professor Orton, as a summary of results arrived at in the course of a number of years of desultory exploration among the sub-carboniferous and infra-carboniferous rocks of Ohio. These studies occupied such intervals of time as could be filched from a laborious professional life and cannot be said to have had much coherency or system. The results, such as they are, have been published in the Bulletins of Denison University, the American Geologist, and the Bulletins of the American Geological Society. That these studies have contributed something to the solution of a vexed problem of long standing is to be attributed, first, to the method employed, viz.: the strict coördination and mutual supplementing of paleontological and stratigraphical data. In a region where, in the nature of the case, lithological characters are inadequate and unreliable, the necessity of minute and pains-taking study of the organic remains of each horizon is imperative. Such detailed study is chiefly desirable from a biological standpoint and the comparatively small amount of work done in the present case is sufficient to prove that there is a most interesting field for the study of evolutionary changes in the Waverly rocks of Ohio. It is only the uninitiated who need to be warned that in strata apparently barren of fossils the labor involved is enormous. The writer will, perhaps, never hope to again have the patience to examine, literally inch by inch, acres of shales as has been done in the prosecution of this study. The second fortunate element in our work has been the circumstance that it was begun in a typical portion of the series where the (hitherto over-looked) landmarks separating important subdivisions are conspicuous. The fact that the Waverly has been most often studied as exposed in the northern part of the State, where only one of the members is well developed, has occasioned much confusion. The strange assumption that the entire series of over 500 feet is essentially homogeneous paleontologically has militated against a correct appreciation of the nature of the problem. This may be in part explained as a result of the great monotony of the lithological characters of the series and is, in part, an illustration of the dominancy of a name. So long as collectors remained satisfied with labeling specimens "from the Waverly group of Ohio" (as adequate a datum as "from the Upper Silurian of New York" would be), it is little wonder that the formation was found irreconcilable to any scheme of classification.

Furthermore, the fact that the strata are almost exclusively littoral and that their position is frequently complicated by sand-bar and fluviatile agencies explains many perplexing complications. In the present paper it will be impossible to enter into detail; in the paleontological portions especially it must be admitted that a final clearing up of the synonomy cannot be undertaken until the numerous species more or less fully described by the lamented Alexander Winchell shall have been reviewed and illustrated. This work, which the distinguished Michigan geologist left unfinished when so unexpectedly called hence, remains an imperative need of American geology. It should also be remembered that the writer makes no pretense at being a professional paleontologist and only ventured to describe the material collected when it was possible to accompany the description by a figure which would serve to enable others to use the data on which his conclusions were drawn. After some years of complete neglect of this subject, to which he never expects to return, it would be useless to attempt a revision of the descriptions already as fully elaborated as the opportunities permitted. The accompanying illustrations will enable the reader to determine at a glance the salient characters of the several horizons. Mistakes of various sorts made during these studies and incident to the method of publication have been corrected as far as possible, while those which remain are recommended to mercy. It remains to acknowledge the assistance afforded me in this study by my revered friend, Professor Edward Orton, to whom Ohio and the science of Geology, in common with hundreds of students who have sat under his personal instruction during more than a score of years, are deeply indebted.

Historical.

It will be unnecessary to attempt a complete resumé of the history of opinion because Professor Alexander Winchell has given a very elaborate discussion of the subject in the Proceedings of the American Philosophical Society, vol. XI, 1869. The earliest reference to the rocks here in discussion is a paper by Dr. S. P. Hildreth in the American Journal, Vol. 29, upon the "Bituminous Coal Deposits of the Valley of the Ohio."

In this paper they are described as "argillaceous sandstone rocks, very fine grained," and the fossil remains are imperfectly illustrated by Dr. S. G. Morton. Although C. Briggs, in his paper in the First Annual Report of the Ohio Geological Survey, 1838, applied the name Waverly Sandstone series to these rocks, they were for a long time designated simply "Fine grained sandstone series."

When Professor Hall, in 1842, announced the results of his extended western explorations (American Journ. Science, XLIII, etc.), he regarded all the strata lying between the black (Ohio) shale and the mill-stone grit as equivalent to the Chemung and Portage.

The black shale was considered as the only representative of the Marcellus shale of New York, the Hamilton group, and Genessee slate. The equivalence of the Ohio "fine-grained sandstone series" with the Chemung was several times reiterated by Professor Hall and Professors White and Whitfield, and seems not to have been called in question, although evidence was fast accumulating that the equivalent horizons in Missouri, Iowa and Michigan have a Carboniferous habitus, until 1862, when Professor Hall remarks that "the Waverly sandstone group of the Ohio reports, at one time regarded by me as entirely equivalent to the Portage and Chemung groups may, in its upper members, constitute a distinct group, though we do not know any line of demarkation between them[1]." More direct evidence of the position of the Waverly was afforded by the descriptions of Crinoids from Richfield, O., in 1863. The list, containing seventeen species, was reissued by Professor Hall in 1865[2], and closes with the statement that "Left to the evidence afforded alone by the collection, and the means of comparison at present possessed, I should infer that the geological position of these beds is between the Hamilton group and the lower Carboniferous beds; while the occurrence of a single species identical with a species in the middle of the Chemung group will ally them more nearly with the fauna of the Hamilton group than with that of the Carboniferous period." With respect to this statement it may be added that in the locality mentioned there is exposed almost solely a small range of very fossiliferous shale from the lower third of the Waverly in which we nowhere find the typical Waverly faunal habitus. The upper portion of the series is wholly absent and only here and there are remnants of the middle Waverly (Kinderhook) to be found and these often in abnormal proximity to the lower series. The next lower fossiliferous horizon is that of the Bedford shale, which, as I have shown, has a large series of forms identical with or similar to Hamilton species. It thus appears that inasmuch as, faunally at least, these beds lie between Kinderhook and Hamilton horizons, it is not unnatural that the Crinoids should have resemblances to Devonian types. At the same time the fact, now abundantly proven, that true Chemung (Erie) beds lie below

[1] Canadian Naturalist and Geologist, vol. VII.

[2] XVII Rep. N. Y. Regents. 1865.

the Bedford shales in the northern tier of counties shows the fallacy of seeking exact parallelism of strata or faunæ originating under such diverse physical conditions.

In July, 1865, Professor Alexander Winchell undertook a comparison of the faunæ of the various formations supposed to be the western equivalents of the Chemung of New York, and found to his astonishment that not a single species out of about 175 forms collected in Ohio, Iowa, Michigan and Illinois proved identifiable with Chemung species. He says "In the light of these identifications, and in the absence of all identifications between western species and those of the Chemung, as well as between the species of this so-called Chemung conglomerate and those of the Chemung, it might not seem unreasonable to doubt its affinities with recognized Chemung rocks and to suspect its continuity with the supposed Carboniferous conglomerate until observation shall have demonstrated that its stratigraphical position is really below that formation. And further, since we must probably abandon the attempt to coördinate the Chemung of New York with the fossiliferous portions of the sandstones and shales of the west lying between the 'Black slate' and the Coal conglomerate, it seems not unlikely that we may yet be able to prove the conglomerate of Western NewYork to be the attenuated and littoral prolongation of those western sandstones and shales—at least of the superior and fossiliferous portions of them, so that the latter would stand as a hitherto unrecognized group of strata lying at the very base of the Carboniferous system, while the Chemung rocks of New York fall within the Devonian system, toward which the writer is now inclined to think that their paleontological affinities attract them."

In 1866 Professor Winchell made a brief survey of Knox and Coshocton counties in company with Professor Newberry, and reported that several of the Waverly species were known to extend into the Coal Measures, and therefore suggested that the "chocolate shales" (estimated thickness 534 feet) are the equivalent of the Portage and Chemung. The chocolate shales here referred to embrace the Bedford, Berea, Cuyahoga and Waverly shales of my own reports.

Professor Winchell is therefore to be credited with the first attempt to separate an upper, sandy (Logan) group as Carboniferous in faunal characters from a lower shaly, Devonian portion.

On the other hand, the attempt to definitely parallelize the upper Waverly with the Catskill group of New York may be said, in the light of our present knowledge, to have proven quite futile.

In 1866 Professor Hall again insisted on the Chemung age of the Waverly and his conclusions were so generally accepted as to close, for the time, all discussion of the subject.[1]

In 1869, however, Professor Winchell again resumed the discussion and published in the Transactions of the American Philosophical Society

[1] Trans. American Philosophical Society, 1866, p. 246.

a very elaborate historical and paleontological review of the whole question, seeking to effect a parallelism between the formations of all the western states and New York. To this paper the reader is referred for the materials for a critical study of the question. The second part of this paper appeared in May, 1870, and contained a list of over 400 species from rocks supposed to be contemporaneous with the Waverly or Marshall group. Of these 139 were from Ohio and 160 from Iowa, and something over 100 from Michigan. At least 50 species in the Iowa list are also found in Ohio and 27 found in Michigan were also found in Ohio. It should be noticed that Professor Winchell distinctly separates the Marshall from the chocolate shales of the lower Waverly. It is necessary to apply a name to the exclusion of the "Chocolate Series" of Ohio, underlying the fossiliferous sandstones of the Waverly series.

He did not discover that the Cuyahoga shale, and indeed the entire exposed Waverly of the northern counties of Ohio, belongs to this lower shaly series, nor that, instead of being unfossiliferous, it is locally one of the most richly fossiliferous horizons of the State. Had he discovered that the strata upon whose fauna Professor Hall pronounced the Waverly of Chemung age belonged in the "chocolate series" which he expressly relegated to the Devonian, we had been spared a long and fatiguing discussion.

It still remains to note that the upper and sandy portions are by no means as homogeneous as supposed hitherto. All of the attempts to assign the Waverly to its proper position in the series have been wrecked on the fatal fact that the collections have been made indiscriminately without regard to altitude in the series. This is due to the lithological and physical similarity of the rocks from top to bottom and to the very fickle and irregular character of the conglomerates.

It may be added that the extent to which the upper surface of the Waverly has been eroded varies greatly in various parts of the State so that the distance beneath the Millstone grit is absolutely no guide in those portions where the entire series is represented, and much less so where the fluctuations in level have superposed the grit on the projecting base of the Waverly series. In no other way can the Waverly problem be understood than by considering the slow but extensive oscillatory or rocking movements of the earth's crust which have shifted the depositing waters back and forth, and even caused two adjacent basins or regions to play hide and seek with each other.

Of the work of the Ohio Geological Survey, it is here unnecessary to speak. The paleontological work of Mr. Meek served to throw into stong relief the Carboniferous character of the Waverly. The list of fossils studied was very small and Mr. Meek was at the time in precarious health, so that we unfortunately were deprived of a thorough discussion of the subject at the hands of the ablest of American paleontologists. To this lack may be ascribed the slow progress subsequently made in

Ohio stratigraphy. The economy which sacrifices exhaustive paleontological study of a series of stratified rocks is sure to prove short-sighted in the long run. Mr. Meek said, "I have seen no reason to change an opinion long since expressed in a joint paper with Prof. Worthen, that this rock and its equivalents in Illinois, Indiana, etc., belongs to the Carboniferous system. It may also be added that, from the first, I have been impressed with the rather curious fact that many of the Waverly fossils have much more closely allied representatives in the Coal Measures of our Western States than in the Lower Carboniferous limestones of the same region." He adds that he has not the slightest suspicion that the Waverly should be included in the coal measures[1]. Of the thirty-two Waverly species described only about twelve are from the lower portion of the Waverly which might alone be sufficient to indicate that the opinion of Professor Meek was chiefly formed upon the basis of specimens from the Logan group or sandy portion of the Waverly. But of the remainder it is significant that the forms are either species with a recognized wide range, like *Grammysia hannibalensis*, *Hemipronites crenistria*, etc., or species like *Palæoneilo bedfordensis* which too closely resemble Devonian forms, or new species whose resemblances are either decidedly Devonian or unsignificant. The great weight of Mr. Meek's opinion cannot, there fore, be applied to sustain the Carboniferous relationship of the lower division of the Ohio Waverly. Professor Newberry insisted that "the series of strata which begins with the mechanical sediments of the Portage has a fauna more Carboniferous than Devonian in character. The commencement of the epoch of the deposition of this series of mechanical sedimnts * * * was in fact the beginning of the Carboniferous period." In the second volume of the Ohio Geology he says: "That all its rich fauna is of a decidedly Carboniferous type; second, that it includes a number of species of the lower Carboniferous rocks of Kentucky, Tennessee, Illinois, Iowa, and Michigan; third, that it furnishes at nearly all of its fossiliferous localities certain species which are also common in the coal measures above; fourth, that our collections made include no Chemung or Portage species; fifth, that it is continuous with the 'vespertine' and 'umbral' rocks of Pennsylvania." The curious fauna of the Bedford was at that time almost unknown nor had the abundant fauna of the concretionary shales near the base of the Waverly been explored. The basal shales were supposed to be practically unfossiliferous. In the fifth volume of the New York Paleontology, Professor Hall seems to withdraw his oft-repeated statements as to the Chemung habitus of the Waverly fauna; he says: "A careful examination of those species supposed to have a vertical range from the Chemung group to the Waverly group, has shown that they are allied forms but specifically distinct." The genera, however, are for the most part identical, only four genera of lamellibranchs found in the Waverly are not also found in the Hamilton or Chemung.

[1] Paleontology of Ohio, Vol. II, p. 272.

Professor Orton's carful stratigraphical work has done much to place the Waverly question on a permanent and satisfactory basis. In as much as his labors have been largely directed to the lower portion of the series, particularly the Berea grit and associated strata, he has not attempted to employ paleontological data to as large an extent as might be requisite in a similarly detailed study of the upper series. Professor Orton suggested a division of the Cuyahoga of Newberry (all the Waverly above the Berea) into an upper sandy portion, which he terms the Logan group and a shaly basal series, for which he retained the name Cuyahoga shales. The student of the Waverly is referred to volume VI of the Ohio Geological Survey reports for a summary of our knowledge of the subject. In this resumè Professor Orton corrects many of the errors of earlier writers and offers the most satisfactory description of the Waverly which had appeared up to that time. In the meantime the writer had been feeling his way toward the same results by means of a minute comparison of the faunæ of various horizons. A first result of these studies was printed in the third volume of the Bulletin of the Laboratories of Denison University, April, 1888. This paper was chiefly devoted to an annotated list of fossils from Licking county and adjacent regions in Ohio. In this paper it was attempted to show that the Waverly consists of three rather distinct portions, which, in central Ohio, are bounded by two thin layers of conglomerate. The lower division, incluing the Berea and Waverly shales, was considered to have a decidedly Devonian habitus, while the middle portion included a mingled fauna of Carboniferous and Devonian character (the latter prevailing), and the upper third merged rapidly into the lower Carboniferous. The following passage is quoted as substantially embodying the results of a study of the Waverly in central Ohio:

"The Waverly group of Ohio is a composite assemblage of lithologically constant character. The lower portion of it is chiefly composed of greyish, yellowish, and greenish arenaceous shales with local grits and nodulary masses of limestone and occasionally, near the base, intercalated layers of bituminous shale. This series is faunally nearly distinct in central Ohio and should be regarded not only as Devonian, but as containing persistent elements from the Hamilton type in connection with Portage and Chemung forms. Moreover, it is believed that geographical variation must be called in very largely to explain the specific divergences, while generic resemblances remain perfectly obvious. Our division II, although so relatively small, was evidently a transition period. Most of the strata may have been deposited while the Catskill was forming at the east, but the fauna was essentially of Chemung character. Nevertheless the connection in Ohio was much more direct with areas where carboniferous types were already appearing and a more or less marked admixture was the result. Conglomerate II marks a slight oscillatory wave passing from north to south, resulting first in mud flats in which burrowing mollusks thrived, and later, in shore-lines kept supplied with pebbles by re-invigorated rivers. When the sea next returned it was with its freight of Carboniferous forms, but the old Chemung species had chiefly perished during the slight oscillation. Comparatively few deep-sea forms accommodated themselves to the littoral conditions for some time, but such as did are related to Burlington or Keokuk species, which formations were then accumulating to the westward."

In this paper, by a curious mistake, the word "Berea" is included in a table on page 26 at the level of the Licking county freestones (Kinderhook) and has given rise to some misconception. In December of the same year the concluding portion of the same paper appeared, completing the list of fossils and summing up the evidence then at command. About forty species regarded as new were described and most of the forms mentioned were figured. A few cursory collections in the uppermost layers at Cuyahoga Falls led to the suspicion that there existed a thin band of shales belonging to horizon of division III. This opinion was materially strengthened by the report of Mr. E. O. Ulrich which appeared in the fourth volume of the Bulletin of Denison University. In his own words, "The bryozoa are thus decidedly indicative of an equivalence between the Cuyahoga shales on one hand and the Keokuk group on the other."

We noted the fact that "an almost entire change in fauna appears a mile or two below Cuyahoga Falls and there is little in common between the upper shales and those below the flags forming the second falls of the Cuyahoga. Subsequent observation has served to emphasize the last statement, but renders it improbable that there is any considerable representation of division III in the typical Cuyahoga as exposed at the falls of that name. It was sufficient to attract attention to discover, by a more careful examination of Mr. Ulrich's list, that a number of identical species occur in the Cuyahoga shales at the Falls and at Bagdad, Richfield and Lodi, as well as in the shales at Moot's run in Licking county, the position of which was well known to be near the base of the Waverly. An abundant fauna, with a strong Devonian facies, was found at this horizon. Glancing at the list of bryozoa we find twenty-four species not previously described. *Fenestella aperta*, *F. tenax* and *F. burlingtonensis* were recognized on admittedly imperfect material while the form identified with *F. regalis* was thought possibly varietally distinct from the Keokuk type. Similarly with the other genera; many of the species may have a wide vertical range and others of those compared to Keokuk species are not well preserved. *Glyptopora megastoma*, if associated with *Spirifer striatiformis* at Sciotoville, is from a horizon comparable with the Burlington. Thus it appears that the evidence for the Keokuk age of the Cuyahoga is less convincing than was at first supposed. In a subsequent visit to these northern localities the calcareous concretionary layer which has yielded so abundant a fauna in central Ohio, was discovered at a distance of forty feet beneath the coal-measure conglomerate and most of the characteristic species re-collected. This served to settle the question conclusively except for the few feet above this horizon. At a level twenty feet higher a curious depauperate fauna is found which seems to be the greatly modified product of the above mentioned. The conditions appear to have been unfavorable and the same species which is large and conspicuously marked in the forty-foot layer is here half the size and faintly marked. A few species belonging to a horizon just beneath conglomerate I, have also been found just below the coal-measure conglomerate at Weymouth. This is a most interesting illustration of the effect of changed conditions on the fauna.

At the August meeting of the American Geological Society in 1890 the writer summarized the then state of the problem substantially as in what here follows. It should be added that valuable assistance was afforded in the field work in various parts of the state by Mr. W. F. Cooper.

General Summary.

As stated by Professor Orton, the Waverly rests with practical conformability on the great series of "Ohio Black Shales," including three divisions which are distinct in the northern part of the State, but, according to Orton, are blended in the central and southern parts of the State. Whether the Huron, Erie and Cleveland shales are fused or regarded as distinct in age (as Dr. Newberry insists) or whether the Erie be regarded as a wedge inserted from the east into homogeneous series formed by Huron, Cleveland and Bedford in the west, it cannot be doubted that the Erie is a close homologue and direct continuation of the New York Chemung. The paleontological and stratigraphical evidence for this statement is complete.

The following passages from a paper in the Bulletin of Denison University, vol. 12, express the general conclusions reached by a study of these faunæ:

"All discussion of the age of the lower Waverly now turns upon the question as to the age of the Erie and Bedford, and this question stands in need of careful field-work and especially more extended and minute palæontological examination. Meanwhile the following suggestions may be hazarded. First, we may assume as proven that the Erie shales are of Chemung age, that is, in the broad sense, including Portage. The fossils, on the whole, indicate lower Chemung or Portage. Are we to conclude from this that all which lies stratigraphically above the Erie is certainly later faunally than the top of the Chemung as seen in New York strata? We think this does not by any means follow. We are struck in examining the stratigraphy of the Waverly by the fact that the dip of the true Waverly strata is southeast and the great area of its deposition is in a different basin from the Chemung. The Waverly strata thin out to the northeast while the Erie increases in thickness in the same direction. The point where the Erie and Waverly strata come into juxtaposition is not, however, along the shore of the Waverly sea, but far to the eastward of the littoral deposits. The two sets of rocks were formed then by different but occasionally interblended seas. The line of strike measurably conforms to the shore line in the Waverly. Thus the plane of 1,000 feet elevation intersects the Moot's run horizon in Licking county and some distance west of Portsmouth in southern Ohio, while at Lodi the same horizon seems nearly at 825 feet probably, throwing the line of intersection further toward the west. There has not been any considerable change of level since the sediments were deposited beyond the gradual sinking of the centre of the basin. It is evident that the Devonian basin in New York and that of the Carboniferous in Ohio are not coincident nor have their movements followed the same rhythm."

"When the strata which constitute the Chemung in New York were forming, what was going on in Ohio?"

"There seems to have been a pretty general uniformity in conditions during the Hamilton period over the entire area considered—indeed a much more extensive one. The change which made the sediments of New York littoral sands and induced a modification of fauna may not have been felt at once in distant areas in Ohio. The undisturbed seas in Ohio may have been concealing a fauna more closely allied to the Hamilton, while the oscillation along the western border of the Chemung area may have once and again thrown a great apron of its own sediments over Hamilton beds, only to be in turn covered by a similar apron from the Ohio beds."

"What, indeed, is to prevent us from believing that when the early fluctuation of the northeastern part of this area was bringing more and more of the Silurian shore-line within its own erosive power and accumulating coarse detrital material in great masses, the weedy sea of the Hamilton continued unaltered in Ohio. Sandy bottom, stormy waves and unaccustomed conditions of all kinds must have their effect on the organization of the fauna and, if accepted ideas of the causes of evolution are correct, a sudden change would be seen in a faunal development more or less forced, one-sided, and local."

"Great variety within narrow groups is the rule under such conditions. Just as the sudden formation of a prairie out of a morass develops hundreds of species in a few genera, so, in this case, such groups as could cope sucessfully with the new conditions would expand, while others disappear. As the agitation extended westward the plot thickens. Somewhere on the western part of our area we should expect to find strata strangely interblended, just as a player in cutting and shuffling a pack thrusts the edges of the cards between each other. Here we should find a stratum marking the return of the former conditions."

"Such a state of things as we have supposed would explain the conditions in northern Ohio in the period before the Berea grit, which put an end to all this by calling in the agency of shore action on its own account in the western part of the basin. Of this there is abundant evidence in the oblique lamination and fucoids of that horizon. If we admit the probability that Hamilton and New York Chemung played a game of hide and seek during the preliminary oscillation they certainly were sadly disturbed during the Berea epoch."

"Then followed a gradual depression with occasional infiltration from the Chemung area, now rapidly contracting. The Berea shales mark the long period of isolation and gradual depression. When the subsequent upheaval began the sea must have extended as far as to the northern highlands and, after gnawing away at their bases and storing up great reservoirs of material, there began the gradual depression which spread them over the whole of the area. Time was then ripe for the opening of the Carboniferous period. The old descendents of Hamilton forms had done what they could, assisted by strays from the Chemung areas further east, and having grown sadly out of fashion they were now subjected to nearly the same influences which were applied in the Chemung area. Littoral action and coarse sediments soon bore fruit in a fauna very like the later Chemung, though that period was now closed in New York."

"Thus grew up our Kinderhook or middle Waverly. But a temporary recession swept the waters backward depositing a shale containing a few descendants of the old Waverly-shale fauna with interspersed forms of Carboniferous types. It was now sub-carboniferous time and the elevation which next followed left its trail of sandy material with a fauna not unlike the Burlington but so hastily retreating as to build no limestone fortifications. But in the far southeast now these limestones gathered strength and with the next gain of Neptune flung a thin apron over the lap of southwestern Ohio into which stormy Coal-measure seas cast millions of tons of stones worn by the universal torrents from the northern shores."

"There can be little doubt that the materials of middle Waverly sandstone and conglomerate were carried by rivers or the like. The epoch of coal-measure conglomerate we have also spoken of as a torrent period. On what grounds? 1st. The accumulation of tree trunks of Carboniferous aspect. 2nd. The nature of the deposits. 3rd. The fickle distribution of the material. 4th. The combination of new and old material in its make-up, etc."

An episode in the evolution of the Waverly problem was the publication of a paper by Professor H. S. Williams[1] announcing the discovery at the base of the Chemung at High Point, Naples, N. Y., of a fauna with decidely Carboniferous aspect, most nearly resembling that of the Kinderhook. This statement rests upon the similarity of the fauna with that

[1] On a Remarkable Fuana at the base of the Chemung Group in New York. American Journal of Science, Feb., 1883.

of the so-called Lime creek beds of Iowa, which latter were, however, referred by Professor Hall to the Chemung and by Western geologists to the Hamilton. The general conclusions are thus referred. "The Kinderhook, well-developed in the interior of the continent, is represented by a thin wedge at the base of the Chemung period of New York; that the upper Chemung fauna probably did not extend far west of New York state, but if it does appear farther west, it should be looked for in the upper part of, or above the Kinderhook group."

In a subsequent number of the American Journal, Professor Calvin[1] discusses these statements, and, while admitting the equivalence of the High Point and Lime Creek faunas, shows clearly that neither is legitimately comparable with the Kinderhook of the West. He says, "Not a single species of the Lime Creek fauna has yet been recognized in all the Kinderhook of Missouri, Indiana and Illinois." The generic assemblage is also entirely distinct. This discussion is referred to for the reason that it seems to indicate that in New York, as well as the western states, there are instances of the apparent interpolation of lower strata in higher. If the High Point fauna prove to be Hamilton or Helderberg, the case is similar to the Bedford fauna in Northern Ohio.

We may next take up in order the several horizons with such help as can be gained from paleontology and stratigraphy.

The Erie Shale.

Dr. Newberry has apparently never recognized the necessity of combining the Cleveland, Erie and Huron shales as the Ohio Black Shales. The Huron he regards as the representative of everything in New York, from the Gardeau shale to the Marcellus, inclusive, finding in it in central and western Ohio, fossils of the Portage, the Genessee, and the Marcellus shales, viz: *Goniatites complanatus*, *Leiorhynchus quadricostatus*, *Lingula spatulata*, *Discina lodensis*, *Lunulicardium fragile*, *Styliola fissurella*, *and Leiorhynchus limitaris.*

If Professor Orton's suggestion that the Cleveland forms "the larger half of the great black shale of southern Ohio" be correct, many of these forms may be derived from that horizon. However this may be, we are treated to a complication quite as perplexing in the fauna of the next group.

The Bedford Shale.

This so-called "chocolate shale" has long been regarded as the base of the Waverly. The shales vary greatly in color and habitus, but as Professor Orton says "there is not a stratum in our geological column that can be followed across the State in more easily demonstrated identity than this." The description given by this author in volume VI of the Ohio

[1] On the Fauna found at Lime Creek, Iowa, and its relations to other Geological Faunas. American Journal of Science, June, 1883.

Geological Reports is so complete that a reference is all that is here requisite. Dr. Newberry has long since decided that the Bedford is Carboniferous, basing his conclusions upon the occurrence of such fossils as *Syringothyris typa*, *Hemipronites crenistria*, *Chonetes logani*, *Orthis michelina, and Spiriferina solidirostris.* As Professor Orton states, "none of these fossils have been reported south of the lake shore," and a study of these localities and collections on which Dr. Newberry's opinion was founded has convinced the writer that these species do not occur in the typical shaly Bedford, but in thin flags associated or interbedded, while the typical Bedford, especially in central Ohio where it reposes directly upon the "Black Shale," carries a considerable series of fossils forming a decidedly Devonian assemblage. More remarkable still, the specific resemblances are unquestionably with Hamilton (in the broad sense) rather than the Chemung fauna.

List of Fossils from the Bedford Shale.

1. *Lingula melie*, H.
2. *Orbiculoidea newberryi*, H.
3. *Orthis vanuxemi*, H.*
4. *Chonetes scitu a*, H.*
5. *Ambocœlia umbonata*, H.*
6. *Hemipronites*, sp.
7. *Macrodon hamiltoniæ*, H.*
8. *Microdon bellistriatus*, *Con.**
9. *Leda diversa*, var. *bedfordenis*, var. n. (*)
10. *Palæonilo bedfordensis* (=var. of *P. constricta*.)
11. *Pterinopecten*, sp.
12. *Bellerophon newberryi*? (*)
13. *Bellerophon lineata*, H. ?
14. *Loxonema*, sp. (resembling *L. delphicola*.*)
15. *Orthoceras*, sp. (resembling *O. linteum*.*)
16. *Goniatites*, sp. (resembling Portage sp.)
17. *Pleurotomaria* (cf. *sulcomarginata*.*)

These fossils are figured on plate XX. The absence of unconformity between the black shale and the Bedford, and the occasional lapses into the same lithological peculiarities in the latter, permit us to assume a substantial continuity of faunæ from one to the other. The peculiar interblending of faunæ along the border region of northern Ohio is to be explained, as already indicated, by the shuffling of the sediments of adjacent basins—a process which was continued in the Cuyahoga shale. Very careful study of the Bedford has not been rewarded by any fossils south of Columbus. The most complete series of fossils

*The species thus marked are identical with, or closely related to Hamilton forms.

was found near Central college, near Westerville. If there is substantial continuity up to the Bedford, an equally close transition connects the latter with the following.

The Berea Grit.

This very constant and well-marked stratum has been most exhaustively described by Professor Orton, in volume VI of the Ohio reports. It is exceedingly poor in fossils and with the exception of *Strophomena rhomboidalis* and a few lingulæ, these are not identifiable. In all probability the fauna was identical with that of the next.

The Berea Shale.

This layer of black bituminous shale which forms the immediate cover of the grit, contains besides fish remains a vast number of *Lingula melie* and *Discina newberryi* wherever it occurs throughout the State. In northern Ohio the same fauna, supplemented by other species of Lingula, is continued some distance higher.

The writer has in previous papers extended the term to the gray and greenish shales following, which, as admitted by Professor Orton, cannot be sharply separated. The faunal similarity would warrant such a procedure, but it has the obvious disadvantage of leaving the upper limit of the Berea shale ambiguous. It will be preferable to restrict the term to the bituminous portion with the understanding that it is but a lithological modification in a continuous series. It can hardly be doubted at present that the Berea grit is the real floor of the series—not necessarily the base of the Carboniferous, but the most convenient base line for the Waverly, if this term is still to be used for this remarkable series of Ohio shales and flags.

The Cuyahoga Shale.

In deference to the usage of the Ohio geologists, this term is here used to embrace everything between the Berea shale and conglomerate I, but it should be remembered that in fauna this series is not homogeneous but presents at least a three-fold subdivision. The lower courses contain beds of flags in southern and central Ohio, of which the Buena Vista beds are the most important. In Scioto county these beds follow immediately the fifteen feet of Berea shales and attain a thickness of twenty-five feet. In central Ohio, while less distinctively developed they nevertheless can be recognized. They are followed by a few feet of shales, which have yielded to a long continued search only a few specimens of imperfectly preserved fossils.

Several days' labor during which the shale was systematically examined bit by bit, inch by inch, have yielded about half a dozen species in obscure fragments. A spirifer apparently intermediate between *Sp.*

marionensis and *Sp. disjunctus*, a Chonetes like *C. scitula*, a Palæoneilo like *P. sulcatina*, a Schizodus somewhat like *S. medinaensis*, a fine Pleurotomaria, *consimilis* and a Proetus being the entire find. The patient student will perhaps secure added material from exposures of this horizon one mile east of Harlem and four miles west of Jersey.

In northern Ohio the same series may be found near the lower falls of the Cuyahoga, where a number of specimens occur, constituting a faunal assemblage quite different from that nearer the conglomerate. (*Allorisma cuyahoga*, *Discina newberryi*, etc., occur.) At Portsmouth, in southern Ohio, this series of shales is nearly suppressed and the true Cuyahoga fauna appears only a few feet above the Buena Vista flags.

The most important portion of the Cuyahoga is that which occupies the upper 90-100 feet at Cuyahoga Falls. Professor Orton says, "The fossils with which the Cuyahoga shale has been credited have been largely derived from the division next to be described [Logan Group] while this was counted part of the shale. As here limited, it is for the most part very poor in fossils." This, as we have seen, is true of Mr. Meek's work but does not apply to the collections studied by Professor Hall and others. Geologists have been looking at two sides of the shield. Statements based on the collections from the Logan do not apply to the Cuyahoga. At the present time it can no longer be said that the Cuyahoga is poor in fossils. As stated in 1888, "This division is one of the most interesting in the State, preserving its fossils, thanks to the calcareous concretions, in perfect condition. The species are mostly new to science but have analogies with Chemung and Hamilton forms. The bryozoa have not furnished conclusive evidence, most of them being new. The upper thirty or forty feet contain the concretions with three or four new trilobites, and *Spirifer marionensis*, *Fenestella herrickana*, *Lyriopecten ? cancellatus*, *Pterinopecten cariniferus*, *Streblopteria fragilis*, *Promacra ? truncata*, etc., are characteristic species. Traces of the same fauna can be followed downward over 100 feet."

Probably the best consecutive exposure of the Waverly is near Lyon's Falls a few miles southwest of Loudonville. Here the fauna of this horizon is abundantly represented, both in calcareous concretions and the enclosing shales. The characteristic portion is seventy feet below conglomerate I. and contains *Phæthonides spinosus*, *Proetus præcursor*, *Edmondia sulcifera*, *Limatulina ohioensis*, *Lyriopecten cancellatus*, *L. nodocostatus*, *Palæoneilo ignota*, *Pterinopecten cariniferus*, *Pterinopecten shumardianus*, *P. ashlandensis*, *Streblopteria fragilis*, *Cyclonema strigillatum*, *Chonetes tumida*, *Spirifer marionensis*, *Sp. tenuispinatus*.

An identical fauna is found in the same horizon at Moot's run some five miles west of Granville in Licking county, where it has been most carefully studied.

Along the Ohio river the same association of fossils is found in the shales twenty feet above the Buena Vista flags, and may be easily studied one mile west of Portsmouth. The upper part of this horizon appears below highwater mark at Sciotoville, at which point it disappears from view. The constancy in fauna is only more remarkable than the lithological uniformity. The same calcareous or ferruginous concretions loaded with fossils greet us at all exposures.

When the same band of concretions was found at the water's edge, 40 feet below the carboniferous conglomerate at Cuyahoga Falls and at Akron in the creek bed near the tile works, the stratigraphy of the Waverly became clear.

A large percentage of the fossils found in Licking county have since been collected from the calcareous nodules in Cuyahoga valley. The depauperate faunæ of the shales in which these concretions lie when compared with the well-formed species of the concretions is explained, and we are convinced that, with the possible exception of 30 feet immediately below the conglomerate, there is nothing in the Cuyahoga valley to represent any part of the Waverly of southern Ohio which rises above the conglomerate I.

Subsequent study of the exposures at Bagdad, Weymouth, Richfield and Lodi, have shown that at a little distance from the margin still more of the series appears and some elements of a fauna which in Licking county lies immediately below conglomerate I are represented in the highest part of the shales. It becomes necessary, accordingly, as already indicated, to place nearly all of the bryozoa and crinoids of the Waverly in this subdivision.

It has already been seen that the crinoids suggest a Devonian age for this series. The bryozoa are mostly new and cannot afford a decisive answer. What of the remainder of the fauna? Unfortunately the species are chiefly unique, but the generic assemblage should be instructive. Among the trilobites we have three genera—Phœthonides extends from the Upper Helderberg to the Hamilton. No trilobites being found in the Chemung, its upper limits in America remained uncertain. It does not occur in the Carboniferous. It extends to the top of division II of the Waverly, *i. e.* from the base to the top of conglomerate II which is the upper limit of the Kinderhook of our classification. It is most abundant in the shales under consideration.

Dalmanites? cuyahogæ, Claypole, even if it should prove that the pygidium described cannot be included in the genus Dalmanites, adds to the Devonian habitus of the crustacea. Proetus is a genus which in America extends from the Upper Helderberg to the Hamilton. In the Waverly it is represented by several species which merge into Phillipsia as we enter division III. A species occurs at the very base of the Cuyahoga shales and others are abundant in the Kinderhook. The obvious resemblances of our species are to the Hamilton forms. The evidence of the trilobites is strongly in favor of the Devonian age of the Cuyahoga shale and affords a beautiful illustration of the slow evolution of genera.

Thus, the genus Phillipsia was evolved during the Kinderhook from Proetus and the genus Brachymetopus from Phæthonides. Turning now to the lamellebranch mollusks, what is their evidence as to the age of the Cuyahoga shales? The genera Leiopteria, Lyriopecten, Palæoneilo, Pterinopecten, Streblopteria and particularly the forms representing them have a decided Devonian habit. Crenipecten occurs in the middle Waverly and Aviculopecten only near the summit of the series. The species of Schizodus are mostly allied to Devonian types. Among the brachiopods Productus and Chonetes are Carboniferous genera, but in the Cuyahoga they are sparingly represented and are mostly allied to recognized Devonian groups. Productella is more abundant than Productus proper The fossils which have been referred to carboniferous species seem in every case to have been incorrectly identified. Productus semirecticulatus does not occur within the Ohio Waverly. Without too greatly extending this discussion it would be useless to consider the remaining groups, but enough has been said to show that the Cuyahoga shales are Devonian and lie above the Hamilton. That the fauna is unlike that of the New York Chemung is explained by the different physical conditions prevailing in the two basins. Professor J. J. Stevenson has recently shown[1]

First, that the Chemung and Catskill deposits were laid down in a shallow basin subsiding most rapidly at the east and along a line rudely parallel to the Blue ridge trend;

Secondly, That the deposits would be much greater near the mainland at the east than at two hundred miles away; so that six hundred feet or more of fine material would more than fairly represent the four thousand feet of Chemung in eastern Pennsylvania; and

Thirdly, that the water beyond the reach of the great land wash held a Chemung fauna throughout the whole of the time of the Catskill deposit. He concludes that the series from the beginning of the Portage to the end of the Catskill, forms but one period; that the deposits of the Catskill were not made in fresh-water lakes; that the disappearance of animal life over so great a part of the area toward the close of the period was due to the gradual extension of the conditions existing in southeastern New York as early, perhaps, as the Hamilton period, and that the Chemung should be retained in the Devonian. Professor Stevenson suspects that the westward prolongation of the Catskill may be found interlocking with the Bedford and Cleveland shales For our own part we should not be surprised to find that the Catskill included representatives of our conglomerates I and II and that Ohio temporarily suffered from influences which prevailed for a much longer period in New York. This would make the Catskill the eastern equivalent of the Kinderhook as nearly as such a parallel could be carried through series originating under so diverse conditions. Our present contention is for the essential

[1] Address before the Section of Geology of the American Association, Aug., 1891.

Devonian habitus of the Cuyahoga and not for any strict chronological parallelism.

The upper fifty feet of the Cuyahoga shale in central Ohio (that portion previously called "Waverly shale"[1]) has a remarkable and very distinct fauna. This has apparently not been fully studied by any previous observer. The typical exposures are between Granville and Newark and a few other localities in Licking county. The same fossils are found near Loudonville, at Gann, at the water's edge below the dam at Portsmouth, etc.; in all these cases these fossils are within a few feet of conglomerate I. Most of the species are limited to the horizon, not extending more than thirty feet below this conglomerate, which may be sought below the freestone everywhere quarried in Licking and adjacent counties. It is a noteworthy fact that this stratum contains a very large portion of the Waverly species which have also been described in Michigan. *Ctenodonta iowensis*, *Edmondia burlingtonensis*, *Grammysia famelica*, *Nuculana spatulata*, *N. similis*, *Orthonota rectidorsalis*, *Palæoneilo elliptica*, *P. plicatella*, *P. elegantula*, *P. marshallensis*, *P. allorismiformis*, *P. attennata*, *Sanguinolites unioniformis*, *S. senilis*, *S. naiadiformis*, *Schizodus prolongatus*, *Streblopteria squama*, *S. media*, *Bellerophon cyrtolites*, *B. galericulatus*, *Orthoceras rushensis*, and many others give an unmistakable habitus to the assemblage. Many of these or allied forms occur in the Kinderhook and Marshall groups and quite a number are found above the conglomerate in the freestone of the middle Waverly.

Division II—Kinderhook Group—Waverly Freestone—Lower Part of the Logan Group—Waverly Conglomerate.

This period was one of greater activity and slight fluctuations in level. The distance between the two conglomerates is only about 60 feet in a normal section and the conglomerates vary from a few inches to several feet. The writer has attempted to show that many of the difficulties in the way of a clear understanding of the middle Waverly arise from the local eccentricities of these conglomerates. That there are two such bands seems not to have been suspected. Both are subject to great local variations. They may take the place of the whole series. On the other hand, they may be absent or only represented by a few pebbles of quartz. Fortunately both are indicated by the remarkably persistent associated fauna. That of the lower conglomerate has been recognized near the top at Weymouth.

A number of fossils are characteristic if not exclusively restricted to the freestone of this division, viz: *Proetus auriculatus*, *Allorisma nobilis*, *A. cooperi*, *Dexiobia ovata*, *Crenipecten winchelli*, *Leiopteria ortoni*, *Microdon reservatus*, *Modiola waverlensis*, *Modiomorpha hyalea*, *Myalina michiganensis*, *Oracaraia cornuta*, *Pholadella newberryi*, *Sanguinolites*

[1] The Cuyahoga shale and the Waverly problem. Bul. Geol. Soc. America, vol. II, p. 37, Jan., 1891.

naiadiformis, *Schizodus cuneus*, *S. chemungensis*, *S. palæoneiliformis*, *S. quadrangularis*, *S. triangularis*, *Spathella ventricosa*, *Streblopteria gracilis*, *Bellerophon galericulatus*, *Conularia newberryi*, *Cyclonema leavenworthiana*, *C. strigillatum*, *Euomphalus latus*, *Flemingia stulta*, *Goniatites lyoni*, *Platyceras herzeri*, *P. bivolve*, *Cryptonella eudora*, *Rhynchonella sappho*, *R. marshellensis*, *Syringothyris cuspidatus*, and many more.

Crenipecten winchelli is ubiquitous and its presence is almost a demonstration that the rock in question lies within or at most a little above these limits.

The upper portion of this section is a soft blue shale which usually has become but slightly compacted. It retains the boring mollusks which originally inhabited it *in situ*, so that the valves of these shells are found in connection, obliquely inbedded in the soft clay, from which they roll on weathering in a fragile but perfect state.

Such forms are *Allorisma winchelli*,* *A. ventricosa*,* *A. convexa*, *Edmondia depressa*, *Grammysia ventricosa*,* *G. rhomboides*, *Prothyris meeki*,* *Pholadella, newberryi*, *Sanguinolites obliquus*,* *S. aeolus*,* *Discina gallaheri Orbiculoidea newberryi*, *O. pleurites*.

Those species marked by an asterisk may be regarded as diagnostic of this horizon. In a period of collecting, extending over seven years, these forms have never been found far distant from conglomerate II. It seems clear that this section of the Waverly is the specific counterpart of the typical Kinderhook, and with the underlying shale, of the Marshall group of Michigan.

We venture to append the remark published in 1888 which seems in the main to fairly state the case:

"The middle Waverly is essentially a littoral zone and its fossils are for this reason largely peculiar, but it can be readily shown that Prof. Alexander Winchell was correct in identifying this horizon with the Kinderhook, etc., of the west. We do not claim that no fossils of the Kinderhook occur above conglomerate II or below conglomerate I, for this would be contrary to all analogy, but we do believe that, as a rather distinct factor of the Ohio Waverly, this may be wholly referred to that age and is its specific equivalent. That this horizon is equivalent to the Catskill of New York, as suggested by Winchell, would be in our judgment too specific a claim. The Catskill is another such local development but it is more intensely local as it is a restricted member of the Chemung series, itself a littoral and provincial deposit. Very strict correlation of strata deposited under diverse conditions may never be possible. Chronological and faunal equivalences are rarely strictly identical. We may safely say that our middle Waverly is *representative* of the Catskill, and that is enough. It is not necessary to rehearse the accumulated evidence to show that this group is more closely allied to the upper, Chemung than the Carboniferous limestones of the west. The species which give to the Waverly its carboniferous aspect as maintained by all writers, are largely from division III.

"Nevertheless, the transition is gradual and almost imperceptible. The following are a few of the species which substantiate the identity with the Kinderhook. (It should be observed that the fossils of the lower sandy portions of the Burlington have been referred to the Kinder hook, hence quite a number of so-called Kinderhook species occur in our division III.) *Conocardium pulchellum*, *Nucula iowensis*, *Sanguinolites rigida*, *Spathella ventricosa*, *Mytilarca fibristriata* (below) *Dexiobia ovata Syringothyris* sp., *Edmondia burlingtonensis*, *Goniatites lyoni*, *Murchisonia quadricincta*, *Bellerophon cyrtolites*, *Productus arcuatus*, *P. Shumardianus*, *Chonetes logani*, etc."

In Scioto county, where conglomerate II is wanting, the shale, with *Sanguinolites obliquus* and *Prothyris meeki*, occupies the same position as at Loudonville or Rushville.

Division III—Burlington and Keokuk.

Although for a long time laboring under the mistaken notion that a part of the Cuyahoga shales in the northern tier of counties represents the Logan, the personal study of the region has convinced us that the stratigraphical conclusions of Professor Orton are borne out by paleontology. As stated in the 1890 meeting of the Geological Society of America, "Mr. Cooper and I have traced the limits of division II by means of the conglomerates and associated fossils along a line emerging from beneath the coal measures apparently not far from Seville, passing between Wooster and Burbank, southeast of Ashland, west of Independence, west of Granville and Newark, east of Lancaster and west of Rushville to the Ohio river near Buena Vista." The horizon of the second conglomerate is at about the level of the track of the Cleveland, Akron & Columbus R. R. near Holmesville and is about 200 feet above the river at Sciotoville. A fossil characteristic of the strata somewhat above conglomerate II is the small Productus identified as *P. arcuatus*. This is quite constant and serves as an excellent approximate guide. The 150–200 feet which follow are quite homogeneous in appearance and the faunal succession is so gradual that it is difficult to fix upon any basis for subdivision though the uppermost layers contain an interesting fauna as yet but little studied. This series attains its maximum thickness along the Ohio river. West of Portsmouth about 250 feet of shales and flags occur above conglomerate II. The fossils which are characteristic of the lower part of the series are *Spirifer striatiformis*, *Crenipecten crenistriatus*, *C. granvillensis*, *Grammysia ovata*, *Limatula ohioensis*, *Macrodon newarkensis*, *Schizodus newarkensis*, *Productus burlingtonensis*, *P. arcuatus*, and many others as yet insufficiently studied. The general habitus of the fauna resembles that of the Burlington group while a few species seem to be identical. From the upper portions of this series all traces of the Kinderhook fauna have disappeared.

At the very summit of the Waverly is a band of variable thickness which carries a rich though poorly preserved fauna. It is exposed at various places near Rushville and on the summits of the hills west of Portsmouth, and especially immediately below the carboniferous conglomerate near Loudonville. The rock is a crumbling red sandstone with numerous casts of fossil which, on the whole, resemble those of the Keokuk of Illinois more than any other known assemblage. *Phillipsia meramacensis*, *P. serraticaudata*, *Cythere ohioensis*, *Cytherella unioniformis*, *Chonetes illinoisensis*, *Productus burlingtonesis*, *Productus rushvillensis*, *Productus nodocostatus*, and a few bryozoa are common species; a small Cypricardinia like *C. scitula* is also associated with *Spirifer pseudolineatus* at these localities. In the tabulated list of Waverly fossils, given by Mr. Cooper in the fourth volume of the Bulletins of Denison University, there are a number of species of bryozoa, crinoids, and a few other forms referred to this horizon upon the supposition that the upper fossiliferous horizon at Cuyahoga Falls was equivalent to the Keokuk, as suggested by Mr. Ulrich. This position, we have already seen, is now untenable. It is very desirable that the few localities where this horizon is undisturbed by erosion should be carefully studied. At Sciotoville extensive erosion of the surface of the Waverly preceded the deposition of the fire-clay, which here forms the base of the coal measures. The Keokuk is entirely removed and the combined thickness of the Waverly correspondingly reduced.

In conclusion, it may be remarked that the study of the series of deposits long known as the Waverly group of Ohio affords suggestive data toward the solution of many of the perplexing problems connected with the transition in America from Devonian to Carboniferous faunas. The uniformity of physical conditions permitting the deposition of materials lithologically so constant for a long period enable us to study the almost unbroken transition and slow evolution of the faunas of distant horizons. Upon this background of uniformity the striking limitations imposed by many stations upon the life supported in them, become all the more conspicuous. The fact that the slow migrations of aquatic forms in the direction of the slow oscillatory movements of the crust bring unrelated stations into juxtaposition, has been well illustrated in the course of these studies. It is thus, for example, that the seemingly isolated occurrence of a collection of Michigan "Marshall group" species beneath conglomerate I is to be explained. Among the most interesting paleontological results is the evidence that the Carboniferous trilobites evolved gradually from Devonian genera during the period represented by the Waverly, and while the conditions in New York were unfavorable to the existence of these animals. No portion of the series is without trilobites in Ohio. In a single word, we have represented in the Waverly series a large segment of what has long seemed a missing interval in American geological history.

CHAPTER V.

FOSSILS OF THE CLINTON GROUP IN OHIO AND INDIANA.

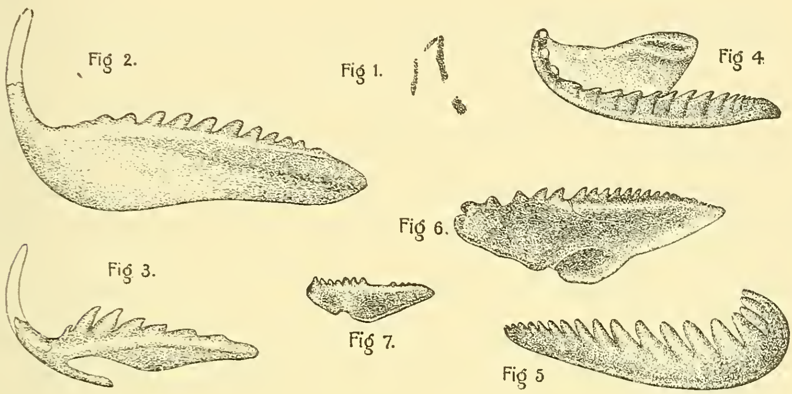
BY AUG. F. FOERSTE, PH. D.

INTRODUCTION.

The Lower Silurian age is represented in Ohio almost exclusively by the Cincinnati Group, the equivalent of the Hudson River Group of New York. Its upper part consists of a rapid alternation of thin limestone layers with blue clays, usually terminating above in a blue clay bed of variable magnitude, sometimes reaching 30 feet in thickness, at other times almost disappearing. So far this blue clay bed has yielded only such types of marine Lower Silurian fossils as are well known in the limestones immediately below. These blue clay fossils however (for example, *Orthis occidentalis* and *Orthis biforata*), are slightly altered in type from their earlier representatives, as though the shells had made an effort to accomodate themselves to new conditions of life. If these consisted in a shallowing sea, the rise of a land surface, and the formation of an intermediate coastal region, the observations so far made in Ohio have not made known any geological facts sufficiently attesting to the existence of these conditions. The upper surface of the blue clay layer formed an undulating surface upon which the rocks of Upper Silurian age were laid down. In consequence, the lower Upper Silurian rocks also have undulating surfaces. Little has been done, however, so far to determine what share of this undulation in the various beds is due to post-Silurian folding locally affecting all the rocks of Silurian age, and to what extent folding may have taken place in the interval separating Lower Silurian from Upper Silurian rocks. The rapid thickening or disappearance of the blue clay bed, in places, is perhaps the only fair argument, at present, for assuming any marked folding of Lower Silurian rocks in Ohio, before the Clinton period of deposition.

The lowest Upper Silurian deposits known in southwestern Ohio are sandy beds of unknown age, presumably Medina. At Fair Haven they are only two feet thick, and a lamellibranch shell (*Pterinea?*) apparently belonging to this layer was lost before it could be determined.

At Todd's Fork near Wilmington this sandstone is about five feet thick, and contains in its lower layers a number of annelid teeth, some of which were described in the *American Geologist*: Notes on a Geological Section at Todd's Fork, Ohio, 1888, p. 412–419. Figs. 1–7, reprinted here.



Annelid teeth from the Medina at Todd's Fork, Ohio. This rock graduates into the basal Clinton so that it is impossible to distinguish the same by a definite plane of separation. FIG. 1. The so-called "skins" of annelids. FIG. 2. *Oenites deripiens*, Foerste. FIG. 3. *Arabellites procursus*, Foerste. FIG. 4. *Lumbriconereites Austini*, Foerste. FIG. 5. *Eunicites falcatus*, Foerste. FIG 6. *Eunicites confinis*, Foerste. FIG. 7. *Eunicites paululus*, Foerste. FIGS. 2–7 much magnified.

So far these are the only localities in southwest Ohio where rocks reerable to the Medina have been seen by the writer. As a rule the Clinton follows immediately upon the blue clay layer. At one point near Belfast in Highland county, Ohio, a conglomerate occurs in the Clinton, containing limestone pebbles of unknown age in a cement full of Clinton fossils. The pebbles often are nearly two and a half inches in diameter. Strongly indicative of land conditions, nothing comparable with this conglomerate has been found elsewhere in the State and at present no data exist which will determine the source of its pebbles. Owing to the absence of similar phenomena in more western areas of the State, where Clinton exposures are not infrequent, it seems not improbable that if the pebbles indicate land conditions at some distance not remote from Belfast, this land surface may have lain entirely outside of that area now well known in geology as the area of the Cincinnati anticlinal.

The Clinton is generally an unusually pure limestone, containing quite commonly 97.75 per cent. of carbonate of calcium. Its upper courses are ferriferous in some of the more southeastern exposures, the limestone having been replaced in part by a red iron ore. Quite regular deposits extend from Todd's Fork, north of Wilmington, southward. At Todd's Fork the ore occurs in the form of so-called oölitic iron grains, which are evidently pseudomorphs formed by ore replacing little round grains formed of bryozoan remains, broken and rounded by the more or less strong currents of the Clinton sea of this region. Sometimes only the original cell walls of the bryozoans are thus replaced, at other times only the original lime cement filling the cells has been altered, or again, both may have been transformed into an iron ore.

The Clinton varies between 10–30 feet in thickness, though sections of greater thickness are quoted in the reports of the Ohio Survey. At its base the Clinton is often massive, with the fossil material so comminuted as to be unidentifiable. The coarser frondose bryozoans are however often still preserved. Towards it upper portion, thin blue clay layers are not infrequent in places and both the limestones and blue clay are then usually filled with fossils. At the very top of the Clinton the blue clay contains not infrequently fossils of Niagara types, not found, at least in as typical a form, in the limestones beneath; some of these are *Orthis hybrida*, *Or.his elegantula*, *Eichwaldia reticulata*, and *Callopora elegan.ula*,

Immediately over the Clinton limestone at Huffman's quarry south of the Dayton asylum, to a much lesser degree in the quarry at the northern edge of Beavertown, more typical in the quarries along the Carrollton road southwest of the Soldiers' Home—occurs a greenish massive rock, with conchoidal fracture, not exceeding fifteen inches in thickness at the most typical exposure: Huffman's quarry. This, formerly called the Beavertown marl, contains a number of small fossils, peculiar to this horizon, and a number of other fossils of upper Clinton type. The fauna of this marl is in part also represented in the ferriferous upper Clinton at Todd's Fork near Wilmington, so that the marl when present is regarded as the close of the Clinton in Ohio.

Immediate above the Clinton, or the marl when the latter is present, lies in many places a firm white compact massive limestone divided by partings at various intervals, often quite constant for long distances. This is the Dayton limestone. South of Dayton it locally sometimes shows fossils on the lower surface of the bottom layer, of such types as are known from the Clinton. It contains few fossils, but persons walking the streets of of Dayton and frequenting the stone yards will have noticed occasionally *Favosites* and *Orthoceras*, rarely *Syringopora*, coarse gasteropods, very rarely *Ha.ysites*, *Strombodes*, and Prof. Orton recently found an *Atrypa* related to *A. reticularis*. In this relation a quarry in the Dayton limesto e, on the east side of the Bellbrook road, half a mile south of its junction with the Beavertown road at the Presbyterian church, or five and a half miles south of Dayton, proved very interesting. Here eight inches of drab, dolomitic, poor limestone, often divided into two courses, was underlaid by sixteen inches of good solid Dayton limestone, forming a single course, and filled with crinoid beads and stems, which were partially visible on freshly broken surfaces but which showed in considerable quantities over weathered surfaces, giving one the idea that the Dayton limestone here was a great mass of encrinital material roughly jumbled together and then consolidated into a massive rock. On freshly fractured surfaces this rock looked like the Dayton limestone elsewhere, suggesting the origin of the Dayton limestone in general as an encrinital mass, the original structure having generally disappeared in consequence of the crystallization of the lime material. Beneath this lay two layers of thin Dayton limestone, each varying from two to three inches in thickness. If the Clinton does not occur immediately beneath, the quarrymen found some other reason for stopping quarrying at this horizon.

It is customary to begin the section of the Niagara series of southwestern Ohio with this Dayton limestone as the base. Above the Dayton limestone there is commonly a thickness of thirty feet or more of a dolomitic rock with frequent partings known as the Niagara shales. It is usually almost entirely destitute of fossils. The Dayton limestone is in reality only a basal variation of these dolomitic limestones, being typically developed between Dayton and Centerville, merging into the *shales* laterally and, locally, also vertically. Above the Niagara dolomitic *shales* are more massive dolomitic limestones, containing *Pentamerus oblongus* quite abundantly and for the first time, and other fossils having a facies intermediate between the Niagara and Guelph. These form the Springfield group, and may be seen along the Eaton pike about three miles west of Dayton. The Cedarville dolomite, representing the true Guelph, occupies the next higher horizon.

In Indiana the succession of the Middle Silurian is not so well known. At Hanover the blue clay at the top of the Lower Silurian seems to be followed by 8 to 10 inches of Medina, and the Clinton, after twenty feet of barren limestone, develops first into a cherty rock 2 to 3 feet thick, and then into the fossiliferous Clinton 12 to 20 inches thick, the last presenting all the characteristics, lithological, and paleontological, of the upper Ohio Clinton, where it is tinged reddish or brown by iron. This fossiliferous Clinton has not been traced north as far as the Waldron beds, by means of its characteristic fossils, but all the detailed work so far done indicates that the Clinton of Ohio and Indiana belongs just below the base of the series of shales which in its upper horizons contains the famous Waldron Niagara fossils. Indeed, the Clinton is represented by limestones at the base of sections not far from Waldron localities. The Waldron shales are the only beds in Ohio or Indiana which closely imitate the typical Niagara fauna of New York. The Clinton of Ohio and Indiana carries a fauna showing many resemblances to Niagara fossils elsewhere, but presenting also many distinctions, and the distinctions have been considered sufficient to warrant the separation of the Clinton fauna in Ohio, from the more marked Niagara fauna as exhibited at Waldron, Indiana, and less perfectly known in Ohio. In general, it may be said that the Ohio Clinton presents forms often closely allied to Niagara forms of other states, but of an earlier type, and sufficiently distinct to make their discrimination from Niagara forms desirable, so as to secure names by means of which it will be possible to designate accurately the types discussed in any future investigation of phylogenetic problems of Middle Silurian life.

It has sometimes been questioned, whether the Clinton of Ohio be really identical with the Clinton of New York. With our present knowledge of paleontological stratigraphy, precise equivalencies will hardly be expected by the modern paleontologist. The lower part of the New York Clinton has still a strong Medina facies. The shales at the top are by many now considered as practically Niagara in type. The limestones and siliceous beds between have a fauna which could very profitably be made the subject of renewed investigation, but from the glimpse the writer was able to obtain of the same in the cabinet of Dr. E. N. S. Ringueberg, at Lockport, New York, he is of the opinion that the Clinton of Ohio, with its upper shaly courses corresponds as well as could be expected with the siliceous and limestone beds of the upper half of the Clinton in western New York, and to those shaly layers immediately above which are of an acknowledged Niagara type. excepting that in western New York it seems possible to draw a line between the two, and in Ohio this line can not be drawn until the base of the Dayton limestone or, in its absence, the base of the dolomitic Niagara *shales* (or the Waldron shales in Indiana) has been reached.

The following table includes a list of the fossils common to the Clinton of Ohio and Indiana and that of New York, as far as may be determined from the literature available. Some of these forms also occur in the Niagara of New York, so that the comparison is not satisfactory. When the comparative study of the typical Clinton and Niagara faunas of New York is again taken up, there will be provided a more satisfactory basis for the correllation of the Ohio Clinton fauna with the typical fauna of New York.

Acidaspis Ortoni.
Illænus Daytonensis.
Calymene Vogdesi.
Sphærexochus pisum.
Phacops trisulcatus.
Encrinurus punctatus.
Cornulites distans.
Orthoceras clavatum.
O. virgulatum?
O. (Discosorus) conoideum.
Bellerophon fiscello striatus, differs from *B. stigmosa* only in the absence of a *carina*
B. (Bucania) trilobatus.
Platyceras (Platystoma) Niagarense, the small Clinton form.
Loxonema subulatum.
Cypricardites Caswelli.
Plectambonites transversalis, var. *elegantulus.*
Leptæna rhomboidalis, small Clinton form.
Strophomena patenta.

Orthis biforata.
Orthis elegantula.
Orthis circula occurs possibly also in Ohio, but the identification is not altogether satisfactory.
Meristella umbonata finds its nearest relatives with Clinton forms in New York.
Atrypa marginalis seems to be identical with *A. plicatula*, but there is need of actual comparison with the types of the New York species.
Rhynchonella scobina is closely related to *Rh. neglecta.*
Phylloporina angulata.
Phænopora platyphylla, is almost certainly *Ph. constellata.*
Rhinopora verrucosa, including also the form *Rh. tubulosa.*
Favosites favosoideus.
Halysites catenulatus.

In the following pages it has not been attempted to make either the list of fossils or the description of the same complete. The writer has simply used such material as was available at the time of writing, there being no satisfactory library at command, and even his private collections not being all at hand, when needed, various portions of this report having been prepared at different places as time would permit. It is hoped, however, that even in its present state it may serve as a contribution to the rather small list of Clinton literature. The full description of the brachiopod forms was prepared for the reason that in the Ohio Clinton it is rare to find interiors or hinge areas, except of a few species, and it was considered desirable for purposes of phylogenetic study to have minute descriptions at least of that part of Clinton brachiopod forms which was known in order to compare the same with better known Niagara material. In the case of trilobites, cephalopods, gasteropods, and lamellibranchs, whereever there was no new material to offer, the descriptions were made as brief as possible, calling attention only to the most important characteristics. No description is provided in the case of bryozoans and corals, excepting where changes of nomenclature or the addition of a new form to the list of previously known species has rendered a description imperative. By this means it has been possible to offer a certain amount of new material, and to keep the chapter within certain bounds, prescribed to the same. Acknowledgments for information and use of specimens are made as far as possible at the appropriate points in the text.

A Description of the Trilobites, Mollusks and Brachiopods of the Clinton Group of Ohio and Indiana.

Acidaspis Ortoni. Foerste.

(Plate 25, Fig. 23; Plate 27, Fig. 1.)

This species was first described from the Clinton rock at Brown's quarry where the species, although by no means common, at least occurs in every day's collecting (Bulletin of Denison University Lab. volumes I and II). In the "Orthoceras block" from the base of the Clinton at Huffman's quarry several heads were found. In the siliceous Clinton, near Lockport, New York, the same form seems to occur, judging by specimens in the cabinet of Dr. E. N. S. Ringueberg.

Very little has been added to our knowledge of this species by recent investigations. The occipital segment is prolonged and pointed posteriorly. In a specimen from the "Orthoceras block," the head anterior to the occipital groove was 5 mm. long; the occipital segment was 3.3 mm. broad, and 3 mm. long, the postero-lateral sides of the segment having a concave outline owing to the posterior prolongation. In the more mature specimens the proportions are not maintained, but the prolongation of the occipital segment posteriorly is always discernable. The "Orthoceras block" specimens showed longer spines along the margin of the free cheek than any hitherto observed. The longest spines are fully 2.7 mm. long. The ridge running from the eye anteriorly curves around inwardly so as to connect with the anterior margin of the glabella, being depressed, however, just before reaching the more convex outline of the margin. A groove outlines the anterior of the glabella and passes thence along the border of the free cheek. Anterior to this groove in that portion of the head anterior to the glabella the marginal border follows a slightly more convex outline than it does along the free cheeks, thus this portion of the border is advanced slightly beyond the general outline of the head, but whether this median portion of the border possessed spines or not is unknown. It is, of course, impossible to determine whether this species is distinct from the *A. fimbriata*, Hall, until that species is better known, but the figure of the free cheek of that species, published, indicates a bend in the postero-lateral spine which is not present in any Ohio specimens.

Acidaspis brevispinosa, sp nov.

Plate 37A Fig. 13.

At Huffman's quarry is found a free cheek which may be easily distinguished from that of *A. Ortoni* by the shortness of the lateral spines, these being scarcely more than lateral monticules in the anterior and posterior parts of the series. The spines, moreover, are not perpendicular to the outline of the free cheek but where longest are directed postero-laterally. Finally the spines do not cease opposite the general posterior outline of the head but are found some distance down the side of the great postero-lateral spine, in which the free check terminates.

A pygidium found at the same quarry was 3.6 mm. broad and, minus the spines, had a length of 1.7 mm. Its entire anterior margin was bordered by a distinct segmental ridge, and from a similar ridge along the posterior border projected the posterior spines. In the center of the pygidium lay the inversely triangular median segment on either side of which, further enclosed by the ridge-like border just mentioned, lay a depressed area. Of spines, there were at least six, the two exterior being larger, but their total length being unknown. The pygidium may not be entire.

Small gabellæ occur at Huffman's quarry, south of Dayton, and also at the Centerville quarry, northeast of the village. At the latter locality a fragment of the free cheek was also found. These small glabellæ are constant in character and are probably the glabellæ corresponding to the free cheek and pygidium already described. The glabella has two strongly defined, strongly convex lobes on either side, there being no additional segmentation of the glabella anterior to these lobes as in *A. Ortoni*. The fixed cheeks are also strongly defined and bold, curving in a semi-lunar way from the occipital groove to about the middle of the anterior lobe of the glabella. The ocular ridge is low and narrow at the eye, becoming broader and stronger anterior to the fixed cheeks and still more so in passing before the anterior of the two lateral lobes of the glabella. The groove anterior to the ocular ridge and the glabella, behind the anterior border of the head, is broad and distinct, especially laterally. The anterior border of the head is markedly convex in front of the glabella, thus projecting beyond the general margin of the head. The occipital furrow is broad, and the occipital segment is broad but does not give evidence of posterior prolongation. The most marked feature is the coarse, close, granular ornamentation on the glabella, its lobes, the fixed cheek, the anterior portion of the ocular ridge, and the middle portion of the occipital ridge. Length of the Huffman's quarry head, 4.5 mm.; of the Centerville head, 6 mm.

All specimens referred to this species occur in the upper shaly courses of the Clinton.

Proetus determinatus. Foerste.

(Plate 26, Fig 5; Plate 27, Figs. 2, 3, 3*a*).

This species was described in the Bulletin of Denison University, Vol. II. from the Soldiers' Home quarries. Since then a well marked glabella has been found at Brown's Quarry. A free cheek with rather broad border, and prolonged postero-laterally into a spine, was found at the last named quarry and may belong to the same species. The occipital segment is separated from the glabella by a strong occipital groove; towards either side of the segment a less deep groove crosses the segment obliquely, giving rise to two lateral lobes within the area of this segment. A specimen recently found at the Soldiers' Home shows that the glabella is low and but moderately convex, and not strongly elevated at the margins above the general curvature of the head. The glabella is defined by a distinct but not deep groove. The fixed cheek and anterior portion of the head continues the low curvature of the glabella, and the anterior border of the head is defined rather by its upward curvature than by any distinct defining groove. The glabella was 3.8 mm. long; the distance from the occipital groove to the anterior border was 4.7 mm. and including the anterior border, 5.1 mm. At the Soldiers' Home the specimens occur in the upper third of the limestone but beneath the shaly portion.

Cyphaspis Clintonensis, Foerste.

Plate 27, Fig. 5; Plate 31, Fig. 22).

This species was described in the Proceedings of the Boston Society of Natural History, 1889, from Brown's Quarry, and the occurrence of the same species at Anticosti, and Cumberland gap, Tennessee was noted. Since then one glabella has been found in the upper third of the Clinton limestone at Huffman's Quarry, and various glabellæ and two more perfect heads occurred in the "Orthoceras block" at the same locality. The latter enable us to define the specific characters of the species much more clearly.

The glabella shows the usual pair of postero-lateral lobes. Anterior to the glabella, separated only by a narrow groove, lies the flattened, thickened anterior border. Both groove and border are continued parallel to the margin of the free cheek, being met at the postero-lateral angle by a similar border and inner groove running parallel to the posterior margin of the head. The free cheeks are continued beyond this angle as a spine. The eyes are boldly convex and very large for such a small species A small but very perfect specimen had a head almost 5 mm. long, and 7 mm. wide. The glabella alone was 3.6 mm. long, and just anterior to the postero-lateral lobes it was 2.7 mm. wide A line joining the most exterior points of the eyes measures 4.6 mm. The eyes are 1.7 mm. long. The postero-lateral spines project at least 2 mm. beyond the posterior margin of the head.

With these data it now becomes easy to distinguish this species from *Cyphaspis Christyi*, Hall of the Niagara group. In that species there is also a narrow groove anterior to the glabella, anterior to which is a broad raised area which, when the real border is broken off, a by no means uncommon occurrence, very much resembles the actual border of the Clinton species. Anterior to this area in the case of the Niagara species, separated by a deeper groove, comes the real anterior border of the head. The Clinton species was probably the progenitor of the Niagara form, by a gradual widening of the groove between the anterior border of the head and the glabella into an anterior area. This groove in the case of the "Orthoceras block" specimens from the base of the Clinton, was very narrow. In the Brown quarry specimens it was wider but still fairly narrow. From the upper red tinged limestone at Huffman's quarry come the specimens with the widest grooves; length of head in one case, 5.2 mm.; of the glabellum, 3.5; of the submarginal groove, 5 mm., an advance towards *C. Christyi* with glabella only half the length of the head.

Illænus Daytonensis, Hall and Whitfield.

(Plate 26, Figs. 4*a*, *b*; Fig. 6; Figs. 7*a*, *b*, *c*; Plate 27, Figs. 6, 10*a*.)

This species is found in the limestones at Soldiers' Home, Centerville, Brown's quarry, Yellow Springs, Ludlow Falls, Fair Haven, Todd's Fork, Fauver's quarry, in the "Orthoceras block" at Huffman's quarry, and at Hanover, Indiana. It occurs also in the flinty Clinton at Lockport, N. Y., in the collection of Dr. E. N. S. Ringueberg. In the quarry in John Glaser's woods, on Brandt pike, a glabella.

Illænus ambiguus, Foerste.

(Plate 26, Figs 9 a, b; Figs. 10 a, b, c; Fig. 11?)

Typical specimens occur in the limestone at the Soldiers' Home quarries, Fauver's quarry, the quarry in John Glaser's wood on Brandt pike, 5⅓ miles northeast of Dayton, Fair Haven, Todd's Fork and Hanover, Indiana, in the limestones. Somewhat similar specimens occur in the Niagara shales at Lockport, N. Y., but it will require further study to discriminate them from *I. Ioxus*, Hall.

In its typical development the pygidium presents an almost semi-circular outline, and a surface which is moderately convex above, but which increases in curvature greatly towards the posterior and lateral borders. Not the slightest trace of a marginal concave curvature ought to be seen towards the border. This pygidium differs from that of *Ill. insignis* solely in its constantly much smaller size, and in its semi-circular outline, there being no trace of elongation as in the latter species. The Niagara specimen from Springfield, Ohio, figured in the Pal. of Ohio, vol. I, plate 15, fig. 5, is of the type of *Ill. ambiguus*. *Ill. insignis*, has a somewhat elongated pygidium, as described later.

Illænus insignis, Hall.

(Plate 26, Fig. 11?)

Pygidia having the characteristics of this species are found in the limestone at Soldiers' Home. The corresponding heads show stronger dorsal furrows than is indicated in published figures of this species. They are stronger on the lower cast than on the upper surface of the original. The specimens usually attain large size, equalling those from Wisconsin. The pygidium, though rounded along the entire exterior margin, is distinctly though not strongly elongated. It attains its greatest height and also its greatest convexity towards the posterior two-fifths of the pygidium. The diagonal antero-lateral furrows soon disappear posteriorly, and along the posterior margin the pygidium retains its convexity, no trace of a concave border being present.

Illænus Madisonianus, Whitfield.

(Plate 26, Figs. 1, 2, varieties; Plate 27, Figs. 7, 8, 9, 10.)

In the limestone at Brown's quarry occur small heads and pygidia showing all the characteristics of this form except as regards size. In the "Orthoceras block" from the base of the Clinton at Huffman's quarry the same form, but of typical size, was common; the movable cheeks being at times still in position, a rare occurrence elsewhere in the Clinton. In form the pygidia resemble those of *I. insignis*, but are less elongated, taking in this respect a position intermediate between *I. ambiguus* and *I. insignis;* this is especially true in the Orthoceras block specimens. The pygidium differs from both species, however, in possessing a distinctly concave border. The hypostoma and rostrum of this species are known from the same "Orthoceras block."

At Huffman's quarry, in the middle limestones, was found a specimen also with a concave border but decidedly elongated, more equally and strongly convex, with the greatest elevation at the anterior third of the pygidium. This form may be designated as var. *elongatus*. (Plate 26, figs. 1, a, b.)

Another form, found at Stoltz's quarry in the limestone, presents also a concave border, but the general form of the pygidium is broad and much less convex; as in the last form, the greatest height is well towards the anterior: in this case near the anterior margin. It may be called var. *depressus* (Plate 26, figs. 2, a, b.)

These forms can scarcely be said to have the value of distinct varieties, yet it may be useful in tracing out the phylogenetic variations of *Illaeni* to have a name for some of the intermediate forms. *Illænus ambiguus*, *Ill. insignis* and *Illænus Madisonianus* form a group of very closely allied species. *Ill cuniculus* seems to belong to the same group. In the cabinet of Dr. E. N. S. Ringueberg I noticed various species or forms of *Illænus*. In the Niagara shales from Lockport, New York, forms like *Ill. Madisonianus*. *Ill. cuniculus*, a form near *Ill. ambiguus*, and *Ill. Daytonensis* were seen. It has already been noted on a former occasion that various species of *Illænus* exist in New York Upper Silurian rocks. All these still await a careful revision.

Calymene Vogdesi, Foerste.

(Plate 25, Fig. 25; Plate 27, Figs. 12, 13, 16; var. Plate 25, Fig. 24; Plate 27, Figs 14, 15.)

This form, first described in the second volume of the Bulletin of Denison University, is scarcely more than a varietal phase of a polymorphus species including a large percentage of the forms found in middle Silurian rocks. Its chief characteristic is its large size; the broad frontal border rather flattened; the deep lateral furrows defining the glabella, especially anterior to the middle pair of lobes; this middle pair of lobes is connected with the high fixed cheeks; anteriorly the fixed cheeks curve a little inwards but do not connect with the anterior end of the glabella as in the case of *C. camerata*, Conrad, from the Niagara of New York. The figures of *C. camerata*, are certainly not exact for our form, but they are so similar in many ways that, not having seen actual specimens of *C. camerata*, it is possible to imagine that the differences are more due to the imperfect preservation of the New York forms than to any actual distinctive characteristics. This larger, more typical form occurs at Centreville, Soldiers' Home, Huffman's Quarry in the upper shaly courses; and in the limestone at the Eaton Pike Quarry, Todd's Fork, Ohio, and Hanover, Indiana. It occurs also in the Clinton limestone of New York, near Lockport. (Plate 25, Fig. 25; Plate 27, Figs. 12, 13, 16.)

A medium sized form with heads about 13 mm. long is found in the middle limestones at Soldiers' Home. (Plate 25, Fig. 24; Plate 27, Figs. 14, 15.)

A small form with heads 8.6 mm. long, and pygidia 7 mm. long occurs in the limestone at Brown's Quarry. The anterior border of its head appears more rounded, and the groove behind it is of almost equal size, so that these forms would agree very well with *Calymene Niagarensis.*

Most species of Calymene are founded upon slight varietal, rather than marked specific characters. Establishing *C. Vogdesi* in this sense, it has lately become doubtful whether it deserves to be separated from *C. Blumenbachii* under any circumstances.

Ceraurus (*Pseudosphaerexochus*) *Clintoni*, sp. nov.

Plate 27, Fig. 17.)

This species was described in the Bulletin of Denison University, Vol. II. Only the glabellæ have been found and these are fairly common at the southern end of the quarry at Brown's Quarry. Since the description was published the occipital segment has become better known. The occipital groove is distinct. The occipital segment is inversely and very broadly triangular, being very obtusely pointed posteriorly, becoming very much attenuated and depressed laterally, and lying close, and almost under, the posterior lobes near their lateral termination. From drawings sent to him, Mr. J. M. Clarke judged these specimens to belong to the proposed sub-genus *Pseudosphærexochus* of Schmidt.

Glabella oval, strongly convex, with three pairs of furrows—the posterior pair is situated about a third of the length of the glabella from the posterior margin of the same, curving regularly inwards and backwards, forming large round posterior lobes, similar to those of *Sphærexochus*, the defining groove terminating abruptly before reaching the nuchal furrow. A little anterior to the middle of the glabella lies the middle, much shorter pair of furrows, also curving more or less backwards. A third, very short pair, lies still farther forward. A strong narrow furrow defines the glabella anteriorly, in front of which lies the very narrow margin of the head, only wide enough to receive an irregular row of granules, of about the same size as those ornamenting the entire glabella. The granules of the glabella vary greatly in size, smaller ones being interspersed among those of larger size, the general effect being decidedly granular as in species of *Lichas*.

Sphærexochus pisum, sp. nov.

(Plate 37A, Figs. 14, a. b.)

In the Niagara shales at Lockport, New York, are found small glabellæ presenting from above and in front a decidedly globular aspect. Anterior to this globose glabella is a deep, very distinct groove, separating as far as known only a very narrow border or rim, forming the anterior margin of the head. Laterally this groove curves around strongly, then upward and backwards, until, after a strongly concave curvature along the side of the glabella, separating, it is presumed, the fixed cheeks, it connects with the strongly characterized occipital groove. The occipital segment is strongly arched from side to side. No evidence of segmentation or furrows occur on the glabella. The surface of the glabella is ornamented by distinct larger granules, between which are interspersed much smaller ones. Both are best developed towards the circumference of the glabella, the larger granules becoming less distinct and widely separated towards the centre of the glabella, while the smaller granules, though becoming much more frequent near the centre, are smaller and far less distinct over the central regions of the glabella. In a figurative sense they may be said to have a somewhat "bald headed" appearance. The type specimen is 5 mm. long and antero-posteriorly the outline of the head describes slightly more than a semicircle. (Plate 37A, Figs. 14, a. b.) Obtained in exchange from the cabinet of Dr. E. N. S. Ringueberg.

In the limestones of the Clinton Group at Soldiers' Home two specimens of this species were found which are evidently the Clinton progenitors. One of these was an imperfect fragment of the glabella. The other, collected by Mr. Geo. Caswell, presented almost the same characteristics as the New York Niagara type. The chief difference consists in a slightly less globose curvature, and in the greater coarseness of the ornamentation, there not being such a fine distinction between the large granules and the finer interspersed ones along the margins of the glabella, though this may partly be due to the state of preservation in a limestone cement. The generic reference is tentative.

Lichas breviceps, Hall.

(Plate 25, Figs. 26 a, b, c, d, e; Plate 27, Figs. 18, 19.)

This species occurs in the Ohio Clinton limestone at Brown's Quarry, common (glabellæ sometimes 22mm. long); Soldiers' Home, rare; Fauver's Quarry, a glabella; in the "Orthoceras block" from Huffman's Quarry; upper shaly courses at Huffman's Quarry, several specimens; Fair Haven, a glabella; Hanover, Indiana, rare. A careful study of the head of the typical forms of *Lichas breviceps* from the Niagara of Waldron, Indiana, was prepared for the Bulletin of Denison University vol. III, plate XIII, fig. 21. An entire head was found in the above mentioned "Orthoceras block." It presents all the features of the Waldron head with one exception. In the occipital furrow—between the postero-lateral lobes of the glabella the occipital segment, and the area posterior to the eye—lies, in the case of this as well as all other Clinton specimens, a transversely oblong, very distinct, and fairly large lobe, represented in the case of the Waldron specimens only by a very slight ridge. When it is desired to distinguish this Clinton form from its Niagara descendant the varietal name *Clintonensis* may be used. The Clinton pygidia show no distinctions. The hypostoma is frequent at Brown's Quarry.

A somewhat shorter type of hypostoma is represented by a single specimen from Soldiers' Home. Plate 27, Fig. 11. It belongs to some distinct species.

In the limestone at Soldiers' Home was found also a glabella, having all the parts very strongly accentuated. This gives it an aspect quite distinct from the ordinary species. Possibly it represents only a cast of the lower side of the more ordinary form, but the convexity of the middle and lateral lobes of the glabella, and of the lobes in the occipital groove is so strongly marked that it may belong to a distinct species. The material will not permit us to determine. It bears a strong resemblance to *Calymene phlyctainoides*, Green, which, judging from the figures alone, may also be some form of *Lichas*. (Plate 37A, fig. 15.)

Phacops trisulcatus, Hall.

(Plate 26, Fig. 3; Plate 27, Figs. 4, 20 21; Plate 31 Figs. 20, 21;)

This species was described from the Soldiers' Home quarries as *Phacops pulchellus* (Bulletin of Denison University Vol. II). Later it was identified at Cumberland Gap, Tennessee (Proc. of Boston Soc. Nat. Hist., 1889.) In the "Orthoceras block" at Huffman's Quarry occurred a pygidium quite similar to that elsewhere associated with this species.

The type specimen of *Phacops trisulcatus*, Hall, is certainly a closely allied form if not identical. It has 11 segments in the thoracic region, the first three lateral segments of the pygidium are distinct, the fourth is visible, the fifth and sixth are mere fine transverse striæ. The first three segments of the medium portion of the pygidium are distinct, the fourth is visible, the fifth is a mere point. It was found in the Clinton at Rochester, New York, and the only distinction so far known lies in the relatively broader pygidium, a character which may be due to the state of preservation when found in shales.

At Brown's Quarry is found a pygidium suggesting affinities with *Dalmanites*, with three pleural segments distinct, the groove along their upper line being better shown in a cast of the lower side than on the upper surface of the original. The fourth and fifth segments are indistinct. The sixth and seventh can barely be made out, and an eighth segment is perhaps possible. The striking feature of this pygidium consists in its broad concave border. The pygidium is 5 mm. long as far as the termination of the axial region; including the border it measures 6.5 mm; the border is inclined and is almost 2 mm. broad. The width of the pygidium is about 7.3 mm. minus the border, but including the latter it measures 9.5 mm. The folds of the pleural segments descend as indistinct wrinkles upon this border, and posteriorly a narrow ridge or elevation descends from the axial region to about the middle of the border. The posterior margin is perfectly rounded, and has no trace of posterior prolongation. A very shallow but distinct groove separates the border from the remainder of the pygidium.

The pygidium figured from the Soldiers' Home is similar but not identical. The groove defining the broad border from the remainder of the pygidium is not present, the pleural segments descend to within a short distance of the margin, there is no distinct border, and while a broad shallow groove runs along the margin posteriorly this is distinct only along the posterior half of the pygidium (Plate 27, fig. 4.)

A much smaller pygidium from the "Orthoceras block" found at Huffman's Quarry shows features identical with the last though it is much smaller: 6 mm. wide and 4 mm. long. There is a sort of elevation running posteriorly from the axial region to the border.

The rounded posterior borders of these specimens suggest affinities with *Phacops*. The Soldiers' Home and Huffman Quarry specimens, especially the latter, resemble the pygidia usually associated with *Phacops trisulcatus*. The first described pygidium from Brown's Quarry, if not identical, belongs possibly to a closely allied species. It is well known that the genera *Phacops* and *Dalmanites* are closely allied.

Dalmanites Werthneri, Foerste.

(Plate 27, Figs. 22 22*a*, 23, 24, 25.)

This species was described in the Bulletin of Denison Uuiversity Vol. I, and figured in Vol. II, from the upper third of the limestone at the Soldiers' Home Quarries. Since then it has been found at Fauver's Quarry, and at Todd's Fork. It is evidently the precursor of *Dalmanites vigilans* and *D. verrucosus*, from which it differs in the character of the pygidium, this being neither spined nor prolongated posteriorly. The anterior outline of the head approaches the latter species more closely. In specimens from Soldiers' Home, with pygidia varying from 8.3 to 14 mm. in length, there are ten or eleven axial segments plainly seen, the eleventh or twelfth being indistinct; eight pleural segments are distinct, the ninth being indistinct, a tenth being barely visible in one specimen but having no groove along the top, as indeed is usually the case with the ninth. Theoretically there ought to be as many pleural segments as axial ones.

Encrinurus punctatus, Wahlenberg.

(Plate 27, Fig. 26.)

This species occurs in the limestone at the Soldiers' Home quarries, rare; Hanover, Indiana, rare; in the Orthoceras block, Huffman's Quarry, rare. The following measurements were taken from various pygidia:

Locality of specimen	Length in mm.	Breadth in mm.	No. of pleurae.	No. of segment at which first tubercle is situated	Second tubercle.	Third tubercle.	Fourth tubercle.	Fifth tubercle.	Sixth tubercle.	No. of segments of axial lobe. First No., distinct, Second No., indistinct Third No., barely visible.
Silceous Clinton, Lockport, New York	10	11.9	7 8th indistinct.	....	7	11	15	19	23	15, 19, 23
Soldiers' Home type of Encr. Thresheri...	8.1	9	7	....	5	8	11, 12. 2 near each other	15	18	13, 18
"Orthoceras block" Huffman's Quarry.	....	....	7	2	5	10	....	......	......	....
Hanover, Indiana.......	9	9.5	7	....	5	8	11	15	......	15, 18

The "Orthoceras block" specimen shows the longitudinal rows of tubercles crossing the pleurae of the pygidium very well. The inner row terminates posteriorily at the fourth, the middle row at the fifth, the outer row at the sixth, and a row just within the terminations of the pleural ridges, at the last pleura. These rows are approximately parallel to the outline of the sides of the pygidium. The Hanover, Indiana, specimen shows similar but less distinct tubercles, with similar arrangement. The

Soldiers' Home specimen shows these lateral rows of tubercles very indistinctly. A glabella in the "Orthoceras block" from Huffman's Quarry was ornamented by strong, coarse tubercles.

Elpe Ulrichi, sp. nov.

(Plate 37. Figs. 14 a. b. c.)

Carapace bivalve, equivalve, the valves apparently smooth, inequilateral, the length of the shell being greater than the height. Both valves are strongly convex, this convexity culminating at a point near the anterior third of the carapace, thus producing a considerable elevation of the valves towards this point. The upper or dorsal border is straight but is infolded transversely both from the anterior and posterior sides, thus producing a transverse groove in the dorsal region of the carapace at a point almost above or slightly anterior to the umbonate elevation of the valves described above. The dorsal view showing this transverse infolding and the outline of the umbonate convexity of the valves is especially characteristic of the species. Length of carapace, 5.5 mm.; height 4.5 mm.; thickness from valve to valve 4 mm.; the umbo or point of greatest convexity lies 1.75 mm. from the anterior edge of the carapace. The specimen was found in the "Orthoceras block" at Huffman's Quarry.

Mr. E. O. Ulrich, to whom the specimen was submitted for generic determination, writes that this "ostracoda is congeneric with Meek's *Cythere Cincinnatensis*, Miller's *C. irregularis* and Ulrich's *Leperditia radiata*. They are quite different from *Leperditia*, belonging more likely to the *Cyprinidae*. The genus into which they must go is not fully decided, Jones being of the opinion that a new genus should be established for their reception, while Ulrich is of the opinion, at present, that Barrande's *Elpe* may justly include them."

Cornulites distans, Hall.

(Plate 30, Fig. 7; Plate 31 Figs 11, 10.)

This shell, as identified by us, is represented by one specimen from Brown's Quarry, and one from Soldiers' Home. One of the specimens from the upper shaly courses at Huffman's Quarry may belong to the same species. In the upper shaly courses of the latter quarry occur a considerable number of specimens, some of which equal *Cornulites distans* in size, but all of them agree in the habit of being more or less flexuous and in being attached by one side to some other object. In the cases at hand these objects were *Orthis elegantula*, *Cyclonema bilix*, *Rhinopora frondosa*, and *Homotrypa confluens*. It is evident from this that it grows upon any object it can find. Whether, as in the case of *C.*

proprius, Hall, these forms are only young stages of species whose subsequent growth becomes free and more erect cannot be determined with the material at hand.

In a second specimen from Brown's quarry, the same habit of shell was noticed; it started its growth attached to the side of *Platyceras*, curved around on its surface, attached to it along one side, and then, swinging loose from the *Platyceras*, assumed a straight course for the rest of its growth. The straight species also occurs at Pennsylvania, as collected by Prof. E. W. Claypole, from the top of the Clinton just under the red Onondago shales, near Mifflintown, Juniata county, Pennsylvania.

Gomphoceras Ortoni, sp. nov.

(Plate 33, Figs. 8 a, b; Plate 36, Figs. 7 a, b, c.)

In the Proc. Boston Soc. of Nat. Hist., 1889, Plate VIII, fig. 8, was represented the living chamber of a species of *Gomphoceras* found at Brown's Quarry (See Plate 33 of this volume). Recently the specimen figured has been better cleaned from the encrusting calcite and though in the form of a cast of the chamber its configuration can now be better determined. The living chamber was contracted towards the top and bent a little backwards so that the posterior side is slightly concave in outline about 17 mm. above the base of the chamber. The various intricate markings towards the aperture caused by flexures of the shell will be better undersood by a reference to the figures than by a detailed description.

At the same quarry was found a specimen with the living chamber only indifferently preserved, but almost the entire septate part of the shell is shown, thus adding considerably to our knowledge of this species. The specimen belongs to the collection of the Ohio State University. At the base of the body chamber the shell is 30 mm. broad. Measuring along the sides of the shell, the fifth septum below this point is 16 mm. distant, and the septum has a diameter of 22 mm. The tenth septum below the body chamber is 28 mm. distant and the diameter of the septum is 14 mm. The fifteenth septum below is 38 mm. distant and the septum has a diameter of 9 mm. The twentieth septum is 47 mm. distant; this portion is less well preserved, but the diameter does not seem to have been less than 8 mm. In other words, after a rather low rate of expansion, the shell expanded rapidly up to within three chambers of the living or body chamber, after which the rate of increase was again very small. A fragment of some *Gomphoceras* found in the upper shaly courses at Huffman's Quarry, consisting of two chambers only, is referred to the same species, on account of its similar rate of expansion at a corresponding diameter of the shell. Of course this determination is practically without value excepting as a means of calling the attention of collectors to the possibility of finding this form at the locality named.

Cyrtoceras Clintonense, sp. nov.

(Plate 36, Figs. 2 a, b, c, d, e.)

In the upper shaly courses at Huffman's Quarry was found a specimen measuring 55 mm. along its convexly curved side which describes an arc of 67°, and 29 mm. on its inner or concave side which describes an arc of 40°. Laterally the shell is strongly compressed. The inner concave side remains distinctly and quite evenly rounded, while the outer or convex side is angulated by the meeting, along this side, of the two lateral flattened faces of the shell at almost a right angle. The specimen shows 14 septa, the later formed ones becoming rapidly more distant and larger, and describing an angle of 40°. The transverse diameters at the smaller end are 12 mm. and 7 mm., at the larger end 30 mm. and about 22 mm. The siphuncle is contracted as it passes through the septa, and the separate divisions meet each other obliquely, but in longitudinal sections the divisions of the siphuncle present a nearly tubular outline, though enlarging somewhat above, if the contraction immediately at the septa be not considered. The siphuncle lies within 2 mm. of the outer margin. The width of the siphuncle at the larger extremity is 3 mm. Careful examination of the curvature of the septa showed that in general these were regularly concave, but that towards the outer and inner sides, for a short distance from the junction of the septa with these portions of the shell, the degree of concavity decreased so as to give a slightly reflexed appearance to the outline of the septa, as seen along these sides in the case of the internal casts of the shell. A similar specimen was found in the upper shaly courses at Centreville, Ohio.

In the collection of the Ohio State University is found a fragment of a *Cyrtoceras* from Brown's Quarry which also possesses an angulate outer and a rounded inner side, compressed lateral sides, a similar siphuncle also within 2 mm. of the outer margin, and a similar curvature of the septa. The specimen, however, differs widely from the type in the rate of increase of the shell. The fragment which is 55 mm. long, with 15 septa, measures 28.5 mm. for its greater diameter at the smaller end and 34.5 at its larger extremity. The smaller diameter shows an even lower rate of increase within this length of shell. The general rate of curvature of the fragment is also less. The decreased rate of expansion and the smaller curvature of this Brown's Quarry specimen are, however, only characters which quite commonly belong to the older stages of growth of species of *Cyrtoceras*, the younger stages of which frequently show more rapid rates of expansion and greater curvature than the later growth, and the Brown's quarry specimen is therefore regarded as representing merely an older portion of the species just described.

Cyrtoceras (*Glyptoceras*) *subcompressum*, Beecher.

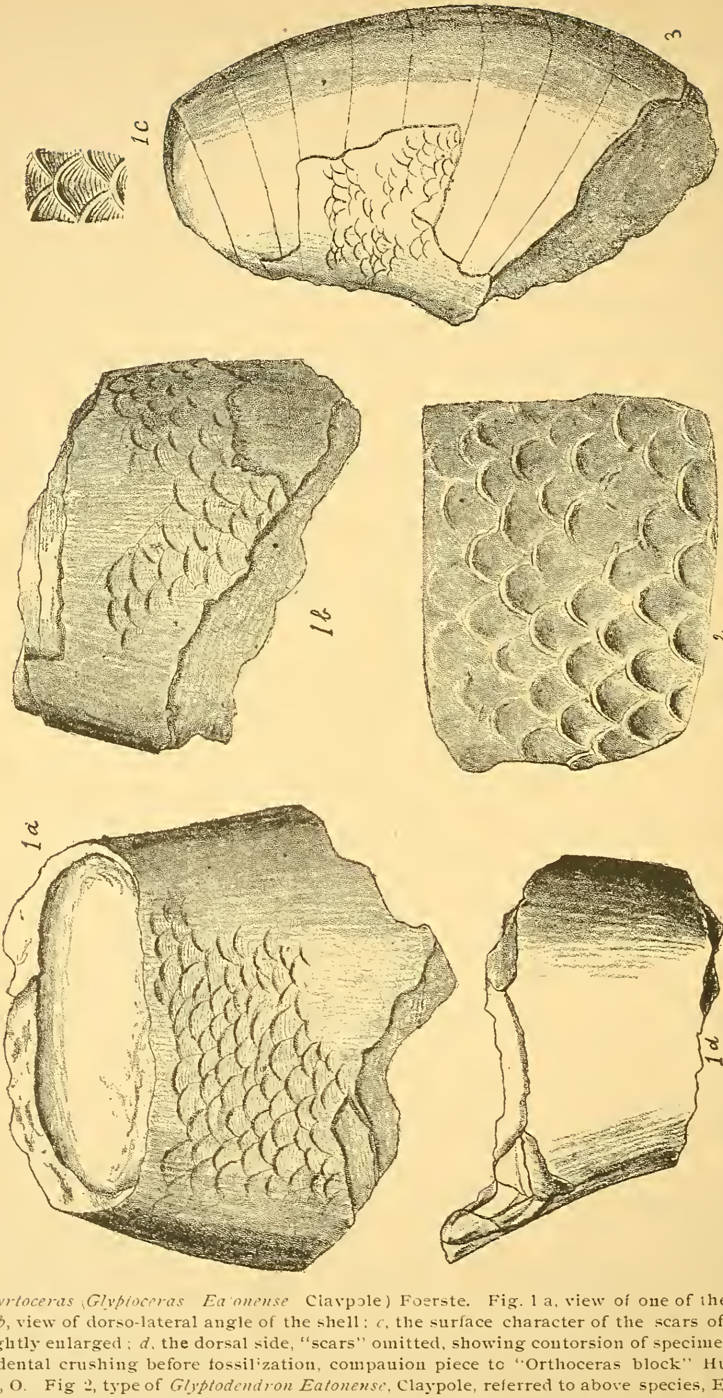
(Plate 32, Figs. 7 a, b, c, d; Fig. 3 of plate on page 536.)

The type specimen came from Brown's Quarry (Pal. N. Y., Vol. 7, p. 35). Other specimens were collected at the same locality (Proc. Bost. Soc. Nat. Hist., 1889; Am. Geol., Sept., 1893). The shell increased quite rapidly in size and was strongly bent, but not coiled as at first supposed. The outer or convexly bent side of the shell was flattened, giving rise to angulate outlines on either side where this outer side merged into the lateral faces of the shell. The inner side of the shell shows the greater convexity in cross-sections. A fuller discussion is provided in the publications above mentioned.

Cyrtoceras (*Glyptoceras*) *Eatonense*, (Claypole) Foerste.

(Figs. 1 a, b, c, 2, of plate on page 536.)

At the base of the limestone at Huffman's Quarry, in a companion piece to the "Orthoceras block," was found a specimen of this genus whose concave septa can readily be seen at the fractured ends of the shell, above and below, but the siphuncle is not exposed. At the smaller ends its diameters are 60 mm. and 53 mm., and here the specimen has a sort of transversely quadrangular appearance in spite of its general rounded form, due probably in part to compression. Towards the upper end the shell, although the fragment is only 45 mm. long, is seen to increase very rapidly in size. The surface of the shell is well preserved. It is covered by a regularly arranged series of markings, crossing each other in diagonal rows, being larger on the outer curve of the shell. Each marking is bounded beneath by a concave raised more prominent ridge, above which lies a moderately concave or depressed region traversed by ridges slightly less prominent, which are also concavely curved, following the outline of the defining ridge. Owing to the arrangement of these figures in diagonal rows and the interference of newly added figures with the upper margins of the older ones, a sort of imbricated appearance is produced, which, were it not for the additional ornamentation caused by the parallel curved lines above described, might be likened to the imbrication of leaf scars in the case of *Lepidodendra*. The width of these figures is 6 mm. on the inner side and 8 mm. towards the outer curve of the shell. On closer examination it may be seen that the larger ridges, defining the bases of the figures or scars, are formed by the deflection and massing together of the minor parallel ridges where these pass over the defining or limiting borders of the figures. The peculiar structure produced is therefore only an aberrant form of the transversely striated type of ornamentation.



Cyrtoceras (*Glyptoceras Eatonense* Claypole) Foerste. Fig. 1 a, view of one of the lateral faces; *b*, view of dorso-lateral angle of the shell; *c*, the surface character of the scars of the latter, slightly enlarged; *d*, the dorsal side, "scars" omitted, showing contorsion of specimen owing to accidental crushing before fossilization, companion piece to "Orthoceras block" Huffman's Quarry, O. Fig 2, type of *Glyptodendron Eatonense*, Claypole, referred to above species, Eaton, O.

Cyrtoceras (Glyptoceras) *subcompressum*, (Beecher), Foerste. Fig 3, this is the opposite side of fig 7 b of plate 32, and corresponds to *b* of Fig. 7 *a* on the same plate.

Repeated examination of the type of *Glyptodendron Eatonense* Claypole has led to the conclusion that our species was not distinct from that form. The Eaton specimen possesses the same ridge defining the lower border of the figures. To be sure the figures in *Glyptodendron Eatonense* have a greater height compared with their breadth than our specimens, but it has been noticed in the Huffman Quarry specimen that the relative heights of the markings increase towards the outer or convex side of the coil. The Eaton specimen is therefore regarded as a cast of the surface of the outer side of the shell, where it is convexly bent. The general contour of the figure is preserved, but the finer markings are gone. The type specimen was described from the Clinton near Eaton, Ohio, Geol. Mag. Dec. II, Vol V, London, 1878. Further discussion may be found in the Amerian Geologist, loc. cit. The writer here acknowledges the repeated generosity and courtesy shown him by Prof. E. W. Claypole in the use of this and other specimens, and for all information desired in connection with this and other geological subjects.

Recently a large *Cyrtoceras* fragment has been found in the upper shaly courses at Huffman's Quarry, having a diameter of 150 mm. It includes 4 chambers, the total height of which toward the middle is 60 mm. The siphuncle was large, the segments are much contracted at the septa, and are very oblique. They are 26 mm. in width in a direction parallel to the septa, and 20 mm. high in a direction perpendicular to that surface. A certain amount of compression has evidently also taken place.

The ornamentation of the two species here described is so remarkable that the subgeneric designation, GLYPTOCERAS, may be valuable for distinguishing this class of species from the more ordinary types.

Orthoceras (*Actinoceras*) *Youngi*, Foerste.

(Plate 33, Fig. 3; P.ate 36, Fig. 1.)

The type specimen was found at Hanover, Indiana, (Proc. Boston Soc. Nat. Hist., 1889). Recently three magnificent specimens were obtained from the "Orthoceras block" at Huffman's Quarry. These enable us to give a much better description of the same. Of these the finest was 190 mm. long; at its larger end it was 63 mm. in diameter, and at its smaller end 31.5 mm. At its larger end 10 septa occurred in a length of 57 mm. In a second specimen of about the same length, the siphuncle was seen to be distinctly contracted toward the septa, securing thus a structure which may be compared to a string of large beads in which however the beads join each other closely. There where the shell had a diameter of 66 mm. the siphuncle had annulations 9.5 mm. wide. Where the diameter of the shell was only 32.5 mm., the siphuncle had annulations 7 mm. wide. The two points chosen for measurement were about 195 mm. apart. The connection between the annulations was 7 mm. and 4.2 mm.

wide at these extreme points. The septa near the smaller end showed arcs of 90°. This is considerably less than in the case of the type specimen, yet, all other features being identical, the variation in the degree of concavity of the septa only serves to indicate to what extent this feature is variable. The exterior surface is smooth. The shell itself was thick. Near the larger end of the Ohio specimens just described the shell had a thickness of 8 mm.

Orthoceras (*Actinoceras*) *clavatum*, Hall.

(Plate 33, Fig. 2; Plate 36, Figs. 5, a. b. c.)

The type of *O. rhythmoides* was found at Brown's Quarry (Proc. Boston Soc. Nat. Hist., 1889.) It showed rather closely placed septa, and, as far as we could judge, the rate of increase in diameter of the shell was very small. A section across the same showed no siphuncle. A second specimen in the collections of the Ohio State University having septa disposed at similar intervals, and describing similar arcs, but possessing a greater rate of increase in diameter undoubtedly belongs to this species and sheds much light upon the same. It is 56 mm. long, and presents in this distance, 21 septa. The diameters at the opposite ends are 27 mm. and 19 mm. respectively. The siphuncle is contracted at the septa producing bead like segments; at opposite ends of the specimen their width is 4 mm. and 3 mm. respectively. A tiny remnant of the surface seems to indicate that the shell was smooth. This second specimen resembles closely the cast figured by Hall from the Clinton of New York as *O. clavatum*, with which the Ohio species is therefore provisionally identified.

Orthoceras (*Actinoceras*) *lata-nummulatum*, Foerste.

(Plate 33, Fig. 4.)

The type came from Soldiers' Home (Proc. Boston Soc. Nat. Hist., 1889.) The large size of the species and its very broad strongly annulated siphuncle are its chief distinctions.

A fragment of some very large and closely related species is represented by a fragment in the collection of Geo. Caswell. Its siphuncle is very large and is strongly excentric. Plate 35, Figs. 4, a, b, c.

Orthoceras (*Actinoceras*) *turgido-nummulatum*, Foerste.

(Plate 33, Fig. 7; Plate 35, Figs. 1, 2.)

The type specimen from Soldiers' Home shows an annulated siphuncle which is rather broad, considering the diameter of the shell. (Proc. Boston Soc. Nat. Hist., 1889.) This seems to be its chief distinction from the next species. A much better specimen occurs in the collection of Mr. Geo. Caswell; it was found at the type locality, Soldiers' Home. Plate 35, Fig. 1. A second specimen in Mr. Caswell collection has more distant septa. Plate 35, Fig. 2.

Orthoceras (*Actinoceras*) *Daytonense*, Foerste.

(Plate 33, Fig. 6.)

This species, described from Soldiers' Home (Proc. Boston Soc. Nat. Hist., 1889) has a broadly annulated siphuncle and rather close septa.

Orthoceras (*Eu-Orthoceras?*) *rectum*, Worthen, var. *junius*, Foerste.

(Plate 32, Figs. 1, 2.)

The very low rate of increase of diameter in this shell and its very distant septa are the only features known at present which will serve to characterize this species. (Proc. Boston Soc. Nat. Hist., 1889.) The siphuncle and surface have not been seen.

Orthoceras (*Eu-Orthoceras*) *ignotum*, Foerste.

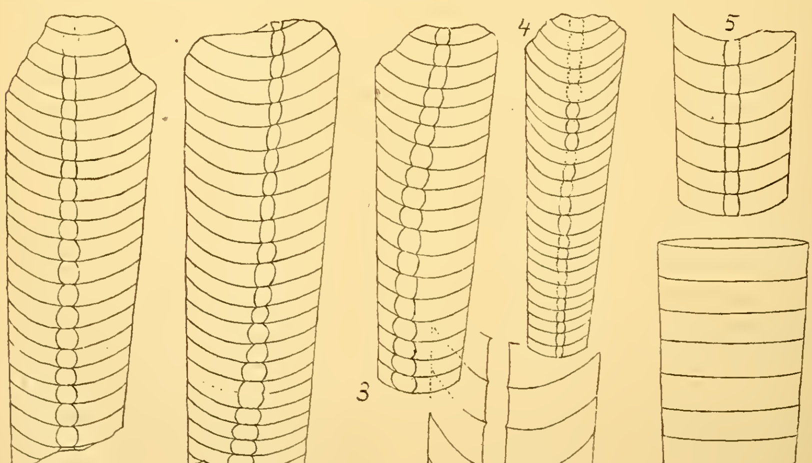
(Plate 32, Fig. 4; Plate 36, Figs. 6, a, b, c; Figs. 5, 6, 7. Page 540.)

The type specimen was found at Hanover, Indiana. On re-examination it appears that the figure published Proc. Boston Soc. Nat. Hist., 1889 (See Plate 32, Fig. 4, of this volume) represents the divisions of the siphuncle distinctly contracted at both ends towards the septa, whereas they are in reality almost cylindrical, enlarging very slightly towards the upper septum in each case, and contracting suddenly before passing through the septum. The same form is found in the upper shaly courses at Huffman's Quarry. Fragments of the same individual were found which, when added together, gave a length of more than 180 mm. One of these fragments, 59 mm. long, was 17 mm. broad at the upper, and 13 mm. at the smaller end, and contained in this length 16 septa. Another fragment, 47 mm. long, contained in this length 12 septa, and at its upper extremity where the diameter was 20 mm. the almost cylindrical siphuncle was 2.3 mm. broad. In another specimen 35 mm. long, with 10 septa, 20.5 mm. broad at the upper extremity and 17 mm. at the lower, the siphuncle was 2.8 mm. at the larger end. The divisions of the siphuncle between the septa were almost cylindrical, showing only a trace of convexity in longitudinal sections. This last specimen showed a thin shell .25 mm. thick. It was perfectly smooth. Its septa described an arc of 100° in cross-section. Another specimen 23 mm. long, with the diameters at the ends 17 and 15 mm. respectively, shows 7 septa, and the cylindrical siphuncle is 2.1 mm. wide; the shell is thin and smooth. (See

Fig. 5 on this page.) A specimen from Soldiers' Home retains the diameter of 12.5 mm. in a length of 21 mm. including 8 septa; the cylindrical siphuncle is 1.7 mm. wide; the surface of the thin shell is smooth. The very low rate of tapering shown by this specimen is worthy of note, but is not sufficient for its separation from the previous ly described forms. A more typical but much smaller specimen was found at Todd's Fork, in the upper ferruginous layer. It was 35.2 mm. long, with diameters at its extremities of 10.5 mm. and 8.2 mm.; at the larger end the cylindrical siphuncle was 1.4 mm. broad, the specimen showed 15 septa; the shell was thin and smooth, the arc described by the septa was only 80°, but this does not warrant the separation of this specimen from the species.

A single specimen from the Soldiers' Home presents many characteristics of *O. ignotum*; the shell is rather thin and seems to have been smooth, the septa describe an arc of 105°, the siphuncle is 2.9 mm. wide, and is cylindrical; the shell has a diameter of 22 mm. In two important particulars this specimen however differs from the former. In a length of 37 mm., it maintains the same diameter, and in this same length it has only 7 septa, whereas the more typical forms of equal size would show 9.5 septa. Fig. 7 on this page—a partial figure.

Specimens showing the same rate of expansion and the same relative distances between the septa as *Orthoceras ignotum* are known from Todd's Fork. Their shell is quite thick, .4 to .5 mm. Their siphuncle is unknown but they very probably belong to this species. Several specimens are in the cabinet of Dr. Chas. Welch.



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Orthoceras (*Eu-Orthoceras*) *erraticum*, Foerste, Figs. 1, 2, 3, showing the change from an annular to a more cylindrical siphuncle. Figs. 2 and 3 show the variation in position of the siphuncle. Fig. 1 is cut transversely to this plane of variation and so does not show the change in position of the siphuncle. "Orthoceras block," Huffman's Quarry, Ohio.

Orthoceras described on page 542 Fig. 4, Todd's Fork, Ohio.

Orthoceras ignotum, Foerste, Fig. 5, a medium sized specimen; section showing siphuncle, Soldiers' Home, Ohio. Fig. 6, interior cast, Huffman's Quarry, Ohio. Fig. 7, section of fragment from large sized specimen, Soldiers' Home, Ohio.

Orthoceras (*Eu-Orthoceras*) *erraticum*, Foerste.

(With characters of *Actinoceras* when young).

(Figures 1, 2, 3, on page 540.)

In the "Orthoceras block" at Huffman's Quarry were found rather abundant fragments of a form which shows about the same rate of tapering as *O. ignotum*. In several cases, the more aged parts of the shell, where they were 24 mm. wide, practically ceased tapering, producing in this manner a cylindrical growth in the later formed parts of the shell. These shells were very instructive in showing certain variations which siphuncles may undergo not only in the same species but even in the same shell. The remarkable fact was discovered that fragments more than 18 mm. in diameter showed cylindrical siphuncles, and those less than 16 mm. in diameter had siphuncles whose segments were more or less strongly contracted towards the septa, thus producing the appearance of a close string of beads. Moreover in three cases the gradual change of the siphuncle from an annular or bead like one to a cylindrical one could be distinctly traced. Judging from this series of specimens it would therefore seem that the annular siphuncle was the earlier form from which the cylindrical form was a later development. Moreover the position of the siphuncle varied in quite a number of specimens in such a way that the siphuncle, which was annulated and excentric at smaller diameters of the shell, became central while becoming cylindrical, and then continued to change its position in the same direction so that the more recent cylindrical part of the siphuncle was again excentric, but situated on the opposite side of the shell from the siphuncle in the earlier part of its growth. The freedom with which the siphuncle has changed its place in these specimens is remarkable, and may well nigh be regarded as a characteristic of the species. Whereas it has been observed before that the position of the siphuncle was variable in the same species, its position in the same individual has usually been found to be more constant. Moreover in the other Clinton species so far examined the variability of the siphuncle has been slight. It will be instructive, therefore, to add a few measurements showing this variation in the Orthoceras block specimens. In one specimen 48 mm. long, with 18 septa, the centre of the siphuncle was 4 mm. away from the shell at the smaller end, and had passed to the centre near the larger end. For this entire length the segments of the siphuncle were very distinctly and almost equally contracted towards the septa; at the smaller end, 11 mm. in diameter, the siphuncle was 2.8 mm. wide; at the larger end 16 mm. in diameter, the siphuncle was of the same width. In a second specimen 55 mm. long, with 20 septa, the centre of the siphuncle was moderately excentric at the smaller end with a diameter of 15.5 mm., the siphuncle being 2.6 mm. wide. Where the shell has a diameter of 18 mm. the siphuncle is 2.8 mm. wide, showing a slight accidental increase of its diameter; here the centre of the siphuncle lies only 8 mm. from the side of the shell. From this point the diameter of the siphuncle decreases so rapidly that the fifth succeeding segment is only 2.2 mm. wide. At the larger end where the shell has a diameter of 20.5 mm., the siphuncle is 2.1 mm. wide, and while approaching very closely to a cylindrical siphuncle, it yet shows a moderately convex outline in longitudinal sections. Another specimen with 17 septa, 47 mm. long, shows an annular siphuncle 2.8 mm. wide at the smaller end, which has a diameter of 15 mm., and an almost cylindrical siphuncle only 1.8 mm. wide at the larger end where the shell has a diameter of 20.5 mm. The septa describe an arc of 80°. Figs. 1, 2, 3, on page 540).

Orthoceras (*Eu-Orthoceras*)———.

(Fig. 4 on page 540).

Specimens of a small Orthoceras occur having septa at distances intermediate between those of *O. erraticum* and *O. Hanoverense*, but the shells show neither the markedly variable siphuncle of the first nor the peculiar groovings of the internal cast of the last species. Good specimens of Orthoceras are not common enough in the Ohio Clinton to settle all doubtful points and in the case of the specimens just mentioned it will be necessary to let their position remain doubtful for the present.

At Todd's Fork was found a specimen tapering in a length of 44 mm. from 8 mm. to 14 mm. It had a smooth shell; there were 26 septa, which varied considerably in convexity. The siphuncle was annular during its entire length and, where the shell had a diameter of 12 mm., was 1.8 mm. wide. The siphuncle changed its position slightly during its growth, but the change of position was too small to have any special significance. (Fig. 4 on page 540).

Several small fragments of the same type were found at Hanover, Indiana, though they were too small to show anything but the annular siphuncle and too short to show any considerable change of position of the siphuncle, even if any occurred.

A specimen from Brown's Quarry with smooth shell, and septa approaching each other as closely as those of the forms just described, is doubtfully referred here. The siphuncle is not preserved.

Specimens in the form of casts with septa at distances from each other corresponding to those in *O. erraticum*, and with slightly eccentric siphuncle, are common at Todd's Fork, but the form of the segments of the siphuncle is unknown. The shell is about .2 mm. thick, and, while the surface is practically smooth, a trace of cross-striation owing to irregularity of growth is seen in some specimens. This shows how closely related must be the subgenera *Eu-Orthoceras* and *Cycloceras*. The vertical linear marking, called a carina, is seen on one side in some specimens. Until the siphuncle is better known, these specimens will be best referred to the present variety.

Orthoceras (*Eu-Orthoceras*) *Hanoverense*, Foerste.

(Plate 32, Fig. 6; Plate 35, Fig. 5.)

This species was described from Hanover, Indiana, in the Proc. Boston Soc. Nat. Hist., 1889. It may well be questioned if all the interesting and peculiar structures discovered in the type specimen will be found characteristic of the species. From typical forms of *Orthoceras ignotum* it can always be distinguished, but whether the greater number of septa and the somewhat narrower, and at a corresponding age more moderately annulated siphuncle will always serve to distinguish this form from the species *O. erraticum* remains to be determined.

A species from Hanover, Indiana, shows the numerous septa, but the cast of the chambers has no obliquely impressed line as in the type; it did not show the siphuncle, its shell surface was smooth. (Plate 35, Fig. 5.) A second specimen from the Soldiers' Home in the cabinet of Mr. Geo. Caswell, and a third in the collection of Dr. Chas. Welch, from Todd's Fork, possess similar close septa, but no obliquely impressed line. For the present at least these forms will be placed under *O. Hanoverense*.

Orthoceras (*Eu-Orthoceras*?) *virgulatum*, Hall?

(Plate 32, Fig. 5: Plate 35, Fig. 3.)

This very doubtful form, described from the Soldiers' Home, (Proc. Boston Soc. Nat. Hist., 1889), is characterized by a very low rate of increase in diameter, rather distant septa, and a very attenuated cylindrical siphuncle. *O. inceptum* seems never to have the septa so far distant in the broader parts of the specimens, nor the siphuncle so regularly attenuated as this specimen. A form with somewhat broader siphuncle occurs in the collection of Mr. Geo. Caswell from Soldiers' Home. Plate 35, Fig. 3.

Orthoceras (*Cycloceras*) *inceptum*, Foerste.

(Plate 25, Figs. 1 a, b c.)

Typical specimens of this species are rather common in the Beavertown marl at the top of the Clinton Group at Huffman's Quarry (Bull. Denison Univ. Vol. I), and in the corresponding marl at Geo. Young's quarry, west of Soldiers' Home. At both localities the specimens are always in the form of internal casts. They are quite small, the largest specimens attaining a diameter of only 5.5 mm. The position of the siphuncle is almost invariably well shown; it is only moderately excentric. Most of the casts are perfectly regular and present nothing unusual. In others, however, the surface of the cast shows on one side a vertical series of markings which are so regular in size and form as to indicate that they are connected with some internal structure of the shell. These markings consist of an impressed line which rises from each lower septum to about half the height of the chamber, and then falls again, describing a convex curve extending from one-fourth to one-third the distance around the shell. Apparently the region along this line often weathers away and in that case the part below the impressed line remains behind as a triangular projection with rather concave lateral sides, bounded along these sides by deep grooves which gradually disappear laterally along the lower septum, but which unite above and reach the upper septum. The bottom of these grooves is at times pitted, and the exterior of the casts also at times shows very faint vertical lines, which may be pitted, but at present it is no longer possible to place any stress upon this pitting since it is too exceptional, and seems to be simply a sign of weathering. Although the termination of the septa at the siphuncle is well shown in longitudinal sections, the siphuncle itself is almost never seen, and even then not satisfactorily. The best section indicates that it was cylindrical, and narrow, a view which gains support from other specimens described next.

In the "Orthoceras block" at Huffman's Quarry were found in considerable numbers a species of *Orthoceras* which in its rate of tapering, slightly excentric siphuncle and curvature of the septa resembles the marl specimens from the same quarry. The septa seem in general to be rather more closely arranged. The siphuncle is cylindrical. The exterior surface of the shell is marked by transverse rings or striæ, which are very variable in distinctness but which in general may be said to gain in strength and distinctness and to grow more distant in the larger, later parts of the shell. Quite a typical rate of curvature is shown by a specimen 20.5 mm. long, with diameters of 2.9 mm. and 5.3 mm. at the opposite ends. In another specimen 30 mm. long, the diameter increases from 3.8 mm. to 8.2 mm. Now this larger diameter approaches closely to the smaller diameter of a larger specimen also with transverse but coarser striæ and a cylindrical siphuncle, at times showing a slight tendency toward annular structure. This specimen in a length of 19.5 mm. increases in diameter from 8.7 mm. to 11.2 mm. and shows 12 septa; the siphuncle is 1.4 mm. wide at the larger end, a rather abnormal width for this size. Another specimen with a siphuncle 1.2 mm. wide reaches a width of 13.3 mm. at its larger end. The larger specimen collected had a diameter of 17 mm. There seems no reason for separating the larger specimens from the smaller ones described earlier, and therefore small size ceases to be a distinguishing feature of this species, although most specimens found are small. At a point 3.7 mm. in diameter one specimen showed a siphuncle .5 mm. wide. At a diameter of 10 mm. another siphuncle was 1 mm. wide.

Whether certain specimens in the marl at Huffman's Quarry, which consists only of casts of the siphuncle, are to be associated with this species as an indication that also the larger forms existed there, remains to be proved. One of these siphuncle casts was 2mm. broad and three of the segments occupied a length of 10 mm.

Small specimens, not exceeding 6 mm. in breath, showing all the characters above described except the problematical structure of the casts occasionally present in the marl specimens, and lacking the exterior surface, are found at Todd's Fork in the upper ferriferous courses, and seem to belong to the more typical forms of this species.

Orthoceras inceptum, var acceleratum, var. nov.

(Plate 37 A, Fig. 10.)

A single specimen in the collection of Geo. Caswell, from Soldiers' Home is remarkable for the rapidity with which the distance between the septa increases with growth. For this we suggest the term: variety *acceleratum.*

Orthoceras (*Cycloceras*) *Nova-Carlislense*, Foerste.

(Plate 30, Fig. 25; Plate 33, Fig. 1.)

This species is rather common at Brown's Quarry. (Proceedings Boston Soc. Nat. Hist., 1889.) Its exterior surface is transversely striated, about 40 striæ occupying a length of 20 mm. Other specimens showed twelve to thirteen striæ in a length of 2 mm. These much finer and closer striæ are interpreted as belonging to the inner shell of the species Neither surface shows longitudiual striations.

Orthoceras (*Spyroceras?*) *spyroceroides*, sp. nov.

Associated with *Orthoceras Nova-Carlislense* at Brown's Quarry is another form, presenting the same stout cylindrical siphuncle almost 4 mm. broad, there being 8 septa in 32.5 mm. where the shell is 29 mm. broad. The rate of increase and general habitus is the same as that in the preceding species, and it would be associated with it were it not for its surface ornamentation. The writer feels dubious whether all forms intermediate between this and the last species will not eventually be found, but since writers who have made special study of ORTHOCERATIDÆ seem to arrive at conclusions that the distinctions to which we here call attention, are of subgeneric if not of generic value, it seems necessary at least to place this form in another species. It shows quite distinct transverse striæ, about 40 striæ in a length of 43 mm. although that is of course likely to prove a variable feature. The longitudinal striæ are very fine, about twelve of the stronger ones occupying a width of 8 mm., but very much finer, almost hair-like striæ, which require a lense to be seen, are intercalated between these.

Orthoceras (*Spyroceras?*) *Jamesi*, Hall and Whitfield.

(Plate 32, Fig. 3.)

Quite a number of specimens, none of them of any considerable size or length, have been found at the original locality, Todd's Fork, in Clinton county, Ohio.

Orthoceras (*Cycloceras*) *amycus*, Hall.

(Plate 33, Fig. 5.)

A large specimen, not preserving the shell, was described from Brown's Quarry (Proceedings Boston Soc. Nat. Hist., 1889, pp. 282, 283). A similar specimen from Ludlow Falls had annulations 26 mm. broad; five annulations occurred in a length of 21.5 mm.; they were slightly more prominent than those of the Brown's Quarry specimen.

At Huffman's Quarry a very small specimen was found in the upper shaly courses. It had 5 annulations in a length of 7 mm. and the shell itself was about 9 mm. broad. In the "Orthoceras block" from the same locality three specimens were found, 9, 13, and 19 mm. broad and with 5 annulations in 8.3, 11, and 15 mm. respectively. All of these Huffman Quarry specimens showed transverse striæ in addition to the annulations, often distinct enough to be recognized without a lense. In the smaller fragments so far found no measurable degree of tapering is discovered. No longitudinal striæ occur. The siphuncle is sub-central and its sides are nearly straight, showing but a very slight degree of contraction towards the septa. For a siphuncle of this kind it is very broad, having a width of 2.5 mm. in the specimen 13 mm. broad. The septa are of medium concavity, forming an arc of about 100°.

Orthoceras (*Kionoceras*) *Crawfordi*, Foerste.

(Plate 30, Fig. 26.)

The type, collected at Soldiers' Home, is in the collection of Ira Crawford (Proc. Boston Soc. Nat. Hist., 1889). The exterior of the shell is ornamented by numerous fine distinct longitudinal striæ of which 9 or 10 occupy a width of 2 mm.

Orthoceras (*Discosorus*) *conoideum*, Hall.

(Plate 36, Fig. 8.)

Forms essentially like those figured from New York are not uncommon in the Clinton group, at Todd's Fork, near Wilmington, Ohio. All the specimens seen are in the cabinet of Dr. Chas. Welch, of Wilmington. They are evidently the siphuncles of some cephalopod belonging to the Orthoceratidæ.

Coleolus Clintonensis; sp. nov.

(Plate 37a, Fig. 11.)

In the limestone at Soldiers' Home doubtful forms occur, having the rate of increase of the specimens of *Orthoceras inceptum*. One specimen has very faint indications of transverse striæ. A second has, instead, very sharp and clear-cut transverse very fine groovings, which are so regular and occur at such equal distances that it does not simulate the forms of *O. inceptum*. The failure to find either septa or siphuncle in these specimens, even when 24 mm. long, has led to the opinion that they are Clinton species of *Coleolus*, for which reason the term *Coleolus Clintonensis* has been reserved for them. They are very rare and for this reason their generic reference is not considered as satisfactory as though many specimens had been found habitually to lack the septa and siphuncle.

Conularia Niagarensis, Hall.

Plate 30 Fig. 16.)

In the Proceedings of the Boston Society of Natural History, 1889, a specimen found at Todd's Fork was identified with *C. Niagarensis*, Hall. More recently the same form was found at Huffman's Quarry in the upper shaly courses. A comparison of the two specimens enables us to make the following observations. Although when flattened out so as to expose two sides simultaneously this shell seems to have a considerable apical angle, when in its natural condition the apical angle is seen to be small. Our specimens are not perfect enough to give this apical angle with exactness, but approximately in one specimen 18 mm. long the diagonal diameter measured 7.8 mm. at the smaller end of the specimen and 10 mm. towards the larger end. Along the four corners the shell was incurved, forming a longitudinal furrow which was most distinct below, but grew less distinct near the upper or larger end. The sides themselves were very gently convex.

Conularia bilineata, sp. nov.

(Plate 37a, Fig. 12.

A very small fragment of a species of *Conularia* was found at Soldiers' Home. In it the normal simple transverse striæ of this genus were represented by so many pairs of very distinct striæ, the pairs being separated by the usual strong grooves, crossed by rather more distant and less sharp longitudinal striæ than in *C. Niagarensis*. Seven of these pairs of transverse striæ occupied a length of 2.2 mm., and 9 longitudinal striæ occupied a width of 1.7 mm. The name *Conularia bilineata* is suggested for this species.

Bellerophon fiscello-striatus, Foerste.

(Plate 25, Figs. 19 a, b, c, d, e)

This species when first described in the Bulletin of Denison University, Vol. I, was known only from Stoltz quarry near the Soldiers' Home. In the Proceedings of the Boston Society of Natural History, 1889, its occurrence at Brown's Quarry and near Hanover, Indiana, was noted. Since then it has been found in the "Orthoceras block" from the base of the Clinton at Huffman's Quarry, and in the shaly layers of the same quarry have been found compressed shells with median slit-band, longitudinal and less distinct transverse striæ, which might be the same species.

Recent examinations of *Bellerophon stigmosus* from the flinty beds of the Clinton near Lockport, New York, showed similar surface ornamentation, but the median slit-band was raised into a low yet distinct carina, a fact never true of the western forms here described. Whether this be enough to distinguish the species is very questionable.

Bellerophon (*Bucania*) *exiguus*, Foerste

(Plate 25, Figs. 18*a*, *b*; Plate 31, Fig. 3; Plate 37a, Figs. 2*a*, *b*, *c*.)

This species was first described in the Bulletin of Denison University, Vol. I, from the Beavertown marl, at Huffman's Quarry. Since then it has been found in the upper more shaly courses at the same quarry, at the quarry north of Beavertown, and in the equivalent of the Beavertown marl at Geo. Young's Quarry. In the Proceedings of the Boston Soc. Nat. Hist., 1889, larger specimens from Hanover, Indiana, were referred to this species, and the specimen from Todd's Fork, Ohio, showing surface markings, was also referred here. As at present understood this species presents two constant characteristic features; one of these is the narrow umbilicus, the last whorl not closing the same; the second is the character of its surface ornamentation. This consists of transverse striæ only, which from the low carina or median angulation of the shell bend backwards. The sides of the shell spread out considerably at the aperture. The marl specimens are usually small, and show rather coarser transverse striæ, moreover the carina in many specimens is a little more developed. The specimens from Todd's Fork are larger, the carina is always only a low median angulation, and the transverse striæ are perhaps a little finer. The largest specimen measured was 18 mm. across, and its aperture must once have spread to 19mm.

Bellerophon (*Bucania*) *opertus*, sp. nov.

(Plate 25, Figs. 18*c*, *d*; Plate 37a, Figs. 3*a*, *b*.)

The type specimen of this species is a specimen from Hanover, Indiana, but small forms, apparently of the same species, though not preserving the exterior markings, occur in considerable numbers at

Huffman's Quarry. When the shell itself has been entirely removed the space remaining vacant in the umbilical region is larger in this species than in the case of *B. exiguus*. But when the shell is preserved, the last whorl closes the umbilical region, leaving only a very shallow depression there. The specific term is intended to recall this feature of a closed, covered, umbilical region. Along the median line or back of the shell there never is a distinct carina, a very indistinct median elevation may be found towards the aperture of larger individuals, but this has never been observed to be as strong as in the case of B. *exiguus*. The largest diameter of the shell is 17 mm. and it must have had about the same width at the aperture.

Bellerophon (*Bucania*) *trilobatus*, Sowerby.

(Plate 27, Figs. 33*a*, *b*.)

Conrad's *Bucania trilobata* is at least generically related to the *Bellerophon trilobatus* of Sowerby. If therefore it be not identical it requires at least a new name. A form of this general character was found in the Beavertown marl at Huffman's Quarry. Prof. E. W. Claypole has found more typical specimens in the top of the Clinton, near Mifflintown, Juniata county, Pennsylvania.

In these specimens the shell was preserved here and there in a fragmentary way. The surface was smooth; no trace of a carina nor of a slit-band was present.

Cyrtolites Youngi, Foerste.

(Plate 31, Figs, 7, 7*a*.)

The shell is very much compressed laterally, the sides meeting under very acute angles forming a sharp keel. The surface of the shell is ornamented by fine not very distinct striæ, visible under a lense, bending backwards toward the keel. The specimen is 6.8 mm. long, and the aperture is 1 mm. wide. The type was found at Hanover, Indiana.

Pleurotomaria inexpectans, Hall and Whitfield.

But little can be added to the description of this species, published in the Paleontology of Ohio, Vol. II. The species is not at all infrequent at Todd's Fork, near Wilmington. In one good specimen six transverse striæ occurred in a distance of 2 mm. Longitudinal striæ are scarcely visible, being best seen below the median ridge of the last volution. This median ridge is a longitudinal or revolving striation which passes along the middle of the upper part of each volution, gradually increasing in size towards the mouth. It is present in all specimens examined recently, and, while never sharp, becomes broad and high enough to form at least a low ridge. The slit does not form a groove bounded by distinct raised ridges or striæ as in most *Pleurotomariæ*, but forms an obtuse ridge there where the flattened upper side of the shell meets the regular and strong curvature of the sides and the lower, ab-apical surface. There is no umbilicus. The inner lip is slightly thickened and stands out from the last volution. The striæ are almost obsolete in some specimens.

Pleurotomaria filitexta, sp. nov.

(Plate 37A, Figs 6 a, b.)

This shell has quite a low spire, owing to the fact that the newer whorls rise high up on the previous whorls, covering their slit-band entirely. The upper part of each whorl (holding the initial end of the shell upwards) is less convex than its sides, thus assisting in the general depressed appearance of the spire. The shell is 10 mm. wide, the spire shows an elevation of 1.7 mm. above the surface of the end of the last whorl. It has 5 whorls. The total height of the shell is hardly 6 mm. Along the middle of the side of the volutions runs a slit-band which is barely two-fifths of one millimeter wide near the mouth of the shell. It consists of a broad groove, bordered on each side by a single striation, which is distinct, though but slightly raised above the general surface of the shell. On the upper surface numerous very regular, distinct, close, filiform, transverse striæ ornament the surface and curve back to the slit-band, forming with it an angle of about 70 degrees, if no account of the more rapid backward curvature at the slit-band itself be taken into account. Below the slit-band, similar striæ also curve backward to the slit-band. Near the aperture about 22 striæ were counted in a length of 2 mm. This species was found in the "Orthoceras block" at Huffman's Quarry.

Raphistoma affine, Foerste.

(Plate 26, Fig. 18; Plate 37A, Figs, 1 a, b, c.)

Since the description of this species in the Bulletin of Denison University Vol. I, the exterior of the shell has been observed in specimens from Todd's Fork Ohio. The transverse striæ are close and fine; from the junction of each whorl with the preceeding one, the striæ bend back strongly towards the quite sharp angle, which is formed at the middle of each whorl, laterally. In a general way the striæ form an angle of forty-five degrees with the latter. In the larger shells there is commonly a very shallow depression on the upper surface of the last coil, a short distance from its edge, which causes an apparent slight thickening of the shell along the edge, especially towards the aperture. The mouth is oblique, facing diagonally downwards (if the apical end of the spire be placed at the top). The largest specimen so far found had a greatest diameter of 20 mm. The height of the spire varies considerably. It is usually very low. The species occurs in the Beavertown marl at Huffman's Quarry, and in the corresponding formation at Geo. Young's Quarry. It also occurs in the upper shaly courses at Huffman's, and in the upper ferriferous courses at Todd's Fork, Ohio. In the Clinton on the east side of Taylor's Ridge, Summerville, Georgia.

Cyclonema bilix, Conrad.

(Plate 26, Fig. 15, var; Plate 30, Fig. 15; Plate 37A, Fig. 9, var.)

The outer lip of the aperture is sharp. The inner lip is strongly broadened, thus increasing a little the size of the aperture. This broadened flange of the lip meets the lower surface of the shell with a concave curvature, which is strongest toward its inner end of attachment to the previous whorl; here it forms often a strong though rounded groove with the slightly raised margin of the shell. In other respects the shell is very variable. In the ordinary form the whorls are rounded. Very distinct fine close sharp striæ of growth traverse the shell transversely, indicating the outlines of the aperture at various stages of development. In addition to these striæ, transverse wrinkles of moderate distinctness and having the same general direction, also are frequently present. The longitudinal revolving striæ are much less closely placed, and at more or less regular intervals certain of these striæ are very strong and sharply elevated, forming the most prominent lines in the exterior ornamentation of the shell. This form is found at Soldiers' Home, Fauver's, Huffman's, Centreville, Brown's, Todd's Fork, Ohio, and Hanover, Indiana. (Plate 30, Fig. 15.)

In a variation of this form the surface ornamentation is identical, but the spire of the shell is much more strongly elevated, the apical angle is therefore less and the successive whorls do not differ so much from each other in transverse measurement. Succeeding whorls do not conceal quite so much of the earlier smaller ones, and the latter are therefore more exposed and appear more convex. This form occurs at Brown's Qaurry.

A third variation shows a similar increase in height of the spire, and a corresponding rounding of the successive whorls. But in this case the last or fifth whorl shows only the fine transverse striæ; these are less sharp and hence give a more fibrous appearance to the ornamentation. The longitudinal revolving striæ are either absent upon the main surface of the whorl, reappearing only towards the lower side of the shell, or else they are at least sufficiently indistinct not to be readily seen at an ordinary examination of the shell. The younger whorls however usually show these revolving striæ more distinctly, indicating that this is a character lost only in the adult shell, while still present in younger specimens. This form is found at the Soldiers' Home. In it the transverse wrinkles are more prominently developed, especially along the suture line of the last whorl.

A form with the spire much less elevated than usually, with the transverse striæ well developed though less sharp, and with the revolving striæ indistinct or obsolete on the last whorls, except towards the under surface of the shell, represents another extreme of this species, comparable with the form last described. It is not improbable that the earlier whorls also showed the revolving striæ more distinctly. This form occurs at Soldiers' Home (Plate 26, Figure 15).

Finally a form occurs which differs from the ordinary types enough to form at least a distinct variety. In it the transverse striæ are very fine and close, much more so than in ordinary forms. Of the revolving striæ only the stronger ones remain. These are much more distant from each other, and are strongly raised, the intermediate parts of the shell being strongly concave in cross section. It is these distant coarse revolving ridges which gave the name *varicosum* to the variety. This feature can be seen already at the end of the second whorl, which indicates that it is a variation of a much more distinct character than the others so far described. The altitude of the spire is quite normal. This variety occurs at Soldiers' Home, and Todd's Fork, being not uncommon at the latter locality. (Plate 37A, Fig. 9.)

Cyclora alta, Foerste.

(Plate 26, Figs. 17 a, b.)

This species looks very much like a very small *Holopea*. The specimens seem to occur almost invariably in the form of smooth casts. In one single specimen it was thought that minute transverse striæ could be detected under a lense. It is very common in certain parts of the "Beavertown marl" at Huffman's Quarry, and occurs also in the corresponding layer at Geo. Young's Quarry. At the latter quarry it occurs also in the upper shaly courses of the Clinton.

Straparollus (*cf. Oriostoma*) *incarinatum*, sp. nov.

(Plate 37a, Fig. 7 a, b.

The transverse striæ show no trace of sinuous flecture anywhere, corresponding to the obtuse sinus of *Straparollus*. Any possible affinities of this species with *Oriostoma* can not safely be determined as long as no characteristic operculum has been found. Some species of *Straparollus* have a sinus so faint that it would be but a small step to this specimen, which shows none at all. The spire is very depressed, rising but four-fifths of a millimeter above the surface of the last whorl near the aperture. The total height of the shell is 4 mm. The greatest width is 7 mm. The mouth is round, but situated oblique to the vertical diameter. The umbilicus is wide, permitting a view of all the whorls from beneath, though from its position each whorl hides a little of the previous one. The surface is marked by numerous close, fine, transverse striæ, too fine as a rule to be seen without a lense. Traces of very fine, distant, longitudinal striæ are indistinctly visible under an ordinary lense; in other cases they might be altogether obsolete. No longitudinal carinæ of any kind are visible.

This species was found in the "Orthoceras block" at Huffman's Quarry, Ohio.

Platyceras (*Platystoma*) *Niagarense*, Hall.

(Plate 25, Figs. 3 a, b; 22 a, b.)

This is in some respects quite a variable species, yet on close inspection it will be seen that the variations are characteristic chiefly of the later stages of life, and hence are usually found in the last whorls or at least the later ones, while the earlier whorls of various forms are apt to be closely similar. Thus the earlier whorls of almost all specimens form a quite regular, though rapidly widening spire, in which smaller whorls successively expose about half of their height above the larger, partly enveloping, succeeding whorls. At this stage the aperture shows a distinct though neither large nor deep umbilicus, a thin outer lip, and an inner lip, the latter, after having passed the umbilicus, apparently terminating on the lower surface of the previous whorl—so that the upper end of the outer lip (holding the shell with the initial end up) appears to join the previous whorl independent of the lower lip. In reality, the upper inner edge of the lip has grown tight to the previous whorl.

From these similar younger stages of growth are developed the different variations. The normal and mo.e common type shows a very rapid expansion of the last whorl, which, however, does not envelope the previous whorl much more than is the case with the younger whorls, so that a moderately elevated spire is produced. Less commonly this last whorl envelopes the previous whorl to a greater extent, at least for two-thirds its height, thus giving the upper, apical part of the shell a much more flattened aspect. In these forms it is usual to find the upper part of the inner lip still adnate to the surface of the previous whorl, even in specimens 20 mm. wide (Plate 25, Fig. 22). There is also a much rarer variety, comparable to the variety *plebeium*, Hall, in which the last whorl leaves from two-thirds to four-fifths of the height of the previous whorl exposed, thus producing a much more elevated spire (Plate 25, Fig. 3 b). These forms all show, with very rare exceptions, well marked though fine striæ of growth; fine revolving striæ are also present; they often equal the transverse striæ in distinctness, though quite as commonly they are less distinct. Very rarely the revolving striæ are very distinct and the transverse are almost obsolete. These various forms occur at Soldiers' Home, Fauver's, Centerville, Fair Haven, and Brown's Quarry, Ohio.

In the previously described forms the last whorl is frequently more or less expanded towards the aperture producing a slightly trumpet shaped peristome. At Brown's Quarry are found specimens having a maximum transverse diameter of 25 mm. In these the shell is also rapidly expanded towards the aperture, but the peristome is more or less strongly wrinkled perpendicularly to the edge of the lip, the upper edge of the inner lip, however, being adnate to the surface of the previous whorl as heretofore. At Huffman's Quarry, in the upper shaly courses, the end of the last whorl becomes free from the earlier whorls of the shell, and becomes more or less distant from the rest of the shell. The inner lip, therefore, is no longer adnate to the surface of the previous whorl, but assists in forming the more or less strongly angulated peristome, wrinkles transverse to the edge of the lip being developed as in the previously described form. On examining the inner lip of these Huffman quarry specimens, it is seen to be twisted, and interiorly, along the line of the twist or fold, a certain amount of thickening has taken place. In these shells with the transversely wrinkled or plicated peristome the surface of the last whorl usually shows only transverse striæ, the revolving striæ being almost obsolete even over most of the remaining parts of the shell, though sometimes preserved on the younger whorls. These forms attain a width of 25 mm.

It does not seem possible to maintain any distinction between the genera *Platyceras* and *Platystoma*.

Platyceras Niagarense, Var. Clintonense, var. nov.

(Plate 37a, Fig. 8)

In the ferruginous limestone at the top of the Clinton, just under the Onondaga shales, near Mifflintown, Juniata county, Pennsylvania, Prof. E. W. Claypole found a number of specimens of *Platyceras* of a type quite distinct from those just described. The young are very much after the fashion of the previously described shells excepting that the spire is perhaps more depressed. Two to three of the initial whorls touch each other, after which the succeeding whorls grow loosened from each other, and show a tendency towards a straight growth, the last whorl being of the form of a massive, spirally twisted pillar, in which the coiling is but very moderate. No trace of longitudinal or revolving striæ were present. Transverse striæ were frequent, but these were broad and flattened, and did not have the sharpness often seen in the ordinary Ohio specimens. It may be distinguished as variety *Clintonense* and seems to be the precursor of such forms as *Plactyceras spirale*, Hall, of the Lower Helderberg.

Subulites directus, sp. nov.

(Plate 37a, Figs. 5 a, b.)

Shell elongate, slender, fusiform; some of the specimens are almost straight, most of them however show a very moderate curvature. the curvature being sufficiently pronounced to be readily recognized; sometimes the curvature is more marked but it never equals that of such forms as *Subulites ventricosa*. The largest specimens were about 50 mm. long; the length of the third whorl was 1.5 mm.; of the fourth, 2.5 mm.; fifth, 3.5 mm.; sixth, 5 mm.; seventh, 7 mm.; eighth, 12.5 mm.; the body whorl was not shown for its entire length but in another specimen of about equal size it was 30 mm. long and 10 mm. broad. It is possible that the measurements of this body whorl, as taken from another specimen, are slightly too small. The aperture was 18 mm. long and, as far as one could judge from the outer broken lip of the shell, about 5 mm. wide or possibly a little less. In the case of several specimens the shell surface was well preserved, but it was perfectly smooth. The shell itself was quite thick.

This species is closely related to *Subulites terebriformis*, Hall and Whitfield, of which it is the precursor, and of which it may be regarded as a variety. The Clinton form differs in having a much shorter body whorl, which shows greater curvature on the side opposite the aperture; the mouth is broader and more elongate-ovate.

The moderate curvature shown by many of the specimens of this species, suggests the origin of these forms from a still more curved form while they themselves are precursors of the straight Guelph species, *Subulites terebriformis*. *Subulites attenuatus*, Lindström is a still more similar form.

This species occurred in considerable abundance in the "Orthoceras block," from the base of the Clinton at Huffman's Quarry, Ohio.

Subulites (*Polyphemopsis*) *plani-lateralis*, sp. nov.

(Plate 37a, Figs. 4 a, b, c.)

This species is represented by the single specimen used as the type, belonging to Mr. Geo. Caswell, who informed the writer that he had himself cut the specimen out of a piece of Clinton limestone, from the Clinton rock of the Soldiers' Home Quarry. It is now 8.2 mm. long, but has lost its apical whorl which would have given the specimen a total length of at least 8.5 mm. Its width was about 3 mm. There were 7 whorls in the complete specimen. The mouth was 8.5 mm. long and perhaps about 1.7 mm. wide; above, towards the apical end of the shell, it was pointed; at the opposite extremity it was rounded evenly; the inner lip of the shell aperture was formed by the curvature of the outer lip around so as to join the previous whorl on the inner side; it thus formed a moderately elevated inner lip on the side opposite the outer lip, which became obsolete on reaching the middle height of the aperture. The whorls present flat sides, very moderately incurved near the line of meeting of successive whorls, so as to form a very moderate groove there. The surface is marked by straight, rather faint striæ, which curve moderately at the point where the flat sides of the shell curve rapidly inwards so as to form the mouth. Since this is the line of junction for successive whorls the curvature of the striæ can only be noticed along the lower side of the last whorl, but over the main body of the shell only straight striæ appear It was the decidedly flattened sides of this shell, and the straight striæ, showing no trace of even a very obtuse sinus which forbad the reference of this specimen to *Loxonema* or any other genus having a sinus. Some published figures of *Polyphemopsis*, such as *P. nitidula* seemed to show at least a strong external resemblance. No notch in the lip was noticed. There is a resemblance also to such forms as *Eunema cerithioides*, Salter, which however seems to differ considerably from the type of the genus, *E. strigillata*, Salter. There is also a certain similarity with *Orthonema conicum*, Meek and Worthen, which differs however from the more typical species of this genus (if the fig. 5a of Plate 29, Geol. Surv. Illinois, vol. 5, be taken as the type of this species), in the absence of more or less strong striæ, usually one above and one below the suture lines between the successive whorls. The above reference to *Polyphemopsis* seemed therefore the best possible one under present circumstances, though not made with confidence.

Loxonema? (*cf. Holopellm*) *subulata*, Conrad.

(Plate 30, Fig. 21.)

The generic reference of these specimens is doubtful. In the Proceedings of the Boston Soc. of Nat. Hist., 1889, a specimen from Todd's Fork, Ohio, was described, which showed traces of transverse striæ in the last whorl, of such a kind as to preclude the idea that a slit, even a very shallow obtuse one, had ever been present. This would shut it out from *Loxonema*, and hence these shells are rather doubtfully referred to that genus.. At Huffman's Quarry specimens were found whose relationship to the Todd's Fork specimen is undoubted, although only in the form of a cast. One specimen was about 25 mm. long. The Ohio specimens seemed to have the whorls less oblique than the forms figured from New York, and hence the whorls are less frequent in the same distance, but this may not indicate a different species.

Paleopupa abrupta, *gen. et sp. nov.*

(Plate 37a, Figs. 21 a, b.)

The material serving for the description of the species is a single shell and a cast of a second, neither one perfect. It is with diffidence, therefore, that a new generic term is established. The reason lies in the failure to discover any old genus to which it seemed to have clear affinities. The spire is sinistral. The last two whorls do not differ greatly in width, but the third from the last, which is probably the second one of the spire, is very much narrower, producing an effect very much like that of small varieties of *Pupa*. But if the lip of our shell be all the shell ever possessed, then it will be noticed that its margin is not turned outwards, but remains perfectly simple and thin along the outer lip, while bending inwards slightly along that part of its margin usually called the inner lip. The aperture is oval or almost round. The surface of the shell is perfectly smooth. The height of the fourth whorl was 1.9 mm., of the third 1.4 mm., of the second .7 mm., and of the first considerably less, as well as measurements could be made out in one specimen; the width of the fourth whorl was 3 mm., and of the third whorl 2.6 mm. In the cast, the fourth whorl was 1.7 mm. long, the third 1.3 mm., the second .25 mm.; the width of the fourth whorl being 2.2 mm., the third whorl about 2 mm., the second 1 mm.

Whether there be any real genetic relationship between *Paleopupa* and the later fresh water forms belonging to the old genus *Pupa*, it is difficult to tell, though the general form of the shell might suggest that conclusion. The specimens described were obtained in the "Orthoceras block" at the base of the Clinton, Huffman's Quarry, which was filled with a great variety of well known Clinton forms, none of which suggested a fresh water origin, so that the fresh water nature of our shell cannot be asserted. For the present, therefore, the generic name must indicate an old form of the same general appearance as *Pupa*, rather than the existenceof a genetic connection with the latter genus. Its possession of a sinistral spire might be emphasized.

Pterinea brisa, Hall.

(Plate 25, Figs. 14 a b; Plate 27, Fig. 20.)

Pterinea brisa, Hall, is probably identical with *Pterinea striæcostata*. McChesney, and the latter name should have precedence. In Ohio the species is very common at Brown's Quarry; very few specimens have been found in the limestone at Soldiers' Home; a single specimen was found in the upper shaly courses at Huffman's Quarry; very typical specimens occur at Todd's Fork. The species is too well known, and is well enough indicated by the accompanying figure, to require detailed description.

The anterior wing is sinuate at its junction with the body, this sinuosity giving rise to a concave area between the wing and the body, towards the margin. The wing is quite convex, excepting at the hinge margin where it is moderately concave before the beak. From the beak radiate striae traverse the entire surface of the shell, and concentric striae cross these. Sometimes both are equally developed, at other times the concentric striae are more distant, being less like striae but rather resembling lamellose layers ending at the surface of the shell. The shell is bent and depressed along the entire length of the posterior hinge line, forming a raised hinge area interiorly on which one or two teeth were probably inserted.

Avicula Whitfieldi, Foerste.

(Plate 37, Fig. 5.)

Prof Edward Orton kindly lent me the original specimen from which Hall and Whitfield described their *Cypricardites ferrugineum* from Todd's Fork, Wilmington, Ohio, in the Paleontology of Ohio, Vol. II. It soon became evident that the gutta-percha cast which the authors had used for study and illustration had been a failure. From a much better cast we have been able to secure a better interpretation of the fossil, though much is yet to be desired as regards our knowledge of the anterior and the posterior extremities of the hinge line. It is evident however that we have here an aviculoid shell. If an *Avicula*, the name given by its first authors is preoccupied by the *Avicula ferruginea* of Conrad, and hence a new name, as above, is suggested. Attention is called to the somewhat similar forms published under *Avicula subplana* by Hall in the Paleontology of New York, Vol. 2, especially to figure 2 b, on plate 59.

The valve, the only one so far found, has in general a rather orbiculoid outline, interrupted of course at the straight hinge line, which it meets posteriorly at a general angle of about 110 degrees. To the best of the writer's judgment the posterior side of the valve was slightly concave before reaching the hinge line, but there is no direct evidence of inæquivocal character that the outline did not continue to be convex as far as the hinge line, as is the case with *Leptodomus undulatus* for instance. The hinge line posterior to the beak is straight and about 27 mm. long. The beak itself is strongly inclined, and presents a strongly angled and raised, though rounded, upper margin which becomes indistinct at 11 mm. from the tip of the beak. Posteriorly it is defined by a strongly concave area which also soon looses its pronounced character, but which continues obliquely to the posterior end of the shell as a sort of indistinct concave slope between the umbonal ridge and the posterior wing. The umbonal ridge soon disappears into the general rounding of the shell. The anterior third of the shell is but moderately convex or rather flattened except near the margin, especially towards the upper anterior extremity of the shell. The surface of the valve as here described was covered by a series of concentric undulations, quite distinct from each other except on approaching the region anterior to the beak, where they become narrower and more like coarse, broad, low striæ. At the farthest point to which they can be traced they still show an outline convex towards the anterior. This point is so near any possible hinge line that it is altogether improbable that a short concave curvature intervened, so as to define an anterior wing. Moreover, the shell is here strongly convex and the last point to which the shell can be traced is too near the plane of the junction of the valves to permit the idea that a concave line of surface intervened between it and the upper margin of the shell. All the evidence is therefore in favor of a rounded anterior outline, becoming concave above, anterior to the beak, as in the figure 3*a*, of plate 59, in the second volume of the Paleontology of New York, repesenting *Avicula subplana*. The greatest length of the valve was 43 mm., the greatest height 36.5 mm., the greatest depth of the valve 9 mm.

In the collection of Mr. Geo. Caswell is a valve, which is evidently that of an *Avicula*, which has a slight exterior resemblance to that of *Avicula Whitfieldi*, but there is a stronger indication of an anterior wing, and posteriorly along the hinge line a part of the exterior surface is still preserved showing the presence of numerous fine, sharp, radiating, and concentric striæ. Its specific identity could not be determined. Plate 37, fig. 6.

Mytilarca mytiliformis, sp. nov.

(Plate 37, Figs 11, a, b, c.)

In the absence of all interiors to show the characters of the hinge line or the teeth, the position of this shell can only be approximately determined by means of its exterior surface. The shell is mytiloid, and very gibbous. The beak is terminal. The anterior margin of the valve extending almost the entire length of the shell is gently and quite evenly convex. The hinge line posterior to the beak is not long. The posterior margin almost rounds into the hinge line; at first it is only moderately convex but posteriorly it rounds more strongly, merging into the anterior margin with a very convex curve. An umbonal ridge extends with slight curvature from the beak to the posterior extremity. From the beak it rises up strongly for a distance equalling one third the length of the shell, after which it looses in elevation and distinctness. A flattened, but gently rounded, surface is enclosed by this umbonal ridge and the anterior margin of the shell. It is strongly inclined, making an angle of about 60 degrees with the median plane between the valves. Posteriorly the shell is quite regularly and not very strongly convex, except towards the hinge line at which the curvature becomes concave where the umbonal regions slope down towards the hinge line. The greatest convexity of the shell lies therefore along the umbonal ridge, especially towards the beak. Length of the valve here described 34 mm; greatest width 20 mm; distance from the anterior end of the beak to the posterior end of the hinge line, 14 mm; the greatest measurement in line of thickness of the valve is the elevation of the umbonal ridge at one third the distance from the beak above the margins of the valve: 12 mm. The anterior margin makes a general angle of about 60 degrees with the hinge line. The surface is marked by numerous but not very fine concentric striæ.

Mr. E. O. Ulrich, to whom this specimen was referred for generic determination, says regarding the same: "The lamellibranch I regard as a species of *Mytilarca* which is placed with the AMBONYCHIIDÆ in the new classification. Hall's *Ambonychia aphara*, and *acutirostra* are regarded as congeneric, likewise his *Myalina mytiliformis*. All four of these species are closely related but it can not be said that any two are identical. They have cardinal and obscure lateral teeth as in *Ambonychia radiata*, a species really distinct from *Ambonychia*. *Mytilarca* and *Plethomytilus* differ chiefly in having a byssal opening. In this they agree on the other hand with the original *Ambonychia*, which differs again in having radiating striæ and a peculiar plate beneath the beaks."

Modiolopsis rhomboidea, Hall.

(Plate 37. Figs. 8 a.)

In the upper shaly courses of the Clinton at Huffman's Quarry the interior cast of a shell was found presenting the following characteristics: It is 20 mm. long. The form is rhomboidal oval; the greatest height is at the posterior end of the hinge line, where it is about 11.3 mm. The length of the hinge line posterior to the beak is 12 mm. The posterior end of the shell is 15.5 mm. distant from a line drawn vertically through the beak. The hinge line in the cast leaves an elevated line both before and after the beak. The shell was but slightly convex except along the umbonal ridge. In the cast a line of depression or broad groove extends along, and a short distance within, the basal margin; it becomes more distant from the margin going posteriorly, also at the anterior extremity of the cast, where this groove rounds towards the beak. Anterior to this curved line at the anterior end of the cast is a semi-lunate elevation, corresponding to a similar depression in the original shell. These markings indicate the presence of a raised pallial line, and of a deep anterior muscular scar in the original. The identity of this specimen with the species described by Hall from the Upper Silurian at Arisaig, Nova Scotia, is probable. (Plate 37, Fig. 8 b.)

Modiolopsis subrhomboidea, Simpson.

(Plate 37, Figs. 7 a.)

At Huffman's Quarry in the upper shaly courses was found a valve 17 mm. long and 9.5 mm. high. The basal line is moderately convex, curving strongly at its extremities. The anterior margin is strongly rounded, being concave however just before the beak. The posterior margin is slightly convex, or quite straight, meeting the hinge line at an angle of about 125 degrees. Valves moderately convex, more strongly convex along the umbonal ridge. The hinge line is slightly oblique. The posterior end of the hinge line is about 10 mm. from the beak. The anterior muscular impression is not well marked, but it was thought possible to trace a sort of impression similar in its interior outline to that published by Mr. Simpson for his type, in the Dictionary of Fossils of Pennsylvania. The surface was marked by concentric striæ.

The type used by Mr. Simpson came from the Clinton shale above the fossil ore, at McKee's ore bank, northeast of McKee's house, Ferguson Valley, seven miles northwest of Lewiston, Mifflin county, Pennsylvania. (Plate 37, Fig. 7 b.)

Cypricardites Caswelli, Foerste.

(Plate 26, Figs 12 a, b ; Plate 37, Figs. 1 a, b, c).

Since the publication of this species in the Bulletin of Denison Univ., Vol. I., additional specimens have been found at Soldiers' Home, and one was also collected at Fauver's Quarry north of Dayton. The same species occurs also in the flinty rock of the Clinton and in the shales of the Niagara, near Lockport, New York, as witnessed by flattened specimens in the collections of Dr. E. N. S. Ringueberg.

The generic relations of the species cannot be determined with certainty owing to the absence of interiors or interior casts, but it has an exterior similar to that of some species referred to *Cypricardites*. The valves are strongly inequilateral. The total length of the shell is about 40 mm.; from the beak to the anterior extremity of the lunule was 8 mm. and from the beak to the posterior end of the hinge line was about 22 mm. Measured in vertical projection the beak is 8 mm. from the anterior end of the shell and 32 mm. from its posterior end. The height of the shell posterior to the slopes of the beak was about 24 mm. The beaks rise about 2 mm. above this height. The greatest thickness of the shell lies near its middle and amounts to about 23 mm. From these measurements it may be seen that it is strongly and quite equally ventricose. The anterior and lower margin is quite regularly convex, rounding into the posterior margin which slopes anteriorly so as to meet the hinge line. The anterior lunule is short, and distinct, the hinge line forming a median ridge for the same. The beaks are strongly incurved. Posterior to these the character of the hinge line is practically unknown, no specimen preserving the same. There is no evidence of ridge lines, curved or otherwise in addition to the line of junction of the two valves. From the beak a rounded umbonal ridge runs backwards and downwards towards the posterior extremity but merges very soon into the general rounded surface of the valves. Concentric series of low rounded ridges ornament or rather wrinkle the shell. Probably it once had also finer concentric striæ but these have so far not been observed.

Cypricardinia undulostriata, Hall.

(Plate 37, Figs. 9, a b.)

In the collection from Soldiers' Home occurs a left valve and in that from Brown's Quarry a better preserved and more typical right valve, which are referred to the *C. undulostriata* of Hall (Plate 37, Fig. 9 C.) from the Niagara shale at Lockport, New York. The valves are subovate, strongly convex, especially along the umbonal ridge. The basal margin is moderately convex. Both extremities are rounded. The beak has a position near the anterior end of the shell along the hinge line. The posterior side is very moderately convex, and makes a general angle of about 135 degrees with the hinge line. The hinge line is moderately inclined. The surface is marked by distinct though rather distant concentric striæ, between which occur much finer and more numerous striæ of growth, seen only under a lense.

The specimen from Brown's Quarry is 6.2 mm. long, and 3.8 mm. high. The depth of the valve is about 1.2 mm. Of large concentric striæ there are five, not counting those within a millimeter and a half of the beak. (Plate 37, Fig. 9 a.) The Soldiers' Home specimen was 7.5 mm. long, and 4.3 mm. high. The depth of the valve was 1.3 mm. (Plate 37, Fig. 9 b.)

Tellinomya elliptica, Hall.

(Plate 37, Figs. 4 a, b, c.)

In the collection of Dr. Charles Welch, of Wilmington is a valve obtained at Todd's Fork by his father. As regards identity with known species the choice lies between *T. elliptica* of the Clinton (Plate 37, Fig. 10) and *T. æquilatera* of the Coralline Limestone (Plate 37, Figs. 4 d, e, f). With only the published figures to serve as guide the first species is a little larger and has a more rounded posterior extremity, but the beak is similarly located. The second species has nearly twice the size. So that the Todd's Fork specimen seems to more nearly agree with *tellinomya elliptica*.

The Todd's Fork specimen is 33 mm. long and 21 mm. high. The lower outline is equally convex. The upper outline is rather straight from the beak for some distance towards either extremity. The anterior extremity is more rounded than the posterior one. From a line drawn vertically through the beak the anterior extremity of the valve lies 13.5 mm. and the posterior 19 mm. The shell is quite regularly convex. A sort of rounded ridge extends from the beak backwards and a similar one forwards, marking off a posterior and an anterior lunule. Concentric striæ are rather indistinct and not regular in disposition. No teeth were found and hence the generic reference of this shell is not certain.

Tellinomya (Nucula?) minima, Foerste.

(Plate 26, Figs 8 a, b, c; Plate 37, Figs. 13 a, b, c.)

This form, first described in the Bulletin of Denison Univ., Vol. I, is represented by only a few specimens from the Beavertown marl at Huffman's Quarry. They are all casts, and the following description refers to these casts: A raised line extends along the hinge margin. Along this, especially in the anterior lunule, one specimen shows traces of transverse teeth, but whether the series is interrupted at the beak or not is unknown. In the posterior lunule two lateral ridges branch off from the median one. The posterior lunule has a lanceolate outline, the anterior one is very broadly ovate. The shell is oblong, much longer than high. The convexity is most marked at the beak. The length of the largest specimen is 3.9 mm., the height is 2.7 mm., and the thickness from valve to valve 1.9 mm. The beak is near the anterior fourth of the cast.

Tellinomya (Nucula?) socialis, sp. nov.

(Plate 37, Figs. 12 a, b, c.)

The great majority of the minute lamellibranchs found in the Beavertown marl at Huffman's Quarry, and in the corresponding layer at Geo Young's Quarry, on the Carrollton Pike west of Soldiers' Home, belong to a species quite distinct from the last. All are casts. A raised line extends along the hinge margin, and shows transverse teeth plainly both in the anterior and in the posterior lunules, but whether the series was interrupted at the beak or not could not be determined. The posterior lunule has a lanceolate outline though narrower than in *T. minima*. The anterior lunule is of almost linear outline, and this alone will readily distinguish the two marl species. The form of the shell is also different—being triangular oval. The convexity is most marked at the beak. The largest shell is 3.5 mm. long, the height is about the same, the thickness is 1.9 mm. from valve to valve. The muscular impressions are well shown, that of the anterior muscle being narrower.

Tellinomya (Nucula?) Clintonensis, sp. nov.

(Plate 37, Fig. 15.)

In the collections made by Prof. E. W. Claypole in the ferruginous Clinton limestone near Mifflintown, Juniata Co., Penna., occurs a valve of a decidedly nuculoid shell. Its precise generic relations could not be determined owing to the fact that the row of teeth is well shown only along the posterior hinge line, and its interruption or continuation at the beak could not be determined. In Middle Silurian rocks *Tellinomya* is however apt to be a more common genus than *Nucula*, and hence the reference to that genus. The anterior extremity of this shell is not perfect, but, even if it were, there is no doubt that the beak would have a more anterior position, and the anterior margin would bend more abruptly into the lower margin than is the case with *T. mactriformis*, Hall; moreover, the shell is relatively less long. The resemblances to the published figure are also striking, but since Hall does not redescribe it in volume 2 of the Paleontology of New York, it is probable that the form he described was in reality not to be considered very distinct from some other species of *Tellinomya*, such as *T. lata*, Hall, for example, in which case the Pennsylvania specimen probably belongs to a different type of this genus. The valve is 10 mm. long, and 8.2 mm. high. The basal margin is gently rounded, increasing in convexity posteriorly as far as the upper side of the umbonal ridge, whence the posterior margin takes a straight course at first, becoming convex again as it meets the posterior hinge line. The latter is at least 5 mm. long. At the anterior extremity of the shell the basal margin curves quite suddenly upwards, following a straightish course at first, becoming slightly convex as it joins the short anterior hinge line. The shell is moderately convex in general, more so along the umbonal ridge. The area above the latter is rather flattened, and a slight tendency in the same direction is shown by a narrower area along the anterior margin. The surface is covered by fine, regular concentric striæ, about seven to the millimeter near the posterior end of the shell. There are also several more distinct and rather distant lines of growth; these are grooves caused by the growth of the shell in thickness without adding much to its margins.

Nuculites (*Cleidophorus*) *ferrugineum*, sp. nov.

(Plate 37, Figs. 2 a. b.)

In the same piece of rock with the type specimen of *Cypricardites ferrugineum*, Hall and Whitfield, in the collections of the Ohio State University, is a cast of a valve bearing the oblique impression characteristic of many species referred to *Cleidophorus*. A close comparison however of this impression with that of published figures of *Nuculites oblongatus*, the types of the genus *Nuculites*, does not show the slightest difference. It is evident that this impression in the cast corresponds to a raised ridge in the shell, defining sharply the anterior muscular impression from the general body of the shell interior. But in the shell here described the lower border of this muscular impression, and the posterior muscular area remain undefined. The general form is transversely elliptical, with strongly convex extremities. The length of the cast is 7.7 mm., the height 5 mm. The convexity is moderate. A groove runs along the hinge line of the cast posterior to the beak and another for a short distance anterior to the beak. No transverse teeth were seen.

? *Crania dubia*

(Plate 37A Figs. 17 a, b.)

At Soldiers' Home was found a specimen which may possibly have been a *Crania*. A closely similar specimen from Hanover, Indiana, shows that we are dealing at least with forms of definite shape and size. No surface structure remains. Only the interiors are shown and these do not exhibit muscular scars. Hence it is only possible to say that the identity of these fossils with *Crania* is within the reach of probability. The shell is convex conical, the apical point is excentric, the valves are broader than long. The regions posterior to the apical point are quite regularly convex, those anterior to the same are much steeper, and in the more median regions show decided flattening.

The Soldiers' Home specimen is 8 mm. long, and 9 mm. broad. The apical point lies 5.2 mm. from the posterior edge, and about 2 mm. from the anterior line. The convexity of the valve is 2.3 mm. at the apical point. The Hanover, Indiana, specimen is 7.3 mm. long, 9 mm. broad. The apical point is 5.2 mm. from the posterior edge, and about 2 mm. from the anterior end. The convexity of the valve is 2 mm. The name *? Crania dubia* is suggested.

? *Craniella Clintonensis*.

Plate 37, Fig. 3 a, b.)

In the collection of Dr. Chas. Welch, at Wilmington, Ohio, collected by his father, is a peculiar cast of a valve, from Todd's Fork, Ohio, which is very much more satisfactory, inasmuch as it preserves muscular impressions. As regards its relationship to some known genus there is considerable doubt. Possibly it is a *Craniella*. The accompanying figure is sufficiently explanatory. Its length is 11 mm., its breath 11.5 mm. its convexity is 1.9 mm. The convexity of the shell is quite regular except near the margin where a concave border prevails as shown in the side view. The muscular markings are distinct for the two upper circular elevations of this cast, and for the upper end of attachment of the lateral sinuous lines. Between the two upper circular elevations is a delta shaped elevation distinct only anteriorly. For this form the name *Craniella Clintonensis* is suggested.

A single linguloid shell was found in the Clinton, near Dayton, Ohio. It still preserved its phosphatic calcareous shell. The specimen was merely a fragment and would not be worth mentioning at all, were it not for the fact that it is the sole fragment of a linguloid shell so far found in the Clinton of the west.

Plectambonites transversalis, Wahlenberg.

(Plate 25, Fig. 5, a, b; Plate 30. Fig 13; Plate 31, Fig. 6.)

The variety *prolongata* occurs at Soldiers' Home, Fauver's Quarry, and Huffman's Quarry, Ohio, in the upper shaly courses. The hinge area is long and narrow, its inner anterior border is straight. The cardinal process is elongate triangular. The two divergent crural plates are closely approached to the process, and have coalesced with it below, so that the cardinal process falsely appears to be trilobate. No interiors have been found. The great width of the shell is the distinctive feature. It is usually strongly bent near the beak, and is much more moderately convex anteriorly. (Plate 25, Figs. 5 a, b; Plate 30, Fig. 13.)

The variety *elegantula*, including the forms with medium width of shell, rather more equal convexity antero-posteriorly, and with some of the striæ rather decidedly elevated above the general surface of the shell, is common at Hanover, Indiana. (Plate 31, Fig. 6.)

Leptaena rhomboidalis, Wilkins.

During the earlier stages of growth the pedicle valve is moderately convex and the brachial valve still more moderately concave. In some individuals the curvature of the shell remains moderate until the geniculation is reached, the latter being found at the last anterior and usually strongly elevated concentric wrinkle; shells of this description are of medium size, and occur at Brown's Quarry, Soldiers' Home, and elsewhere. In other individuals the curvature of the shell posterior to the geniculation is more marked, the last concentric wrinkle is less sharply elevated, and the anterior part of the shell beyond the geniculation is far more developed, almost equaling at times the part posterior to the geniculation in length; shells of this kind are of largest size, and occur at Soldiers' Home, Huffman's Quarry and elsewhere. In addition to the concentric wrinkles occurring posterior to the geniculation, numerous fine radiating striae exist, crossed by often still closer, less prominent concentric striae. Hinge area of the pedicle valve very narrow but still broader than that of the opposite valve. The delthyrium is closed by a convex triangular deltidium except at its apex where one of our specimens shows a small foraminal opening. The teeth are quite short and very oblique, a groove defining their postero-lateral side.

The muscular area is strongly bordered laterally by a very narrow but sharp ridge. In a small valve the sides slope outward a short distance anterior to the hinge area, and then inwards with a small curve which increases anteriorly, where the border almost disappears. The general outline of the muscular area in this case was obovate. In a mature strongly curved pedicle valve the postero-lateral borders of this area diverge strongly at first, and then are almost parallel along the sides, incurving again strongly along the anterior margin where they become indistinct before meeting. This gives a strongly quadratic appearance to the muscular area. In other words the muscular area of the pedicle valve of Ohio specimens is distinctly elongate. A fine median striation divides the muscular area; it disappears anteriorly. The adductor muscular impressions lying on either side of it are narrow. Lateral branches of the median striation, which start out some distance anterior to the hinge area, and curve almost directly forwards, making a low angle with the median striation, define the posterior and lateral part of the adductor impressions, but disappear anteriorly in one specimen, while in another they become once more distinct anteriorly at the median line which here is again a raised striation.

The cardinal process of the brachial valve is so strongly divided anteriorly as to appear like two strongly diverging teeth, fastened to the lower side of the valve. A foraminal opening appears in one specimen at the beak, where two divisions of the cardinal process meet. Two, much lower, and more diverging ridges, twice as long as the divisions of the cardinal process, and occupying the outer angle between these divisions and the hinge area, represent the crural plates. The muscular area does not show distinct impressions in the meagre material so far found.

This species occurs in the upper shaly courses at Soldiers' Home, Huffman's, Centerville, Fauver's, Beavertown; in the middle limestone at Soldiers' Home, moderate; Huffman's, rare; Brown's, common; Todd's Fork. In the upper courses of limestone at Brown's Quarry.

Strophomena (*Orthothetes*) *Hanoverensis*, Foerste.

(Plate 31, Fig. 1; Plate 27, Fig. 34.)

Since the publication of this species but little new material has been added to our collections. What is regarded as the brachial valve is strongly convex in mature shells, although the degree of convexity varies considerably in different shells, especially if extreme forms are compared; moreover, the point of greatest curvature or highest elevation of this valve varies considerably. In a specimen in the cabinet of the Ohio State University this valve is very evenly convex, whereas, as a rule, there is a region of greatest convexity which may lie nearer the beak, usually within 8 mm. of the same, or which rarely lies nearer the anterior margin. In the latter case the greater anterior curvature is due to the presence of larger wrinkles of growth, these wrinkles of growth being not infrequent in this valve, although entirely absent in some specimens, as for instance in the above mentioned cabinet specimen. These brachial valves are quite common. Ridiculous as it may sound to others who have not worked in our western Clinton limestones, it was at first impossible to determine with confidence the character of the pedicle valve. The valves always adhere by one face or the other to the matrix; the hinge area is not shown, the shell is usually more or less exfoliated, the muscular area can not be detected and so it becomes impossible at times to tell whether the exterior or the interior of a valve is present, even when both are known to be present, among this partly exfoliated material. On the same piece of rock with the cabinet specimen above mentioned, and in one collected by the writer at Todd's Fork, Ohio, (Plate 27, Fig. 34) flattish valves or rather moderately convex valves are found presenting an unequivocal exterior surface with numerous fine radiating plications or striæ, and much finer concentric striæ of growth visible only in good specimens and with a lense. The radiating striæ are quite equal in size except for the intercalated less prominent striæ, which do not however occur in groups between the larger specimens, but are found usually only one or two at a time between the larger striæ. Judging from the similarity of their surface ornamentation, and their similar size, the specimens should belong to the same species, while their being so much less convex makes their identification as pedicle valves exceedingly probable. We have here therefore pedicle valves which are not concave but moderately convex. As a rule the brachial valve shows a very slight median depression near the beak, while the pedicle valve does not in the same region in the Todd's Fork specimen, which is regarded typical. In the cabinet specimen in the Ohio State University there seems to be a very shallow median depression.

This species occurs at the Soldiers' Home and Todd's Fork in Ohio, and more abundantly at Hanover, Indiana. The double convexity of this shell, if determined with greater certainty from a greater supply of material, will remove it from the more typical strophemenoid shells, and will place it apparently with *Orthothetes*.

Strophomena (*Orthothetes*) *tenuis*, Hall.

(Plate 27; Figs. 31, 32, 38.)

Shells of this species are quite readily recognized by their flattish pedicle valves, moderately convex in the immediate neighborhood of the beak which is therefore a little elevated. The brachial valve on the contrary always shows pronounced convexity, although this convexity never reaches the point of the shell being even moderate gibbous. By digging away the shell from the matrix the pedicle valve was found to have its muscular area sharply outlined postero-laterally by a ridge on either side, which began near the beak where the teeth usually are, and continued antero-laterally, soon disappearing. The postero-lateral outlines form an angle of fifty or fifty-five degrees near the beak. A low rather broad median elevation is seen in the posterior part of this area but soon disappears anteriorly. Antero-laterally and anteriorly the muscular area does not show any boundaries in our specimens. The brachial valve shows a fairly low linear but distinct or moderately triangular cardinal process flanked on either side by a diverging linear ridge, and these are flanked in turn on the exterior side by a much larger linear ridge, the crural plate, the extension of which antero-laterally serves to give a distinct outline to the more posterior parts of the muscular area, which anteriorly shows no outlines in our specimens. A broad median low ridge starts from the cardinal process but soon disappears anteriorly.

This shell is found at Fauver's Quarry, Soldiers' Home, Huffman's Quarry, Fair Haven, Ohio, and apparently at Hanover, Indiana.

Strophomena (*Strophonella*) *patenta*, Hall.

(Plate 27, Figs. 35, 36, 37, young specimens.)

The shell begins its existence with the pedicle valve convex and the brachial concave. Later the anterior and lateral margins of the pedicle valve become concave or turned up, and those of the brachial valve convex or turned down. This is likewise true of *Strophonella* (*Amphistrophia*) *stria a.* In spite of the abundance of this shell in the Clinton of Ohio and Indiana, no interiors have yet been found, nor has a clear hinge area been seen. By digging away the shell from its matrix in case of the pedicle valve, it was found that the postero-lateral angles were well defined, owing to a sort of low ridge running from the usual position of the teeth antero-laterally, the ridges on either side of the muscular area presenting a concave outline for a short distance near the beak and after that being strongly divergent. These ridges in our rather unsuccessfully cleaned specimens can usually not be traced more than 5 mm., hence the general form of the muscular area must remain undetermined, but it seemed to us that as far as it extended it showed rather strongly typical strophomenoid characters. In one specimen, 15 mm. long, the ridges were seen to curve forward and a little inward before they disappeared, while not leaving the slightest trace anteriorly. In this they resemble the degree of distinctness of outline of the muscular area in *Str. striata*, but the included area is relatively somewhat broader. A low median elevation seen near the beak soon disappears entirely, but not before showing in some specimens at least a fine median groove, which begins a short distance anterior to the beak and also soon disappears.

The exterior of the shell is marked by numerous fine radiating plications or rather striæ. These are intercalated so frequently and develop, in size so gradually anteriorly that the earlier started plications are of larger size, and are more prominent than those successively later in origin, so that anteriorly the shell shows stronger striæ at more or less regular intervals among the finer striæ. Very fine concentric striæ of growth cover the entire shell. At Fauver's Quarry occur specimens in which the radiating striæ are rather more equal in size and are rather larger than usual. The species occurs also near Dayton, at Soldiers' Home, also at Fair Haven, Centerville, Ohio, and at Hanover, Indiana.

At Hanover, Indiana, and at Soldiers' Home, Ohio, occur specimens which look like sickly specimens of *Str. patenta*, in which the radiating striæ are rather large for this species, and the shell is decidedly flattened. so that in the brachial valve for instance the part anterior to the usually more or less geniculate bending of the shell is but moderately depressed below the general surface of the shell, and in the case of a large Soldiers' Home specimen, 28 mm. long, the curvature was reversed a second time within 4 mm. of the margin, the shell becoming quite concave; so that in this specimen the brachial valve was plainly concave near the beak, turning to moderately but distinctly convex at 14 mm. from the beak, and it again became concave at 25 mm, from the beak. In these sickly forms there is a tendency to an obscure irregular mesial fold, owing to the general flattening of the shell. A careful examination of the specimens precludes the idea that these peculiar specimens could be due to pressure acting upon the ordinary *Str. patenta.*

Orthis (*Orthis-Dinorthis*) *calligramma*, Dalman.

(Plate 25; Figs. 12, a, b; Plate 31, Figs 4, 5; Plate 37a, Figs. 20 a, b var.)

This is a very variable species, of which the extreme forms are readily distinguishable, but between these are all imaginable intermediate stages, as a former publication (Proc. Boston Soc. Nat. Hist. vol. XXIV, pp. 308–312, 1889) attempts to show.

One extreme is represented by a rather large form with a moderately convex brachial valve, with a shallow broad median sinus, and a strongly convex pedicle valve, especially convex along its median area, towards the beak, the beak itself being strongly incurved. In this form are found the fewest and strongest radiating plications. The plications are strong and rounded and are separated by grooves of breadth almost equal with the plications, in exfoliated specimens apparently broader. The shell is further marked by numerous much finer and closer radiating striæ, and by fine striæ of growth, which in the specimens examined are somewhat less distinct than the radiating striæ. Search was made for little oblique openings along the middle of the plications, but nothing could be accurately determined as such, although at times it was thought that they could be seen in exfoliated specimens. This form finds its nearest relatives with typical *Orthis*, as redefined by Hall and Clarke. It is found at the Soldiers' Home, Fauver's and Huffman Quarries in Ohio, and at Hanover, Indiana. (Plate 25, Figs. 12 a, b.)

The other extreme of this is represented by a form with much more strongly, although still moderately, convex brachial valves and a pedicle valve, which although quite strongly convex when very young, becomes decidedly flattened when older. At this stage the shell begins to curve strongly inward only near the beak, and this for such a short distance that the cardinal area remains almost flat. The radiating plications are in general much more numerous and closer, though still presenting the same general characteristics. In this form the finer radiating striæ could not be distinctly detected, while the concentric striæ of growth were very distinct. If this character should hold good in larger collections, it would indicate another means of differentiating these extreme form's but that seems at present doubtful. Specimens showing these characteristics are found at Soldiers' Home Quarry, Ohio, and at Hanover, Indiana. (Plate 31, Figs. 4, 5.)

Specimens of this type find their nearest relatives, at least as regards external form, in the sub-genus *Dinorthis* of Hall and Clarke. Moreover in the internal characters there is more resemblance than has perhaps been suspected. At least on cleaning specimens of pedicle valves from Soldiers' Home, Ohio, and Hanover, Indiana, muscular scars were found, which bear considerable resemblance to those of *Orthis pectinella* except in the character of the adductor muscular impressions. The anterior edge of the muscular area is namely strongly indented, and its antero-lateral border is more or less sinuately concave, giving to the middle portion of this area the greater width. The adductor muscular impressions are represented by a narrow median linear groove, bordered on either side by a narrow ridge. This linear groove is traversed at times lengthwise by a fine raised striation. In *Dinorthis* the adductor muscles are confined to the more central portion of the area, and are of an oval-oblong form.

The muscular impressions of the first described form were not distinct in specimens from these localities, but, as far as could be made out, were of practically the same character. In a former paper a strongly bordered and markedly tripartite muscular area, with a broad central division, was figured from a pedicle valve found at Hanover, Indiana. (Plate 31, Fig. 4.) Its anterior margin was greatly thickened, and from its middle extended a short median ridge, very soon disappearing anteriorly, or in other words these are characteristics recalling features of the muscular area of the pedicle valves of *Orthis fausta* and *Orthis Daytonensis.* The convexity of this valve is moderate and rather equal, though apparently occupying quite an anomalous position in this group of shells; forms with a closely similar structure of the muscular area in the pedicle valve will be described below.

Orthis flabellites as recently figured by Hall and Clarke, occupies an almost exactly intermediate positon between the extreme forms above described. Its brachial valve is about as convex as that of the second of these forms. Its pedicle valve is however neither as convex nor as much flattened as in the above described extreme forms. The artist evidently found the anterior margin of the muscular area of the pedicle valve of the typical Lockport, N. Y. forms to be indented as in our specimens. If it be indeed necessary to distinguish our American forms specifically from the European *Orthis calligramma* (or perhaps *Orthis callactis*), then the name *Orthis flabellites*, Hall, will do very well to represent the intermediate forms, while the forms with quite flat brachial valves and very convex pedicle valves could be conveniently designated as variety *eu-orthis*, and the other extreme with more convex brachial valves but decidedly flattened pedicle valves would be variety *dinorthis*.

Very closely related to this latter form is a series of shells found at Reed's Hill, in the quarry just north of Beavertown, and at Huffman's Quarry in Ohio. (Plate 37A, Figs. 20 a, b.) The brachial valve is quite strongly convex in the specimens from Huffman's Quarry, but very moderately convex in most of those from Reed's Hill. The median sinus is chiefly posterior and shallow, with its outlines undefined. The pedicle valve is very much flattened. In specimens from Huffman's Quarry this flattening is not so marked as to exclude at least a very moderate convexity of the shell, especially towards the beak. In valves from Reed's Hill the flattening is more marked, beginning almost at the very beak, and admitting almost of no curvature anteriorly. The radiating plications are finer and closer and therefore more numerous than in variety *dinorthis* at the same stages of development. The rounded plications are branched, often twice in full grown specimens, a feature shown in a less marked degree by that variety. A further resemblance to it is the presence of very fine concentric striæ of growth, distinctly visible under a lense. This is the only form of which interiors were found in the Ohio collection, the previously described interiors having been obtained by cutting away the shell and taking an impression of the cast of the interior thus prepared. The interior of the brachial valve, although 22 mm. long, does not show thickening excepting along a median line, posteriorly, where a rounded elevation, broadening and disappearing anteriorly, serves to separate the muscular area into halves. This muscular area is however not further defined, the grooves of the exterior showing up as radiating plications over the interior of the shell. The cardinal process is a narrow linear and not much elevated ridge. The crural plate is a continuation of the edge of the hinge area bordering the delthyrium, and a well marked, rather deep notch in the outer angle between it and the hinge area serves as a socket for the teeth. The interior of a pedicle valve likewise shows radiating plications, except over the muscular area. This is divided into three parts by two diverging ridges, which are very low, though still distinct enough to be recognized. The two lateral divisions are bounded laterally by similar low but more distinct convex ridges, which uniting anteriorly give the area there a circular outline, though the border happens to be very indistinct in front of the middle section in our specimen. The middle division is concave, of about equal size with the lateral divisions, and does not show signs of a median ridge. The interesting feature of this shell is the tripartite division of the muscular area, similar to that of the valve figured from Hanover, Indiana, described on page 715. The presence of muscular scars of such different character in specimens of the same species seems truly remarkable, but could no doubt be readily explained if the more intimate anatomy of this species were known. This variety reaches a length of 27 mm. and around the margin of the larger individuals about 70 radiating plications may be counted. For this variety the name *fissi-plicata* is suggested.

At Brown's Quarry a small form 8 or 9 mm. long is found with simple coarse plications. The ventral valve is strongly convex, and its muscular area has a quite prominent border. In one valve the tripartite character of this area is strongly marked, the middle division being a little larger than the two lateral ones.

Orthis (*Herbertella*) *fausta*. Foerste.

(Plate 25, Figs. 15 a, b, c, d; 16 a, b.)

Both valves of medium and almost equal convexity, the greatest curvature of the pedicle valve being about two-fifths the distance from the beak. The brachial valve has a small, narrow, ill-defined median depression or sinus posteriorly which disappears usually towards the middle of the valve and is, therefore, a character retained only in the young of this species. The adult forms of the ancestral types of the species, of Lower Silurian Age, had usually a distinct, though often shallow sinus, a character perhaps retained in part only by the young of the present species. Both valves marked by rather sharp radiating plications, crossed by lines of growth, which in some specimens are merely fine striæ, but which in others are more prominent, developing into lamellose striations, the zigzaging lamellæ being either more or less appressed to the shell, or distinctly elevated above the same, in the latter case giving the shell a highly ornate appearance. Hinge area of the brachial valve low and erect, that of the pedicle valve much higher, outwardly inclined below, incurved above, rarely marked by horizontal, parallel striæ of growth. Delthyrium open in both valves, in the brachial valve bordered by the raised margin of the hinge area, which here forms a sort of ridge increasing in size anteriorly, jutting beyond the outline of the hinge area and forming the crural plate. A diagonal notch in the angle between the tooth and the hinge area receives the tooth of the other valve. The sharp, inner margin of the hinge area of the pedicle valve where it borders upon the delthyrium is also prolonged anteriorly, forming a plate-like tooth, resting upon the plate-like walls bounding the muscular area laterally, as a support; no notch separates this tooth from the hinge area, of which it is practically an outgrowth.

The cardinal process of the brachial valve is a very thin erect plate along its posterior line of attachment, the curved upper margin of this plate, as far as its anterior end of attachment, being thickened, sometimes more or less abruptly, so as to form a sort of recurved cardinal tooth resting posteriorly upon a thin plate as a support.

The valves are thin, readily showing the radiating plications interiorly, except where they have been thickened at the muscular areas. In the brachial valve this thickening is almost confined to the production of a low median elevation, which separating the adductor impressions scarcely extends the full distance. From this branch off perpendicularly two narrower elevations, obsolete in the great majority of specimens, and separating the anterior from the posterior pair of adductor impressions. The posterior of these impressions is very small, and the anterior ones though of twice the diameter are also small. They cannot be said to have any anterior or lateral boundaries. The muscular area of the pedicle valve is much better defined owing to the thickening of the shell which has taken place over its area, this thickening ceasing at the anterior boundary of the scars, where it is also the most developed. The anterior end of the area has a rounded or slightly trilobate form, the area itself being often traversed by fine striæ parallel to its anterior outline. Laterally where the shell of the area is thinnest the radiating plications show through; two larger striæ, also diverging, border the strongly thickened elongate triangular median portion, occupying the larger portion of the muscular area. If this be regarded as the adductor muscular impression, the smaller lateral portions of the area will be the diductor muscular impressions. Bordering the latter on the sides is a low ridge, rising posteriorly into acute erect, platelike walls supporting the teeth, as already described. The shell structure is fibrous-impunctate.

The typical forms of *Orthis fausta* differ from *Orthis Nisis* of Hall and Whitfield from the Niagara at Louisville, Kentucky, in having coarser radiating plications than the type of that species, and a less elevated cardinal area in the pedicle valve. But the two forms are evidently very closely related and the Clinton species is regarded as phylogenetically the immediate precursor of the Niagara *O. Nisis*. *Orthis rugæplicata* is a much coarser species.

Orthis fausta is found in the upper shaly courses at Soldiers' Home, Huffman's, Fauver's, Centreville, and probably in the limestone at Brown's Quarry.

Orthis fausta, var. squamosa, var. nov.

(Plate 37A, Figs. 19 a, b.)

Associated with *Orthis fausta* at the Carrollton Pike Quarry, about half a mile west of the Soldiers' Home, near Dayton, Ohio, and south of the road, is a distinct form, readily recognized, but evidently related to the former, and hence here described merely as a variety. Its internal features are not known; but when found these may raise the variety to the dignity of a species.

The shell has in general the same characteristics as that of *Orthis fausta*. The brachial valve is moderately convex and has a faint suggestion of a median sinus posteriorly, owing to the intercalation of radiating plications in this region at a sufficient distance from the beak to cause this suggestion. The pedicle valve is more strongly convex, especially towards the beak. The hinge area is narrow and erect in the brachial valve and considerably higher and outwardly inclined in the pedicle valve. No delthyrium could be detected, although the hinge area was distinct, but this may have been filled up in the specimens found. The breadth of the shell is however relatively greater than in *Orthis fausta* in shells of the same size, the largest specimen of the variety *squamosa* having a brachial valve with a length of 9 mm. and a width of 15 mm. while in *Orthis fausta* a valve of the same length would have an average width of about 13 mm. Moreover, for the same sized shell the variety has fewer radiating plications, especially fewer which start from a point near the beak. This difference is well seen in the brachial valve, where in the case of variety *squamosa* only eight to ten radiating plications seem to reach or almost reach the beak, whereas in *Orthis fausta* this number of plications varies from twelve to fifteen on the average. The radiating plications of the variety are therefore more divergent, more distant, and seem therefore to be larger and bolder. Lastly, the concentric lines of growth in the variety are more prominent; being lamellose, and the borders being rather strong, and at the same time distinctly elevated above the general surface of the shell, the valves have that coarseness of ornamentation, to which the name *squamosa* was intended to give expression. The lamellose lines of growth are bent in zigzag fashion over the plications, but in the type specimen to such a moderate extent that the shell seems ornamented by coarse, fairly regular, concentric lamellæ, rather than by zigzaging striæ of growth. The greater width, fewer plications, and stronger and more elevated concentric striae of growth are therefore the distinguishing features of this form.

This form has a different outline from *O. rugaeplicata*, Hall and Whitfield, the radiating plications are less prominent, but the concentric squamose striations are at least equally distinct if not more prominent than in the Louisville species. It is also less obese. The species do not seem closely related.

Orthis (*Herbertella*) *Daytonensis*, Foerste.

(Plate 25, Figs. 13, a, b, c, d: Figs. 20 a, b: Fig. 21.)

When young both valves are moderately and almost evenly convex. With increasing age the brachial valve becomes more and more convex, while the pedicle valve diminishes in convexity, owing to the flattening of anteriorly added portions of the valve, and a somewhat similar flattening of the area added to the postero-lateral angles of the same. In the mature shell the brachial valve is therefore strongly convex, and the pedicle valve is decidedly flattened excepting in its posterior half, around the beak. A shallow narrow median depression or sinus extends in the brachial valve from the beak, anteriorly, usually disappearing before reaching the middle of the valve; a similar sinus appears in *Orthis fausta.* It is a character belonging to the young of this species. The marked flattening of the pedicle valve, anteriorly, is seen also in related Lower Silurian types, where this flattening may even be represented by a more or less developed broad sinus. The numerous, fine, rounded, radiating plications are crossed by fine concentric lines of growth, which in well preserved specimens are seen to be lamellose. These fine lamellæ are appressed to the anterior portions of the shell, or are but moderately elevated above the same, never as much as in *Orthis fausta.* Finer concentric striæ are seen at times between the lamellæ. Hinge area of both valves quite flat, that of the pedicle valve a little incurved towards the beak. In the brachial valve it is erect, in the pedicle valve it is inclined outwards. In both valves the area is marked horizontally by fine close parallel striæ of growth, which are crossed at times diagonally by still finer striæ, scarcely visible under a lense. Delthyrium open in both valves, the adjoining margin of the hinge area being slightly elevated, forming a minute bordering ridge or striation, best seen in brachial valves, where an anterior continuation of this margin of the hinge area gives rise to the crural plate, which is supported upon a part of the callous thickening which characterizes the hinge region of this valve, interiorly. This posterior thickening of the valve occurs in younger specimens only near the teeth, as in *Orthis fausta*, but in older specimens is continued almost to the postero-lateral angles of the shell, strengthening this part of the valve. In the angle between this crural plate and the hinge area is either a deep diagonal notch, or a deep rounded impression, forming the socket for the tooth of the opposite valve. The margin of the hinge area bordering the delthyrium in the pedicle valve is also produced anteriorly forming in fact an angular extension of this part of the hinge area; it is supported by the plate-like elevation of the posterior part of the border defining the muscular area. At times there is the merest trace of a depression in the angle between the tooth and the hinge area.

The cardinal process of the brachial valve consists as in *Orthis fausta* of a thin vertical plate posteriorly, considerably thickened at its margin above and in front, this thickening increasing and widening anteriorly, until an ovate process is formed which almost altogether hides its lower more posterior plate-like portion.

The valves are thin, and frequently show the radiating plications interiorly, especially towards the anterior and lateral margins. The thickening of the shell over various areas, to be described later, frequently covers up these plications, especially in the older shells. In the brachial valve this thickening extends chiefly along the hinge margin; elsewhere it is moderate, being most pronounced over the muscular impression area, and at times a little within the anterior and lateral borders of the valve. From the anterior end of the cardinal tooth a ridge extends forwards which is strong and well defined between the posterior adductor impressions, and quite high in older individuals, and lower and narrower between the anterior adductor impressions. The posterior impressions are smaller and are separated from the anterior ones by a low ridge running from the median ridge antero-posteriorly, the two branches of the median ridge making an angle of about one hundred and thirty-five degrees. The anterior border of the anterior adductor impressions is more or less parallel to the ridges just described. The lateral boundaries are nearly enough parallel to the median ridge to give all the adductor impressions a general rhomboid shape. The anterior and lateral outlines of the muscular area are sometimes indifferently indicated in these valves; at other times, especially in older specimens, they are very distinct. The degree of distinctness of the muscular impressions is evidently a question of the degree of thickening of the shell between and around the points of attachment of the muscles. Under favorable circumstances other markings may be seen. Along the exterior side of the lateral border of the muscular area this border gives rise to lateral branches which soon disappear laterally, and which give rise to a number of depressions along the borders of the muscular area, especially along the anterior adductor impressions. These are the ovarian markings. From the antero-lateral angles of the muscular area the anterior and the lateral borders extend forwards towards the margin of the shell. A third, usually smaller, ridge extends between them. The anterior border of the muscular area and its anterior continuations describe a sort of semi-circular figure. The grooves between these ridges branch a little anteriorly. These are the vascular markings.

The pedicle valve has a muscular area whose anterior and lateral edges are indicated by the line of greatest thickening of the shell in this region, posteriorly this border rises suddenly into a vertical wall supporting the teeth. The posterior end of the muscular area is quite thin, often permitting the radiating striae to be seen. The thickening increases more or less gradually anteriorly. Fine striae parallel to the anterior and lateral margins traverse the area, and may be regarded as striae of growth with reference to these margins. Two elevations, usually low and indistinct, becoming more evident anteriorly, traverse the muscular area, dividing it into three long triangular areas, of which the central area is a little larger than the lateral ones. Corresponding to these divisions of the area, the anterior border of the area is often more or less roundly triangulate. It is difficult to determine to what extent the middle triangular area represents the adductor muscular impressions; perhaps a part of this area was occupied by other muscles which have not left separate impressions. The lateral areas are ascribed to the diductor muscles. Ovarian markings have not been detected. Vascular markings are rather common but are quite variable. In all cases they consist of a few parallel low ridges extending from the anterior border of the muscular area anteriorly about half the distance between the muscular area and the anterior margin of the shell. Here evidently the vascular tissues branched considerably. This is well shown in some specimens, while in others the abnormal and at times very marked thickening along the margin of the shell, especially along its anterior border, gives rise to a broad, often very thick border, against which the aforesaid vascular markings abut, without giving further indication of their course. Usually two broad and very distinct elevations extend forward from the muscular area. Between these may lie a single, much narrower ridge marked by a median groove anteriorly, or a broad ridge of equal or even greater width may lie between them, and this elevation also is then marked by a median groove anteriorly; in some specimens these median elevations are far more distinct and much broader than the ridges between which they lie, increasing in width anteriorly, whereas the lateral elevations on the outside of this pair are but moderately distinct. All of this seems to indicate the existence of a median vascular tube, which at times did not approach the shell until near its anterior extremity; also the presence of a vascular tube on each side of the median one, usually quite close to the shell. On the outside of these lay perhaps on either side another vascular tube. From the last named pair of tubes branches curved outwards and backwards towards the lateral margins of the shell, branching dichotomously two or three times. From the inner pair of vascular tubes a branch starts off laterally in the same direction. From this branch of the inner vascular tubes, from the tubes themselves, and from the median tube, a series of branches start off anteriorly leaving on the shell, as casts, a series of reticulating grooves with rather wide meshes, if this figure may be used. None of these vascular markings continue to the very edge of the shell, and they are never seen where the border is abnormally thickened. The degree of thickening of this border is sometimes remarkable and may reach a thickness of 4 mm., though this is shown only by a single specimen. In other shells of the same size the margin of this valve of the shell can hardly be said to be thickened at all. It is difficult to assign a reason for such a great variation in the thickening of the shell. It is usually accompanied by a corresponding unusual thickening over the muscular area, but this is not necessarily the case.

This species is found at Soldiers' Home, Fauver's, Huffman's, and Centreville in the upper shaly courses.

Orthis (*Platystrophia*) *biforata*, Schlotheim.

(Plate 25, Figs. 7, 8.)

Brachial valve with a strong median fold corresponding to a deep sinus in the opposite valve. Both valves very convex, marked by strong radiating plications, traversed by fine striæ of growth, more frequent towards the margins of older specimens, and further ornamented by minute granules, arranged in more or less regular close, intersecting rows. One of the diameters of the quincuncial figures thus formed is often fairly parallel to the zigzaging striæ of growth where these traverse the sides of the plications. Hinge area in both valves fairly erect, incurved, leaving perhaps less of the area exposed to view in a perfect shell than is true of many lower Silurian varieties of this species. The area is marked by straight parallel horizontal striæ of growth, corresponding to, and often connecting with the striæ of growth on the exterior surface of the valves. Vertical to these are still finer parallel striations, crossing the area in its shorter diameter, and visible only under a lense. Delthyrium open in both valves, the hinge area on either side slightly elevated into a sort of bordering ridge.

In the brachial valve this ridge after crossing a slight groove is continued in the acute angled outline of the crural plate where the latter borders the delthyrium. The plate is strongly recurved, so that the upper and broader side of its somewhat triangular acute tip passes beneath the corresponding tooth of the pedicle valve along its inner side, a deep notch in the outer angle between the plate and the hinge area serving as the resting place for the tooth of the pedicle valve. The acute, strongly recurved tips of the crural plates of the brachial valve are rarely well preserved. The inner margin of the tooth of the pedicle valve is also evidently in line with the raised margin of the hinge area bordering the delthyrium, and it likewise has a deep notch along its outer angle, to receive the adjoining border of the hinge area of the brachial valve. In specimens with strongly incurved beaks at times only two narrow slits communicating with the space between the hinge areas remain for the exit of any pedicle.

In the brachial valve the cardinal process is a low linear ridge. This ridge in well preserved specimens is however often bordered on either side by two similar ridges, which may be of the same size throughout, may widen anteriorly, or may be replaced anteriorly by another pair of ridges.

The valves are thin, readily showing the radiating plications interiorly, except in the vicinity of the muscular area; at the latter place the shell is considerably thickened. The muscular area of the brachial valve is quadruplicate, the posterior adductor scars being sunk into the thickened shell; they are bounded laterally by low, broad ridges, often not well defined; their limits anteriorly are indicated by the line at which the thickening of the shell suddenly becomes very slight. Anterior to this line lie the anterior adductor scars, in an area where the shell is but slightly thickened; their anterior margin is but rarely well defined, and, when best indicated, consists of a few striations there where even the meagre thickening over this area totally ceases. The posterior adductor scars are separated by a low flattish elevation, often provided with a median groove. The scars on either side are traversed by longitudinal ridges, parallel to the lateral boundaries of the scars, with reference to which they may be regarded as striæ of growth. Crossing these and sometimes almost concealing them are curved striæ following the inner contour of the anterior boundary of the adductor scars, with reference to which they may be regarded as striæ of growth. In one specimen a single striation parallel to the outer contour of the anterior boundary of the scar is seen, and this is also a striation of growth. A much narrower low ridge branches from the posterior end of the median elevation and extends a little beyond the middle of each scar where it usually becomes indistinct. A median ridge of moderate width, decreasing in size anteriorly, separates the anterior adductor scars.

The muscular area of the pedicle valve is sharply defined laterally by a limiting ridge which is low anteriorly, where the thickening of the valve abruptly diminishes but which posteriorly becomes developed into thin very acute erect plates, serving as a support to the teeth, this posterior portion being rarely well preserved. Along the bottom of this muscular area extend several diverging striations, on a moderately elevated flattened surface. In the specimens where this part of the shell had undergone but very little thickening three striations were seen, corresponding to three grooves between two plications in the sinus, as seen from the exterior of the valve. In cases where the thickening of the shell over this area is more pronounced the striæ are sometimes quite well preserved, but often in less distinct form; at other times however the central striation disappears more or less, and the other two striæ seem to be less divergent than they were during their earlier growth. The linear area between these striæ coresponds to the adductor muscles; the elongate areas on either side, to the diductor muscles; no line of dilimitation serves to fix the boundary of the pedicle muscle in the specimens at hand, but striations following the anterior outline of the area mark the inner surface of the scar in the more thickened specimens. Ovarian impressions characterized by the presence of numerous short subparallel striæ, following in a general way the direction of the plications of the exterior shell, are often seen covering a considerable area on either side of the muscular area in the pedicle valve, but in the opposite valve these striæ, if present, are confined to a very narrow area on either side of the muscular scars. Vascular markings evidently extend from the anterior end of the muscular scars of the pedicle valve forwards but their course could not be traced in the material examined. The shell structure is compact and finely fibrous without punctation.

The detailed description just given is drawn from specimens designated in an earlier publication as the variety *reversata* (Plate 25, Fig. 7), established to contain forms which have usually an odd number of plications on the median fold and an even number in the sinus, and in which plications are intercalated with more than usual frequency, conspicuously so in the sinus and on the mesial fold. It occurs in Ohio, in the upper shaly courses at the Soldiers' Home, Fauver's, Huffman's, in the quarry just north of Beavertown; Centerville quarries in the shaly Clinton; at Reed's Hill in the limestone; at Huffman's in the Beavertown marl; also in the Clinton of New York at Lockport. A smaller form was designated as variety *Daytonensis* (Plate 25, Fig. 8). This has usually much fewer striations; it occurs in the solid limestone of the Clinton at Soldiers' Home, near Dayton, Ohio, quarry in John Glaser's woods five and a third miles from Dayton on Brandt pike, Hanover, Indiana, Lockport, New York, and at Cumberland Gap, Tennessee, Collinsville, Alabama, and elsewhere extending also into the Niagara. The markings of the interior of the shells valves of this species are but little known. It is probably also represented at Brown's Quarry.

Orthis (*Dalmanella*) *elegantula*, Dalman.

(Plate 25, Figs. 11, a b; Figs. 17, a, b.)

Brachial valve flattish or moderately convex, with a median sinus or line of depression, fairly distinct near the beak, but widening and usually becoming less distinct anteriorly, at least as regards its lateral boundaries. Pedicle valve strongly convex, especially towards the beak along the median area of the shell. Both valves are marked by rather fine, frequent radiating plications. With the aid of a lense, the surface of the shell is seen to be further ornamented by fine little granular markings. These apparent granules are arranged much as these described in the case of *Orthis biforata*. They are namely arranged more or less in rows, these intersecting each other so as to give rise to a sort of quincuncial disposition of the granules, though this may not be apparent where the granules are more irregularly arranged. In worn shells it can frequently be seen that these granules open below into very fine tubes, entering the substance of the shell. Whether they are closed above could not be determined in even the best preserved specimens, but it is not impossible that the supposed granules represent only the broken off bases of very fine, hollow, hairlike spines, which once ornamented the shell, and connected with the fine tubes which give the poriferous structure to the worn shell. Hinge area of the valves very unequally developed, that of the brachial valve usually very low, and inclined outward, while the area of the pedicle valve is much higher, being erect and somewhat incurved at the top. In both valves the hinge area is considerably narrower than the width of the shell. The anterior margin in both is a straight line, parallel to which there are often striæ of growth, which are best seen in the hinge area of the pedicle valve. The delthyrium in the pedicle valve is open, that of the brachial valve is almost if not quite closed by the cardinal process. This brachial process varies considerably in different specimens. In form it resembles usually a triangular plug almost filling up the delthyrium, excepting along a narrow groove on either side, which serves to define the neighboring boundary of the hinge area. It juts out a considerable distance beyond the hinge area at times. In one young specimen the process does not show any definite lobation, in another it is marked above by three, strong, acute lobes or ridges. In an older specimen the cardinal process is triangular, and flattish above, divided by a not deep, narrow, median groove. In other specimens only the anterior edge of the process is notched by a groove which extends forward for some distance on the anterior prolongation of the cardinal process which in turn is continuous with the ridge separating the muscular scars. According as the anterior margin of the process is indefinite or a more or less straight line, the appearance of the process will vary greatly. Even in old specimens the process is at times undivided, and prominent; or bilobate, owing to a single median furrow; or it is trilobate, owing to three diverging more or less prominent and often acute ridges on its upper side; or, lastly, quadrilobate, owing to a slight median elevation of the process anteriorly, which is not only itself divided by a median furrow, but which is also bordered on either side by a groove, dividing the upper surface of the process into four ridges. The inner margin of the hinge area along the delthyrium may or may not be slightly raised into a fine bordering ridge, but in either case the sharp crest of the crural plates can be seen to be the continuation of this margin of the hinge area. These crural plates are flattened laterally, and rest for support on thickened callosities, developed in the posterior part of the shell, near the beak. The crural plates jut out strongly from the inner surface of the shell; their elevation above the plane of the hinge area is however much less than might at first be imagined, the hinge area of the brachial valve having a quite strong outward inclination. A quite strong notch or rounded impression in the outer angle between the plate and the hinge area forms the dental socket, and together with the supporting callosities adds to the rather heavy appearance of the crural plates of this species. In the pedicle valve the teeth are also evidently the continuation of the inner margin of the hinge area, along the delthyrium. The teeth, however, usually bend a little towards the lateral side of the shell and at the same time are moderately elevated above the plane of the hinge area, especially along their inner acute outline. They are supported by callosities, which are plate-like anteriorly, and which serve to limit the muscular impressions of this valve posteriorly.

The muscular impressions of the brachial valve are always separated by a median ridge, which may be low in young specimens but which is strong, though rounded, in older individuals. This ridge extends backwards, with about equal width, to its junction with the cardinal process, there being often no well defined line of demarcation between it and the latter. This, in young specimens, is about the only marking to be seen over the muscular area; but in older specimens, owing to the general thickening of the shell, especially posteriorly and towards the beak, except over the muscular impressions, this muscular area receives a distinct boundary postero-laterally, which becomes prominent antero-laterally, and which can be quite distinct or almost absent anteriorly. When best developed it has a rather round outline, with a slightly heart-shaped anterior margin at the termination of the dividing median ridge. It is further divided into anterior and posterior impressions by narrow ridges connecting the median ridge with the lateral margin of the area. These lateral ridges are rarely distinct, so that the anterior and posterior adductor impressions are rarely clearly defined from each other. The anterior adductor scars are a little larger and wider. Vascular markings were not detected unless faint furrows crossing the anterior border of the muscular area and a few indefinite markings anterior to the median part of the muscular area be so interpreted.

The muscular area of the pedicle valve is distinctly bounded postero-laterally by the general thickening of the shell posteriorly around the muscular area. While this thickening, where it adjoins the muscular area and bears the vertical plates that serve to support the teeth, is well marked posteriorly, it disappears so rapidly anteriorly in some shells, that even the lateral boundaries cannot be said to be well defined, whereas the antero-lateral boundaries are commonly indistinct. This being the case, it may be imagined how rarely the anterior margin of the muscular area, which depends for its definition upon a similar thickening of the shell anteriorly, is well defined. When best defined the muscular area of the pedicle valve is seen to resemble in outline that of *Orthis testudinaria*. It has namely, laterally, a diverging outline for a short distance anterior to the teeth, after that a converging outline, after which the outlines on either side of the muscular area become parallel, as far as the antero-lateral angles of the area. Anteriorly the area has a more or less obversely V-shaped outline (Λ), the antero-lateral angles being more or less rounded or acute. At the point where the converging lateral outlines of the area assume a parallel direction, there is found on either side the termination of a sort of low ridge which serves to divide the muscular area into anterior and posterior diductor muscular impressions. These divergent ridges are however rarely developed. Along the median line of the muscular area, between the impressions on either side, there is anteriorly at times as light, or more distinct, elevation or ridge, formed by a thickening of the shell corresponding to that which forms the margin of the area. It serves no doubt for the attachment of the adductor muscles, but is rarely well defined. Commonly therefore the muscular area of the brachial valve is seen only as a rounded area, fairly well defined, divided into halves by a strong rounded median elevation or ridge, and that of the pedicle valve is as a rule well defined only posteriorly.

This species is found at the Soldiers' Home, Fauver, Huffman, Beavertown and Centerville Quarries in the upper shaly courses; at Todd'sFork in the ferruginous limestone; at Brown's Quarry in the limestone; and at Hanover, Indiana.

A smaller form, described as variety *parva*, Plate 25, Fig. 17a, b is found in the limestones of the Soldiers' Home and Fauver Quarries, and in the quarry in John Glaser's woods five and a third miles from Dayton, on the Brandt pike. They probably do not even form a distinct variety, but are only the young stages of this species; but why in the middle limestones of the Soldiers' Home quarry these small specimens should have been so common, and the fully developed specimens either absent or at least exceedingly rare, could not be well explained. In the upper shaly courses at the Soldiers' Home the full-grown forms just mentioned are very common.

Orthis (*Rhipidomella*) *hybrida*, Sowerby.

(Plate 25, Figs 10 a, b)

Of this species no interiors were found. At least no interiors were found which resemble published figures of this species, which would serve as a means of identification, had the existence of this species in the Ohio Clinton otherwise escaped our attention. This may be accounted for by the fact that even the exteriors of this species are quite rare, having been found but rarely in the upper shaly courses at the Soldiers' Home Quarry and in the limestone at Fauver's. The species is readily recognized by the commonly almost equal convexity of the valves, and the fact that in the more mature individuals the anterior half of the pedicle valve is more or less flattened. To a certain extent, moreover, the fine radiating plications are finer and closer than those of *Orthis e.egantula*.

At Brown's Quarry is found a form also with fine radiating plications, and with the valves about equally convex. The anterior half of the pedicle valve, however, does not show flattening. But since our specimens are not more than 11 mm. long it is probable that this represents either a less developed form or merely the young of *Orthis hybrida*, corresponding to the variety *parva* of *Orthis elegantula*.

At Brown's Quarry are also found forms in which the hinge area does not seem to be sufficiently elongated to form postero-lateral angles in the outline of the shell. The beak is strongly developed. The shell has the aspect of *Meristella Prinstana*, or of some slightly more elongate type, like *Meristella intermedia*, but it is covered with fine radiating striae exteriorly, like those of *Orthis elegantula* in size. On closer examination it seemed possible to recognize the pitted structure of this section of the genus *Orthis*, and so the specimens are probably an aberrant form of *Orthis elegantula*, with at times several concentric lines of growth. Interiors have not been found, and these shells are mentioned only for the sake of completeness, and to indicate the difficulties at times attending the identification of these Ohio shells, the hinge area being frequently not shown, even on otherwise fairly preserved exteriors.

If *Orthis circulus*, Hall, be indeed present in Ohio rocks, it can be only represented by a few valves found at the very top of the Clinton at Soldiers' Home, where it changes to the stratigraphical equivalent of the Dayton limestone, the base of the Niagara, by a decrease in the amount of lime, and the increase of the magnesium carbonate, the rock not being here a true limestone. These valves resemble valves of *Orthis hybrida*, but are larger, 19 mm. long, and the anterior half of the pedicle valve is not so much flattened, remaining slightly convex in all directions. What was regarded as the brachial valve was similar, with the posterior half of the surface, especially near the beak, more convex than the rest of the valve. It will be impossible to identify these forms more accurately until better specimens are found, some showing the two valves in position, and others showing the muscular scars and the hinge area.

Triplecia Ortoni, Meek.

In the initial stages of growth this species has both valves nearly equally convex. In specimens 10 mm. long the pedicle valve has become more flattened than the brachial valve, the latter having become strongly convex. This difference is increased by the appearance of a broad shallow median sinus in the pedicle valve, and a less distinct median fold in the brachial valve. As growth increases the sinus becomes deeper, broader and more distinct. In mature specimens the sinus forms a rather triangular area, the general surface of which is more or less equally concave posteriorly, but anteriorly the median region is often quite flattish, the sides of the sinus rising more abruptly to the general surface of the valves, giving thus more distinctness to the rounded lateral boundaries of the sinus. This sinus is strongly convex antero-posteriorly. Leaving however the sinus out of account, the pedicle valve is seen to be much flatter, in mature shells, than the brachial valve. In forms with a long hinge area this flattening is much more marked than in those with a short hinge area. The median fold increases in height and breadth with age. Owing to its broad lateral slopes anteriorly, it is not so easy to appreciate the full degree of increase in width of the fold as the increase in width of the median sinus. The median fold has therefore a more elongate triangular appearance. Often the lateral boundaries of the median fold are rendered more distinct by broad, shallow grooves, which begin 10 mm. or more from the beak, and extend anteriorly along their border. Occasionally the anterior and lateral parts of the valves are slightly wrinkled radially, forming very shallow, broad, indistinct radiating plications. Very fine concentric striæ of growth are readily detected with a lense.

The hinge area is quite variable in length. In the short-hinge forms the area has a length equivalent to only half the width of the shell. In the long-hinge forms the length of the area is equal to about four-fifths of this width in the majority of shells, but occasionally longer hinge areas are found, the longest being that of one specimen in which the length of the area equaled six-sevenths of the width of the shell. From this it may readily be seen that the general outline of the shell varies from a quite triangular form, to one whose more nearly parallel sides give it quite a quadratic appearance, excepting along its anterior margin. In well preserved specimens the posterior part of the lateral outline is always more or less concave, making more prominent the postero-lateral angles, especially in the shells with more quadratic outline.

The hinge area of the pedicle valve is low, and outwardly inclined, this inclination varying from an angle of thirty to one of seventy-five degrees when measured with reference to the plane passing through the lateral margins of the shell. The delthyrium is narrow, and is covered by a linear or moderately triangular convex plate, excepting at its posterior extremity where a small circular foramen is seen. In specimens in which the outer surface of the shell at the beak has been worn, this foramen is seen to be the mouth of a small tube which lies close to the exterior of the shell, and this tube in good interiors is seen to open by an equally small, round opening at the posterior extremity of the muscular area, thus passing behind and under the callosity formed by the thickening of the shell posteriorly. The straight anterior edges of the hinge area are continued inwards, beyond this junction with the teeth, but they do not join at the median line of the shell, leaving a small notch anterior to the deltidium on either side of which there is at times a slightly increased thickening of the posterior regions of the shell, to support these inner angles of the hinge area. In one specimen the shell was not thickened posteriorly beneath the hinge area, and here it can be seen that the teeth are an outgrowth from the interior of the valve, starting at a point on either side of the beak, under the hinge area. Thence they grow out in a very divergent direction, resting on the shell beneath and being connected with, and supporting, the hinge area above. As a rule the posterior parts of the shell below the hinge area are strongly thickened, especially nearer the teeth. In that case the outer side of the teeth is no longer so distinctly shown, but is merged into the callous thickening of the shell laterally. The teeth project beyond the margin of the hinge area, at a broad angle, forming a deep notch laterally, rendered still more distinct by a narrow groove outlining the anterior edge of the hinge area. The inner surface of the teeth is flat, the anterior margin being acute, and curved upwards, the tip of the teeth being acute and rather pointed, and rising a little above the plane of the hinge area. The brachial valve does not possess a real hinge area. The posterior border of the valve is an almost straight, sharp ridge, from which diverges at a very low angle another fine, sharp, almost paralled ridge, starting near the crural plate and extending almost or quite to the postero-lateral angles of the shell. The narrow groove between these fine ridges or striae serves as a resting place for the acute anterior outline of the hinge area of the pedicle valve. In one specimen this margin of the pedicle valve seems to have slipped out of the groove at one time, and a new pair of striae, at a slightly greater angle was formed anteriorly, providing a new groove as a socket for the anterior margin of the hinge area of the opposite valve. The space between all these striae belongs to the hinge area. This may be all of the hinge area of the brachial valve which is developed, but not infrequently anterior to these striae, a long and very narrow surface, with a straight anterior margin is seen, more or less flattish towards the middle regions of the hinge line, and strongly inclined outward. Posterior to the teeth it usually shows fine parallel striae of growth. This is the remainder of the hinge area. In many of these specimens it may be seen that the delthyrium is closed, since the anterior margin of the hinge area turns up abruptly over the outer posterior side of the cardinal process, forming there a callosity and leaving behind it a groove into which fits the indentation of the hinge area of the pedicle valve, the anterior edge of the deltidium. In some valves the continuous connection of this callosity with the anterior margin of the hinge area is not seen, so that were it not for the other specimens it would seem to be only the posterior thickening of the cardinal process itself.

The cardinal process varies considerably in its minor features, but it is always very large, and deeply bifurcated; the supporting region of the beak is always strongly incurved, so much in fact that the cardinal process after growing downward and inward for a short distance, curves abruptly backward and occupies, in shells with a short hinge area, and more convex pedicle valves, an almost horizontal position, whereas in shells with larger hinge area, and flatter pedicle valves the process is obliged to take a more inclined position, its extremities being apparently directed more towards the anterior of the opposite shell, in order that the cardinal process may find room within the pedicle valve. The undivided portion of the process may be more or less rounded or flattened laterally, often so as to give its inner median line quite an acute edge, especially anteriorly, or it may be flattened above and below so as to give the lateral edges a more acute outline, or the broadening of the cardinal process may be of such a character as to give a general triangular cross-section. At times the anterior edge of the process where it curves strongly inwards is produced somewhat anteriorly beyond its point of attachment so as to form a small anterior projection. The bifurcated extremities of the process are strongly grooved above in most specimens, the grooving however rarely extends beyond the point of junction of these extremities, although sometimes reaching the hinge margin as a much finer groove. In some specimens the bifurcated extremities are evidently hollow interiorly, and the grooves above named are then caused by the failure of the sides of these tubular extremities to meet above. The crural plates are pointed, rather triangular bodies, diverging strongly on either side of the cardinal process; their tips are often curved upwards; their triangular cross section is caused by their rather acute upper margin from which the flattened sides slope towards either side to the rounded lower surface of the process. As a rule the teeth are quite prominent, but by the thickening of the posterior parts of the shell, the teeth are at times almost covered up, so as to leave only their tips projecting distinctly above this callous thickening. The thickening takes place at first around the cardinal process and the crural plates. Thence it extends laterally to other regions anterior to the hinge line. At first it is greatest near the process, but in old specimens the thickening increases until it involves also regions anterior to the cardinal process, and in the most pronounced case of thickening, where the shell had a thickness of 8 mm., this maximum measurement came from a region a short distance anterior to the cardinal process. In these extreme cases the thickening causes a sort of very broad convex transverse ridge in the interior of the shell, decreasing rapidly posteriorly to the hinge line, and anteriorly to the muscular impressions, to be described later.

The pedicle valve is therefore moderately thickened near the hinge line, towards either side of the teeth, while the brachial valve is also thickened near the hinge line, but the maximum is reached along the more median portions of the shell, near the teeth and the cardinal process, or just anterior to the same; the strongly concave inner surface of the beak of the brachial valve is usually filled up in this way. It may be imagined from the descriptions above given that posterior portions of brachial valves, with their teeth and cardinal process, which are quite commonly found as fragments separated from the remainder of the shell, may present quite a series of variations, greater perhaps than one is accustomed to expect in shells of the same species.

Except over the thickened area already described the pedicle valve is very thin. The inner edges of the thickened portion of the shell continue for a short distance the border of the muscular area furnished by the base of the teeth, but this thickening soon disappears anteriorly, so that the muscular area is not defined anteriorly. In one specimen the triangular space thus partially bordered seemed indistinctly striated radiately. Towards the anterior of this striated area a sort of very broad median elevation appears, which may have something to do with the strong indentation of the anterior border of the muscular area. The antero-lateral edge of the area was probably rounded, but our specimens only allowed a faint suggestion of such a rounding in one case. At the posterior end of the muscular area, within the anterior end of the teeth, the anterior edge of the callous posterior thickening is often slightly and rather roundly indented. This is the resting place for the distal extremities of the bifurcated cardinal process. The broad oblique flange-like teeth of the pedicle valve rest firmly behind the acutely pointed rather upturned crural processes. From a point near the hinge area and a little to one side of the teeth of the pedicle valve, two or three narrow parallel grooves extend antero-laterally across that portion of the shell where usually ovarian markings would be looked for. These grooves however seem to be vascular markings.

In the brachial valve at least sufficient thickening occurs anterior to the great posterior thickening of the shell, already described, to render more or less distinct the muscular impressions of this valve. These in mature specimens are usually quite distinct. The muscular area is divided by a median ridge, which may be low and indistinct posteriorly in shells in which this region does not seem to have been greatly thickened. In proportion however as this posterior thickening increases, the posterior end of this median ridge becomes more prominent by the development of two lateral furrows, which terminate abruptly at their deeper posterior end, and thus give a high relief to this part of the median ridge. These grooves have their posterior termination at the anterior edge of the region of marked thickening, and therefore are quite a distance anterior to the crural plates and cardinal process. Anteriorly these defining grooves rapidly decrease in depth; the median ridge, rounded and strong posteriorly, becomes less elevated, broader and flatter anteriorly; a median groove begins to appear usually before the anterior adductor muscular impressions are reached, and increases in distinctness between the latter. Between the more anterior parts of these anterior muscular impressions this groove is traversed by a fine median striation or ridge. In mature specimens, about 5 mm. anterior to the distinct posterior end of the median ridge as just described, curved lateral branches start out from the sides of the ridge antero-laterally, and separate the muscular area into anterior and posterior adductor impressions. The lateral ridges are low and are distinct only between these impressions; their inner posterior edge curves backwards laterally, forming a scarcely visible border for the antero-lateral portion of the posterior adductor muscular impression, but even this faint border fails more posteriorly. The posterior adductor impressions are therefore distinctly defined only along their anterior half, the posterior half having no distinct margin and being usually smooth owing to the generally marked thickening of this portion of the shell. Low broad ridges, fairly parallel to the strong main median ridge, traverse the anterior part of this posterior impression, being most distinct near its anterior border and disappearing rapidly posteriorly. In one specimen as many as ten of these low ridges form a lunate arc occupying the anterior part of this impression. The general form of the posterior adductor scars is obliquely oval. The anterior adductor impressions are well defined only along their posterior and inner margins as described above. In one specimen the edges of the median ridge separating them seem fairly parallel almost to the anterior end of the anterior adductor impressions, but in one case this grooved median ridge begins to separate about on line with the middle of these impressions, the divisions curving strongly outwards laterally and becoming faint so rapidly that the continuation of this ridge into a slight border, caused by the thickening of the shell which bounds the sides of the anterior impressions and connects with the lateral ridges defining their posterior margin, was perhaps rather suspected in one specimen than definitely determined. No markings seem to characterize the area of these anterior adductor impressions. The impressions are therefore distinctly bounded only posteriorly and along their inner margin; they are obliquely oval in form.

This species is found at the Soldiers' Home, Fauver, Huffman, Centerville quarries in Ohio, in the upper shaly courses, rarely in the lime stones.

Meristella umbonata, Billings.

(Plate 25, Figs 2, a, b.)

The absence of interiors of this and other meristelloid shells in Ohio makes it not only impossible to determine accurately their generic relations, but casts considerable doubt upon their specific identification, no matter how carefully made, by means of their exterior characters. Nothing has been added to our knowledge of Ohio forms of the species identified as *Meristella umbonata*, Billings. After a careful examination of New York Clinton and Niagara forms of this and related genera, the Canadian species, above mentioned, still seemed to be the most nearly related form. The even curvature of the lateral outline, the total absence of antero-lateral angulation, the very moderate curvature of the line of junction of the two valves anteriorly, and the very even though elongate convexity of the shell, seemed to be the characteristic features. The surface of the shell is marked by fine concentric striae of growth. The exfoliated pedicle valve of a small specimen left a matrix which indicated an elongate deep delthyrium slightly constricted anteriorly at its base, then widening out anteriorly into the muscular area, which shows six to eight moderately radiating striae, and a shallow median groove. This form is found at Soldiers' Home, Ohio. Single valves are found at Huffman's Quarry and at the Soldiers' Home in Ohio, which indicate a much broader form, the general outline of the pedicle valve being more ovate and much less elongate, the sides being not at all compressed. In other respects this form agrees exteriorly with the last there being no antero-lateral angulation, no tendency of the anterior border to be strongly sinuate, nor to flatten out so as to suggest a triangular outline for the shell. The surface is marked by fine concentric striae of growth. At Hanover, Indiana, a small entire shell was found which seems to belong to this form. In outline these shells most nearly resemble *Meristella Prinstana*, Billings. From *Meristella intermedia* they differ in the more rounded outline of the postero-lateral parts of the shell.

Atrypa marginalis, Dalman.

(Plate 25. Fig. 6; Fig 9. Plate 31. Figs 8 9, 9 a.)

This species, though quite variable, presents certain general characteristics which are readily recognized and which are quite characteristic. Thus the median fold of the brachial valve which is fairly high and strong anteriorly, begins as a simple plication near the beak, and may retain its simple character for almost four or five millimeters before it begins to divide. Moreover the fold is defined laterally by a bordering line of depression, these lines of depression or grooves being most distinct posteriorly, where they not uncommonly meet so that in those cases the median fold starts as a simple narrow plication a slight distance anterior to the beak. This median ridge usually does not begin to rise above the general surface of the shell, at least to any marked degree, until it is 5 to 7 mm. distant from the beak, so that for a time it has rather the appearance of resting in a sort of median sinus. The pedicle valve begins to develop a median sinus close to the beak, which becomes deep anteriorly. In forms from Brown's Quarry, the sinus remains narrow for quite a distance, increasing but moderately in depth, after which the sides curve outwards and the depth of the sinus increases rapidly. This valve shows a tendency towards flattening laterally. At Huffman's Quarry, Fauver's and at Soldiers' Home a slightly different form occurs in which the sides of the sinus diverge more regularly, and the sinus therefore increases in depth earlier. The pedicle valve is usually a little more convex.

Variety *multi-striata* from Hanover, Indiana, (Plate 31, Fig. 8.) has still more divergent sides to the sinus, and the number of radiating plications is somewhat greater. Aside from the radiating plications the surface of the valves of this species shows only more or less strong concentric wrinkles.

Atrypa lati-corrugata, sp. nov.

(Plate 37A, Figs, 16, a, b, c, d.)

In the "Orthoceras block" found at Huffman's Quarry, shells were found which on superficial examination might be taken for a form of *Atrypa reticularis*, but which a closer view shows to be intimately related to *Atrypa marginalis.* It has developed, however, new characters of sufficient distinctness and constancy to be regarded as a new species, and it is described here as *lata-corrugata*, a form regarded as related to *Atrypa marginalis* genetically. The median fold of the brachial valve and it's lateral defining depressions are visible only in young individuals and are retained only near the beak, within 6 to 8 mm. of the same, in adult specimens; but since at this stage the median fold never rises above the general surface of the shell, the appearance is rather that of two diverging grooves, disappearing at the first strong concentric wrinkle, or at least showing but faint traces anterior to this point. The median sinus of the brachial valve has left yet fewer traces. Its position is indicated by the strong convexity of the shell along a median line just anterior to the beak, but the traces of the sinus are confined to the existence of two radiating plications which occupy the position of the sides of the sinus, and which are raised either indistinctly, or slightly, or more or less distinctly, above the general surface of the shell, but the depression which ought to lie between these lines does not exist. As a rule, no traces of either the median sinus nor the fold appear over the middle or the anterior regions of the shell, but in one specimen a broad low elevation, with its corresponding depression in the other valve, indicates a reversal of this specimen to its former habits of growth in its old age. The surface of both valves is marked by radiating plications, and by a series of concentric wrinkles, which are so strong and so distant from each other as to form the most conspicuous feature of this variety, and to give name to the same. The partial retention of the characters of *Atrypa marginalis* in the young of *A. lata-corrugata* is an interesting illustration of similar facts in higher orders of animal life.

Rhynchonella scobina, Meek.

Rhynchonella scobina is a very frequent shell in many localities in Ohio. Corresponding to its general distribution is a wide range of variations in form. The typical specimens present a rather rotund outline, when mature; the postero-lateral sides of the pedicle valve form a wide angle, often 90 degrees or more, and the straight contour of the shell along this region is too short to make the beak *break in* very much upon the general rotundity of outline. Both valves are very convex. The adult pedicle valve has a deep sinus, and the brachial valve a high well defined median fold, with steep sides. Three plications are found in the sinus of the pedicle valve, and four on the median fold of the brachial valve; in each case the two exterior plications are much less elevated and narrower. The line of junction of the valves is very sinuous at this fold or sinus. A variation of this type has an equally strong convexity of shell, but the width is so great as to exceed the length. The young of both of these forms show a rather rotund outline, and a considerable convexity of shell, even when only 7 mm. long. In a third variation the flattening of the postero-lateral sides is sufficiently extended to give the shell a more triangular outline; this appearance is increased by the fact that these sides usually form much less than a right angle at the beak, at times only 70°. Corresponding to this difference the shell is less strongly convex, the sinus and fold are narrower, all the plications are narrower and closer, a fact which can be readily remarked even in the young when only 7 mm. long. The height of the fold and depth of the sinus is usually less, these median regions not unfrequently projecting a little beyond the anterior outline of the shell. In a fourth form the outline is quite rotund, but the shell is still less convex, so as to show in comparison with the ordinary types, a considerable flattening, even in adult shells, so that a shell 16 mm. long may show a depth of only 7 mm, this flattening being still more marked in smaller specimens. Rarely these flattened specimens have lower and broader plications, giving still another aspect to the shell. The surface of all these forms is ornamented by very fine concentric striæ of growth visible under a lense. These striæ of growth are interrupted at regular intervals. When these intervals are longer, the striæ are formed by a succession of short, fine, minute ridges; when shorter, the striæ are reduced to a succession of minute granules; the latter are rather more common, though both forms may be seen on the same shell. The intervals of interruption occur with such regularity as to produce that quincuncial arrangement of granules already remarked while describing the similar surface ornamentation of *Orthis biforata* The species is found in considerable abundance at Huffman's Quarry, Soldiers' Home, Centerville, more rarely at Fauver's, Todd's Fork, and rarely at Brown's Quarry, in the quarry in John Glaser's woods five and a third miles northeast of Dayton, on Brandt pike.

Rhychonella acinus, *var. convexa*, Foerste.

(Plate 31, Fig. 13, a, b, c.)

Found at Todd's Fork, Soldiers' Home and more commonly at Hanover, Indiana, in the Clinton. Described in the Proc. Bost. Soc. Nat. Hist. for May 1, 1889.

Cyclospira ? sparsi-plica a, sp. nov.

Plate 37A, Figs. 18, a, b.)

At Huffman's Quarry a shell was found with the pedicle valve exceeding the brachial in convexity and depth, the beak of the former being also much more incurved and its umbo more elevated. The posterior half of the valves is evenly convex. The anterior half is plicated, especially towards the anterior margin of the shell, the general effect being the production of a sort of broad median sinus in the brachial valve and a corresponding elevation in the opposite valve. Two broad plications occupy the fold, flanked on each side of the fold by one that is less distinct. The sinus contains one plication and its boundaries are formed by two plications less distinct, especially along their exterior margin. All of these broad plications as well as the sinus and fold soon disappear posteriorly. The surface is marked by fine concentric striæ of growth, visible under a lense. The general outline of the shell is circular. Among published species it most closely resembles *Camerella Ops*, Billings, from which however its general form will readily distinguish it, and *Cyclospira biculcata*, Emmons, a small Trenton form. No specimens showing the hinge area or internal structure were found, and hence the generic determination is largely a guess.

Eichwaldia reticulata, Hall.

(Plates 25, Figs. 4, a, b.)

This species was found by Mr. E. M. Thresher at Fauver's Quarry, and is represented by a specimen in his cabinet.

Stricklandinia triplesiana, Foerste.

(Plate 26, Figs 13, a, b, 14.)

The hinge line almost equals the shell in width, and is not much shorter than the length of the shell. Both valves slope posteriorly to the hinge line, very much like the sides of a dull, cold chisel. Their convexity is moderate and about equal in the two valves. A low median fold marks the brachial valve, and a corresponding sinus the pedicle valve. Both sinus and fold are indistinct at the beak, and become distinct features first at five to ten millimeters from the beak, after which they broaden out and become more accentuated anteriorly. Fine concentric striæ of growth are visible under a lense. The radiate fibrous structure of the shell is also visible, perhaps owing to partial exfoliation. The type specimens were found at the Soldiers' Home Quarry in the middle limestones. Since then it has also been found at Huffman's Quarry.

TRILOBITES, MOLLUSKS AND BRACHIOPODS OF THE CLINTON GROUP IN OHIO AND INDIANA.

TRILOBITA.

Acidaspis Ortoni, Foerste.
Acidaspis brevispinosa, sp. nov.
Proetus determinatus, Foerste.
Cyphaspis Clintonensis, Foerste.
Illænus Daytonensis, Hall and Whitfield.
Illænus ambiguus, Foerste.
Illænus insignis, Hall.
Illænus Madisonianus, Whitfield. (*var. elongatus*, *var. depressus.*)
Calymene Vogdesi, Foerste.
Calymene Niagarensis, Hall.
Ceraurus (*Pseudosphærexochus*) *Clintonensis*, sp. nov.
Sphærexochus pisum, sp. nov.
Lichas breviceps, Hall. (*var. Clintonensis.*)
(*Lichas phlyctainoides?* Green.)
Phacops trisulcatus, Hall.
Dalmanites Werthneri, Foerste.
Encrinurus punctatus, Wahlenberg.

OSTRACODA.

Elpe Ulrichi, sp. nov.

ANNELIDA.

Cornulites distans, Hall.

CEPHALOPODA.

Gomphoceras Ortoni sp. nov.
Cyrtoceras Clintonense, sp. nov.
Gyroceras (*Glyptoceras*) *subcompressum*, Beecher.
Gyroceras (*Glyptoceras*) *Eatonense*, Claypole.
Orthoceras (*Actinoceras*) *Youngi*, Foerste.
Orthoceras (*Actinoceras*) *clavatum*, Hall.
Orthoceras (*Actinoceras*) *lati-nummulatum*, Foerste.
Orthoceras (*Actinoceras*) *turgido-nummulatum*, Foerste.
Orthoceras (*Actinoceras*) *Daytonense*, Foerste.
Orthoceras (*Eu-Orthoceras*) *rectum*, Worthen, var. junius, Foerste.
Orthoceras (*Eu-Orthoceras*) *ignotum*, Foerste, variety *erraticum* var. nov.
Orthoceras (*Eu-Orthoceras*) *Hanoverense*, Foerste.
Orthoceras (*Eu-Orthoceras*) *virgulatum*, Hall?
Orthoceras (*Cycloceras*) *inceptum*, Foerste, *var acceleratum.*
Orthoceras (*Cycloceras*) *Nova-Carlislense*, Foerste.
Orthoceras (*Spyroceras?*), *spyroceroides* sp. nov.
Orthoceras (*Spyroceras?*) *Jamesi*, Hall and Whitfield.

Orthoceras (*Cycloceras*) *amycus*, Hall.
Orthoceras (*Kionoceras*) *Crawfordi*, Foerste.
Orthoceras (*Discosorus*) *conoideum*, Hall.

PTEROPODA.

Coleolus Clintonensis, sp. nov.
Conularia Niagarensis, Hall.
Conularia bilineata, sp. nov.

GASTEROPODA.

Bellerophon fiscello-striatus, Foerste.
Bellerophon (*Bucania*) *exiguus*, Foerste.
Bellerophon (*Bucania*) *opertus*, sp. nov.
Bellerophon (*Bucania*) *trilobatus*, Sowerby.
Cyrtolites Youngi, Foerste.
Pleurotomaria inexpectans, Hall and Whitfield.
Pleurotomaria filitexta, sp. nov.
Raphistoma affine, Foerste.
Cyclonema bilix, Conrad. (*var. varicosum*, Hall.)
Cyclora alta, Foerste.
Straparollus (*cf. Oriostoma*) *incarinatum*, sp. nov.
Platyceras (*Platystoma*) *Niagarense*, Hall. (*Var. plebium; var. Clintonense*.)
Subulites directus, sp. nov.
Subulites (*Polyphemopsis*) *plani-lateralis*, sp. nov.
Loxonema? (*cf. Holopella*) *subulatum?*, Conrad.
Paleopupa (Gen. nov.) *abrupta*, sp. nov.

LAMELLIBRANCHIATA.

Pterinea brisa, Hall.
Avicula Whitfieldi, Foerste (equivalent to *Cypricardites ferrugineus*, Hall and Whitfield.
Mytilarca mytiliformis, sp. nov.
Modiolopsis rhomboidea, Hall.
Modiolopsis subrhomboidea, Simpson.
Cypricardites Caswelli, Foerste.
Cypricardinia undulostriata, Hall.
Tellinomya elliptica, Hall.
Tellinomya (*Nucula?*) *minima*, Foerste.
Tellinomya (*Nucula?*) *socialis*, sp. nov.
Tellinomya (*Nucula?*) *Clintonensis*, sp. nov.
Nuculites (*Cleidophorus*) *ferrugineus*, sp. nov.

BRACHIOPODA.

(*Crania dubia.*)

(*Craniella Clintonensis.*)

Plectambonites transversalis, Wahlenberg. (var. *elegantulus*, var. *prolongatus* Foerste.)

Leptæna (formerly *Strophomena*) *rhomboidalis*, Wilckens.

Strophomena (*Orthothetes*) *Hanoverensis*, Foerste.

Strophomena (*Orthothetes*) *tenuis*, Hall.

Strophomena (*Strophonella*, *Amphistrophia*) *patenta*, Hall.

Orthis (*Orthis*, *Dinorthis*) *calligramma*, Dalman (var. *eu-orthis*; var. *flabellites*, Hall; var. *dinorthis*); var. *fissi-plicata*, var. nov.

Orthis (*Herbertella*) *fausta*, Foerste, var. *squamosa*, var. nov.

Orthis (*Herbertella*) *Daytonensis*, Foerste.

Orthis (*Platystrophia*) *biforata*, Schlotheim.

Orthis (*Dalmanella*) *elegantula*, Dalman.

Orthis (*Rhipidomella*) *hybrida*, Sowerby.

Triplecia Ortoni, Meek.

Meristella umbonata, Billings.

Atrypa marginalis, Dalman (var. *multistriata*), var. *lati-corrugata*, var. nov.

Rhynchonella scobina, Meek.

Cyclospira? sparsi-plicata, sp. nov.

Eichwaldia reticulata, Hall.

Stricklandinia triplesiana, Foerste.

Bryozoans and Corals of the Clinton Group of Ohio and Indiana, with a List of Localities, and Occasional Notes.

BRYOZOA.

Ptilodictya lanceolata, *Goldfuss*, var. *Americana* var. nov. (Plate 36, Fig. 3 a, b). This form is very common at the Soldiers' Home Quarry; in the quarry in Glaser's woods five and a third miles from Dayton on the Brandt pike. It is the form confused by Hall and Whitfield with their *Phaenopora expansa* at the time of publication of the latter species. It is evidently closely related to the Gotland species *Ptilodictya lanceolata*, from which it may differ in attaining a larger size, or being at least broader, and in the fronds showing a tendency towards undulose folding laterally.

Ptilodictya Whitfieldi, sp. nov. (Plate 28, Fig. 5; Plate 36 Fig. 4). This is a form with flat, not very broad fronds, with almost parallel edges, except of course towards the base. One of the specimens in the Ohio State University collection from Todd's Fork is 80 mm. long and 19 mm. broad. A second in Dr. Chas. Welch's collection from the same source shows a tendency towards a falciform outline at its basal extremity, but its upper two-thirds are quite straight. It is 11 mm. broad, 2 mm. thick, and 80 mm. long. A specimen in the writer's collection from this locality is 8 mm. wide and 1 mm. thick. This is another form confused by Hall with his *Phænopora expansa* in the 12th Annual Report of the Indiana Survey, 1883. This form has never been seen by the writer from Dayton quarries.

Clathropora frondosa, Hall (Plate 28, Fig. 3), Soldiers' Home, Fauver's Quarry, Centreville, Todd's Fork, Ohio; Hanover, Indiana. In the Clinton iron ore at Red Mountain near Birmingham, Alabama, very typical specimens in Ohio State University collection.

Clathropora Clintonensis, Hall and Whitfield (Plate 28, Fig. 4), Soldiers' Home, Fair Haven, Fauver's.

Phænopora ensiformis, Hall, according to E. O. Ulrich in the Clinton of Ohio.

Phaenopora expansa, Hall and Whitfield (Plate 29, Fig. 1). This species is probably identical with *Phaenopora constellata*, Hall. In the Beavertown marl at Huffman's and Geo. Young's Quarries only forms with low monticules and thin fronds have been found. Low monticules also predominate in the upper shaly courses at Huffman's. Medium sized monticules occur at Fair Haven; and in the upper, shaly courses at Centreville, Huffman's Quarry and Soldiers' Home, the fronds are of medium thickness and only a small number of interstitial cells are added to the normal number (two between every cell) in the monticules. The most prominent monticules occur in the limestone specimens at Soldiers' Home, and occasionally in the shaly courses; here there is a considerable increase in the number of interstitial cells in the monticules. A frond from Todd's Fork measured 94 by 24 mm. and a second was 50 mm. broad. In the collection of the Ohio State University occurs a specimen from Brown's Quarry. Prof. E. W. Claypole collected this species at Yellow Springs, It occurs also at Siebold's Quarry on Brandt pike.

Phaenopora magna, Hall and Whitfield (Plate 28, Fig. 6; Plate 29, Fig. 2 a, b, c.), Soldiers' Home, Brown's Quarry, with branches 5.5 to 7.3 mm. wide. Fauver's Quarry; in the cement of the conglomerate at Belfast, Highland county, Ohio.

Phaenopora multifida, (Van Cleve) Hall. (Plate 29, Fig. 3), Soldiers' Home, Brown's quarry, with branches 3 mm. broad and 2 mm. apart. Hanover, Indiana, very typical.

Phaenopora fimbriata, James (Plate 28, Fig. 7), Soldiers' Home, Fauver's Quarry, Centreville, Todd's Fork, Fair Haven, in the cement of the conglomerate at Belfast, Ohio.

Pachydictya emarcescens, Foerste, (Plate 31, Fig. 30 a, b) Eaton, Ohio.

Pachydictya farcta, Foerste (Plate 31, Figs. 31), Eaton, Ohio.

Pachydictya rudis, Foerste (Plate 31, Fig. 32, 33), Eaton, Belfast, Ohio.

Pachydictya emaciata, Foerste (Plate 28, Fig. 8), Soldiers' Home and Fauver's Quarry.

Pachydictya bifurcata (Van Cleve), Hall (Plate 28. Fig. 9). Soldiers' Home, Fair Haven, Centreville, typical. At Brown's Quarry this species occurs with narrower branches (4 mm. wide), with more cells laterally in a distance of 2 mm. (=8 to 8.3 cells), but with the same number of cells in 2 mm. measured longitudinally (=5.5 cells). At Brown's Quarry forms with 7 cells in 2 mm. measured laterally, also occur.

Pachydictya bifurcata, var. *instabilis*, Foerste (Plate 28, Fig. 10), Brown's Quarry.

Pachydictya turgida, Foerste (Plate 28, Fig 11), Soldiers' Home, Fair Haven.

Pachydictya obesa, Foerste (Plate 28, Fig. 12), Soldier's Home.

Trigonodictya Eatonensis, Ulrich. The Bryozoa of the Lower Silurian in Minnesota, 1893, Eaton, Brown's Quarry.

Stictopora similis, Hall. In the cementing material of the conglomerate at Belfast, Highland county, Ohio.

Rhinopora verrucosa, Hall (Plate 28, Figs. 13, a, b, c), Soldiers' Home, Centreville, Fair Haven, Todd's Fork, collected at Yellow Springs, by E. W. Claypole. Fauver's Quarry, Brown's Quarry, the frondose variety. "Orthoceras" block at Huftman's Quarry, also at Siebold's Quarry on Brandt pike.

Hemitrypa Ulrichi, Foerste (Plate 28, Fig. 2), Brown's Quarry, Yellow Springs (E. W. Claypole's collection), Reed's Hill, common and typical at Siebold's Quarry, Fauver's, Soldiers' Home, Huffman's.

Phylloporina angulata, Hall (Plate 28, Fig. 1), Brown's Quarry, Yellow Springs (E. W. Claypole's collection), Fauver's Quarry, Soldiers' Home, Siebold's Quarry four and three-quarters miles from Dayton on the Brandt pike, Fair Haven, Todd's Fork, Centreville.

Homotrypa confluens, Foerste (Plate 29, Fig. 4a, b.). According to a letter from Mr. E. O. Ulrich the species belong to the section of *H. separata*. It possesses cystiphragms and mesopore-like interspaces, the latter however very short. Soldiers' Home, Centreville.

Aspidopora parmula, Foerste (Plate 28, Fig. 14), Huffman's quarry in the Beavertown marl; quite common at the same quarry in the upper shaly courses of the Clinton. Soldiers' Home, in the upper ferriferous layer of Todd's Fork. The completed frond is discoid in form, very thin, slightly curved so as to be convex above, about 25 mm. in diameter. A form with little areas about 3 mm. apart, within which the regular cells are very distant, giving the appearance of *lacunæ* in the frond; may be designated as var. *fenestelliformis*.

Callopora elegantula, Hall. Huffman's Quarry in the upper shaly courses.

Callopora magnopora, Foerste (Plate 29, Fig. 5). According to E. O. Ulrich it is doubtless a direct development of *C. ampla* of the Trenton, and *C. subplana* of the Cincinnati rocks.

Lioclemella (gen. nov.) *Ohioensis*, Foerste (Plate 29, Fig. 6). The following notes are taken from a letter to the writer from Mr. E. O. Ulrich, who very kindly assisted him here as well as elsewhere in his work. This species belongs to a new genus having relations to *Lioclema*, Ulrich, from which it differs almost solely in its mode of growth. *Lioclema*, as is usual with ramose forms is attached to foreign bodies by a broad, continuous basal expansion. In *L. Ohioensis* and other species of the same type, the zoarium is simple or but sparingly divided, and the base pointed, whether for articulation as in *Ptilodictya* or other cases can not be said. The new genus will include besides *L. Ohioensis*, Foerste, and *Trematopora ? nitida*, Ulrich, one or two undescribed Cincinnati species, most probably Whitfield's *Trematopora annulifera*, and perhaps his *Chætetes fusiformis* as well. Mr. Ulrich suggests the use of *L. Ohioensis* as a good type of the new genus. Centreville.

Ceramopora expansa, James, Todd's Fork, in the collection of Dr. Chas. Welch, son of Dr. L. B. Welch, the collector; Brown's Quarry, a typical specimen.

HYDROZOA.

Dictyonema pertenue Foerste (Plate 27, Figs., 27 *a*, *b*.). Soldiers' Home.

Dictyonema scalariforme, Foerste (Plate 27, Figs. 28, 29). Soldiers' Home.

Clathrodictyon vesiculosum, Nichols and Murie. Yellow Springs.

ANTHOZOA.

Heliolites subtubulatus, McCoy. Ludlow Falls, Fauver's Quarry, Huffman's Quarry, Fair Haven. At Brown's Quarry the form with cells 7 mm. in diameter occurs, also a second form with cells 1.2 mm. broad. Siebold's Quarry on Brandt pike.

Favosites favosus, Goldfuss. Fair Haven, Brown's Quarry.

Favosites favosoideus, Hall. Soldiers' Home.

Favosites Niagarensis, Hall. Fair Haven, Brown's Quarry, Soldiers' Home, Siebold's Quarry, Ludlow Falls. At Todd's Fork specimens occur with 10 tubes in a width of 18 mm. At Brown's Quarry, tubes 1.8 mm. in diameter occur, with 9–11 diaphragms in 4 mm. Another form has tubes 1.9 mm. wide, and 6 to 7 diaphragms in 4 mm. A third has tubes 2.2 mm. wide.

Favosites venustus, Hall. Ludlow Falls, Fair Haven.

Alveolites Niagarensis, Rominger. Ludlow Falls.

Striatopora flexuosa, Hall. Fair Haven, Ludlow Falls.

Halysites catenulatus Linnæus. Ludlow Falls, Fair Haven, Soldiers' Home, Siebold's Quarry.

Syringopora (Drymopora) fascicularis (Davis), Foerste. Ludlow Falls, Fair Haven, Siebold's Quarry on Brandt pike.

Aulopora precia, Hall, var. *compressa*, Foerste. Ludlow Falls.

Cyathophyllum celator, Hall, var. *Daytonensa*, Foerste. (Plate 34, Figs. 9–11.) Soldiers' Home.

Cyathophyllum? caliculum, Hall. (Plate 34, Fig. 8.) The outer area is supplied with dissepiments; the value of this character in distinguishing this form from the genus *Streptelasma*, the writer has not the material to determine. Soldiers' Home, Huffman's, Fauver's, Fair Haven. Casts of apparently the typical form occur at Collinsville, Alabama.

Ptychophyllum ipomea (Davis) Foerste. Centreville.

Diphyphyllum cæspitosum, Hall. Brown's Quarry, Ludlow Falls, Soldiers' Home, Centreville, Yellow Springs.

Acervularia Clintonensis, Nicholson. Yellow Springs.

Streptelasma Hoskinsoni, Foerste. (Plate 34, Figs. 1–6.) Brown's Quarry.

Streptelasma? geometricum, Foerste. (Plate 34, Figs. 7, 12, 13.) Soldiers' Home, Todd's Fork. This may be but another form of *Cyathophyllum caliculum*, but no dissepiments were noticed.

Streptelasma obliquins, Foerste. (Plate 34, Figs. 14, 15.) Hanover, Indiana.

CHAPTER VI.

THE FOSSIL FISHES OF OHIO.

BY PROF. E. W. CLAYPOLE, B. A., D. SC., (LOND.), F. G. SS. L.E. AND A.;
BUCHTEL COLLEGE, AKRON, O.; WITH A SUPPLEMENT BY
PROF. A. A. WRIGHT, OF OBERLIN COLLEGE, O.

No more interesting or more important contribution has been made from Ohio to the world's knowledge of its extinct forms of life than the chapter which begins with the breaking open of a concretion near Delaware, by the Rev. H. Hertzer, in 1864. He, by that stroke, exposed the earliest of the strange fleet of Upper Devonian fishes, clad in bony armour, which subsequent discoveries have so multiplied that it now forms a fauna scarcely second to that which was brought to day by the labors of Hugh Miller from the almost equivalent rocks of the Old Red Sandstone of Scotland.

Taking up the work where it was dropped by Mr. Hertzer, Mr. Terrell of Oberlin, and Dr. Clark of Berea, have been the foremost laborers in the field though others have given important assistance. Chiefly through the indefatigable efforts of these two men we now have collections of fossils equaling in interest and value those which have been yielded by any area of equal size anywhere. They have made the shales of northern and central Ohio classic ground forever to the palæontologists of the world.

It was the genius of the late Dr. Newberry that interpreted the fossils thus brought to light, traced their relations and illustrated their structure. He it was who sagaciously outlined the anatomy of the strange monsters of the Devonian seas leaving to his successors the task of filling in the details and extending the work.

No single species proved identical with any on the other side of the Atlantic and though new genera were defined to receive most of them, yet their family resemblance was obvious to the anatomist. Parallel types were found to have existed in both continents with wide differences of detail.

Since that time, however, further research has discovered a few European genera here and a few American types have been found in

Europe. By these "finds" the fish-fauna of the two worlds has been brought into closer agreement.

That no actual or immediate communication existed between the waters of Europe and of North America is rendered certain by the differerence of the species. But that such communication had once existed cannot be doubted when the obvious similarity of structure in the fossils-indicative of genetic connection, is taken into account.

Into this question however of Devonian and Silurian geography we cannot here enter. The evidence is too indirect to admit of condensation into the space at our command. One point in connection with these fossils is nevertheless of sufficient general interest to justify a short notice.

The line of descent of these strange armored monsters has not yet been traced. They appeared suddenly in the waters of the Devonian seas and at present stand as it were almost without father and without mother. But no one accustomed to modern views of the relationship of the animal kingdom, fossil or recent, doubts that behind creatures of so comparatively high a development there must have existed ancestors nearly as high, of which we at present know nothing. The rocks below those which have yielded such treasures must hold other treasures thus far unknown—the fossils of earlier seas hitherto unfound. This statement will be better understood after examining the following table.

The Cleveland Shale of Dr. Newberry (upper part of the Ohio Shale of this report) is the stratum from which have been extracted nearly all the fossils above alluded to. This is the uppermost part of the Devonian of Ohio of most authors, but it was placed in the Carboniferous by Dr. Newberry. Below it lie the beds as here given:

Devonian	Ohio Shale	Cleveland Shale	Fish-fossils abundant.
		Erie Shale	Fish-fossils absent.
		Huron Shale	Fish-fossils present.
		Hamilton Shale	Fish-fossils absent.
		Corniferous Limestone	Fish-fossils abundant.
Silurian		Lower Helderberg Limestone.	
		Salina Group.	
		Niagara Limestone.	
		Clinton Limestone.	
		Medina Shale.	

Thus we see that while the Cleveland shale is so rich the immediately underlying Erie Shale is absolutely barren, but the still deeper and therefore older Huron has yielded at least five species. Below this again the Hamilton or Olentangy has, so far as I am aware, proved entirely devoid of fish-remains, while the Corniferous Limestone, the base of the Devonian rocks of the State, is even richer than the Huron, holding as it does several large and striking forms of ichthyic life and abundant fragments of smaller species. It is hardly necessary to add that these statements refer only to the State of Ohio.

At the base of the Corniferous Limestone we lose in Ohio all trace of vertebrate existence and must go elsewhere to find any older forms. And even elsewhere the search has not been very well rewarded in so far as it regards the problem of the ancestry of fishes. Though the Upper Silurian strata of Europe have yielded a considerable number yet these differ in structure so far from those of Devonia that comparison is difficult, and direct lineage scarcely probable. Similar fossils were found in 1883 in rocks of almost the same age in Pennsylvania *but they furnished no new material for answering the question. The Silurian type is one and the Devonian another and very different and the links are lacking.

Some hope was raised in 1890 by a reported discovery of fish-fossils in Colorado, in Ordovician (Lower Silurian) strata.† But the results thus far have not realized the expectation, and the evidence is far from sufficient to bridge for the palaeontologist the enormous time-interval or to outweigh logically the immense improbability that creatures so comparatively high existed at a date so remote. Time will show, but at present we must admit that the origin of the vertebrates is shrouded in mystery.

Possibly the imperfection of the geological record is sufficient to account for the whole of this great gap in evolutionary history. So much destruction and relaying of the rocks has taken place that the old family record of the fishes may have been altogether destroyed, or if still in existence it may be buried deep beyond our reach. But if we may trust that the future will be as the past there is ample ground to hope that when the yet unexamined parts of the globe are studied by geologists, or even when a more thorough investigation shall be made of regions comparatively well known, we shall come upon precious fossils that will be eloquent to the ear of science regarding the ancestry of the long extinct but deeply interesting residents of our State before it had been raised above the waters of the primaeval ocean.

The discoveries of the Rev. H. Hertzer were made known to the world by Dr. Newberry at the meeting of the American Association at Buffalo, in 1866, and excited considerable interest. This was the greater because the beds in which they were found had been previously regarded as altogether barren. In like manner the Cleveland Shale where Dr. Clark and Mr. Terrell have since made discoveries rivaling those of Mr. Hertzer in all except date, was looked on by geologists as barren ground. It is so generally, but the fact that these usually unfossiliferous beds prove in certain places so wonderfully productive should encourage all to search well a stratum before condemning it.

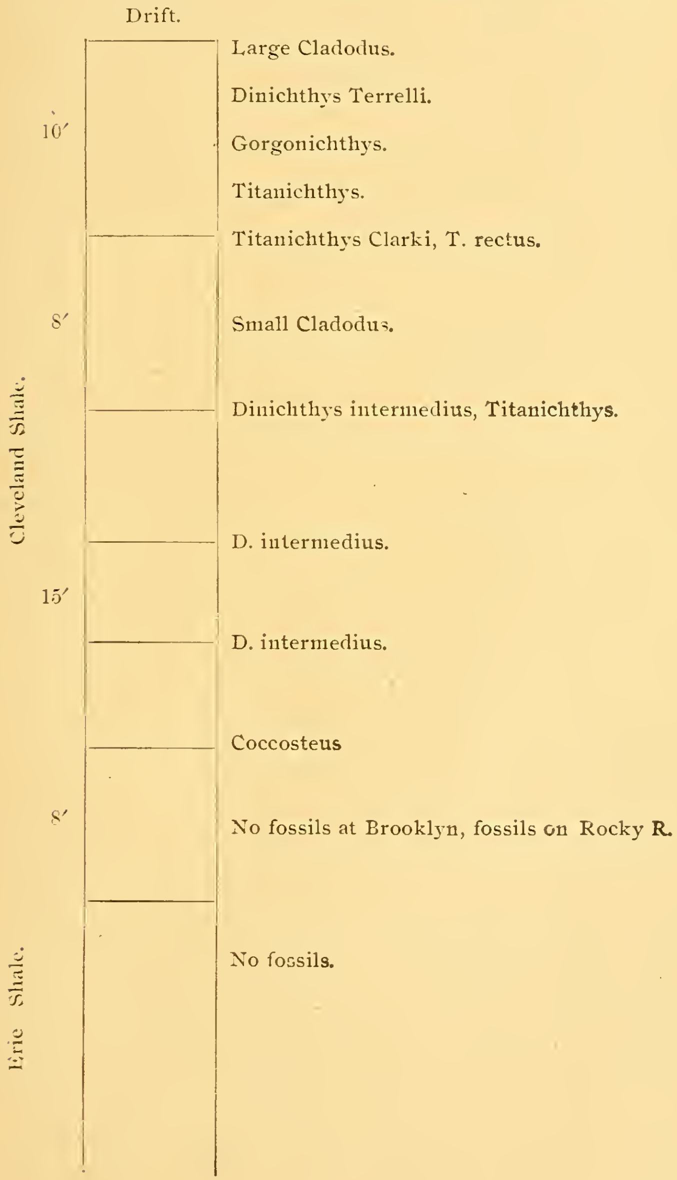
Accounts of the fossil fish fauna of the Ohio Shales have been published in three places—in the first and second volumes of the "Palaeontology of Ohio," in the "Monograph of the Fossil Fishes of North

* E. W. Claypole on *Palaeaspis* in Quart. Jour. Geol. Soc. Lond.. 1884 and '91.

† C. D. Walcott in Bulletin of Geol. Soc. of America, 1892, p. 153.

America" and in the annuals of the New York Academy of Science. All three came from the pen of Dr. Newberry, and since the appearance of the last named work nothing of importance has been published except a few articles in the "American Geologist," the results of which will be for the most part incorporated in this chapter which is intended to supplement the work of the late State Geologist of Ohio.

SECTION OF CLEVELAND SHALE IN CUYAHOGA COUNTY.



DINICHTHYS, Nby.

Of this genus of strange fishes that inhabited the early sea of Ohio the first described and the typical species, as already mentioned, was that found by the Rev. H. Hertzer in 1864, and named by Dr. Newberry *D. Hertzeri.* It is still the oldest known *Dinichthys* (excluding one doubtful form), having been found in the Huron Shale about 500 feet below all the rest of its congeners in Ohio. The shape of the mandible and its dentition proclaim at once its relation to the Coccosteids, but its size surpasses nearly tenfold the largest Coccosteus hitherto described.

Not until some years later was another member added to this ancient family and then it came from the Cleveland Shale on the shore of Lake Erie, where Mr. J. Terrell found another species with still more extraordinary dentition. In this species, *D. Terrelli*, the jaws are not set with teeth along the upper edge as they were in the older form but close one on another as a pair of shear-blades, the upper one cutting outside.

Since then *D. Gouldi*, named after its discoverer, *D. intermedius* and *D. curtus* have been added to the list, all of about one-half the size of the older species, and all showing the shear-blade dentition of *D. Terrelli*, *D. corrugatus* and *D. minor* are still smaller species whose dentition is not yet fully known. The fragments found do not prove the presence or absence of the cutting shear-blade. Of *D. tuberculatus* only a few plates have been found and these do not include the jaw. They came from the Chemung near Warren, Pa. It is noteworthy that this species is said by Dr. Newberry to be identical with one found near Liége, in Belgium, and now in the collection of Prof. Lohest of that University. If so it is probably the only international species of fish yet found in Ohio.

All these additions to the Dinichthyid family, except the last, have come from the Cleveland Shale of Northern Ohio.

It is very doubtful if the dorsal plate from the Corniferous Limestone called *D. præcursor* will prove to belong to the genus when its other parts are known.

Of *D. Ringuebergi* (*minor*), from the Portage Group of N. Y., only a single dorsal plate has been described, and *D. Newberryi* is represented by the mandible only.

In addition to the above a single premaxillary tooth (of N.) was lately described by Mr. Whiteaves from the Upper Devonian of Snake I, in L. Winipegosis, Manitoba, and this, named *D. Canadensis*, with a doubtful *D. Eifelensis* from Belgium, completes the list of named and described species of this genus down to date so far as the writer is aware. After this chapter was put into type three additional species were described by the writer in the *American Geologist* for December, 1893.

A New Species of Dinichthys.

In Dr. Clark's collection is a single mandible of a *Dinichthys* which I cannot identify with any of those already described and am therefore obliged to consider it new. It is represented on Plate XLI fig. I. A glance will be sufficient to assure any one familiar with the genus that it can belong to none of the four heavy forms—*D. Hertzeri*, *D. Terrelli*, *D. curtus* and *D. intermedius*. From *D. minor* and *D. Gouldi* it differs in its greater slenderness and from the former also in its lack of the second denticle. It more resembles *D. corrugatus* but surpasses even this in lightness. With *D. tuberculatus* we cannot compare it as the jaw of that species is unknown. Moreover, it was found in Pennsylvania. The upturned end of the mandible is almost at right angles with the shaft which carries on the upper edge a thin wing of bone beveled off to a feather blade and continued up the hinder face of the front tooth. The upper edge of this blade is not even, being low in front as shown in the figure. But there is no sign of the trenchant cutter which characterizes several species of this genus and indeed with so thin and slender a mandible such a blade would have been powerless, for this jaw can hardly have been employed as a weapon of offense by its wearer. The narrowness of the spatulate expansion at the back would also indicate that the motor-muscles were less massive than in the more formidable species. So far as I am aware this is the only part of this *Dinichthys* that has yet come to light and it was found in Cuyahoga county, O., and I have named it *D. gracilis* from its slender build.

Structure of the teeth of Dinichthys.

The shear-blade of the mandible of Dinichthys shows an interesting microscopical structure well adapted to the work which it performed. As many artificial cutting-tools it is composed of a dense material forming the edge backed by a less dense and brittle substance to sustain the pressure.

A polished section of the mandible is represented on fig. 1. Pl. 43. The inner part is of a deep brown color, almost black, solid, and to the eye homogeneous. The outer part is dense in texture and lighter in tint. When cut or ground down thin for microscopic examination the two parts as shown in the small figures present very different appearances. The open and spongy tissue of the jaw (figs. 2, 3) is traversed by a great number of very wide Haversian canals with thick walls in which are scattered the lacunæ or osteoblasts in moderate abundance with their accompanying canalicules. The Haversian canals are so large and numerous that they occupy most of the space, the solid portion of the bone consisting merely of their walls and these do not exceed in thickness the diameter of the canals. These latter are filled with pyrites which is perfectly opaque and shows in clear distinction from the bone which is stained dull red with infiltered material.

On contrasting this structure which characterizes all the bony plates of Dinichthys as well as the jaw with that of the inner and solid dense portion, the difference is obvious. The large Haversian canals of the former are represented by the merest traces (fig. 5). Successive deposits of bone on the inner faces of the walls have so far lessened their diameter that they are almost effaced while the solid tissue filling their place is crowded with lacunae and traversed in every direction and in every spot with canalicules forming a perfect and minute net-work over the field of the microscope—a feature which could not be well shown in the same figure without overcrowding it, but which is represented in a small degree in fig. 5.

This dense bony tissue forms upwardly the inner edge of the mandible, and as the shear-tooth of the upper jaw closed down outside of it the constant use and wear ground down the outer soft tissue and kept a permanent, sharp edge upon the inner bone thus exposed, as shown in figure 1.

It is not easy to see with such a structure of the dental apparatus how any renewal of the tissue was possible, and probably the life of the creature was limited to the duration of its mandibular edge. That very extensive wear actually occurred is evident from the appearance of specimens which have been found and which show no indication of repair. This is contrary to the usual structure of fishes where provision is generally found for the renewal of the dentition almost *ad infinitum*.

This dense tissue of the mandible in no respect resembles true tooth structure. There is no trace of dentine or of osteo-dentine, still less of enamel. It is true bone, but exceedingly dense and hard, and consequently more resembling the cementum of the teeth of the higher vertebrates. In this respect however it is in close accord with the tooth-structure of most fishes which is traversed by similar canals and contains abundance of lacunæ and of inosculating canalicules. It is, in fact, a kind of trans itional materal between typical bone and typical tooth.

TITANICHTHYS.

When Dr. Newberry published his "Fossil Fishes of North America," he mentioned two species of this genus. These were all that were then known from Ohio, and the genus has not yet been reported elsewhere.* Of these two species *Titanichthys Clarki* was the larger and heavier form *T. Agassizi* the lighter and slenderer. The type of the former is in the Museum of Columbia College, in New York, and that of the latter in the Museum of Comparative Zoology at Cambridge.

In the present state of our knowledge it is not possible to characterize the whole fish. Only separated and scattered parts have thus far been found, except in a few cases. Of these parts the most frequent and

* *Titanichthys Pharao*, of Dames, from the Cretaceous of Egypt of course drops as a synonym, being published only in 1887. This fossil has no connection with those here mentioned.

at the same time the most characteristic are the lower jaws or mandibles. It is consequently advisable for the present purposes to define the various species by these organs, reserving the special appropriation of the other plates and bones to their several jaws until accidental discovery of specimens showing them in direct or indirect combination shall furnish the requisite evidence, or until their structure can be interpreted by the analogy of kindred or similar species. By this plan the multiplication of names is avoided.

On this method of distinction we now add to the genus a third species whose jaw differs from the other two in the absence of curvature. Wide at the spatulate or hinder end it narrows and thickens forward developing the gouge-like form of the other species by the incoming of the alveolus. In consequence of this straightness which at present sufficiently characterizes the mandible, we propose for the species the name of *T. rectus*.

One of the most remarkable of the fish fossils of the Cleveland shale lately discovered is figured on Plates XXXVIII and XXXIX. It consists of three bones, two at least of which are in their natural position. The largest of the three—an exceedingly massive plate—measures 17 inches by 17 and is of the form of a carpenter's square, consisting of two arms meeting at a rounded right angle. Of these two arms one, as shown, is a plate perfectly flat on one face and straight on one (outer) edge while the other, curving from the point sweeps out and meets it at a slightly acute angle. Both edges are thin, the latter showing a slight underlapping margin. The other arm, also nearly plane, is narrow and much thicker than the former and makes at its end a sutural connection with the bone next to be described.

From the extreme point of the first plate there rises gradually a strong flange which becomes higher and thicker as it nears the angle. At length it separates and forms a wide, strong bone nearly as heavy as the other which it really doubles. (Pl. XXXVIII.) This also ends in a form that seems to indicate sutural connection with some other bone. Considerable space is left between the branch and the main plate at their ends but a curved bony connecting plate exists throughout.

To the suture first mentioned at the end of the plate is firmly united the second of the series, which is of the same general form as the preceding but its angle is turned in the opposite direction. This bone is very thick and rounded. One arm measures five inches and the other four inches in length. Its free end indicates a suture to form a connection with another yet unknown.

The third bone of this set lay across the second in its angle. Its length is about ten inches and it is somewhat club-shaped, tapering down from the large end which is in contact with the other bone. See figs. plates XXXVIII and XXXIX.

That these three plates are organically related admits of no reasonable doubt. Two of them are still in union and the third cannot have been much if at all displaced. Its position suggests the possibility that it may in life have been united with the branch plate mentioned above whose end indicates such a suture.

Regarding the position of these bones in the fish we cannot be certain That the flat plate was external and ventral can hardly be doubted. That the flange and other bones were so is unlikely. Bones so heavy must have served an important purpose in the economy of the animal, and it seems quite legitimate to regard them as the supporting mechanism of the fins or locomotive organs whatever these may have been.

This reference would bring them into the position of the shoulder or pelvic girdle of one of which they probably are parts. The elements of the former are the scapula, clavicle and coracoid but among these it is not easy to determine which of these is, or are represented.

The plates have considerable resemblance to one figured by Dr. Newberry, on Plate XLVIII of the Palaeozoic Fishes, as the clavicle of *Dinichthys*, though the specimen represented in his figure seems to possess only one of the parts here described. The two are almost equal in size but differ considerably in outline as may be seen on comparison. Though the cranium is not present yet the other plates indicate that the whole "find" was a specimen of *Titanichthys*, and we can therefore scarcely do otherwise than consider these three bones as a part of the or pelvic shoulder girdle of that genus.

Yet the massiveness of these bones ill agrees with the thinness of the armour of the head of Titanichthys, but we must bear in mind that so vast a body needed powerful moving organs and that these in turn must have had a heavy framework to carry them. The shoulder girdle need not have corresponded in lightness with the cranium.

Dr. Newberry says of a specimen of an apparent homologous plate in his possession (p. 131). "A strong framework was required for the locomotive apparatus of so large a fish and some of the bones of the shoulder girdle are remarkably large and strong. The coracoid for example is nearly two feet in length and one end is a massive, cylindrical bone nearly as large as one's arm. The clavicles are more than two feet in length but were composed of a relatively thin shell of bone which was once lined and reenforced with cartilage."

The specimen in the hands of Dr. Newberry if homologous must have differed considerably from that here described, but the differences may have been due to age, sex or species so that it does not necessarily exclude either from the genus.

We may add that these probably belong to the right side of the fish and the specimen of Dr. N. to the left. The latter also seems to represent only the first of the three bones here described.

If we carry on the comparison to the case of Coccosteus, we should consider these plates the homologues of the interlaterals of that genus. But in those no sign of sutural separation is indicated in any of the figures or descriptions that are accessible to me. Perhaps the small size of Coccosteus may render this intelligible, as the whole clavicle there does not exceed two inches in length.

On Plate XXXIX is figured, on the same scale, a smaller plate obviously homologous with that above described, but found by the Rev. H. Hertzer in the Huron Shale at Delaware, O. As the Huron Shale has thus far yielded no specimens of *Titanichthys* it is reasonable to refer this specimen to *Dinichthys Hertzeri*, though so little has yet been done in the above named stratum that the reference must be merely provisional.

Again on Plate XXXVIII is figured on the same scale another homologous plate in the collection of Dr. Clark, only six inches in length and differing from both the others. There are the same flat surfaces on one side and the same strong ridge rising into a flange and then becoming separate so as to form a double bone at the thick end.

It seems likely, therefore, that plates of the same general form and nature composed parts of the skeleton of *Dinichthys* and of *Titanichthys* with differences of size and outline betokening distinct species.

The bone figured on Plate XL, fig. 1, is also provisionally referred to Titanichthys. That it was a median plate admits of no doubt. That it was a ventro-median is almost as certain. It would in that case correspond to the "lozenge-plate" of Coccosteus. It is very thick and solid and shows a wide overlapped margin all round. At one end is shown another plate which formed a continuation either forward or backward, fitting into the socket excavated in the larger plate. This would then correspond to the antero-ventro-median of Coccosteus.

Dentition of Titanichthys.

Since the publication of the Monograph on Fossil Fishes a considerable amount of detail regarding the dentition of *Titanichthys* has been discovered, and we are now able to represent it much more fully than was then possible. A reference to that work will show that the evidence at hand induced Dr. Newberry to believe that the grooved mandible was covered with horn, as in the turtle, or held bony wedges which had disappeared. In addition to this he figures in Plate XLVIII a tooth doubtfully referred to *T. Clarki*. The latter of the two structures above mentioned is now known to have been the actual one, in consequence of the discovery by Dr. Clark of the teeth of this species which are represented in place in Fig. 2 of Plate XLII.* One of these was found as represented, the other is supplied from the evidence given by the jaw.

*NOTE. Several slight differences between the specimen here figured and that given in the Monograph will be noted on comparison, but in the present condition of our knowledge they are not important enough to constitute a specific distinction.

The largest of these teeth is almost four inches long and bluntly conical, and was set in the alveolus of the jaw as shown. This structure is not common among fishes where the teeth are either attached to the skin as in the shark, etc., or are anchylosed to the mandible as in most of the Teleosts. Examples are not, however, wanting of their insertion in an alveolus or even in distinct bony sockets as in *Pristis*, *Sargodon*, etc.

Though we actually know the teeth of *T. Clarki* only, yet it is scarcely rash to infer that the other species were similarly furnished.

The only parts previously described of *Titanichthys* were as follows:

Titanichthys Clarki; Mandibles, Ventral? plate, Suborbital, Suprascapula and Coracoid with a tooth marked doubtful. (Monograph, Newberry.)

T. Agassizi; Mandibles, Cranium, Suborbital, Exoccipital (part.) (Monograph, Newberry.)

We have at present no means of determining to which species the clavicles? here figured belong as no part of the head was found with any of the specimens.

Regarding the habits of the genus we can do little more than speculate. A glance at the mandibles represented on Plate V is sufficient to show that they cannot have been tyrants of the ocean as were the Dinichthyids. Jaws so long and slender were ill-adapted for tearing and fighting. They lacked the bony strength and motive muscles of *Dinichthys*. Yet the teeth were formidable to creatures less heavily armoured. The size of the mouth, 3 by 4 feet when open, enabled *Titanichthys* to take in fishes of no small size which were most likely swallowed whole or but slightly crushed. But the thinness of the plates of the head rendered it far inferior to *Dinichthys* as a warrior.

The suggestion has even been made that *Titanichthys* was a vegetarian and used his long jaws and their teeth for collecting sea-weed. Such a mode of life is possible but far from probable. Few fishes, so far as we know, live on sea-weed and very few large fishes are not carnivorous. Some day the coprolites will be found and will solve the problem.

Titanichthys attenuatus, Wright, sp. nov.

(Plate 42, Figs. 1, 2.)

Mandible, slenderer and lighter than in the two species of the genus, described by Dr. Newberry, the anterior portion running out into a thin,

NOTE. To state more minutely and exactly the evidence on this somewhat critical point we will give the details of this find: The base of a tooth was found set in the alveolus but the tip was missing. About three inches from this spot the second tooth was found broken into two pieces. One of these, the base was in the same slab with the jaw. The other was in the adjoining stone so that the parts were only separated by a natural joint.

The attachment of the teeth to the mandible was not apparently very close, and certainly there was no bony union as this is the only specimen yet found showing teeth that can confidently be referred to the genus.

flat plate, somewhat horizontally directed, but bent upward as it proceeds forward; extremity truncated; the groove upon the upper surface of the mandible forming a broad and shallow trough which becomes obsolete anteriorly several inches before reaching the extremity; the under surface of the mandible slightly concave along its median axis, while the outer and inner longitudinal angles are somewhat thickened and rounded, the inner angle approaching the outer angle as it runs backward.

Total length of the portion figured	14 inches
Breadth at anterior end	$1\frac{3}{4}$ inches.
Breadth at posterior end	$2\frac{1}{4}$ inches.
Greatest width of upper groove	2 inches.

Locality; Cleveland Shale, east branch of Vermillion river, Florence, Huron county, Ohio. Collected by Jay Terrell, Esq.

The specimen upon which this species is based is one of a considerable series of Titanichthys bones in the museum of Oberlin College, discovered by the indefatigable and experienced collector, Mr. Jay Terrell. Although the posterior part of the mandible is missing, the most characteristic anterior portion is perfectly preserved; and, as is well known, no portions of the skeletons of the fossil fishes of the Cleveland Shale are more distinctive than the mandibles. I have for comparison specimens of the mandibles of *T. Clarkii* and *T. Agassizii*, of Newberry;* and while the present species approaches the general outlines of *T. Clarkii*. it is distinctly slighter and lacks the compressed form with narrow and deep superior groove of that species, and has no approach to the tolerably stout, gouge-like anterior extremity which characterizes *T. Agassizii*. The exceedingly thin p ate, only an eighth to a sixteenth of an inch thick and three or four inches long, into which the mandible is drawn out anteriorly, seems to reach the climax of the surprising contrasts in the skeletal structures of these two genera of huge fossil fishes *Titanichthys* and *Dinichthys*, which swam the seas of northern Ohio together in the Paleozoic era. Especially is this true, as the weaker dentition belongs to the larger fish.

As to the nature of the functional surface of the mandibles of *Ti anichthys*, whether it was covered with a horny sheath, or whether the groove was set with bony "teeth," the specimens at my command yield no positive information. The present species furnishes less suggestions than does *T. Clarkii* that there was a horny sheath as Dr. Newberry inclined to believe. None of the species of *Titanichthys* could have been so predaceous as *Dinichthys* plainly was; and the present species would seem to be a retrograde development from the more typical forms of the genus, in that the possibility of any powerful use of the mandibles seems to be more widely removed. This suggests that its food must have been either simple vegetation or minute pelagic animals, which require no very

* Paleozoic Fishes of N. Am., Monographs U. S. Geol. Survey, vol. 16.

hard mouth parts either for capturing or for mastication. The causes which produced the retrogrde development in the jaws of some modern Sirenians may have wrought with corresponding effect upon the jaws of *Titanichthys*.

The details of the structure of the anterior part of the mandible are exhibited in the series of cross sections given in figure 2 of the plate. The posterior portion of the mandible was not preserved; but if it was as long proportionally as in the other species the entire length may have reached thirty inches. This description was contributed by Prof. A. A. Wright.

Gorgonichthys Clarki, Cl.

Formidable as was the dentition of both the species of *Dinichthys*, the researches of Dr. Clark in the Cleveland shale have lately been rewarded by the discovery of an armored monster whose offensive weapons surpassed even those carried by these terrible fishes. In 1891 he found a pair of mandibles presenting characters not previously recognized and with them a mass of bony plates evidently belonging to the same creature. Little of the material has yet been worked out, but following the principle here adopted of defining the species as far as possible by the lower jaws, they were first extracted from the matrix. It then became obvious that in several respects they differed from any previously known. The shearing tooth and edge of the lower mandible were lacking. In place of the latter was a blunt process rising at some distance behind the great front tooth and set with rounded tubercles on its fore and hind slopes. Opposed to this in the upper jaw was an enormous doubly pointed tooth so set as to play on the top of this process which was received between its two points. This character alone is sufficient for the identification of the genus if the mandibles are obtainable. No doubt when the rest of the plates have been extracted from the matrix, or other specimens found, many more characters will be determinable.

The great front tooth so closely resembles that of *Dinichthys* that no special description is requisite. Its antagonist in the upper jaw closed down behind it as usual in *Dinichthys* but only its tip was present in this specimen, the rest having been broken off at or before its discovery. This tip lay in the groove which it had worn in the back part of the lower tooth as shown in the figures, but for the sake of clearness it has been represented lying entirely clear. See Plate XLI.

In size the mandible of *Gorgonichthys* about equals that of *Dinichthys*, being about 25 inches in length. But it is considerably heavier and better adapted to meet the greater weight of the opposing tooth in the upper jaw. This tooth measures nine inches from front to back by seven in a vertical direction. Like the rest it consists of the peculiarly hard, black, dense, bony tissue of which the shear-tooth and blade of *Dinichthys* are composed. The structure of those parts enabled them to resist the severe usage to which they must have been subjected.

The enormous teeth of *Gorgonichthys* constitute the most formidable dentition known in the animal kingdom, unless possible exception be made in favor of the great Eocene shark, *Carcharodon*.

Coccosteus Cuyahogæ, sp. n.

A single plate was described by Dr. Newberry in the second volume of the Palæontology of Ohio (p. 32), which so closely resembled the dorsomedian plate of *Coccosteus* both in form and in ornamentation, that it was named *C. occidentalis*. This, if rightly named, was the first specimen of the genus from North American strata, all previously described having come from Europe. In the first volume of the same work Dr. N. had figured a small jaw under the name of *Liognathus spatula us*, and suggested that it belonged to the same fish or was at least Coccostean. The specimen is very imperfect and it is impossible to feel certain of the reference. If it really belongs to this genus it differs considerably from all the other known mandibles.

Both these fossils came from the Corniferous limestone at Delaware and belong consequently to the lower part of the Devonian strata.

Since the publication of Dr. Newberry's report, Mr. Whiteaves, of the Canadian Survey, has published the *description of a *Coccosteus* (*C. Acadicus*), from the lower Devonian beds of Campbelltown, N. B., whereby the geographical range of the genus is extended to the Atlantic coast in the northeast.

Coccosteus does not occur in the lowest or flagstone beds of Scotland and is not found until the middle strata are reached. In Acadia it is associated with *Cephalaspis*, a fossil characteristic of the lowest Scottish Devonian. Conditions probably had much to do with this distribution but the evidence of the vertebrates seems to point to a conclusion that the Corniferous of Ohio does not exactly correspond to the lowest Devonian of Europe, but rather to the overlying strata there classed as middle Devonian. The complete absence, so far as yet known, of all Cephalaspidian and Pteraspidian fossils bears strongly in the same direction especially as we now know that fishes of this order existed in New Brunswick in early Devonian and in Pennsylvania in late Silurian times.

The recent discovery by Dr. Clark of a *Coccosteus* in the Cleveland shale enables us to add another species to the American list and to carry the upper limit of its generic range almost to the top of the Devonian system.

The new species is much larger than any previously reported. The largest of the Scottish species (*C. decipiens*) measures only sixteen inches

* Illustrations of the Fossil Fishes of the Devonian rocks of Canada, 1881.

in length and its jaws are but three inches long. *Liognathus*, of Dr. Newberry, is yet smaller. But the anterior part of the new species—the only piece found—is five and a half inches long and indicates at least eight inches as the total length of the mandible when perfect, that is to say, a living *Coccosteus* of about forty inches. This is in harmony with the great size attained by the other species in late Devonian time.

The mandible shows a row of eight blunt denticles on a raised part of its upper edge in advance of the middle. In front and at the back of these the edge is lower. The characteristic symphysial teeth are present, but have been broken so that only their bases can be seen. There are three of these, as may be seen by an examination of the end view of the mandible shown at *a* in figure 2. The number of these in *Coccosteus* varies from five to eight. In Hugh Miller's figure six are represented, though only five are spoken of in the description.*

In writing of the mandibles of *Dinichthys* and *Titanichthys* (Monog. p. 132), Dr. Newberry has likened them to that of *Coccosteus*. He says:

"I found in the British Museum a number of jaws of *Coccosteus* in which the form is essentially that of *Dinichthys*, viz., the anterior extremity is turned up and forms a prominent denticle and the whole organ is only a miniature copy of the mandible of *Dinichthys Hertzeri*."

There is, however, no such resemblance between the jaws here described and those of *Titanichthys* and *Dinichthys*. No indication of the upturned tip forming a pointed tooth can be detected. Nor is any semblance of such a structure shown in any figure of *Coccosteus* known to the writer. The explanation of the confusing statement of Dr. Newberry is given by Mr. A. Smith Woodward, in his "Catalogue of Fishes in the British Museum," (p. 285, vol. II), where he writes: "This and the following specimens are probably referred to by Newberry as closely resembling the mandibular rami of *Dinichthys*. The beak-like appearance, however, is entirely due to the accidental flaking of the bituminous substance into which the fossils are converted."

The Sharks of the Cleveland Shale.

But these gigantic Placoderms or armor-clad fishes were not the only denizens of the ancient sea of Ohio. If they dominated the muddy bottom where the black shale was accumulating as do the mud-fish of the present day, yet above them in the clearer water swam sharks of various forms and sizes. Between them these two groups probably divided the empire of the sea.

We as yet know only a few of the latter group. The labors of Messrs. Fyler and Kepler, and especially later of Dr. Clark, have brought to light several specimens, the first of which were figured in the Monograph by Dr. Newberry under the names of *Cladodus Kepleri* and of *C. Fyleri.*

* Old Red Sandstone.

The fossils are unfortunately not very well preserved, being, as is usual in this formation, heavily pyritized. But to the palæontologist they are nevertheless invaluable. Thus far we have known nothing of the form and appearance of these early sharks. Containing, as do all the rest of their family, a skeleton that was almost entirely cartilaginous, they left few fossil bones or plates to carry down to us an idea of what they were. Their disjointed teeth which, being attached to the skin of a jaw for the most part cartilaginous, were set free by its decay and strewn over the sea-bottom, together with the strong and often highly ornamented spines which fronted the dorsal and other fins, have hitherto been almost the only relics of the shark-life of the older seas. On these teeth and spines genera and species have been founded for want of better data, and doubtless in not a few cases the temporary nomenclature thus established will be found largely synonymous. Not a few of these genera and species are based on a single tooth, and when we consider the variety of form and pattern of the teeth in the mouth of a single shark we can fully understand how one fish may be bearing several names. This is unavoidable in the present state of our knowledge, but cannot lead to serious error except in those who are unacquainted with the limits of discovery. The palæontologist will not be deceived, because he well knows that these terms are merely the names of teeth or spines and not of fishes, and he is awaiting the time when their connecting links shall be found.

These few words of explanation will serve to show the value of the recent discoveries in the Black Shale of Ohio. Though in consequence of their want of distinctness we are unable to characterize the species as fully as is desirable, yet we are able for the first time to form a conception of the general form and outline of these primæval elasmobranchs and to recognize in them many of the features that mark their descendants of to-day.

The specimen described and figured by Dr. Newberry was found by Mr. Fyler. A second was discovered by the Rev. W. Kepler and a third by Dr. Clark. The last was figured under the name of *Cladodus Fyleri*, but no description was given and there is apparently very slight ground for its separation from the former. No teeth are visible.

Since the Monograph was issued several other specimens of these sharks have been found by Dr. Clark, indicating the existence of other species, one of which will be described below.

Considering the nature and date of these fossils we are justified in drawing the inference that the sharks are among the oldest ichthyic inhabitants of our globe. They shared the Devonian seas of Ohio with the Placoderms and their teeth are found yet deeper in the Corniferous Limestone. Shagreen, indicating shark-life, occurs in the English Ludlow or Upper Silurian rocks among almost the oldest fish-remains known in the Old World and no vertebrate remains of undoubted authenticity are yet known below the Upper Silurian strata. We must therefore date the primeval sharks as the comrades or the antagonists of the primeval Pteraspidians of the Silurian seas.

The genus Cladodus was founded by Agassiz in 1843 to receive certain teeth consisting of a median cone on an elliptical base with one or more lateral denticles on each side, the largest of which (if several were present) were at the two extremities. The tooth of the species described by Dr. Newberry was of this character, with however only a single denticle on each side, as shown in Plate XLVI. The second specimen, figured as *C. Fyleri*, shows no teeth and was referred to the genus from its general resemblance to the former.

One of the specimens found by Dr. Clark is of a very peculiar form, and allowing for a considerable change due to the conditions of fossilization which may have somewhat modified its original outline, it yet markedly differs from Dr. Newberry's species. It is shown on Plate 43, fig. 6. Its reference to the genus Cladodus must be regarded as merely provisional as no teeth have been found with it or on it. The head is wide behind and narrower in front. It was comparatively a small fish, not measuring more than twenty-eight inches in length, allowing for the incomplete condition of its posterior end. The body is thicker in proportion in the middle than is usual with sharks and tapers rapidly behind. The pectoral fins are less straight in outline and less rigid than in *C. Kepleri*. They contain about seventeen or eighteen rays the larger of which fork near the tip. The margin is membranous.

At its hinder end the body or rather probably its superficial skin is extended into a wide membranous sheet lying horizontal, rather abrupt in front and tapering away behind till it merges in the median extension of the body carrying the caudal fin. This fin is not shown but the bases of two distinct bony rays are seen indicating its presence. These spinous rays are better shown in some of the other species.

No ventral or anal fins are visible, they having been apparently of a very soft and perishable nature, differing much in this respect from the powerful and thick-rayed pectorals. Traces of the jaws and of the branchial arches remain. The shagreen covering the body is well preserved in many places. No trace of a dorsal fin or of any fin-spines can be detected. The dorsal surface is shown for the most part except where the stone flaked so as to expose the lower aspect near the head. There is consequently no appearance of the scaly ventral defensive skin, that is seen on these fossils when the lower aspect is exposed.

For this species the name *Cladodus? sinuatus* is proposed, on account of the sinuous outline of the head as it is preserved in the fossil.

Another of Dr. Clark's specimens shows in spite of the necessary indistinctness of a pyritized fossil, points of divergence so strongly accentuated as to render it doubtful if it can rightly be referred to the same genus. Yet in other respects it so clearly resembles the above as to forbid the drawing of any very strong line of demarcation between them.

In general outline they correspond. The caudal fins are better preserved but do not apparently differ in any essential feature. The ventral and anal fins are not preserved. The single specimen yet found shows the dorsal aspect and the shagreen coating differs little if at all from that of the other species. The pectoral fins are also of the same form as in those but contain about twenty rays.

But the fossil measures sixty-three inches in length, in spite of some slight imperfection at the hinder end, and its teeth which are remarkably well preserved and have been exposed with great care and skill, show none of the usual cladodont features in the presence of lateral denticles. For these reasons I am induced to separate this large form from the others generically and yet to indicate its relationship by adopting the name *Monocladodus*, in allusion to its single coronal tooth, which is shown in Plate XL, fig. 2.

The tooth consists of a single flattened pointed medial cusp, slightly striated below and forking near the base which does not outwardly extend beyond the front of the cusp, but inwardly widens out so far as to form a spreading surface of attachment to the skin of the jaw. In front view the general form is strikingly suggestive of *Lamna*, but the resemblance disappears on close examination. The striation is strictly confined to the lower part of the cusp and does not consist merely of a longitudinal roughening or of a faintly visible line-marking as in *Cl. Kepleri*, but of distinct and tangible unevennesses of the surface. The front face is nearly flat, the hinder convex or doubly sloping

Perhaps the most remarkable peculiarity of these teeth lies in the fact that toward the back of the jaw they stand in pairs as shown in the figure, one being close outside of the other. The outer one is frequently broken, but this has evidently been done during fossilization or in the extraction of the specimen from its refractory matrix. At least four of the eight teeth remaining in position in the left mandible show this character and more than one on the right side is also double. It is therefore not an accidental circumstance. Moreover in the front part of the jaw two at least of the teeth show at their bases, outside, what are apparently the points of others that scarcely rise above the base of those in front of them. These cannot be young teeth, for the young teeth in the sharks grow inside and behind those outside them which show signs of use and wear that are not visible on these. If the outer teeth are really in the act of being shed they would scarcely present the appearance shown by those in the front of the mouth though this interpretation might be accepted regarding those near the back of the jaw.

I propose to give to this fish the name *Monocladodus Clarki.* It was found in the Cleveland Shale in Cuyahoga county, Ohio, by Dr. W. Clark.

Supplement.

ON THE VENTRAL ARMOR OF DINICHTHYS.

By Prof. Albert A. Wright, Oberlin, Ohio.

PLATE VII.

Owing to the isolated and imperfect condition in which most of the remains of Dinichthys are found, it has not yet been possible to give a complete account of the skeleton and armor of the fish, or to assign the plates to their correct positions. Many unfigured and undescribed bones in the collections are awaiting the hitherto undiscovered evidence as to their precise position and relationships. From time to time, however, advances are made by the finding of more perfectly preserved materials, either in their correct original relations or in those that are very suggestive; and I am now fortunate enough to be able to add something to our previous knowledge of the ventral armor of Dinichthys from specimens in the museum of Oberlin college.

The facts which I have to offer are not precisely an addition to knowledge in a region where nothing was known before; but principally a rearrangement of some of the isolated elements of the armor, which elements have already been figured and described.

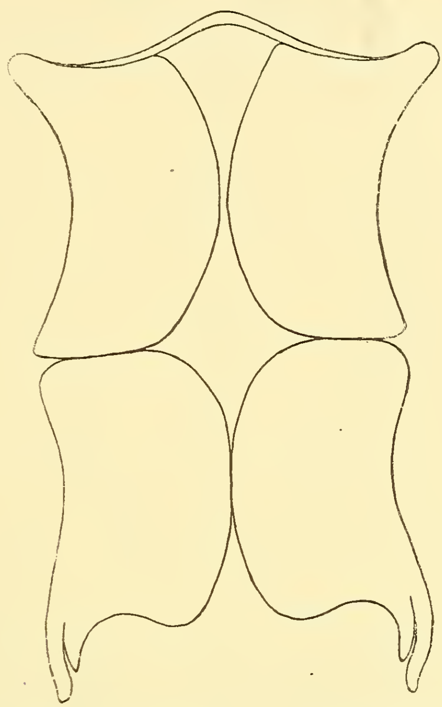
In order that these facts may stand in a clear light, it will be necessary to refer to the original account of the ventral armor given by Dr. Newberry in the Paleontology of Ohio* and to his supplementary account in the Monograph upon the paleozoic fishes of North America†

These accounts give an instructive history of the progress of discovery in this field, and of the changes which it has already been necessary to make in the arrangement of the plates.

*Ohio Geo. Survey, Paleontology Vol. II.

†U. S. Geol. Survey, Monographs, Vol. XVII.

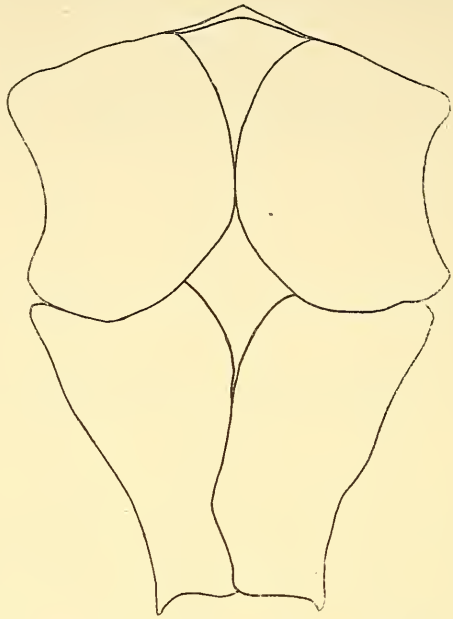
In the former of the two volumes above quoted the five plates which were originally supposed to constitute the "plastron" are figured in outline (p. 10) and fully described. The cut is here reproduced.



Ventral Armor of Dinichthys Terrelli N. Dr. Newberry's first restoration.

The upper pair are designated as "anterior ventrals," the lower pair "posterior ventrals," while the narrow one between the anteriors is the "ventral median" plate. The general correspondence of this plastron with that of Coccosteus as restored by Pander is noted, as well as the divergencies, which latter are greatest in the posterior pair.

Prior to the publication of the Monograph referred to above (1889), the true position of the so-called "posterior ventrals" was found to be upon the sides of the head, where they constituted the "sub-orbitals," and to this position they are assigned in the latter work. The place thus left vacant in the plastron is not positively supplied by anything described in the Monograph. The subject is alluded to however as follows: "No figure is given of the plates which are supposed to have formed the posterior half of the plastron, because no perfect ones have been found, but I have numerous fragments of relatively large plates which must have been oblong in form and had the moderate and uniform thickness and plainness of surface which characterize the plates that defended the under side of the body. As they are apparently assignable to no other place in the armor of Dinichthys I provisionally locate them here." (P. 138).



Ventral Armor of Coccosteus decipiens, Ag. Pander's restoration.

But while the vacancy in the plastron in not positively filled, another series of four bones is described which is believed to have defended the under side of the head. These are a pair of "jugulars" fitting into the arched space between the mandibles, and a pair of "post jugulars" or "hyoids" which overlapped the jugulars at their tips. The description is as follows: "They [the jugulars] are each semi-elliptical in outline, sixteen inches in length by seven and a half wide; the outer margin is symmetrically arched; the inner margin nearly straight; the posterior ends are obliquely truncated and overlapped by the anterior extremity of a second pair of plates. * * * The posterior pair of jugulars—or as they should perhaps be called *hyoid* plates—are long triangular in outline, smaller than the anterior pair, but much thicker. Their anterior angles overlap and are sunk into the obliquely truncated ends of the jugulars. The outside and posterior ends of the hyoid plates are irregular and thin and show that they were overlapped by other plates." [Monograph p. 137-8.]

The valuable material in my hands now enables me to show, as I think beyond a doubt—

First, that the "post jugular" or "hyoid" bones refered to above are in reality the anterior ventrals of the plastron, but with their apices turned in the opposite direction.

Second, that the plates called jugulars are not such, but are the posterior laterals of the plastron. They are the missing pair which are needed to replace the sub-o bitals.

Third, consequently the four plates supposed to form the jugular armature are the four principal plates of the plastron in reversed position. The fifth, a median plate, should doubtless remain in the plastron.

Fourth, this arrangement shows the plastron of Dinichthys to have a much closer homology with that of Coccosteus than has hitherto been supposed to exist.

The outline figures on Plate VII give various views of the four bones in question. The arched bones (3, 4, 6, 7, 9), are the "jugulars" figured in Dr. Newberry's Monograph; the others are the anterior laterals of the plastrons.

Taking up the points above enumerated in their order I have first to show that the so called "post jugulars" are really the anterior ventrals. The most perfect specimen of an anterior ventral of *D. Terrelli*, which I have seen is that shown herewith in figure 8; the inner or dorsal side being there represented. The four accompanying cross-sections show the nature of the margins. This bone was figured by Dr. Newberry, in the large chart accompanying the second volume of the Paleontology of Ohio. His specimen, however, was incomplete, lacking five or six inches of the triangular apex. The dotted line by which he indicated the supposed outline lacks the triangular apex, which is fully preserved in my specimen. Placing the latter upon his chart, the two coincide in outline perfectly, with the exception mentioned. The corresponding bone for two smaller species, *D. intermedius* and *D. curtus*, is figured on plates XLVIII and L of the Monograph. In the first of these also the apex is wanting, while in the second it is complete and its identity unmistakable. If the apex had been preserved in Dr. Newberry's original specimen of *D. Terrelli*, he would have been spared the discussion of the question as to why the anterior ventrals of *Coccosteus* overlapped the posterior pair, while those of *Dinichthys* did not* and his original restoration of the plastron of Dinichthys might have been quite different from that given.

II. The plates with arched outlines which are described by Dr. Newberry as "jugulars" in his Monograph are demonstrated by my material to be the companions of his "anterior ventrals." The three cases of overlapping which I have figured on Plate VII furnished the proof upon this point. The bones numbered 1, 2, 3 and 4, belonged to a single individual of *Dinichthys Terrelli*. When the posterior apex of the anterior ventrals is applied to the sunken triangular area on the so called "jugulars," it precisely fits. The four bones are arranged in the drawing, in very nearly their natural position. The anterior and posterior plate on each side are in their exact natural relation to each other, but the space between the two anteriors may have been a trifle wider, to

* Paleontology of Ohio, Vol. 2. p. 11.

admit of the presence of the ventro-median plate which was not preserved. The margins of the overlapping area, both on the right and left sides, are so entirely coincident, that no one on seeing the specimens can doubt that the two were related to each other as shown.

The bones numbered 5 and 6, belonging to another individual, constitute a third case in which there is a perfect fit in the overlapping. Whether these two belong to the same species as the other four is a matter of no moment so far as the relationship of the bones is concerned. The three cases taken together make an array of fact which must be conceded to be conclusive. The only alternative would be that each fish carried somewhere upon his armor a pair of bones other than the anterior ventrals, which nevertheless had the same shape and size of tip as the anterior ventrals, and which therefore would fit into the excavations upon the "jugulars." I have already quoted Dr. Newberry's description of his supposed "post jugulars" and "hyoid" bones which overlapped the "jugulars." It will be seen that the description corresponds almost completely with that of the perfect anterior ventrals which I am now able to figure. If he had procured perfect specimens of the "post-jugulars," I feel confident that he would have figured them with the "jugulars" in the Monograph. And as his published figures of the anterior ventrals lacked the triangular tips which fit upon the "jugulars," we must assume that his material failed to show him the identity of his "post-jugulars" and "anterior ventrals."

III. Since the so called "jugulars" and the anterior ventrals were companion bones, the question arises whether these four plates (together with the narrow median plate) covered the jugular or the pectoral or the ventral portion of the fish. The preponderance of evidence to my mind is in favor of placing them in the ventral position, the "jugulars" becoming the posterior ventrals with their arched outlines pointing backward.

I am not aware that any individual specimen has yet been found with the bones so completely in place as to settle this question. There are some difficulties in the way of the view which is taken, to which reference will be made later. But there are a number of weighty considerations in favor of it. In the first place the so called "jugulars" are pretty large for service as jugulars. They are longer than the mandibles: In the specimen from which figures 3 and 4 were taken (a fish of which eighteen bones were preserved together), the mandibles were fourteen and a half inches in length while the "jugulars" are sixteen, measured either from tip to tip or around the arched border. Fig. 6 is $22\frac{1}{2}$ inches long, while a plate of the general shape of Fig. 4 has been discovered near Columbus, as I am informed by Professor Claypole, who has kindly sent me a tracing of it, which was at least 30 inches in length. They would thus seem to be somewhat large for filling the "space between the mandibles," while upon he belly there was room for considerable expansion.

In the second place the nature of the overlapping joint between these bones and the anterior ventrals is one which was not adapted to furnish the freedom of motion which the jugulars under the jaws of the predatory *Dinichthys* would need. The same, in a less degree, may be said of the overlapping joint between the two "jugulars," the nature of which is shown in figure 9.

To this must probably be added the overlapping joint between the "ventro-median" or "sternal" plate which bound all four of the bones together into a piece of armor not especially flexible.

These points might not be against the idea that this portion of the armor was drawn back to a pectoral or intermediate position between the jugular and the ventral, by which the arched outline of the jugulars would still be anterior in position.

And thirdly, if we consider all these plates as forming the ventral armor, retaining the anterior and median ventrals as Dr. Newberry placed them, and making the "jugulars" the posterior ventrals, we shall have a most complete and convincing homology with the plastron of Coccosteus, removing discrepancies which were previously supposed to exist, and adding some harmonies which were not before suspected.

All the points of harmony which Dr. Newberry so admirably makes out* concerning the anterior laterals and median plate remain in their full force. If now the "jugulars" be placed as the posterior plates there will be added: First, the overlapping of the posterior plates by the extremities of the anterior plates; second, the overlapping of the right posterior plate by the left posterior plate along the median line; third the sinuous line of overlapping between the posterior plates in both genera; fourth, the less breadth of the posterior plates behind than in front.

This brings the whole plastron of the two genera into striking accord and it is difficult to resist the belief that whatever position upon the body was occupied by the "plastron" of *Coccosteus* must likewise have been occupied by the ventral armor of *Dinichthys*. If it was really ventral in the one, it doubtless was in the other.

A real point of difficulty in this view may seem to exist in the absence of any projecting angles upon the arched margin of the posterior plates of *Dinichthys*, with which other plates could have articulated. I do not detect any evidence that other plates, either by overlapping or articulation, were connected with the outer margins of the posterior ventrals of *Dinichthys*. Such a bold, curved outline might seem to be more easily explainable in an anterior position than in a posterior. But the balance of evidence is so strong upon the other side that it must be accepted as best expressing our knowledge upon the subject.

To recapitulate, then, this discussion shows that the four bones, which have been supposed to constitute the jugular armor of *Dinichthys*,

* Paleontology, Ohio, Vol II, p. 11.

viz., the "jugulars" and the "post jugulars" or "hyoids," really belong to the ventral armor, the supposed hyoids being identical with the anterior ventrals, but with their points turned in the opposite direction, and the "jugulars" being the missing posterior ventrals. This arrangement of the plates brings out new points of harmony between the two placo-ganoids *Dinichthys* and *Coccosteus*.

In connection with the figures now published it may be well to allude to one point. The outer margins of the anterior ventrals are seen to be "rabbeted" for a considerable part of their length, as if for the reception of the margin of some contiguous plate. No plate, however, has yet been brought to light which could occupy this position.

It may be of assistance to future students of Dinichthys to give the measurements, and therefore the relative size, of various bones which are known to have belonged to one individual specimen of *D. Terrelli* a specimen of moderate size, found upon the east branch of the Vermillion river by Mr. Jay Terrell.

Cranium, length, median line, 15½ inches.
width, flattened, with suborbital, 24 inches.
width between supra-clavicular joints, 16 inches.
back of supra-occipital to center of eye-orbit, 12½.
Suborbital, length 17½ inches, width 6 inches.
back extension from center of orbit, 12 inches.
Supra-occipital, vertical thickness, 2½ inches.
Premaxillary, width of tooth, 3 inches, height 5½ inches.
width, with prong, 4¼.
Mandible, length, 14½ inches. height, tooth, 5½ inches.
length of posterior ramus 7½ inches, width 3¾ inches.
Maxillary, length 4¾ inches, width 3½ inches.
Dorsal shield, length 13 inches, with neck, 19 inches.
width 17 inches.
Posterior ventrals, ("jugulars"), length 16 inches, width 7 inches.
Anterior ventrals, width 5 inches, length 16½ inches.

CHAPTER VII.

NEW AND LITTLE KNOWN LAMELLIBRANCHIATA FROM THE LOWER SILURIAN ROCKS OF OHIO AND ADJACENT STATES.

By E. O. Ulrich.

Description and figures of many of the following species were prepared in 1881 for Dr. Newberry's proposed Volume III on the Paleontology of Ohio. After successive failures to secure an appropriation from the legislature, the plan of publication by the Ohio Survey seems to have been abandoned, since much of the work prepared for the volume has appeared through other channels. The same course would have been adopted in my own case had my plates not been destroyed in a fire at the lithographing establishment that was to print them.

Although at the time a great disappointment, I cannot but believe that science has, after all, gained through their loss, for the work as now presented is more thorough and as I believe better in every respect. Whether it is accepted as good or not, the fact will remain that I have spent a great deal of time and labor on the class and that I have conscientiously striven to do my best under what, to say the least, were not always favorable circumstances.

The present addition to our knowledge of paleozoic Lamellibranchiata is really to be viewed as supplemental to the work which I have just completed for the paleontological report of the Minnesota Geological Survey. In that work, which is now going through the press, the student will find an amended classification of the paleozoic representatives of the class and full descriptions of nearly all the genera occurring in the Lower Silurian rocks of America. It may have seemed to those who were not conversant with the facts that much had been done on the Lower Silurian forms previous to the present decade, but I would assure them that it amounts to little indeed compared with what has been done since the beginning of 1890 and what remains yet to be accomplished. Including the present work no less than twenty-three new genera have been proposed by the author, and four by Mr. S. A. Miller for Lower Silurian types.

The erection of a new genus is a serious matter and, unless the type is very obviously distinct, ought not to be attempted except on sufficient evidence showing that the proposed grouping of species actually obtained in nature. Opinions will always vary as to what degree of difference is required to establish a genus, but all agree that it is a larger or smaller group of closely related species. The first essential then is to show that the supposed generic characters exist in two or more specifically distinct forms—the more the better for the genus.

Now, it happens that a majority of the new genera founded by me upon shells of the Cincinnati group have earlier representatives in the Trenton limestones of the Northwest, and these as well as the genera are described in the Minnesota work referred to. The real types and bulk of the genera, however, could find no place in that work, and I do not doubt that their publication would have been postponed for years had the present opportunity not become available. That it did is most fortunate, since I was thereby enabled to give a degree of thoroughness to my studies that would not have been possible had I been obliged to depend entirely upon my own resources. This thoroughness lies chiefly in the delineation and comparison of the generic groups in accordance with facts gathered in a study of collections containing a large nnmber of hitherto unknown forms. By itself the Minnesota work is probably insufficient in its specific part to establish all the innovations proposed, and it is therefore again fortunate that the date of the present publication will be little if at all subsequent to that of the Minnesota volume. Between the two it is hoped that the desired completeness may be obtained, and that the validity of some of the new genera will be established almost by force of numbers alone.

So far I have published nothing on the *Aviculidæ*, although the Lower Silurian forms have been studied thoroughly and drawings of many of them prepared. Some important facts relating to their preservation have been discovered, and sufficient new material to make an interesting paper by itself, is already available. Aside from the aviculoids there remains also a considerable number of Lamellibranchiata that have never been described. Indeed, of nearly every Lower Silurian genus established previous to 1890 from one to as high as six and seven undescribed species are known, and with every year the number is increased. I have not therefore by any means exhausted the subject even in its specific part, and when it comes to the classification of the species and genera we are really but little beyond a good beginning. And, according to my views, this is just as it should be. I go namely from the standpoint that the higher classification must evolve itself, and come, if the expression be allowed, as a by-product from our studies of individual and specific forms, and finally of the generie types.

The plates accompanying the present work were prepared by myself. The specimens used, except where they are credited to other parties, are to be understood as belonging to my private collection.

Class LAMELLIBRANCHIATA.

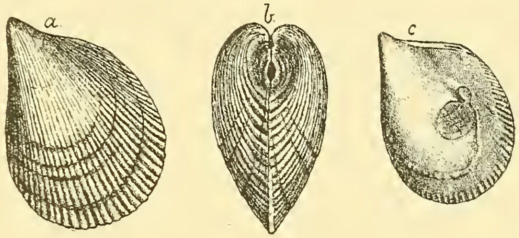
Family AMBONYCHIIDÆ, Miller.

Genus BYSSONYCHIA, Ulrich, 1894.

(Paleontology of Minnesota, Final report vol. III, p. 498.)

Byssonychia vera n. sp.

Ambon chia bellistriata, S. A. Miller, 1874, Cin. Quart. Jour. Sci., vol. I, p. 14. (No Hall, 1847.)



Figs. *a.* and *b*, the left side and an anterior view of a partial cast of the exterior; *c*, excellently preserved, cast of the interior, showing the pallial and muscular impressions, Utica horizon of the Cincinnati group, Newport, Ky.

This name is proposed for the form which, for more than twenty years, has been erroneously identified by Cincinnati collectors with Hall's *Ambonychia bellistriata*. That species is restricted to the Trenton and differs from *B. vera* in its greater obliquity, longer hinge line and finer striæ, and more importantly in wanting a byssal opening as well as posterior lateral teeth.

From *B. radiata* Hall, sp., the type of the new genus, *B. vera* differs in its smaller size, finer striæ, (there being about fifty to from thirty-seven to forty in the typical form of that species,) shorter hinge line, more evenly convex valves, and shorter byssal opening. A new variety of that species, found near the tops of the hills at Cincinnati, and which may be called *B. radiata* var. *approximata*, approaches *B. vera* in being as a rule of smaller size than the typical form and in having the number of the radii increased to as high as forty-five.* In all other respects however this variety is the same as the usual form of *B. radiata*.

B. vera, I am satisfied, is not a descendant of the Trenton variety of *B. radiata*, but of the Galena *B. intermedia*, Meek and Worthen, sp. That species is the earliest known and *B. vera* the second, of a group of species in which the hinge is short, the beaks and the anterior part of the valves tumid, and the byssal opening short and thickened on the inner margins so as to leave an unusually deep and abrupt depression beneath

*A compar son of hundreds of specimens of the various species of *Byssonychia* has shown that wit in reasonable limits the number of the radiating costæ is constant for each species, and the same in specimens of all ages. Young specimens therefore appear to have been much more finely striated than the old shells, but a count will show, as also will a comparison of the young shell with the rostral portion of the old, that the number of the striæ is approximately the same in both.

the beaks in casts of the interior. Other species of this type are the *B obesa* and probably *B. grandis*, and one or two other species of this report. Of these the first is larger and has coarser radii, while the second is very much larger and has anteriorly flattened and widely separated beaks. *B. intermedia* is more gibbous, especially in the umbonal region, and *B. tenuistriata*, Ulrich, from the upper beds of the Cincinnati group, has much finer radiating striæ, the number being not less than seventy.

Formation and localities: Utica horizon of the Cincinnati group, occurring at localities in the vicinity of Cincinnati, Ohio, from 50 to 200 feet above the bed of the Ohio river.

Byssonychia obesa, n. sp.

Plate 45, Figs. 10–12.

Shell usually of less than medium size, obese, ovate in outline except where the full and prominent beaks project beyond the regular curve; hinge short, rounded behind; byssal opening small, situated high, the inner margin thickened so that a decided depression is formed in the anterior side of casts of the interior. Radii from forty-two to forty-five; length from 20 mm. to 33 mm.; height (from beak to base) from 26.5 mm. to 40 mm.; thickness from 15 mm. to 25 mm. In one specimen that differs a little from the rest these measurements are respectively 27 mm., 38 mm. and 20 mm.

This species rarely occurs except in the condition of casts of the interior, but these are easily distinguished from *B. radiata* Hall, sp., with which collectors have generally identified them, by their more ventricose valves, more rounded form, and deeper byssal excavation. From *B. vera* the species is separated by its greater size, and more ventricose valves. *B. grandis* is much larger and has carinated beaks, they being flattened on the anterior side; *B. suberecta* is a more erect shell and has a longer hinge. Probably nearer than any of these species, at any rate in the general expression of casts of the interior, is the Galena limestone species described by Meek and Worthen as *intermedia* (*Ambonychia intermedia*). Young specimens may be difficult to distinguish from that species, but I have not yet seen any of *B. obesa* that were as small as the largest of *B. intermedia.* Aside from the point of size, comparison shows that the Galena species is, relatively speaking, higher, and that the outline is less rounded especially in the postero-cardinal region.

Two large specimens from a lower horizon (about fifty feet below the tops of the hills at Cincinnati,) may belong to an early variety of this species. As however they had at least fifty radii we might be equally justified in regarding them as examples of a gigantic variety of *B. vera.* The length of the larger of the two is about 60 mm.

Formation and locality: Near the top of the Cincinnati group at Richmond, Indiana, where it occurs in association with *B. richmondensis*, Ulrich, and *Ortonella hainesi*, Miller, sp.

Byssonychia alveolata, n. sp.

Plate 48, Figs. 1–3.

Shell of medium size, moderately convex, obliquely acuminate-ovate, wider than usual, with the basal half of the outline semicircular; cardinal margin somewhat shorter than the middle length of the shell; umbones full, beaks but little incurved, separated; ligamental area very large; beneath the beaks the anterior side is impressed, forming an obscurely defined subcordate lunule, in the lower part of which the byssal opening is situated. Surface marked by about fifty rounded radiating costæ.

The large ligamental area indicates relationship with *B. grandis* and *B. obesa*, both of which are restricted to a higher horizon. The first is sufficiently distinguished by its carinate umbones; the second is a more erect shell, with a shorter hinge line, narrower area, and differently shaped byssal depression. The wide area should separate the species at once from *B. radiata* with which a careless collector might confound it.

Formation and locality: Middle beds of the Cincinnati group, Cincinnati, Ohio.

Byssonychia grandis, n. sp.

Plate 46, Figs. 6–9.

Shell large, ventricose, subquadrate, the length and height as ten is to thirteen; anterior margin sinuate above, broadly convex in the lower two-thirds; outline of basal half semicircular; hinge line about two-thirds as long as the shell is at the middle of the height. Beaks projecting less than usual, carinate, flattened on the anterior side; apices separated widely, the intervening space being occupied by a broad, striated ligamental area. Upper part of the anterior side with a broad and deep impression in the bottom of which lies the byssal opening. Surface marked with about forty radiating costæ. These are rounded and broad in the lower half of the shell. Posterior lateral teeth small, two, situated near the extremity of the hinge.

This species probably attained a larger size than any other known. It may be equaled in this respect by the associated *B. cultrata*, a species that resembles it in its outline and in having carinate umbones as well. But the present species is readily distinguished from that one by its greater convexity, coarser and therefore fewer costæ, and by the large depression around the byssal opening, this part of the shell being quite flat in that species. The ligamental area, furthermore, is of a peculiar type and much narrower in *B. cultrata*, allowing the beaks to come into close proximity. Despite the somewhat striking agreements, I am well satisfied that the two species are widely distinct. In *B. robusta*, Miller, sp., the whole anterior side is flattened, the outline different, and the beaks do not curve forward as in this species, nor are they as widely separated. Despite these and other differences, I wish it to be understood that I think it just possible that *B. grandis* is not distinct from the species *intended* by Mr. Miller. I tried to see his types but failed because they were packed away. I am therefore obliged to rely upon his illustrations and to assume that they are correct. Comparing my specimens with his figures it will be noticed that in the convexity of the valves and the number of costæ the two species agree very well, but in all other respects they are so obviously different that we are forced to regard them as specifically distinct. The carinate umbones will distinguish the species from all the other forms of the genus.

There remains to mention that the outline of the shell and the coarse rays, which however are rounded instead of flattened, remind of *Anomalodonta gigantea*, Miller. That species, however, is not so ventricose, and is without the large depressed area which surrounds the byssal opening in *B. grandis.*

Formation and locality: Upper beds of the Cincinnati group, Oxford and Clarksville, Ohio.

Byssonychia cultrata, n, sp.

Plate 45, Figs. 5–7.

Size and outline practically the same as in *B. grandis*, while another resemblance to that species is found in the carinate umbones. Critically compared however a number of well marked differences will be observed. First, the convexity of the valves is less, the thickness of an example 70 mm. high being only 30 mm. Second, the radiating costæ are more numerous, their number varying two or three either way from fifty-five. Third, the upper part of the anterior side is almost flat and not, as in that species, deeply sunken about the byssal opening. Fourth, the posterior lateral teeth are much stronger. And fifth, the ligamental area is much narrower in a dorsal view, thus permitting the beaks to come into close proximity. The ligamental area, in which the species differs also from all the other species of the genus, consists of a narrow but deep and sharply defined groove extending about two-thirds of the hinge from the beaks.

Compared with other species *B. robusta*, Miller, will be found to be more convex, relatively higher, and much straighter anteriorly, while most of the remaining forms are readily separated by their rounded instead of carinate umbones.

Formation and locality: Upper beds of the Cincinnati group, Waynesville, Ohio.

Byssonychia richmondensis, n. sp.

Plate 45, Figs 3 and 4.

Ambonychia robusta (part), Miller, 1880, Jour. Cin. Soc. Nat. Hist., vol. III, p. 315.

Shell large, high, triangular in a cardinal view, the anterior side being flat; height, length and thickness of an average specimen, respectively, 57 mm., 57 mm. and 30 mm. Beaks rather prominent, triangular, carinate, curving very slightly forward, and rather widely separated in casts. Anterior outline nearly straight, the margin projecting a little in the lower part; base strongly convex, posterior margin broadly rounded; hinge line about two-thirds as long as the middle length of the shell, ranging at an angle of about 95° with the anterior margin. Byssal opening large, in casts appearing as an acutely elliptical low prominence, situated about its length beneath the summits of the beaks. Costæ of moderate strength; their number, though not certainly determined, is not less than fifty. Posterior adductor scar and pallial line as shown on plate 45.

The shell of this species has not yet been observed, but the casts are not uncommon, and with their broadly flattened and nearly straight anterior sides are so easily distinguished from all the other species of the genus, except *B. robusta*, Miller, sp., that a name for them has long been desirable. In 1880 (*loc. cit.*) Mr. Miller referred these casts to his species *robusta*, but in a recent conversation he admitted that they probably belonged to a distinct species. *B. robusta*, as figured, is relatively not so high and has coarser rays, their number being only about forty, while in *B. richmondensis* there are at least ten more. *B. cultrata* is closely related, but differs decidedly in its outline, being a wider shell and not so convex. The flattening of the anterior side also is confined to the upper part, while in the lower part the outline curves forward in a much greater degree.

Formation and locality: Associated with *Rhynconella dentata*, Hall, and *Ortonella hainesi*, Miller, sp., in the upper beds of the Cincinnati group at Richmond, Indiana.

Byssonychia præcursa, n. sp. or var.

Plate 45, Figs. 1 and 2.

This form I regard as a small forerunner of *B. richmondensis*, *B. robusta*, and possibly of *B. cultrata* as well. The shape agrees best with *B. richmondensis*, the principal difference being in the hinge line which is always longer and sometimes quite equal to the greatest length of the shell. The number of the costæ varies from thirty-eight to forty-two, the average number being the same as for *B. robusta* and ten less than in *B. richmondensis*.

In the number of costæ and in the outline *B. præcursa* is very much like the typical form of *B. radiata*, Hall, sp. * As a rule, however, the latter is a little more oblique, the hinge shorter and the central part of its valves a trifle wider. But the principal difference lies in the flattening of the anterior side in *B. præcursa*.

* In twenty specimens of the Cincinnati form of *B. radiata* the number of the rays varied between thirty-six and forty, while a good example from an unknown locality in New York has thirty-six.

Formation and locality: Loraine shales, Loraine, New York; also in the equivalent middle beds of the Cincinnati group, at Covington, Kentucky, and Cincinnati, Ohio.

Byssonychia suberecta, n. sp.

Plate 45, Figs. 13–15.

Shell exceeding the medium size for the genus, moderately convex, suberect, the length and height as five is to six. Hinge line forming an angle of about 105° with the anterior margin; this is a few degrees wider than the posterior angle. Anterior outline gently sinuate in the upper half, and in the central part bending forward enough to give the shell the appearance of leaning backward rather than forward; posterior margin broadly convex; basal half with a semicircular curve. Beaks full, rounded, not very prominent, bending somewhat forward and strongly incurved. Greatest convexity in the umbonal region, but taking the surface as a whole it is more uniformly rounded than in any other species of the genus. Radiating costæ rather small, fifty-five to fifty-eight on each valve. Ligamental area about 3 mm. wide, almost vertical, so that in a dorsal view it appears as very narrow, with five or six distinct longitudinal striæ. Cardinal teeth apparently three in each valve. Strong posterior lateral teeth are present, but whether more than one in each valve could not be learned from the material at hand. Byssal opening long though very narrow. Muscular and pallial impression as usual for the genus. In casts of the interior the beaks are comparatively erect and obtusely pointed.

This species has an outline that is closely similar to that of *B. cultrata.* The two species are also associated in the same strata, but can be distinguished at once by the rounded instead of carinate beaks of *B. suberecta.* The latter is also a little smaller. *B. radiata* is probably more nearly allied, but has fewer costæ and is a much more oblique shell.

Formation and locality: Upper beds of the Cincinnati group, at Waynesville, Ohio, and Versailles, Indiana.

Byssonychia acutirostris, n. sp.

Plate 45, Figs. 8 and 9; Plate 46, Fig. 10.

Shell moderately convex, 75 mm. or less in height, acuminate-ovate in outline, the transverse diameter or length usually about two-thirds of the height; without the acuminate rostral portion the outline forms a nearly regular oval. Beaks attenuate, small but prominent, not strongly incurved (rather erect in casts of the interior), obtusely pointed. Upper fourth of anterior side slightly flattened and somewhat sinuate in outline. Hinge line very short. Radiating costæ thirty-six to forty on each valve. Byssal opening rather small and narrow, lying in a sharply defined, small, impressed area; in casts of the interior this impressed area is considerably larger than in the shell itself. Ligamental area narrow, striated; cardinal teeth very small; posterior lateral teeth not observed, apparently wanting.

A large specimen afforded the following measurements: Height, from beaks to center of base, 73 mm.; height from posterior extremity of hinge to same point, 60 mm.; greatest transverse diameter, 42 mm.; thickness, 25 or 26 mm.

The beaks are more attenuate and the hinge line shorter than in *B. radiata*, Hall, sp. The general appearance of the shell is more like that of the proposed *Eridonychia apicalis*, but the presence of cardinal teeth, though unusually small for the genus *Byssonychia*, is quite sufficient to distinguish it from that species and genus. For comparisons with *B. imbricata* see next description.

Formation and locality: Middle beds of the Cincinnati group at a number of localities in the vicinity of Cincinnati, Ohio.

Byssonychia imbricata, n. sp.

Plate 46, Figs. 4 and 5.

Shell rather small, not known to exceed 35 mm. in height, moderately convex, acuminate-ovate in outline, widest a little beneath the middle, the greatest width about two-thirds of the length; beaks prominent, not strongly incurved, approximate; hinge very short, upper half of anterior margin nearly straight; byssal opening small and very narrow. Surface marked with from twenty-six to twenty-eight strongly rounded, almost angular, radiating costæ. These are crossed by distant, strong, imbricating lines of growth, showing quite distinctly through the shell so as to be reproduced on casts of the interior.

The form of this species is almost exactly as in *B. acutirostris*, and, were it not for the distant imbrications, it might be mistaken for the young of that species. That such a view would be incorrect is shown not only by the imbricating lines but by the smaller number of radiating costæ as well. These number, so far as observed, not less than thirty-six in *B. acutirostris* and not over twenty-eight in *B. imbricata*. Compared with *B. radiata*, it will be found that the hinge is shorter, the costæ fewer and the concentric lines very much stronger.

Formation and locality: Middle beds of the Cincinnati group, near the tops of the hills at Cincinnati, Ohio.

Byssonychia (?) *byrnesi*, n. sp.

Plate 47, Figs. 4 and 5

Shell of medium size, obliquely ovate, with a short hinge, the cardinal border often passing almost uniformly into the broadly rounded posterior margin; valves strongly convex in the anterior and umbonal regions, compressed in the postero-cardinal part; beaks moderately prominent, incurved; byssal opening small, not impressed. Surface of each valve with twenty to twenty-two more or less curved, strong, radiating costæ. In the best preserved specimen these are ridge-shaped and separated by wide concave interspaces, while the whole surface is marked with rather regular, sharp, concentric lines distinctly visible to the naked eye. Ligamental area very narrow and short, hinge plate thin, posterior lateral teeth wanting; one oblique cardinal tooth and socket in each valve.

The hinge in this species is peculiar, having no lateral teeth and only one cardinal tooth. It must be a transitional form and, as I believe, from *Byssonychia* to the *Eridonychia* and *Allonychia* types of structure. I cannot now enter into a discussion of these possible relationships, yet, to avoid misunderstanding, I should say that I do not regard *Eridonyichia* as having been evolved from *B. byrnesi*: another aberrant species, *B. acutirostris*, being as it seems to me, better qualified to stand as a progenitor of that restricted genus. With *Allonychia*, however, the case probably is different, at any rate we have no conclusive evidence against the view that this genus is genetically related to the species under consideration.

Considered as a species, *B.* (?) *byrnesi* is so easily recognized that comparisons with other forms are quite unnecessary. The specific name is given in remembrance of the late Dr. R. M. Byrnes, of Cincinnati, Ohio.

Formation and locality: Lower beds (Utica horizon) of the Cincinnati group, at Covington, Kentucky, where it occurs in the banks of the Ohio and Licking rivers; also in an equivalent position at Nashville, Tennessee.

Genus ANOMALODONTA, S. A. Miller.

Anomalodonta, S. A. Miller, 1874, Cin. Quart. Jour. Sci., Vol. I, p. 16; also 1889, North Amer. Geol. and Pal., p. 462.

Shell suberect, equivalve, profoundly inequilateral, alate posteriorly, abrupt anteriorly; beaks terminal, incurved, umbones prominent; byssal opening present, sharply defined. Surface with coarse, radiating costæ. Ligamental area broad, grooved longitudinally; beneath the posterior half of the external area a variable number of large, irregular folds which probably served for the attachment of an internal ligament; at the anterior end of the hinge an oblique, irregularly pitted fold together with a corresponding depression in one or both valves; the pits continue downward as grooves to the byssal opening. Posterior adductor impression large, its inner margin deeply sinuate, situated in the middle of the shell or more or less above and behind the center, the position varying in the species according to the length of the shell; pallial line distinct, extending forward from the posterior side of the large muscular scar in a direction nearly parallel with the margin of the shell, bending around the byssal sinus, and terminating at a point on the inner side of the umbonal cavity. Anterior muscular scar not observed, apparently wanting. A deep pedal muscle scar situated a short distance behind the beak and partly under the hinge plate.

Type: *A. gigantea*, S. A. Miller. Plate 50, figures 1 to 4.

Plate 50, figures 1 to 4.

The above description is based upon a fine series of specimens belonging to my private cabinet and upon the original types of the genus which were kindly loaned for the purpose by Dr. S. A. Miller. I have endeavored to give the facts without prejudice and just as they appear to me after a careful study of the whole family to which the genus belongs. This statement is necessary considering the fact that some points in Dr. Miller's original description were questioned by Dr. C. A. White, notably the position of the muscular scars.*

I shall not, however, enter into the discussion carried on by these gentlemen except to say that Dr. Miller is certainly in error when he says that there is an "anterior muscular scar below the byssal sinus." The depressed subtriangular space (see plate 50, fig. 4), which he mistook for a muscular impression is without doubt due to some abnormal thickening of the internal surface of the valve. Nothing of the kind has been observed in any other of the numerous specimens seen by me, while the true position of the large muscular scar, which was left by the posterior adductor and not the anterior, is unequivocally shown in several cases. The pallial line also is clearly shown in the specimens, and as it runs through the space to which the muscle was supposed to have been attached and on to the cavity of the beak, it affords the very best evidence in favor of the view here adopted.

As understood by me *Anomalodonta* agrees in all esssential respects, except the hinge, with the new genera *Byssonychia* and *Eridonychia*, and as far as the muscular impressions and the pallial line are concerned, with all the genera now referred to the *Ambonychiidæ*. The absence of true cardinal and lateral teeth sufficiently distinguishes the genus from *Byssonychia*. In *Eridonychia*, however, the hingement is very similar to that of *Anomalodonta*; yet it differs and is even more simple in wanting the peculiar oblique fold at the anterior extremity of the hinge plate. The latter is also shorter and not so strong, and the shells more oblique.

Beside *A. gigantea* there are only two or three species that may be referred to *Anomalodonta*. These are the *Ambonychia alata*, Meek, a new species, and possibly the little known *Ambonychia costata*, Meek; and all of them are found only in the middle and upper beds of the Cincinnati group. The generic type seems therefore to have been a limited one in every sense.

*See Cincinnati Quarterly Journal of Science, Vol. I, p, 326, 1874; and Vol. II, p. 280, 1875.

Anomalodonta alata, Meek.

Plate 46, Fig. 1.

Ambonychia alata, Meek, 1872, Proc. Acad. Nat. Sci., Phila., p. 319; also 1873, Ohio Pal., Vol. I, p. 131.

Anomalodonta alata, Miller, 1874, Cin. Quart. Jour. Sci., Vol. I, p. 16.

The interior of the right valve figured on plate 46 was obtained by means of gutta percha from an unusually well-marked cast of the interior. It shows the posterior internal cardinal folds, the large muscular scar, and the pallial line in a very satisfactory manner, and every feature points unmistakably to *Anomalodonta.* Specifically the form is distinguished from *A. gigantea* by the much greater length of the posterior wing, the length of the shell near the dorsal edge equaling or even exceeding the greatest height. Other differences are brought out in a careful comparison of good specimens, but the one mentioned generally suffices in the separation of the two species. In the new species, *A. plicata,* the width of the shell is less, the posterior margin is not produced above, and the radiating plications are fewer in number and therefore of larger size.

Formation and locality: Upper beds of the Cincinnati group, at Clarksville, near Morrow, Blanchester, Waynesville and other localities in Ohio; also at Versailles and other localities in Indiana. Prof. Meek gives Cincinnati as the original locality, but I doubt very much that it occurs so low in the series.

Anomalodonta plicata, n. sp.

Plate 46, Figs. 2 and 3.

This species is founded upon a single specimen, a rather well-preserved cast of the interior of a right valve. Although we have no positive knowledge of the hinge, the downward bend of, and the fold bordering the posterior half of the dorsal edge of the specimen, indicate very strongly the presence in the shell of large internal cardinal folds. The obtusely pointed beak and the depressed space in the cardinal slope also, indeed the whole expression of the cast is so much like that of *A. gigantea* that I cannot hesitate in referring the species to *Anomalodon a.*

The form of the shell is much narrower than in *A. alata*, the leng h being about 38 mm. and the height 55 mm. These dimensions show it to be relatively also narrower than *A. gigantea.* But the difference that will distinguish the new form most readily from those species lies in the number and size of the radiating costae. Their exact number cannot be determined from a cast of the interior, they being too obscurely indicated in the cardinal and byssal regions. Still, as the costae are so uniformly distributed over the surface in this and related genera, it is possible to make an estimate that will not be far from the truth. My judgment places the number at about twenty on each valve. Comparing these with about thirty for *A. alata* and not less than thirty-six in *A. gigantea*, the result is, especially in shells of the same size, a much more coarsely plicated surface for *A. plicata*.

Formation and locality: Middle beds of the Cincinnati group, Cincinnati, Ohio.

Genus ERIDONYCHIA, n. gen.

Like *Byssonychia* and *Anomalodonta*, excepting that the hinge is edentulous. Type: *E. apicalis*, n. sp.

This genus includes, as far as known, a small and comparatively unimportant group of Lower Silurian shells, agreeing with *Byssonychia* in all respects except that their hinges are entirely without cardinal and posterior lateral teeth. A well defined, striated ligamental area however is present, and in the type species several obscure and irregular small ridges beneath the posterior extremity of the external area remind of the internal ligament supports of *Anomalodonta*. But the oblique cardinal fold of the latter genus is not represented, and the acuminate beaks and oblique form of the shells gives them a peculiar expression, so that no other course seemed open than to erect a distinct group for their especial benefit. If we could decide with which of the two genera, *Byssonychia* or *Anomalodonta*, the affinities were greatest, it might be advisable to reduce *Eridonychia* to the rank of a subgenus.

Eridonychia apicalis, n. sp.

Plate 47, Fig. 1.

Shell oblique, ovoid, with prominent, subacute and very little incurved beaks; hinge short, edentulous; ligamental area erect, wide beneath the beaks, tapering posteriorly, marked with four or five horizontal grooves; several obscure folds within the posterior extremity of the hinge; byssal opening long, narrow, its border sharply inflected; at its lower end the outline of the valves is slightly produced and rather abruptly rounded. Surface with about thirty distinct rays, separated by flattened interspaces as wide as the costae.

This species resembles *Byssonychia acutirostris* very closely, and collectors will no doubt find it difficult to separate them when the specimens are not very good. A careful comparison shows that the margin of the byssal opening is more sharply inflected and the beaks, especially in casts, more erect in the *Eridonychia*. The principal differences however lie in the hinge, that species having true cardinal teeth and a narrower ligamental area. (Compare plate 45, fig. 8, and plate 47, fig. 1). *Eridonychia paucicostata*, as the name implies, has fewer costæ. *E. crenata* also has larger costæ and is peculiar in having a crenated margin.

Formation and locality: Middle beds of the Cincinnati group at Cincinnati, Ohio, and localities in the immediate vicinity. Good specimens are very rare.

Eridonychia paucicostata, n. sp.

Plate 47, Fig. 2.

This species, since it agrees very closely with *E. apicalis*, will be sufficiently characterized by pointing out the only difference of consequence shown by the material at hand. The surface namely is more coarsely folded, the costae numbering only seventeen or eighteen, while in that species there are about thirty. It is a difference that strikes the eye at once.

Formation and locality: I have seen only two specimens. These were collected in the middle beds of the Cincinnati group, at Covington, Kentucky.

Eridonychia crenata, n. sp.

Plate 47, Fig. 3.

This form may be a later variety of *E. paucicostata*. It also has coarse plications, but there are more of them, the best specimen having twenty-three. A peculiar feature is the projection of the costae at the lower margin, giving a crenate outline. In the other forms the outline is simple.

Formation and locality: Upper beds of the Cincinnati group, Waynesville, Ohio.

Genus ALLONYCHIA, n. gen.

Megambonia, Meek, 1872, Proc. Acad. Nat. Sci. Phila., p. 321. (Not Hall, 1859.)

Shell attaining a large size, a little obliquely subovate in outline, strongly convex, most gibbous somewhat above and in front of the middle, but with the point of greatest convexity situated further behind the anterior extremity than in any of the other genera of this family; beaks large, tumid, incurved, not terminal. Hinge line short, not alated posteriorly; just beneath the beaks a more or less well-defined, lobe-like protuberance of the anterior side, contains the byssal opening and usually forms the most anterior part of the shell. Surface radially costate. Hinge short, apparently edentulous, ligamental area high; posterior adductor scar large, deeply sinnate above, situated somewhat behind the middle of the valves; pallial line simple, extending up the anterior side to the umbonal cavity.

Type: *Megambonia jamesi*, Meek. (Plate 48, Fig. 7.)

The protrusion of the byssal opening, short, edentulous hinge, and non-terminal beaks are the characters that distinguish this genus from *Byssonychia*. The same features, excepting the one that relates to the absence of hinge teeth, also separate the genus from *Anomalodonta* and *Eridonychia*. The presence of a large byssal opening and the short hinge sufficiently distinguish the new genus from *Ambonychia* as restricted by me. As to *Megambonia*, Hall, under which genus, because of an external resemblance, Meek and others have placed the typical species *jamesi*, it is enough to say that *Allonychia* is totally different internally. Indeed, the two genera cannot possibly belong to the same family.

On plate 48, figure 7 illustrates a large and well preserved cast of the interior of *Allonychia jamesi*. Comparing it with the exterior we learn that the test was thick on the anterior side both beneath and above the byssal protrusion; and that the umbo is more pointed and smaller in the cast than in the shell, and not so much incurved. A small lobe is separated from the upper part of the byssal protrusion and thus lies immediately beneath the anterior extremity of the hinge. It is believed to be equivalent to a similar protuberance met with in internal casts of certain species of *Byssonychia* (*e. g. B. intermedia*, M. and W. sp.) and in *Amphicœlia*, Hall. Perhaps it is also to be likened to the subrostral lobe of *Ambonychia*. Though highly improbable it is still possible that the cavity of which it is the filling may have lodged an anterior adductor muscle. The feature should perhaps have been included in the generic diagnosis.

Allonychia ovata, n. sp.

Plate 48, Figs. 4–6.

The shell in this species is not so oblique (it is almost erect) and relatively higher than *A. jamesi*. The beaks are smaller and situated farther behind the anterior extremity of the shell, giving the false impression, in a side view, of being placed quite in the middle of the hinge. The anterior and posterior slopes of the surface, therefore, are more nearly equal. The number of the radial ribs also is not as great, being about forty and certainly not exceeding forty-five.* Though other differences have been made out, those mentioned will, in connection with the illustrations, suffice for the recognition of the species.

Formation and locality: Middle beds of the Cincinnati group, about 325 feet above the bed of the Ohio river at Covington, Kentucky.

* In a series of eight specimens of *A. jamesi* the number of the ribs varies between fifty-five and sixty-eight, and in only one of these is it less than sixty.

Allonychia subrotunda, n. sp.

Plate 48, Figs. 8-9.

This rather small shell is of a more rounded form than *A. jamesi*, the height being proportionally less and but little greater than the length. Another difference in the outline consists in the greater prominence of the central part of the anterior margin. Indeed, this part projects beyond the byssal lobe. The radii number about fifty.

Formation aud locality: Middle beds of the Cincinnati group, Cincinnati, Ohio; about 400 feet above low water mark in the Ohio river.

Genus OPISTHOPTERA, Meek.

Subgenus *Megaptera*, Meek and Worthen, 1866. Proc., Chicago Acad. Nat Sci., Vol. I, p. 22. (Not *Megaptera*, Gray, 1846.)

Opisthoptera, Meek, 1872, Proc. Acad. Nat. Sci., Phila., p. 319; also 1873, Ohio Pal., Vol. I, p. 131 (note).

Shell equivalve, usually triangular in outline, with the beaks of moderate size, incurved and terminal, and the hinge line straight and very long, in most cases forming a great posterior wing; length greater than the height; anterior side more or less abrupt. In the typical section the greatest height is in the anterior half, and the surface marked with numerous and frequently bifurcating costæ. In another group of species provisionally regarded as congenerie, the posterior part of the shell is the highest, and the radiating costæ few and mostly simple. Byssal opening, muscular scars and pallial line as in *Anomalodonta* and *Byssonychia*. Hinge with two small cardinal teeth in each valve, but so far as known, no posterior lateral tooth; external ligamental area usually narrow; no internal ligament.

Type: *Ambonychia casei*, Meek and Worthen.

In 1866 Meek and Worthen proposed to separate the type of this genus in a subgeneric sense from *Ambonychia*, under the name *Megaptera*. This name, however, cannot stand having been used previously in zoology by Gray. The preoccupation of their name having been brought to the notice of Mr. Meek he subsequently (*loc. cit.*) suggested that if the name *Megaptera* could not stand it might be replaced by *Opisthoptera*. Had he characterized the subgenus and adopted the latter name himself we would have no warrant to reject it, even when the rank of the group is raised to that of a genus. But he did neither, and consequently the group, whether viewed as a subgenus or genus, failed of being established. Still, as the substitution of a new name might lead to undesirable controversy and perhaps create unnecessary confusion, I have decided to adopt *Opisthoptera* and to define the name as that of a distinct genus.

As intimated in the above description *Opisthoptera* comprises two groups of species. The typical section is restricted to the upper beds of the Cincinnati group and contains *O. casei*, *O. fissicosta*, Meek, sp., and probably *O. alternata*, all three having small and bifurcated costæ, and the greatest height of the shell in the anterior half. The other group, comprising *O. notabilis*, *O. laticostata*, and *O. illinoisensis* (*Ambonychia illinoisensis*, Worthen), occurs in the middle beds of the group and possibly in the upper as well. It is distinguished from the *casei* section by the coarsely plicated surface and by the more or less decided posterior position of the line of greatest height. Yet it seems to me a case rather of undiscovered connecting links than one of distinct affinities. In evidence of this view I would cite the finely striated but posteriorly high *O. obliqua*, which links closely enough to *O. alternata*, and the coarsely plicated and centrally highest *O. ampla*. There is, I grant, much room for intermediate forms, but I expect confidently that diligent search will sooner or later close the gaps.

The great length of the hinge line is the character now chiefly relied upon in distinguishing the genus from *Byssonychia*, *Anomalodonta* and *Eridonychia*.

Opisthoptera casei, Meek and Worthen.

Plate 49, Figs. 1–5.

Ambonychia (*Megaptera*) *casei*, Meek and Worthen, 1866, Proc. Chicago Acad. Sci.' Vol. I. p. 23; also 1868, Geol. Sur. Ill., Vol. III, p. 337.
Not *Ambonychia* (*Megaptera*) *casei*, M. and W.?, 1873, Ohio Pal., Vol. 1, p. 133 (*O. fissiscosta*, Meek sp.)

The figures of this species on plate 49 will give, it is believed, a better idea of both its internal and external character than has been presented heretofore. They are also clear enough to render a detailed description unnecessary.

Formation and localities: Good specimens are always rare, and so far as known the species is restricted to the upper fifty feet of the Cincinnati group. More or less imperfect casts of the interior are not uncommon at Richmond, Indiana, and are occasionally met with at Waynesville and Clarksville, Ohio. A good mold of the exterior (see plate 49, fig. 1) was collected near Lebanon, Marion county, Kentucky.

Opisthoptera fissicosta, Meek.

Plate 49, Fig. 15.

Ambonychia (*Megaptera*) *casei?* Meek, 1873, Ohio Pal., Vol. I, p. 133 (The name *fissicosta* is suggested as appropriate should the peculiarities of the species described prove constant).*

* It is unfortunate that Meek so often shirked the responsibility of the erection of a species by merely suggesting a name that may be used should the characters observed by him prove to be constant or of sufficient importance to merit recognition. An injustice was thereby perpetrated upon those who followed him, and who accepted the responsibility that he would not, for they, though not really obliged to adopt his name are still in a measure bound to do so. Such a proceeding may show a cautious mind, but it is a kind of caution that is scarcely to be recommended, since it secures credit that is not deserved.

The outline and general expression of this shell is almost exactly the same as in *O. casei* M. and W. The anterior side seems to be somewhat straighter, a little more oblique, and more obtuse, but the principal difference no doubt lies in the radiating costæ. These are small, subequal, and rather closely arranged in *O. casei*, but in *O. fissicosta* the greater part of them, though at first of nearly equal size, soon become separated by gradually widening interspaces in which new ones are produced by bifurcation and interpolation. Bundles of three to five are then formed with the central one the strongest and most prominent. The inequality of the costæ, however, becomes less in nearing the margin of old examples, while in the cardinal region they appear always to be more equal than in the central portion of the valves.

Formation and locality: Meek gives Cincinnati, Ohio, as the locality for his specimen, but this is probably an error. So far as can be learned the species occurs only in the upper beds of the Cincinnati Group, in which I have seen it at Clarksville and Waynesville, Ohio. Good specimens are very rare.

Opisthoptera alternata, n. sp.

Plate 49, Figs. 9 and 11; also cut on page 645

In this species the surface markings seem to be almost exactly as in *O. fissicosta*, the costæ being at first simple, close together and equal, then, by widening the interspaces and the addition of new ones, either by interpolation or bifurcation, an alternation of the costæ is produced that is highly characteristic of the two species. Though agreeing so closely in this respect, a considerable difference in the outline is at once apparent. Thus, in *O. alternata* the posterior wing is much shorter and the posterior margin therefore much less oblique—indeed, it may sometimes be almost vertical—the angle formed with the hinge line in *O. fissicosta* being less than 40° and over 70° in *O. alternata*. The anterior outline on the other hand is more oblique in the latter. Among other differences it will be found that there is no broad. fold in the wing of *O. alternata* as is always present in *O. fissicosta* and *O. casei*, while the high anterior part of the valves is rounded instead of subangular, the latter being the case in those species. The ligamental area, furthermore, is much more of a feature, being nearly as wide and distinct as in *O. obliqua* (see plate 48, figure 6). In the last species the form is somewhat similar, yet they may be distinguished at once by the greater convexity and the almost flat anterior side of *O. obliqua*. In *O. extenuata* the anterior side is also flattened, but a more striking distinction is afforded by the remarkable posterior prolongation of the wing.

Formation and locality: Upper beds of the Cincinnati Group, Waynesville, Ohio. It seems to be a rare shell.

Opisthoptera extenuata, n. sp.

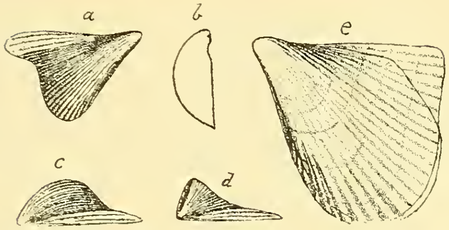


Fig. 2, *a–d*, *Opisthoptera extenuata*, n. sp., upper beds of the Cincinnati group, Warren county, Ohio: *a*, the right valve described, of the natural size; *b*, anterior view in outline; *c*, cardinal view; and *d*, oblique cardinal view showing the flattened anterior side. *e*, *Opisthoptera alternata*, n. sp., upper beds of the Cincinnati group, Waynesville, Ohio. Diagrammatic sketch, x 2, of the original of figure 9 on plate 49. The specimen is very young and therefore has simple costæ only except along the front. With age their number is much increased by interpolation and bifurcation, producing an appearance much as in *O. fissicosta*.

Shell small, triangular, the height and length respectively as two is to three; anterior side thick, flattened, with a nearly straight and rather strongly oblique outline, forming an angle of about 57° with the hinge line; ventral margin narrowly rounded, its center almost directly beneath the middle of the hinge; posterior margin strongly insinuated a little above the middle, sloping backward very gently in the lower part and abruptly prolonged in the wing; hinge long, though seeming not to extend quite to the sharply rounded extremity of the wing. Beaks moderately prominent, strongly incurved. Ligamental area narrow. Beneath the wing the surface of the valves is distinctly depressed. Surface of the specimen described marked with about thirty small costæ at the margin, those on the wing larger than elsewhere. An approximately uniform size is maintained by bifurcation. Greatest length 16.5 mm.; height 11 mm.; from beak to center of base 13.5 mm.; thickness of one valve 4.5 mm.

This species seems to occupy an intermediate position between *O. casei* and *O. obliqua*. For the former the anterior side is too oblique, too flat, and too straight, while the posterior margin also has a much deeper sinus. With the latter it agrees in the anterior and basal parts, but differs very decidedly in the prolonged wing and deeply sinuate posterior margin.

Formation and locality: Upper beds of the Cincinnati group, Warren county, Ohio. The horizon is probably one hundred feet beneath that occupied by *O. casei*.

Opisthoptera obliqua, n. sp.

Plate 49, Figs. 6—8.

Shell small, triangular, highest in the posterior third, and thickest along the oblique anterior side; hinge line as long as the shell, posterior margin vertical, gently convex, basal margin narrowly rounded; anterior side very abrupt, almost flat, forming an angle of about 55° with the hinge. Beaks rather large, prominent, but little incurred and separated by a considerable interval in casts of the interior. Ligamental area very wide. Surface marked with small, apparently bifurcating costæ, of which those near the cardinal margin are if anything smaller than elsewhere. On the whole they may be described as subequal.

This species doubtless is closely related to *O. extenuata*, the two species being very similar in their anterior halves. Still, it is highly improbable that they will ever be confounded, since they are so different posteriorly, this part of the outline being vertical and slightly convex in the present form and deeply sinuate centrally and prolonged above in that one. The ligamental area also is much larger in *O. obliqua*. Compared with *O. alternata* it is found that the valves though more convex are not as uniformly rounded, the anterior side more oblique and much more abrupt, and the costæ of nearly equal size instead of alternately large and small. None of the other species are near enough to require comparisons.

Associated with *O. obliqua* we find *Byssonychia richmondensis*, another species having the anterior side flat. But as it attains a much larger size, is relatively much higher and almost erect, and has a much shorter hinge, they are not likely to be confused.

Formation and locality: Upper beds of the Cincinnati group, Richmond, Indiana. It is there associated with *O. casei* and *Ortonella hainesi*, Miller, sp. The type specimens were collected by Mr. John Misener, and are now in the author's cabinet.

Opisthoptera laticostata, n. sp.

Plate 47, Fig. 6.

Shell of medium size, rather long, obliquely triangular in outline, widest in the posterior half, and most convex in the umbonal and anterior parts; greatest height a little less than two thirds of the length. Hinge line straight, extending the full length of the shell; posterior margin somewhat oblique, on the whole sloping forward and forming an angle of about 63° with the hinge; sinnate in the middle and gently convex above and below; basal margin rounded in the posterior half in front of which the outline ascends with a very gentle curve to the lower extremity of the narrow byssal opening, when it turns abruptly upward and finally forward again to the beaks. The latter are large and terminal, projecting well forward though but little above the hinge. For a short distance behind the lower part of the thin projecting margin of the byssal opening the shell is compressed. A wide, undefined sulcus crosses the valves from the sinus in the posterior margin to the posterior side of the beaks. Surface of the best specimen seen marked with about twenty simple costæ. These increase in size from the cardinal margin downward, the first four being much smaller than those beneath them, while anterior to the tenth, which may be the largest, a gradual decrease is observable. The concentric growth lines are very regular and unusually distinct.

The large costae will distinguish this fine species from all of the preceding forms of this genus. The next species, *O. ampla*, though closely related, is readily distinguished by several obvious differences. *O. notabilis* also is closely allied but has differently shaped ends and seems to be without radiating plications on the cardinal slope.

Formation and locality: The type specimen was collected by Prof. Edward Orton in the upper beds of the Cincinnati group at some locality in Warren county, Ohio. Two imperfect specimens belong to the cabinet of Prof. J. M. Safford and were collected by him in Hickman county, Tennessee, where they occurred in strata regarded as equivalent to the middle or upper beds of the Cincinnati group of Ohio.

Opisthoptera ampla, n. sp.

Plate 47, Fig. 7.

The specimen upon which this species is founded is a cast of the interior and not a good one either. Still it preserves sufficient of its specific characters to give us a fair idea of the position of the species in the genus. Evidently it is more closely related to *O. laticostata* than to any other known. Yet, the greater height, especially of the anterior part, more oblique and more deeply sinnate posterior margin, larger ventral part and differently arranged radiating costae, are differences obvious enough to render the separation of good specimens of the two species a matter of small difficulty. The wing also is broader and the anterior end is not compressed, while the byssal opening seems to have been larger. Being a cast the costae near the cardinal border are difficult to make out, but enough of them can be determined on the wing to show that there is not that uniformity in the increase of the size of the costae which pertains to *O. laticostata*. The large plications will of course distinguish the species at once from all the other forms of the genus save *O. notabilis*, and that one is very different in nearly every other respect.

Formation and locality: Middle beds of the Cincinnati group, Cincinnati, Ohio.

Opisthoptera notabilis, n. sp.

Plate 49, Fig. 16.

Shell very elongate for this family, highest posteriorly, the length and height respectively as sixteen is to nine. Cardinal margin long, nearly straight, rather acutely prolonged posteriorly though not as far as the rounded part of the posterior outline; basal margin broadly convex, ascending anteriorly, turning abruptly into the short, nearly straight, and almost vertical anterior margin. Beaks neither large nor prominent; valves with the greatest convexity in the anterior third, the anterior slope rapid though not abrupt; wing compressed; byssal opening apparently long and very narrow. Surface marked with distinct but irregular concentric lines of growth. Excepting the compressed cardinal slope or wing, on which radiating costæ are very obscure or are wanting entirely, the rest of the surface is thrown into about twelve radial folds, of which the five or six occupying the central part of the valves are large and moderately prominent. The remainder, however, gradually decrease in size and distinctness anteriorly.

Though clearly a near relative of *O. laticostata*, the present species is still not at all likely to be confounded with it nor with any other ambonychioid shell now known. The distinctive features are the unusual length of the shell and the comparative obscurity of the costæ.

Formation and locality: Middle beds of the Cincinnati group, Cincinnati, Ohio.

Genus PSILONYCHIA, n gen.

Shell large, slightly oblique, high, acuminate-ovate; anterior side abrupt, beaks prominent, incurved, terminal. A large byssal opening in the somewhat flattened upper half of the anterior side. Surface marked with concentric lines of growth only. Hinge rather short, scarcely alate posteriorly, apparently without teeth; ligamental area well developed, horizontally striated. Muscular scars and pallial line as in *Byssonychia* and other genera of this family.

Type: *P. perangulata*, n. sp.

This interesting genus seems to occupy an intermediate position between the radially ribbed genera *Byssonychia*, *Eridonychia*, *Allonychia*, *Anomalodonta* and *Opisthoptera*, and the concentrically marked genera *Clionychia*, *Mytilarca*, Hall, and *Plethomytilus*, Hall, having a large byssal opening like the former and concentric surface markings only like the latter. Still, we cannot regard *Psilonychia* as in any way lessening the gap between these two groups of genera. Should species of this type be discovered in, say the Chazy limestone, we might reasonably view the genus as a connecting link. But, why speculate on species that probably never existed? With our present light we are obliged to accept *Psilony-*

chia as a departure from *Clionychia* during the Cincinnati epoch. The radially ribbed, byssiferous genera having been established either previously or at the same time, it follows that *Psilonychia* cannot stand in genetic relationship to them.

Although I am acquainted with two species having the characters of this genus, only one can be described at this time, the specimen of the other being too imperfect for satisfactory delineation. Though so imperfect, it yet preserves all the essential characters of the genus. So far as comparison between it and *P. perangulata* is possible, the undescribed species appears to differ in being more oblique, and in having the anterior and umbonal regions strongly rounded instead of angular. The specimen is also from a higher horizon, having been found at Clarksville, Ohio, in the upper beds of the Cincinnati group.

Psilonychia perangulata, n. sp.

Plate 51, Figs. 1—3.

Shell large, high, accuminate-subovate, very slightly alate, rather narnow above, the lenght of the hinge line equally only about five-eights of the greatest width of the shell; greatest width and greatest height (from umbo to center of base) about as three is to five; cardinal outline straight in the posterior half, anteriorly rising to the umbo; anterior side almost flat and at right angles to the hinge line in the upper half, curving backward below; lower half of outline semiovate. Beaks very prominent, strongly incurved, carinate, the flattening of the anterior side extending to their apices. Byssal opening large, situated about its length beneath the beaks. Surface of test covered with concentric lines of growth. These are rather regular and fine, except in the vicinity of the byssal opening where they are gathered into distinct wrinkles.

Byssonychia richmondensis, though a smaller shell, has a similar form, but as it is restricted to strata between three and four hundred feet above the beds holding *P. perangulata*, and as the *Byssonychia* has strong radiating ribs, which are wanting entirely in the species just described, there is not the slightest occasion for confusion between them.

Formation and locality: Middle beds of the Cincinnati group, near the tops of the hills at Cincinnati, Ohio.

Genus ANOPTERA, n. gen.

Shell subovate, high, moderately convex, with a very short hinge, not alate posteriorly; beaks terminal, directed forward, compressed; a long, lunule-like depression beneath the beaks; no byssal opening. Surface marked with concentric lines of growth only. Hinge apparently edentulous; so far as known, no external ligamental area, but an internal cartilage, extending nearly the full length of the hinge, is indicated by a narrow and sharply defined prominence lying between the compressed beaks of casts of the interior. Posterior adductor scar large, situated in the postero-basal third of the valves; pallial line simple, sharply defined in casts, extending up the anterior side to the umbonal cavity.

Only known species, *A. miseneri*, n. sp.

This remarkable genus probably is related to *Clionychia*, but the relation cannot be very close. The hingement seems to be totally different, and the muscular impression occupies a lower position. The general aspect also is quite different, being much more like that of certain species of *Mytilarca*. Some may see in the new genus an intermediate type between *Clionychia* and *Mytilarca*, but I am fully satisfied that such a view, even considering that *A. miseneri* is found in the proper horizon for it, would be erroneous. The hinge of *Anoptera* is of such a nature that I cannot see how it could have been changed to that of *Mytilarca*. On the other hand, I can readily conceive how the long hinge of *Clionychia* was at first shortened, and then modified by the development of teeth at each end till *Mytilarca* had been established. As now viewed by me, *Anoptera*, like *Psilonychia*, represents a departure from the regular line of *Clionychia* that became extinct with the close of the Lower Silurian.

Anoptera miseneri, n. sp.

Plate 50, Figs. 5-9.

Shell compressed-convex, rather erect, subovate, narrowest above, the length and height respectively as three is to four and a small fraction; hinge line very short, passing gradually into the posterior margin; upper half of anterior outline distinctly concave. Beaks compressed, curving mostly forward over a long and laterally well defined lunule; umbonal ridge defined by a distinct furrow in the postero-cardinal slope. Surface with strong, unequal, subimbricating lines of growth.

I am not acquainted with any Lower Silurian shell with which *Anoptera miseneri* might be confounded.

The specific name is given for Mr. John Misener of Richmond, Indiana, an excellent collector and keen student of the fossils of the Cincinnati, group. Science is indebted to him for the discovery of a number of entirely new forms as well of instructive specimens of several species that were but little known heretofore.

Formation and locality: Upper beds of the Cincinnati group, Blanchester, Ohio and Richmond, Indiana.

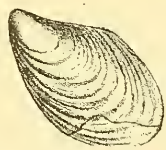
Genus CLIONYCHIA, Ulrich.

Clionychia, Ulrich, 1892, American Geologist, Vol. X, p. 97; also Pal. Minn., p. 493. (In press.)

During the present year I succeeded in obtaining two species from the rocks of the Cincinnati group that seem to belong to this genus.

One is from the lower beds (Utica horizon) and of considerable interest because of its oblique shape and consequent approximation toward the upper Silurian and Devonian genus *Mytilarca.* The other is from the upper beds of the formation and has an erect form like the typical lower Trenton species of the genus.

Clionychia subundata, n. sp.



Clionychia subundata, Ulrich. Left valve of the natural size.

Shell less than the average size for the genus, moderately convex, oblique, the outline obscurely rhomboidal; anterior and basal margins gently rounded, oblique, post-ventral extremity strongly rounded, posterior margin but little convex; hinge line straight, about half as long as the greatest oblique diameter of the shell; post-cardinal angle about 125°, antero-cardinal angle between 65° and 70°. Beaks moderately prominent, not strongly incurved. Surface marked with fine concentric lines of growth and irregular concentric undulations, generally strongest on the anterior slope. Interior unknown.

This species is smaller and more oblique than any other now referred to the genus. *C. rhomboidea* Ulrich, of the lower Trenton (Birdseye limestone) in Minnesota, is the most like it so far as shape is concerned, but the concentric undulations are believed to indicate closer affinities with *C. undata* Emmons, sp. In the latter the surface undulations are much broader, the hinge longer, and the shell much less oblique.

Formation and locality: Lower beds (Utica horizon) of the Cincinnati group, at Covington, Kentucky; associated with *Leptobolus lepis*, Hall.

Clionychia excavata, n. sp.

Plate 51, Figs. 4 and 5.

Shell, as seen in a cast of the interior, of medium size, erect, strongly convex, subquadrangular, straight above, slightly sinuate anteriorly, and rounded below and posteriorly; post-cardinal angle obtuse, perhaps rounded; length of hinge line about two-thirds of the greatest width (length) of the shell; length and heighth respectively as six is to seven. Beaks compressed, scarcely projecting above the hinge, separated by an unusually wide interval; between and beneath them the greater part of the upper half of the anterior side of the shell is deeply excavated.

Muscular scar situated lower than usual, placed just behind the center of the valves. Surface of cast with distant lines of growth in the outer half.

The hinge is shorter and the anterior excavation larger than in *C. lamellosa* and *C. erecta*, two species of the lower Trenton rocks of Minnesota and Wisconsin.

Formation and locality: Upper beds of the Cincinnati group, Richmond, Indiana, where the specimen described was collected for the author by Mr. John Misener.

Family MODIOLOPSIDÆ, (Fischer) Ulrich.

Genus MODIOLODON, Ulrich.

Cyrtodonta (*part.*), Safford, 1869, Geology of Tennessee.

Modiolodon, Ulrich, 1893, Final Rep., Vol. III, Geol. and Nat. Hist. Sur. Minn., p. 521.

Modiolodon oviformis, Ulrich.

Plate 53, Figs. 7 and 8.

Modiolopis Oviformis, Ulrich, 1890, American Geologist, Vol. V, p. 276.

Shell 50 mm. or less in length, slightly oblique, almost regularly oval transversely, narrowest in the anterior half; greatest height and length as three or three and one half is to five. Valves moderately and nearly uniformly convex, the point of greatest convexity a little in front and above the center. Cardinal margin arcuate, basal margin with nearly the same amount of convexity; anterior and posterior ends nicely rounded, the latter much the widest and often produced slightly beyond an even curve in the lower part. Beaks small, inconspicuous, and situated a very short distance behind the anterior extremity in the shell, appearing more prominent and less nearly terminal in casts of the interior; umbonal ridge nearly obsolete. Shell of moderate thickness, strongest in the umbonal region, its outer surface nearly smooth, exhibiting only a few faintly impressed fine concentric lines. Hinge with two subequal, nearly horizontal rather strong cardinal teeth, in each valve, situated mostly in front of the beaks and above the strongly impressed anterior muscular scars.

Casts of the interior, in which condition the species is usually found, are in most cases terminated anteriorly by the well marked pair of muscular scars. Pallial line simple, distinct and pustulose in the anterior third, behind which it is obscurely defined to the large and faintly impressed posterior adductor scar. The latter is obovate and situated close to the posterior extremity of the cardinal border. Umbonal ridge much more distinct than on the exterior of the shell, being defined anteriorly by a distinct sulcus.

This species is widely removed from *Modiolopsis modiolaris*, Conrad, with which collectors of Kentucky fossils have often confounded it. Aside from the well developed cardinal teeth, the more oval shape and rounded instead of sinuate basal margin, should under ordinary circumstances, be quite sufficient to separate them. The *Modiolodon winchelli* (*Cyrtodonta winchelli*, Safford), of the Trenton of Tennessee, I consider as closely related. The latter is distinguished, however, by its less regularly ovate form, the shell being as a rule not so high and always more produced in the post-basal region, and less uniformly rounded at the junction of the cardinal and posterior margins. The cardinal teeth also are more oblique and situated almost entirely behind the beaks, while one in each valve is stronger than the other. Occasionally, again, only one tooth is developed in the left valve.

Formation and locality: This shell is very abundant at numerous localities in Boyle, Mercer, Anderson and Franklin counties in Kentucky. Its vertical range is restricted and it is, therefore, a highly characteristic fossil of the argillaceous limestone beds resting upon the massive crystalline limestone which has furnished so many remarkable forms of cystidea and other echinodermata, and constitutes the base of the Trenton group proper in Kentucky. I believe the species also occurs in a similar position in Tennessee.

Modiolodon oviformis, var. *amplus* n. var.

Plate 53, Figs. 1 and 2.

The above provisional designation is proposed for a form that is to be found associated with *M. oviformis* at Frankfort, Kentucky. It differs, so far as the characters of the variety are shown in four specimens, in the straighter basal margin, more distinct pallial line, and larger size. The length of the four specimens varies between 60 mm. and 68 mm.

Modiolodon subrectus, n. sp.

Plate 53, Figs. 5 and 6.

This species is known only from casts of the interior. Of six specimens the largest is 47 mm. long and 27 mm. high, the smallest 29 mm. long and 17 mm. high. Cardinal and basal margins nearly straight and subparellal, diverging slightly posteriorly; posterior margin obliquely subtruncate, obtusely angular above, most prominent and strongly rounded in the lower half; anterior end short, small, the upper margin sunken considerably beneath the dorsal outline. Beaks compressd, prominent anteriorly, situated well forward, on a line with the back, scarcely incurved, separated by a well defined, wide, channel-like depression extending posteriorly from the points of the beaks half the length of the cast. Umbonal ridge and sulcus strong, extending from the beaks obliquely downward to the central third of the base; and producing a decided compression of the antero-basal third of the cast. Anterior muscular scar very strong, obliquely ovate, large, occupying the greater part of the small anterior end. The inner side of the elevated scar is marked with about six horizontal folds. Pallial line and posterior adductor impression indistinct. The casts exhibit no indications of the surface markings. The hinge plate seems to have been strong, while of cardinal teeth the evidence at hand indicates two in each valve, one larger than the other.

The casts of this species might be confounded with those of small specimens of *Ischyrodonta elongata*, Ulrich, but a careful comparison will show that the *Modiolodon* is narrower posteriorly, the dorsal and ventral margins being more nearly parallel and also straighter; the ventral margin is not sinuate, and there is no small pedal muscular scar above the anterior adductor impression, while the inner side of the latter is thrown into folds instead of being sharply edged. Excepting the following species there is no other known to me with which it need be compared.

That *M. subrectus* is not an *Ischyrodonta* is shown by the black film so characteristic of the *Modiolopsidæ* which is retained by two of the specimens. The absence of the small pedal muscles over the anterior adductor impressions also is significant.

Formation and locality: Upper beds of the Cincinnati group, Richmond, Indiana.

Modiolodon declivis, n. sp.

Plate 53 Figs. 3 and 4.

Of this species also only casts of the interior have been seen. These are so much like those of *M. subrectus* that a detailed description is unnecessary. On comparing the casts we find that *M. declivis* is more elongate, the length being twice as great as the height; the ventral margin is slightly sinuate instead of straight, and the dorsal margin arcuate, the posterior part sloping downward in a manner quite unusual in this family of shells. The two ends are nearly equal, the posterior one being therefore relatively narrower than in *M. subrectus*.

Formation and locality: Upper beds of the Cincinnati group, Richmond, Indiana, where five specimens were collected.

Modiolodon obtusus, n. sp.

Plate 52, Figs. 20 and 21.

Modiolopsis modiolaris, Hall and Whitfield, 1875, Pal. Ohio, Vol. II, plate II, Fig. 17.
(Not *M. modiolaris*, Hall, 1847, nor *Pterinea modiolaris*, Conrad, 1838.)

Shell large, compressed-convex, oblong, subovate or obscurely quadrangular, highest behind, though unusually wide and blunt in front. Cardinal margin very long, distinctly arcuate, passing gradually into the regularly curving anterior margin; post-cardinal angle obtuse, sometimes rounded but always projecting beyond the line of a regular curve; posterior margin nearly erect, not strongly curved, except at the base where the outline turns rapidly forward into the basal line, which may be straight or more or less sinuate. Ventral and dorsal margins nearly parallel in the posterior two-thirds, the height in this part of the shell comparing with the length about as six to eleven, while the height at the beak is represented by a little more or less than four. Beaks small, scarcely distinguishable, situated very near the anterior end; umbonal ridge inconspicuous, low, defined only on the lower side by the broad mesial depression. Surface marked by rather fine concentric lines of growth. Shell thick, especially in the anterior part. Anterior muscular scar large, deep, of rounded or ovate shape. Hinge plate wide, furnished with long cardinal teeth immediately over the muscular scar. There appear to be three teeth in all, one large one in the right valve and two more slender in the left.

In a form obtained from the upper beds of the Cincinnati group, which I shall consider provisionally as belonging to this species, the anterior end is narrower and the anterior muscular scar almost straight on the inner side. A good specimen measures as follows: Length, 79 mm.; central height, 43 mm.; anterior height, 23 mm. It is this variety that seems to correspond with the figure given, as above cited, by Hall and Whitfield as of *Modiolopsis modiolaris*. If this specimen is correctly represented by their drawing, it cannot belong to Conrad's species nor even to the genus *Modiolopsis*, since it had well developed cardinal teeth.

This large shell finds its nearest congeners in the three species described on the preceding pages and figured on plate 53, but as the means for comparison are thus at hand and as the differences between the forms must be obvious to every one, it is not necessary to point them out.

Formation and locality: The typical form is from the middle beds of the Cincinnati group, at Cincinnati, Ohio, and Covington, Kentucky, the exact horizon being about 350 feet above the bed of the Ohio river. The variety mentioned I have seen only from the upper beds of the group near Waynesville, Ohio, but the specimen figured by Hall and Whitfield is credited to Cincinnati.

Modiolodon subovalis, n. sp.

Plate 51, Figs. 11-13.

Shell, as seen in casts of the interior, subovate, highest posteriorly, rather compressed-convex, thickest a little above the middle, the hight and length about as two is to three; length varying in different specimens between 35 mm. and 50 mm. Dorsal outline slightly arcuate; posterior margin somewhat oblique, generally a little straightened (scarcely truncate) in the upper half and well rounded in the lower, at other times more uniformly curved; base broadly rounded, ascending anteriorly; anterior end very short and small, regularly curved, Beaks very small, scarcely distinguishable, situated far in front; no distinct umbonal ridge; mesial sulcus comparatively deep in the umbonal half, not sharply defined however anywhere.

Anterior muscular scar very faint, prominent, occupying about half of the small anterior end; pallial line moderately distinct, submarginal posterior scar very faint. Back of cast deeply channeled, indicating either a strong hinge plate or an escutcheon in the shell, the former most likely. Cardinal teeth were present but they are not shown clearly enough in casts to be described. Surface of casts with a few distant lines of growth.

This species is closely related to the *Modiolopsis truncata*, Hall, but may be distinguished by its more nearly oval outline, and deeper mesial or umbonal sulcus. In the outline it is more like the type of the genus *M. oviformis* but the casts of that species are not channelled dorsally in any degree comparable with *M. subovalis.*

Respecting the generic position of the species, I see nothing to oppose an arrangement with *Modiolodon.* The same applies also to *Modiolopsis truncata*, because it is unquestionably congeneric with *M. subovalis.* Until the latter was discovered and studied I found Hall's species (*truncata*) most troublesome to classify, and for a time I was inclined to place it into the new genus *Eurymya*, founded upon *Modiolopsis plana*, Hall.

Formation and locality: Upper beds of the Cincinnati group, Versailles, Indiana. Five specimens.

Genus ACTINOMYA, Ulrich.

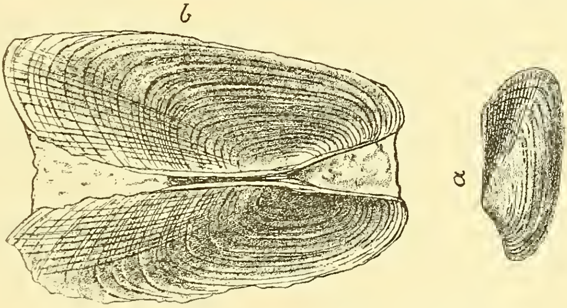
(Final Rep. Geol. Sur. Minn., Vol. III, p. 513 (In press.)

The type of this genus is the *Modiolopsis cincinnatiensis*, Hall and Whitfield, described in the second paleontological report of this survey. It is a common and highly characteristic fossil of the lower fifty feet of the Cincinnati group. The figures given by the authors of the species on plate II of the work cited, do not, according to my observation, correctly represent the species. During the past eighteen years I have had opportunities to examine an aggregate of several hundred specimens, most of them in an unusually good state of preservation, and all of them bearing evidence for the great constancy of the specific characters of the form. None, so far as I can remember, could be said to approach even the figures given by Hall and Whitfield in the angularity of the posterior extremity.

Figure 16 on plate 56 of this report, represents a well preserved cast of the interior of a large right valve. It shows beside the normal form of the shell, the merely outlined anterior muscular scar, obscure traces of the posterior scar, and radial lines on the ventral slope. The latter, as is the case also with other species of the genus, never show on the exterior of the shell but are strictly an internal feature and rarely noticeable except on well grown or old examples.

Associated with this species, at any rate with the shell that every collector at Cincinnati has identified with Hall and Whitfield's *M. cincinnatiensis*, another is found, though much more rarely, which may have been included by them in their *M. cincinnatiensis* and perhaps used in the illustration of their species. The posterior end of this shell has an outline really very much like their figure 14, being subangular at the end of the hinge and but little curved in the oblique slope from that point to the sharply rounded post-basal angle. While I can believe readily that specimens of this second form may have been included among those to which they applied the name *cincinnatiensis*, I cannot understand, considering the attention they were obliged to give it in making a drawing of it, how they could have failed to notice the radiating lines which traverse the cardinal and posterior parts of the surface and are distinguishable even on all the interval casts seen by me. Such radii are not often to be seen on the common form, but it is important to know that they do exist occasionally, though always fainter than in the rare one.

b



a

Figs *a* and *b*. *Actinomya cancellata*? Walcott, sp.

In the above cut *a* represents the cast of a small left valve, and *b* a natural mould of the exterior of two imperfect valves joined together by the external ligament, which, together with the hinge, is retained by the specimen. Comparing these figures with figure 16, plate 56, certain differences appear aside from the posterior radii. Thus the anterior end is relatively a little longer, narrower and less regularly rounded, the post-cardinal angle is better defined, the posterior margin less curved except below where it turns more abruptly into the basal line, and the umbonal ridge more prominent and better defined. These differences, though slight, are constant, and, coupled with the greater distinctness of the posterior radii, it seems reasonable to consider them as of specific importance.

Granting that the two forms are distinguishable, whether as species or varieties is immaterial, the question arises, to which of the two is the name *cincinnatiensis* strictly applicable? The evidence afforded by the description and figures is not entirely conclusive for either the one or the other. One thing however may be accepted as reasonably certain, and that is that the majority of the specimens so named by Hall and Whitfield belong to the common form. Hence, if a separation is to be made, the best justified course is the elimination of the rarer form. Another good reason for this course is found in the fact that Walcott proposed the name *Modiolopsis cancellata** for what I believe to be merely a young example of the latter, which he discovered in the Utica slate of New York.

Actinomya kentonensis, n. sp.

Plate 56, Figs. 18-20.

Shell of medium size, moderately convex, elongate, subovate, narrow anteriorly; thickness, height at beaks, greatest posterior height, and length respectively to each other as three, four and six or seven are to thirteen or fourteen. Cardinal margin nearly straight or gently arcuate, passing gradually into the uniformly rounded—almost semicircular—posterior margin; basal line gently convex behind, nearly straight in the central half, on the whole, rising gradually to the short and narrowly rounded anterior end. Beaks comparatively small, projecting but little beyond the hinge line, situated about one-seventh of the length of the shell behind the anterior extremity. Umbonal ridge rounded, not prominent; mesial depression quite undefined, producing but a slight flattening of the umbones and of the surface of the valves beneath them. Surface marked with rather obscure, concentric undulations and fine lines of growth, the former showing through the shell so as to be visible on casts of the interior. Two or three faint rays may be observed on the posterior half of the umbonal ridge of casts. Anterior muscular scar rather small, obovate, erect, not strongly defined; posterior scar and pallial line faint, not satisfactorily observed. Test very thin.

The position of this fine species seems to be intermediate between the typical section of the genus and that other group of species of which *A. pholadiformis*, Hall, sp., may be regarded as representative. Of described species, there is none that is at all likely to be confused with *A. kentonensis*, but I have illustrated two closely related forms on one of the plates, which, because of a lack of room, had to be omitted from this report.† One has very nearly the shape of *A. pholadiformis*, but is without the peculiar surface ornamentation so characteristic of that species. The obliquely truncate posterior end will distinguish it from the present species. The other is more elongate and has, for so long a shell, an unusually convex base.

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* 1879, Trans. Albany Insti., Vol. X, p. 22.

† I shall endeavor to publish these plates as soon as possible, together with others on Lower Silurian *Aviculidæ*, the only important family of those known from these early paleozoic rocks remaining to receive the semi-final treatment accorded to the other families in this and the Minnesota work.

Associated with this species and *A. cincinnatiensis* I found a single imperfect left valve, agreeing very closely with *A. modioliformis*, Meek and Worthen, sp.

Formation and locality: Lower 75 feet of the Cincinnati group, at Covington, Kentucky, where it has been found only in the banks of the Ohio river.

Genus COLPOMYA, Ulrich.

(Final Rep. Geol. Sur. Minn., Vol. III, p. 522. (In press.)

Colpomya constricta, n. sp.

Plate 52, Figs. 17–19.

Shell somewhat elongate, strongly convex on the umbonal ridge, 25 mm. to 35 mm. in length, 14 mm. to 18 mm. in height at the beaks and at the posterior extremity of the hinge; thickness about three-fourths of the height. Outline subrhomboidal, with the hinge line straight, and extending about two-thirds of the entire length; anterior margin curving neatly backward from the sharply rounded or subangular extremity of the hinge; ventral margin gentle sinnate; posterior margin very oblique, produced and strongly rounded below, but littte curved in the central and upper parts; post-cardinal angle about 135°. Beaks strongly incurved, situated one-third or more of the length of the hinge line from the anterior extremity; umbones large, prominent, distinctly constricted by the small end of the strongly developed, oblique mesial sulcus; posterior umbonal ridge very prominent, not angular but sharply rounded, distinguishable from the beak to the post-basal angle; anterior umbonal ridge consisting of a broad swelling in front of the mesial depression; cardinal slope abrupt, concave. Surface marked by somewhat unequal though on the whole strong concentric lines of growth.

Hinge plate straight and very thin posterior to the beaks, twice as strong in front of them; beneath the beaks of the right valve a tooth like prominence that fits into a corresponding depression beneath the beak of the left valve; in front of and beneath this pit in the left valve a strong process projects obliquely downward, backward and toward the opposite valve and is partly received in a socket that defines the anterior side of the tooth in the right valve, while its lower end curves under that tooth. Anterior muscular scar subovate, not very large, distinct, bounded upon the inner side by a thin ridge running down from the hinge. Immediately behind the top of this ridge a small pedal muscle scar is excavated out of the under side of the hinge plate. Posterior scar and pallial line not satisfactorily shown in the specimens at hand.

Two other species of *Colpomya* are associated with the present form, but as they are much smaller and obviously different in their outlines, there is little likelihood of confusion between them.

Formation and locality: In the uppermost beds of the Trenton limestone on Reservoir hill near Frankfort, Kentucky.

Genus ORTHODESMA, Hall and Whitfield.

Orthodesma, Hall and Whitfield, 1875, Pal. Ohio, Vol. II. p. 93; Ulrich, 1894, Pal. Minn., Final Rep. Vol. III, Geol. and Nat. Hist., Sur. Minn., p. 516.

In the Minnesota report above indicated, I have restricted and redefined this genus, and shown that it is related to *Modiolopsis* rather than to *Orthonota*. So far as known, the genus is restricted to the Lower Silurian rocks in which it is represented by about fourteen species, three of them occurring in the Trenton, the rest in the various beds of the Cincinnati group. The greater number of the latter are new to science and as I found room for only two of them in the present work, the remainder will have to await some other opportunity for publication.

Orthodesma subangulatum, n. sp.

Plate 55, Figs. 21-23.

This species is closely related to *O. rectum*, H. and W., the type of the genus, but may be distinguished by a number of minor differences, chiefly in the matter of outline. The shell is more elongate, the posterior height being less and only about one-third of the entire length. The ventral margin is straighter and sinuate rather than convex, while the central and dorsal outlines are more nearly parallel. The anterior end is uniformly rounded instead of being oblique with the most prominent point in the upper part. Finally the posterior margin is a little more oblique. Of other differences we may mention that the umbones seem to have been somewhat smaller and merely flattened instead of sulcate, while the umbonal ridge is stronger and more curved.

The Trenton species *O. subnasutum* (*Modiolopsis subnasuta*, Meek and Worthen), is higher posteriorly, while *O. curvatum*, Hall and Whitfield has a more rounded posterior end and more sinuate ventral margin. None of the other species are near enough to require comparisons.

Formation and locality: Upper beds of the Cincinnati group, Richmond, Indiana.

Orthodesma parvum, n. sp.

Plate 55, Figs. 19-20.

Shell small, elongate, about 22 mm. long, 7 mm. high at the beaks, and 7.5 mm. near the uniformly rounded posterior end; greatest thickness subcentral, about 5 mm.; anterior end narrowly rounded, almost acute; back straight, base straight in the middle, on the whole very gently convex. Beaks small, not prominent, situated about one-fourth of the length of the shell behind the anterior extremity; umbones and sides of valves flattened; umbonal ridge rather distinct though not angular. About midway between the umbonal ridge and cardinal margin an obscure impressed line. Surface with comparatively coarse concentric lines, strongest and regular on the cardinal slope, faint anteriorly.

The point of greatest convexity is situated farther forward than usual in this genus but in other respects this small species seems tobe a true *Orthodesma.* Of described species it is probably nearest *O. rectum*, H. & W., but as it is much smaller and not so high posteriorly, and has a more evenly rounded posterior extremity it is not likely to be confused with that species.

Formation and locality: Middle beds of the Cincinnati group, Cincinati, Ohio, where it occurs about 400 feet above the bed of the Ohio river.

Genus CYMATONOTA, n. gen.

Orthonota (*part.*), Conrad, 1841, N. Y. Ann. Geol. Rep., p. 51; Hall 1847, Pal. N. Y., Vol. I, p. 299.

Orthodesma (*part.*), Hall and Whitfild, 1875, Pal. Ohio, Vol. II, p. 93.

Elongate solen-like shells, gaping more or less at both ends, with the hinge line long and extending in a straight line anterior and posterior to the small beaks; ventral and dorsalmargins 'subparallel. Hinge plate very thin, edentulous; valves united by a delicate linear external ligament seemingly extending the full length of the hinge. Test very thin, marked externally with fine concentric lines, and on each side of the hinge line by short wave-like furrows. Pallial line and muscular scars so faintly marked that even in the best preserved specimens they can not be made out with certainty.

Type: *Cymatonata typicalis*, n sp.

Species of this genus were first referred to *Orthonota*, Conrad, and later to *Orthodesma*, Hall and Whitfield.

The first of these genera is now generally used and I believe justly so, for upper Silurian and Devonian species only. I admit however, that the proposed genus is in many respects like *Orthonota*, yet I would main- that they are not identical. The ornamentation which usually pertains to the species of Conrad's genus is wanting in *Cymatonota.* The ligiment is believed by Hall to be internal in *Orthonota* whereas it is clearly external in the earlier types here described. Finally, in the absence of any statement to the contrary, we must believe that the margins of the valves do not gape in *Orthonota* while they do at both ends in *Cymatonota.*

The relations to *Orthodesma* are doubtful. That genus is, I am fully convinced, closely allied to *Modiolopsis* and *Whiteavesia*, but I cannot say this of *Cymatonota.* On the contrary the last genus seems to me to be widely different and my arrangement of the group as a member of the

Modiolopsidæ is to be regarded as entirely provisional and mainly in deference to the views of others. While I might indicate a number of differences between *Cymatonota* and *Orthodesma*, I deem it best to postpone their consideration till some more final classification of the genus is undertaken. For the present the generic difference of the two groups of species will be sufficiently established by the mention of a single point. Namely, the muscular scars of *Orthodesma* are precisely as in *Modiolopsis*, the anterior adductor scar being strongly impressed, while the posterior scar is faint. In *Cymatonota* however both scars are exceedingly faint, and even in very favorably preserved specimens not the slightest traces of them are to be observed.

Conrad's species *pholadis*, which I regard as belonging to *Cymatonota*, is the first to follow his generic description of *Orthonota*, and would therefore under ordinary circumstances be entitled to consideration as the type of the genus. It is however clear that Mr. Conrad always regarded his *O. undulata* as the typical species.

Cymatonota typicalis, n. sp.

Plate 55 Figs. 1—5.

Shell elongate, with the dorsal and ventral margins parallel, the length three and one-half times the height, the greatest thickness, which is a little behind the center, about two-thirds of the height; anterior end nearly vertical, rounded but not uniformly, the turn into the hinge line being rather abrupt; posterior margin rounded, slightly oblique, most prominent in the lower half; ventral margin gently concave. Beaks appressed, scarcely prominent, situated one-fifth of the length of the shell behind the anterior extremity; umbonal ridge and mesial sulcus rather distinct features, cardinal region anterior to the beaks sharply compressed. Surface with fine equal striæ anterior to the beaks, of which not over half continue over the flanks of the shell where they take on an irregular character, some being much stronger than the others; or several may be united into a fold. The umbonal ridge is almost smooth, but the upper part of the posterior cardinal slope is marked with rather regular, strong, oblique folds.

Formation and Locality: Upper beds of the Cincinnati group, Waynesville, Ohio.

Cymatonota recta, n. sp.

Plate 55, Figs. 8 and 9.

This species is very much like *C. typicalis* but may be distinguished by the following differences: The length is a trifle greater, the height and length of a specimen in which these dimensions are not affected by pressure being about as three to eleven. The thickness is proportionally a little less, being about 7 mm. in a specimen 12 mm. high. More important difference is found in the mesial sulcus and umbonal ridge, both of these features being less distinct than in *C. typicalis.* Because of the very slight development of the mesial sulcus, the ventral margin, except at the ends, is perfectly straight, and thus furnishes us with another diagnostic point since in that species the base is gently concave. The umbones again are smaller and not so distinct from the cardinal region on each side of them. Finally the ends of the shell are somewhat different, the anterior one being more uniformly rounded and the posterior straighter above causing a sharper post-cardinal angle.

Cymatonota pholadis, or at any rate a form that we identify with Conrad's *Orthonota pholadis*, is closely related and associated in the same beds with *C. recta.* It is however a more elongate shell, the length being quite five times the height, while its valves are more convex, giving the entire shell a sub-cylindrical appearance that is quite foreign to *C. recta.*

The *Orthonata* (later *Orthodesma*) *parallella* of Hall (Pal. N. Y. Vol. I, p. 299; 1847), includes two or three distinct forms. They are badly illustrated and insufficiently described, and it is scarcely safe to draw conclusions respecting their generic affirmities without access to the original specimens. While at least one probably belongs to *Cymatonota*, I am satisfied that all of them are widely different from the species here described.

Formation and Locality.—Middle beds of the Cincinnati group, at several localities in the immediate vicinity of Cincinnati, Ohio. The species has a vertical range of about 60 feet.

Cymatonota semistriata, n. sp.

Plate 55. Figs. 6 and 7.

Length about 35 mm., greatest height about 11 mm. Posterior end subtruncate, base very gently convex, anterior margin sloping backward almost from the right angled cardinal extremity. Umbonal ridge rather distinct and subangular in the upper half; mesial sulcus not developed. Anterior half of surface marked with very fine, thread-like, regular concentric lines. The majority of these lines cease suddenly before reaching the umbonal ridge. Oblique cardinal furrows smaller and more numerous than usual. Three faint lines diverging from the beak may be noticed on the cardinal slope between the umbonal ridge and dorsal border.

This beautiful shell is readily distinguished from *C. typicalis* and *C. recta* by the shape of the anterior end and the more abrupt ceasing and finer character of the anterior surface markings. Other differences may be noticed in comparing the figures on plate 55.

Formation and Locality.—Upper beds of the Cincinnati group, Clarksville and Waynesville, Ohio.

Cymatonota constricta, n. sp.

Plate 55. Figs. 10 and 11.

Shell strongly convex, elongate, the length equaling about three and one-fourth times the greatest height. Dorsal and ventral margin nearly parallel, diverging very slightly posteriorly; dorsal margin straight, ventral margin gently convex in the posterior half, and slightly concave in the anterior half; anterior end somewhat blunt, its outline almost uniformly rounded; posterior margin slightly oblique, gently rounded, subangular where it joins the dorsal line, sharply rounded and most prominent below. Umbones rather large though distinctly impressed by the mesial sulcus; the latter is deeper than in any other species of the genus known and causes the constriction of the shell in a dorsal or ventral view that has suggested the specific name. Umbonal ridge well developed and subangular near the beaks, obscure in the posterior half of the valves. Anterior and posterior gape of valves larger than usual. External surface marked by rather coarse irregular concentric lines of growth, of which only the stronger ones pass through the shell so as to be visible on casts of the interior. Oblique dorsal furrows not sharply distinguished from the lines of growth. In casts of the interior two obscure sulci, one in the middle of the cardinal slope, the other close to the hinge border, may be observed. Hinge and muscular impressions unknown.

This species is quite distinct from all the others referred to the genus. It might be compared with *C. typicalis* when it will be found to differ in its more obtuse anterior end, deeper mesial sulcus, and wider posterior end.

Formation and Locality.—In the lower part of the upper beds of the Cincinnati group, Butler county, Ohio, and Versailles, Indiana.

Cymatonota attenuata, n. sp.

Plate 55. Figs. 12-14.

Shell strongly convex, gaping at the ends, elongate, highest at the beaks, gradually tapering posteriorly, the length at least four times the height; dorsal margin gently arcuate, declining posteriorly; anterior end neatly rounded, ventral margin almost straight, normally, apparently a little concave; posterior end narrowly rounded, above passing rather gradually into the dorsal margin. Beaks small, compressed; mesial sulcus and umbonal ridge but little developed. Surface marked by concentric lines of growth, very fine, crowded and subequal on the anterior third, fewer and coarser on the central and posterior parts, and obscure on the umbonal ridge; oblique dorsal folds strong and regular.

The tapering character or the posterior end will distinguish this peculiar species from all the others now referred to the genus *Cymatonota.*

Formation and Locality.—Upper beds of the Cincinnati group, Waynesville, Ohio.

Cymatonota productifrons, n. sp.

Plate 55. Figs. 17 and 18.

Shell ventricose in the posterior half, only moderately elongate, the length about three times the greatest height. Beaks small, situated more than one-third of the length of the shell behind the anterior extremity. Anterior end very long, tapering slightly, the outline somewhat sharply rounded above; hinge line nearly straight, but little shorter than the greatest length of the shell; posterior end one-third wider than the anterior, the margin rounded; basal line nearly straight in the central half, curving upward strongly at each end. Mesial sulcus and umbonal ridges scarcely defined. Surface marked with concentric lines of growth. These are distinct and regular on the sides of the valves and comparatively obscure on the ends. Dorsal furrows strong and regular for two-thirds of the length of the hinge posterior to the beaks, under a good glass exhibiting exceedingly fine lines of growth.

This shell, though appearing to agree in all other respects with the genus *Cymatonota*, differs very conspicuously from the other species in its greatly produced anterior end.

Formation and Locality.—Only two specimens have been seen of this species, and these were both collected in the lower shales of the Cincinnati group at Covington, Kentucky. The horizon is about 100 feet above the bed of the Ohio river.

Genus PSILOCONCHA Ulrich.

[Final Rep. Geol. Sur. Minn. vol. iii, p. 530 (in press).]

Psiloconcha grandis, n. sp.

Plate 52. Figs. 1 and 2.

Shell large for the genus, compressed convex, highest near the middle, the length two and two-fifths times the height, the thickness less than one-half of the height. Outline elongate subelliptical; cardinal margin nearly straight for one-half of the length posterior to the beaks, declining and very slightly convex anterior to them; posterior end almost regularly rounded; ventral margin broadly yet distinctly convex, the curve accelerating slightly as we follow the outline to the upper part of the anterior margin where it forms an obtusely angular junction with the sloping antero-cardinal edge. Beaks small, appressed, situated one-fifth or a little more of the entire length behind the anterior extremity.

A faint posterior umbonal ridge and an undefined mesial depression or mere flattening. Surface of cast with rather strong concentric striæ or furrows on the anterior half, very few of them passing over the umbonal ridge. On the posterior cardinal slope several obscure rays may be observed. Anterior muscular scar large, acuminate-ovate, pointed above, situated immediately in front of the umbones; posterior scar occupying the center of the cardinal slope, very large and elongate; pallial line simple, rather distinct for so thin a shell.

This is the type of the genus and the largest of the known species. Compared with the other species it is distinguished by the great size and the greater obliquity of the anterior margin. The back also is straighter and the ventral margin more convex than in most of the others.

Formation and Locality.—Upper beds of the Cincinnati group, Waynesville, Ohio.

Psiloconcha subovalis Ulrich.

Plate 52. Figs. 5-7.

Orthodesma subovale, Ulrich, 1879, Jour. Cin. Soc. Nat. Hist., Vol. ii, p. 82.

In this species the shell is higher than in any of the others, the length being usually but one millemeter greater than twice the height. Compared with *P. grandis*, its nearest congener, it is further distinguished as follows: The post-cardinal margin slopes downward in a manner not to be observed in that species, and this peculiarity causes an obliquity of the posterior margin and a greater arcuation of the dorsum. The hinge line is horizontal for a short distance in front of the beaks, and the whole anterior margin is less oblique and more rounded. Finally, there seems to be a difference in the surface markings, the concentric lines being of nearly equal strength on all parts, which appears not to be the case in that species.

Formation and Locality.—The original types were collected at Morrow, Ohio, where they occurred in the middle beds of the Cincinnati group. Recently specimens that cannot be distinguished were obtained from the lower beds of the group by Mr. George Asherman and the author. His came from Boldface creek, Cincinnati, while mine are from a branch of Willow run, near Covington, Kentucky.

Psiloconcha inornata, n sp.

Plate 52. Figs. 11 and 12.

Shell about 30 mm. long, by 12.7 mm. high in the middle, with regularly rounded, subequal ends, very slightly convex ventral and more strongly arcuate dorsal margin. Beaks very small, umbonal ridge and mesial depression scarely distinguishable. Surface markings concentric, very obscure, the surface appearing almost smooth in most cases.

This shell is closely related to *P. subovalis* but does not attain as great a size, is relatively longer, and has a smoother surface and more regularly rounded anterior margin. The last difference is the most important and may always be relied upon.

Formation and Locality.—Middle beds of the Cincinnati group, Cincinnati, Ohio.

Psiloconcha elliptica, n sp.

Plate 52. Figs. 3 and 4.

Shell 30 mm. to 40 mm. in length, and a very little more than twice as long as high; thickness less than half the height. Outline elongate ovate; the regularity and neatness of the curves being a striking feature; yet when examined the posterior half proves distinctly wider than the anterior, the height at the beaks being one-eighth or one-ninth less than the greatest posterior height. Beaks very small, situated 8 mm. behind the anterior extremity in a specimen 38 mm. long; umbonal ridge just appreciable. Surface nearly smooth, marked with mostly distant concentric lines.

Formation and Locality.—Upper beds of the Cincinnati group, Clarksville, Ohio. Several casts of the interior from Richmond, Indiana, may belong here, but for the present I am obliged to consider them as doubtful.

Psiloconcha subrecta, n. sp.

Plate 52. Figs. 13 and 14

Shell about 32 mm. long, 12 mm. high, and nearly 6 mm. in thickness; cardinal margin gently arcuate, posterior end gaping widely, regularly rounded in outline; basal line nearly or quite straight in the central part; anterior end straight on the upper side, then turning abruptly downward, the rest curving regularly like the posterior margin. Beaks very small, situated a little less than one-sixth of the length of the shell behind the anterior extremity; umbonal ridge moderate, mesial depression just appreciable. Surface of the cast with moderately distinct, subequal lines of growth, very obscure on the cardinal slope.

In this species the anterior end is shaped as in *P. subovalis*, but the length is proportionally too great for that species. In *P. inornata* the surface markings are not nearly as distinct, and the anterior end is more uniformly rounded. Of species occurring in the same beds, *P. grandis* is much larger and has a convex basal line, while *P. elliptica* has a more regularly curved outline, and is higher posteriorly.

Formation and Locality: Upper beds of the Cincinnati group, Waynesville, Ohio.

Psiloconcha sinuata, n. sp.

Plate 52. Figs. 15 and 16.

This species is associated in the same layers with *P. inornata*, but it will be distinguished from that form at once by the unusual development of the mesial depression, which is deep enough to produce a slight sinuation of the ventral margin and gives a degree of definition to the umbonal ridge that is not equaled in any other species of the genus. The length also is relatively greater than in any of the others, being 36 mm. in a specimen 13 mm. high. Comparing other features *P. subrecta* has a differently shaped posterior outline, and *P. inornata* is more regularly rounded in front. *P. subovalis* seems to me to be the nearest, differing chiefly in its greater height and much less developed mesial depression. None of the other species are near enough to require special comparisons.

The general expression of the shell reminds greatly of certain species of *Cymatonota*, but the absence of dorsal folds shows that it cannot belong to that genus.

Formation and Locality: Middle beds of the Cincinnati group, Cincinnati, Ohio.

Psiloconcha tenuistriata, n. sp.

Plate 52. Fig. 10.

Shell small, about 11 mm. in length, and 4.5 mm. in height; valves depressed convex, narrowly rounded in front, slightly oblique posteriorly with the ventral margin nearly straight, and the dorsal margin posterior to the beaks very gently arcuate and almost parallel with the basal line. Beak very small, situated more than one-fourth of the entire length from the anterior extremity; umbonal ridge and mesial depression scarcely distinguishable. Except on the cardinal slope, the surface is covered with exceedingly fine thread-like concentric lines, of which as many as fifteen are to be counted in the space of 1 mm

The narrowly rounded anterior end, and the exceeding fineness of the concentric surface markings are the distinguishing features. The small size is probably also distinctive for the species.

Formation and Locality: Near the base of the Cincinnati group, having been found near low water mark in the Ohio river, at Covington, Kentucky.

Psiloconcha minima n. sp.

Plate 52. Figs. 8 and 9.

Shell small about 10.5 mm. high at the beaks, rather strongly convex in the umbonal region when compared with the other species. Outline narrowly elliptical; anterior end a little wider than the posterior, and more regularly rounded; dorsal margin arcuate, base more gently convex. Beaks comparatively prominent, full, strongly incurved, situated about one third of the entire length from the anterior extremity. Umbonal ridge moderately developed, rounded; mesial depression scarcely distinguishable. The specimen described, which is a well preserved cast of the interior, is perfectly smooth. Anterior muscular star faintly defined, relatively large but occupying the same position and of about the same form as in *P. grandis* and *P. elliptica*.

The prominence and less anterior position of the umbones, and the small size of the shell, are the distinctive features.

Formation and Locality: Lower beds of the Cincinnati group, Covington Kentucky, where it was obtained in a layer about 150 feet above the bed of the Ohio river.

Family CYRTODONTIDÆ Ulrich.

Genus ORTONELLA, n. gen.

Cypricardites, S. A. Miller, 1874. Cin. Quart. Jour. Sci., vol. i, p. 147; also (*part.*) 1892, North Amer. Geol. and Pal., p. 476. (Not of Conrad.)

Shell subquadrate, highest posteriorly, equivalve, very inequilateral, with moderately prominent beaks and umbonal ridge. Surface with concentric lines of growth. Hinge as in *Cyrtodonta*, Billings, excepting that the cardinal teeth are relatively stronger and placed immediately beneath the beaks. A well defined lunule and escutcheon present. Adductor muscular scars subequal, the posterior one very faintly impressed, ovate, and situated just beneath the posterior extremities of the lateral teeth, the anterior one very deep, sharply defined on the inner and upper sides by a clavicular ridge extending obliquely backward from the hinge plate, Pallial line simple, distinct. Small pedal muscle attached to the under side of the hinge plate immediately over the anterior adductor scar. Casts of the interior marked by an oblique umbonal sulcus.

Type: *Cypricardites hainesi*, S. A. Miller.

Although on the whole much like *Cyrtodonta*, this genus is still quite distinct and easily separated. The cardinal teeth are different as stated above, and the lunule is a feature unknown in that genus. Then the anterior muscular scar is more deeply impressed and defined on the inner side by a ridge that is not known in *Cyrtodanta.* Nor has that genus a small pedal muscle over the anterior adductors. Finally the two adductors are more nearly equal in size. Practically the same differences, besides others that it is not necessary to point out, obtain when compared with *Vanuxemia*, Billings and *Cypricardites*, Conrad.

It seems to me that *Ortonella* is nearest *Ischyrodonta*, Ulrich. Only two differences have I been able to find. Namely, the escutcheon and lunule, and the posterior lateral teeth, both of which are wanting in *Ischyrodonta.* In all other respects however the shells in the two genera seem to be identical even to the smallest detail.

Ortonella hainesi, S. A. Miller.

Plate 53. Figs. 9-18.

Cypricardites hainesi, S. A. Miller, 1874, Cin. Quart. Jour. Sci., vol. 1, p. 147.

This interesting species is so fully illustrated on plate 53, that a description is unnecessary. It will be well however, to compare it somewhat carefully with species of *Ischyrodonta* that are to be found at the same locality, though not in exactly the same strata.

I refer especially to *Ischyrodonta decipiens*, n. sp., and *I. truncata*, Ulrich. Both may be distinguished at once, providing the specimens are complete enough, by the fact that their hinges are without posterior lateral teeth, *Ortonella* having two strong laterals as shown in figures 11 and 12. Even with respect to this point, the student is cautioned against the possibility of mistaking the linear ridges which served as supports for an internal ligament in *Ischyrodonta* (see plate 54, figures 16 and 19) for lateral teeth. That they could not have served as hinge teeth is proved by the fact that they do interlock. Indeed, the corresponding ridges in the two valves are separated by an interval, the valves being in contact dorsally only at the outer margin. Externally the *Ortonella* is recognized principally by the lunule and escutcheon, but it differs also in its stronger umbonal ridge and in the outline, the basal line being somewhat straighter and the anterior end higher so that the dorsal and ventral margins are more nearly parallel. There is besides a difference in the surface markings, the concentric lines in the *Ischyrodonta* being much coarser.

Formation and Locality.—Ortonella hainesi is associated with *Rhynchonella dentata* Hall, at Richmond, Indiana, where both species, though common fossils, are restricted to a few feet of strata, less than forty feet beneath the extreme top of the Cincinnati group. *Ischyrodonta truncata* seems likewise to be restricted to this bed, but the *I. decipiens*, which is most like the *O. hainesi* has so far been found only in beds at least twenty feet above the *Ortonella* horizon.

Genus ISCHYRODONTA Ulrich.

Anodontopsis (part.), Meek, 1871, Amer. Jour. Sci. and Arts, 3d ser., vol. ii, p. 299; also 1873, Ohio Pal., vol. i, p. 141.

Ischyrodonta, Ulrich, 1890, Amer. Geol., vol. vi, p. 173.

Short or moderately elongate, thick bivalve shells, having small, anteriorly situated beaks, with the hinge line straight or arcuate and extended posteriorly. Hinge plate wide and strong, without posterior lateral teeth, but with two strong cardinal teeth in the left valve, and one large one, and occasionally a small one on each side of it, in the right valve.* Ligament internal, posterior to the beaks, linear, supported by from one to three subcardinal ribs. Anterior adductor impression large, deep, subovate, sharply defined on the inner and upper side by a ridge extending from the cardinal teeth to the base of the scar. A small pedal muscle was attached to the under side of the hinge plate immediately above the inner side of the anterior adductor scar. Posterior muscular scar faintly defined, generally but little larger than the anterior scar, situated a short distance beneath the posterior extremity of the hinge. Pallial line simple. Test thick, chiefly calcareous, without the dark epidermis of the *Modiolopsidæ* and *Ambonychiidæ*.

In casts of the interior the beaks are prominent and strongly compressed, and a more or less well defined sulcus, corresponding to an internal thickening of the shell, extends from the umbones more than half the distance to the center of the basal margin.

Type: *Ischyrodonta truncata* Ulrich.

The relations of this genus are clearly with *Ortonella*. The reader will find them discussed in the remarks following the description of that genus on the preceding page. Through *Ortonella* the genus is linked with the *Cyrtodontidæ*, and in referring the species to this family I have been influenced in a great degree by the composition of their shells which seems to be precisely as in *Cyrtodonta* and related genera, and not as in the true members of the *Modiolopsidæ*. Except for this fact it would be a difficult matter to draw the line between *Ischyrodonta* and *Modiolodon*, the general aspect of the shells and the dentition of their hinges being practically the same in both. It may seem, therefore, that when casts of the interior only are available it is not possible to discriminate successfully between the two genera. This is, however, not so, since the casts of every species of *Ischyrodonta* now known exhibit at least one small feature that has not been seen in any species of *Modiolodon* nor in any now referred to the *Modiolopsidæ*. Namely, the small pedal muscle

* In the original description the arrangement of the cardinal teeth was inadvertently reversed.

scar which in casts appears as a sharply elevated point situated close to the hinge line between the base of the beak and the upper part of the anterior adductor scar.

The total number of species now known to belong to this genus is seven. With one exception, *I. unionoides,* Meek sp., which belongs to the middle beds of the Cincinnati group, all are restricted to the upper one hundred feet of the same formation, leaving over three hundred feet of strata between the known first and second appearance of the genus in which it is as yet unknown. Respecting the origin of the *Ischyrodonta* type of structure, I am obliged to confess total ignorance.

Ischyrodonta truncata, Ulrich.

Ischyrodonta truncata, Ulrich, 1890, Amer. Geol., vol. vi, p. 174; S. A. Miller, 1892. Appendix to N. A. Geol. and Pal, p. 700.

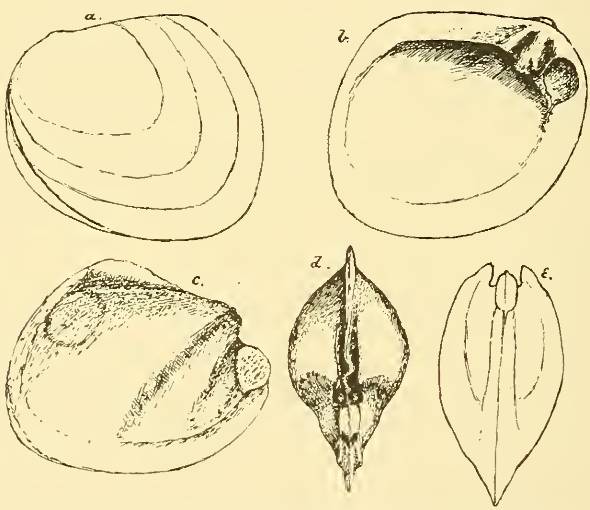

Fig. 1. *Ischyrodonta truncata*, Ulrich, Cincinnati group Oxford Ohio. *a*, outline view of a left valve of this species, slightly restored. In some specimens the anterior margin slopes backward more rapidly and in accordance with the inner line; *b*, internal view of same, showing only the hinge plate, cardinal teeth, and anterior muscular impression. the cavity being filled with adhering matrix; *c*, *d* and *e*, three views of a very nearly perfect cast of the interior. Between the beaks of the central figure is shown a thin film of stone that had originally filled a narrow interstice between the hinge plate and cardinal teeth.

Shell of medium size, rather strongly convex, subquadrate to triangular-ovate, highest posteriorly. Cardinal margin straight or very slightly arcuate, more than three-fourths the length of the shell; anterior end very short, narrow, rounding almost uniformly into the obliquely convex basal margin, from which the outline turns rather sharply up into the truncate-rounded posterior margin; post-cardinal region subangular. Beaks small, umbonal ridge inconspicuous, no mesial sulcus. Surface of the thick shell with a small number of sublamellose lines of growth.

Hinge plate thick and wide, almost flat, with a ridge forming the lower edge in the posterior part; cardinal teeth strong, very oblique, two in each valve, the second often small and obscure. Anterior muscular scar deep, acuminate-ovate, pointed below where the well marked pallial line joins it. Posterior scar very faint, broadly ovate, situated near the post-cardinal angle. In casts of the interior the beaks are prominent and strongly compressed, while a deep and wide sulcus, extending from the beaks nearly to the center of the base, produces an obtuse umbonal ridge of which no sign is apparent on the exterior of the shell. Another but less deep and shorter furrow occupies the space between the long sulcus and the anterior muscular scar and pallial line. Within the latter space the casts often exhibit a series of four or five rounded elevations.

A large testiferous specimen has the following dimensions: Length 39 mm.; greatest oblique length 41 mm.; greatest posterior heighth 33 mm.; from post-cardinal angle to antero-basal margin 35 mm.; greatest thickness 20 mm.

Formation and Locality.—Near the top of the Cincinnati group, Oxford, Ohio, and Richmond, Indiana.

Ischyrodonta decipiens, n. sp.

Plate 54. Figs. 16–19.

Shell scarcely attaining medium size, moderately convex, the beaks small, the umbonal ridge distinguishable though not strong, the outline almost regularly oval excepting that the cardinal region is produced and angular at the posterior extremity. Surface marked with numerous, strong and more or less irregular concentric lines of growth. Cardinal teeth nearly horizontal, three in the right valve, the central tooth much the largest, and two in the left valve. Posterior to the cardinal teeth the hinge plate bears three or four slightly diverging slender ridges, which served as supports for the internal ligament. Muscular impressions subequal, strongly marked, the anterior one especially; pallial line distinct. Internal umbonal ridge undefined so that the surface of casts of the interior is comparatively even.

This species is founded upon an excellent series of specimens, most of them recently obtained from Prof. Joseph Moore and Mr. John Misener of Richmond, Indiana. One specimen I had for at least ten years believed to belong to the similar *Ortonella hainesi* Miller, sp., and it is the liklihood of confusion with that species that has suggested the name *decipiens*. A careful comparison however brings out a number of differences that will appear very obvious to the student after he has once made himself familiar with them. First, the surface markings are much coarser in the *Ischyrodonta;* next, the outline will be found to be not strictly the same; then the *Ortonella* has a well developed lunule and escutcheon while the margin of the valves of the *Ischyrodonta* are not in the least inflected; finally, that shell has a different hinge, having true posterior lateral teeth.

Compared with species of this genus, *I. ovalis* will be found to have a thinner hinge plate and more regularly oval shape, while *I. truncata* is a higher shell, with fewer concentric surface markings, and much more oblique cardinal teeth.

Formation and Locality.—Near the top of the Cincinnati group, Richmond, Indiana.

Ischyrodonta ovalis, Ulrich.

Plate 54. Figs 12–15.

Ischyrodonta ovalis, Ulrich, 1892, Nineteenth Ann. Rep. Geol. and Nat. Hist. Sur. Minn., p. 242.

Shell small, moderately ventricose, almost regularly elliptical, with the greatest heighth and thickness subcentral; heighth and length about as two is to three. Occasionally the ventral margin is less convex than is the case in the specimen figured on plate 54. Beaks small, situated near the anterior extremity, compressed by a flattening of the surface which, expanding, extends over the greater part of the ventral slope. Umbonal ridge strongly rounded, not however prominent enough to constitute a conspicuous feature; cardinal slope abrupt, very little concave. Surface marked with strong lines of growth and a few finer concentric striæ, both somewhat irregular. Hinge plate not very strong, arcuate, widening posterior to the beaks and grooved for the reception of the internal ligament. Cardinal teeth two in the right valve, projecting downward and backward from the hinge plate, which is thin at this point, and supported by an internal process that seems to extend up into the rostral cavity and projects on each side of the teeth so as to give the whole the appearance of a quadrifid tooth. Anterior muscular scar rather small, occupying the anterior end of the valve. Posterior scar and pallial line not observed.

In the original description of this species I stated that it was not strictly congeneric with the types of *Ischyrodonta*. Additional specimens and further comparisons however have convinced me of the error of that statement, and I now regard the species as an unequivocal member of the genus. Specifically it differs from all the other species now referred to the genus, excepting *I. unionoides*, Meek, sp., by its more regularly oval shape. The excepted species is too different in other respects to require comparisons. The associated *I. decipiens* is, I believe, a much nearer species, but, as may be seen by comparing the figures on plate 54, their outlines are quite different in the post-cardinal region and the hinge plate of *I. ovalis* comparatively weaker.

Formation and Locality.—Uppermost beds of the Cincinnati group, near Richmond, Indiana.

Ischyrodonta elongata, Ulrich.

Plate 54. Figs. 20 and 21.

Ischyrodonta elongata, Ulrich, 1890, American Geologist, Vol. VI, p. 175.

Shell large for the genus, transversely elongate-ovate, widest posteriorly, strongly convex, with point of greatest convexity a little in front of the center. Beaks rather large, compressed, almost terminal; umbonal ridge rather strong, mesial sulcus broad. Cardinal margin strongly arcuate; posterior margin nearly vertical in the middle and lower part, uniformly rounded above, sharply curved at the base; ventral margin faintly and broadly sinuate; anterior end very short and abruptly rounded. Surface marked with strong and irregular lines of growth.

In casts of the interior the beaks are very prominent, incurved, and greatly compressed by the deep umbonal sulcus, behind which the somewhat curved and sharply elevated umbonal ridge is distinguishable almost to the basal line. Anterior muscular scar deep, subrhomboidal, sharply defined on the upper side, radially marked and situated immediately beneath the beak. Just above it is the small pedal muscle scar. Posterior scar faint, ovate; pallial line distinct in the basal part of the valves.

This fine species, though closely related to *I. truncata*, is readily distinguished by its much greater length. The next species is also related, but is smaller and widely different in the post-cardinal part of its outline.

Formation and Locality.—Near the top of the Cincinnati group, at Oxford, Ohio, and Richmond, Indiana.

Ischyrodonta miseneri, n. sp.

Plate 54. Figs. 10 and 11.

This species, as far as known, is very similiar to *I. elongata*, and a detailed description is scarely necessary. Though agreeing in most respects very closely with that species, a comparison still brings out differences that doubtless will suffice in discriminating between the two species. The shell of *I. miseneri* is considerably smaller (the largest seen is but 38 mm. in length), comparatively a little shorter, and subtriangular in outline. The posterior margin is more oblique and considerably higher, and its junction with the straight cardinal margin angular, while the post-cardinal region is distinctly alate and thus quite different from the rounded and sloping character of this part of the outline in *I. elongata*. The umbonal ridge furthermore is a more decided feature. Of the other species *I. decipiens* is much shorter, and *I. modioliformis* longer, and more produced and obliquely rounded posteriorly.

The specific name is given in honor of Mr. John Misener of Richmond, Indiana, who collected and from whom I received the best specimens of the shell seen.

Formation and Locality: Upper beds of the Cincinnati group, Richmond, Indiana, where it occurs in association with *Ortonella hainesi* and *Rhynchonella dentata*.

Ischyrodonta modioliformis, n. sp.

Plate 54. Fig. 4-9.

Shell scarcely attaining medium size, moderately convex, modiola-like, elongate subovate, the base straight or very gently sinuate, the back straight for a short distance behind the beaks, then curving very gradually down into the very obliquely rounded posterior margin; anterior end short, sharply rounded, much narrower than the posterior. Beaks small, situated a short distance behind the anterior extremity; both the mesial sulcus and the umbonal ridge are but little developed. The cardinal slope and the posterior part of the surface is marked with rather strong, subregular, concentric furrows, of which from ten to fourteen may be counted in the space of 10 mm. Besides these furrows a set of very fine concentric lines, barely visible to the unaided eye, are to be observed on well preserved specimens. The anterior part of the surface seems to be smooth, the furrows at any rate ceasing suddenly a short distance in front of the middle of the shell.

In casts of the interior a narrow and more or less distinct umbonal ridge may be traced from the beak to the pallial line a short distance behind the center of the cast, while in front of the ridge there is usually a well defined depression or sulcus. Anterior muscular scar strongly elevated, very oblique, sharply defined on the upper side, occupying the greater part of the small anterior end and extending a little posterior to the points of the beaks. Posterior scar very faintly impressed, nearly twice the size of the anterior, situated just within the sloping post-cardinal border of the cast. Pallial line distinct only in the ventral part of the valves. Close to the cardinal border of the casts a long and slightly impressed line represents the support of the internal ligament. Of cardinal teeth there seem to have been but two, one in each valve, the right above the left. The scars left by the small pedal muscles occupy the usual position immediately in front of the cavity between the filling of the beaks.

This well marked species, of which I have seventeen specimens, is probably nearest *I. elongata*. It is however a much smaller shell and readily distinguished by its narrower form, more oblique posterior margin, and different surface markings, the concentric lines of growth extending almost uniformly over the whole surface in that species.

In a general way *I. modioliformis* greatly resembles several species of *Modiolopsis*, but that it is not really related to them is proved by the fact that it has the shell structure, cardinal teeth and small anterior pedal muscles of a true *Ischyrodonta*.

Formation and Locality: Upper beds of the Cincinnati group, Richmond, Indiana.

Ischyrodonta unionoides, Meek.

Plate 54. Figs. 1-3.

Anodontopsis ? unionoides, Meek, 1871, Amer. Jour. Sci. and Arts, Vol. II, p. 299.
Anodontopsis (*Modiolopsis ?*) *unionoides*, Meek, 1873, Pal. Ohio, Vol. I, p. 141.
Modiolopsis unionoides, S. A. Miller, 1890, N. Amer. Geol. and Pal., p. 491.

Shell of medium size, subovate, a little the highest posteriorly, compressed convex, thickest slightly above and in advance of the middle. Anterior margin regularly but rather narrowly rounded; base forming a broad semielliptic curve; posterior margin broadly rounded, very slightly oblique; dorsal outline more or less strongly arcuate, passing gradually into the ends. Beaks small, compressed, projecting very little beyond the hinge margin, placed between one-fourth and one-fifth of the length of the valves behind the anterior extremity; umbonal ridge scarcely distinguishable. Surface showing only a few distant subimbricating marks of growth.

Hinge comparatively weak for the genus, with one oblique cardinal tooth in the right valve and two (?) in the left. The ridge-like internal ligament support leaves a linear depression within the dorsal edge extending posteriorly from the beak for a distance equaling about one-third of the length of the shell. Anterior adductor and pedal muscle attachments having the characters usual for the genus, except that they are with respect to the beaks, more anterior in position for the reason that the anterior end is uncommonly long.

Meek's type of this species has almost beyond question, been distorted by pressure so that its height is now less than it should be. In one of my specimens the height has been reduced to an even greater degree. The second specimen mentioned by Meek (*loc. cit.*), which he refers to the species with doubt because it is proportionally higher, seems to agree exactly with those now illustrated on plate 54, and which I regard as representing the normal form of the shell.

Having the hinge and muscular impressions characterizing *Ischyrodonta*, and the shell structure prevailing among the *Cyrtodontidæ*, the species cannot possibly belong to *Modiolopsis* nor to any other genus of that family. As to placing the shell with McCoy's *Anodontopsis*, it is out of the question if McCoy has defined his genus correctly.

The rather regularly ovate form of *I. unionoides* suggests relationship to *I. ovalis*. It is however a larger shell, relatively higher, especially in the posterior half, not so convex, and has less anterior beaks and different surface markings.

Formation and Locality: Middle beds of the Cincinnati group, at Cincinnati, Ohio, and Covington, Kentucky, where it occurs at an altitude of about 350 feet above the bed of the Ohio River.

Genus WHITELLA, Ulrich.

Whitella, Ulrich, 1890, Amer. Geol., vol. vi, p. 176; Geol. and Nat. Hist. Surv. Minn., Final Rept., vol. iii, p. 564 (in press).

The reader may obtain a good idea of this well marked Lower Silurian genus from the Minnesota work above cited. Descriptions of twelve species, nine of them Trenton, the rest from the Hudson River group, are contained therein.

Whitella Ohioensis, n. sp. or var.

Compare *Whitella compressa* Ulrich, 1890, Amer. Geol., vol. vi, p. 180.

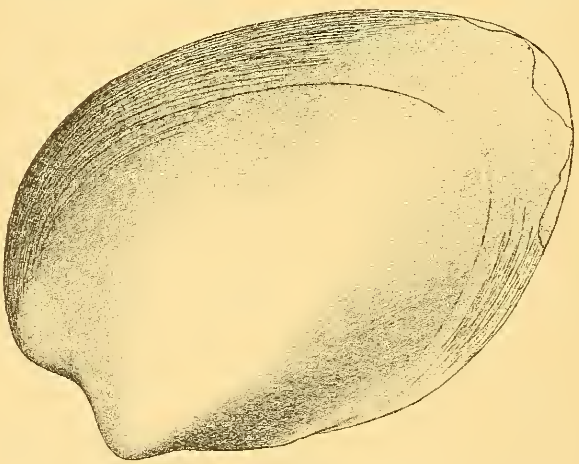

Fig. 2. Right valve of *Whitella Ohioensis*; Cincinnati group, Waynesville, Ohio.

Shell large, compressed convex, subrhomboidal in outline, very little the widest posteriorly. Anterior margin very gently rounded and nearly vertical in the upper half, sharply rounded (almost angular) at the extremity of the hinge, sloping backward below; the outline from the prominent and strongly rounded post-basal angle to the antero-cardinal angle forms nearly a semielliptical curve; posterior margin slightly oblique, nearly straight in the middle, above curving forward and rather gradually merging into the dorsal line. Beaks very prominent but small and not strongly incurved, situated about one-fifth of the length of the shell behind the anterior extremity; umbonal ridge very little developed, especially as compared with the majority of the species of the genus. Surface with distant subimbricating marks of growth and finer concentric lines between them. Escutcheon rather narrow but long and deep.

This shell though larger, is exceedingly like the geologically earlier *W. compressa* Ulrich, from the lower Trenton of Minnesota, and might well be considered, if not a reapparition, a variety of that species. Still, as the Ohio shell is somewhat narrower across the posterior half and represented by casts of the exterior, while the Minnesota form is known only from casts of the interior, it is not unlikely that other differences may be shown when we can compare better and equal material of the two. Differences in their hinges and muscular impressions are to be looked for since there is some evidence to show that these parts were stronger in *W. compressa* than in *W. Ohioensis*.

Compared with associated species, *W. obliquata* Ulrich is much more convex and has stronger umbonal ridges, *W. umbonata* Ulrich is much fuller in the umbones and has a different outline, *W. subovata* Ulrich is ovate rather than rhomboidal in outline, and *W. quadrangularis* Whitfield, sp., is shorter and much more ventricose.

Formation and Locality: Upper beds of the Cincinnati group, Waynesville and Clarksville, Ohio.

Family NUCULIDÆ, Gray.

Genus CTENODONTA, Salter.

Tellinomya, Hall, 1847, Pal. N. Y., vol. i, p. 151; 1857, Tenth Ann. Rep. Reg. Univ. N. Y., p. 181. Not *Tellinomya*, the correct form of *Tellimya*, Brown, 1827, as given by Agassiz in his "Nomenclator Zoologicus" in 1846.

Ctenodonta, Salter, 1851, Rep. Brit. Asso. p. 63; 1859, Can. Org. Remains, Decade 1, p. 34; Ulrich, Final Rep. Geol. Sur. Minn., vol. iii, p. 578 (in press).

I had prepared an entire plate of species of this genus for this paper, but the lack of time required for the final study which it is my habit to give to all species described by me immediately preceding the transmission of the manuscript to the printer, has induced me to delay their publication to some other opportunity. The illustrations of the three species following happened to be placed on plates devoted chiefly to other shells here described, so that I could not very well postpone their consideration.

A full description of the genus and of numerous species will be found in the Minnesota work above cited.

Ctenodonta retrorsa, n. sp.

Plate 50. Figs. 14 and 15.

This species is founded upon the cast of the interior of a single valve, probably the right. If this view is correct the beaks are situated a short distance behind the center and curved toward the longer end, thus giving them the appearance of being turned backwards. The subreniform shape is peculiar, as is also the unusual fullness of the posterior half. The anterior muscular scar is well marked but the posterior one is quite indistinct in the specimen.

Formation and Locality: Middle or *Modiolodon* beds of the Trenton formation, near Burgin, Kentucky.

Ctenodonta cingulata, Ulrich.

Plate 48. Figs. 10-12.

Tellinomya cingulata, Ulrich, 1879, Jour. Cin. Soc. Nat. Hist., vol. ii, p. 23.

The types of this species do not preserve the hinge teeth clearly so that they were misrepresented in the original description and figures. Better examples have since been obtained and the two now illustrated on plate 48 give a reliable idea of both the external and internal characters of the shell. The hinge teeth are very slender and crowded in the central part of the hinge. Their great length and the unusual width of the hinge plate are the principal peculiarities of the species.

Formation and Locality: Upper beds of the Cincinnati group, Boyle and Oldham counties in Kentucky, and Dayton, Ohio.

Ctenodonta perminuta, n. sp.

Plate 46. Figs. 11-14.

Shell very small, commonly about 1.5 mm. in length and 1.15 mm. in height, widest anteriorly; anterior outline rounded below, generally nearly vertical in the upper half, and subangular in the antero-cardinal region; basal margin broadly convex, posterior end obliquely truncate, strongly rounded in the lower half. The species is known from casts of the interior only. In these the beaks are prominent, moderately incurved, and situated between one-fourth and one-third of the entire length behind the anterior extremity. The muscular impressions are unusually distinct for so small a shell, and the structure of the hinge seems to have been very much as in *C. levata*, Hall, sp., and other forms of that section of the genus.

The extreme minuteness of the shell and the comparative strength of the muscular attachments, will distinguish this form at once from all other species of the genus having a similar shape. The *C. obliqua* Hall, sp., another minute species of the Cincinnati rocks, and of which the recently proposed *Palæoconcha faberi* (S. A. Miller, 1892, N. A. Geol. and Pal., p. 498), seems to me to be a synonym, is a higher shell and doubtless belongs to quite a different section of the genus, being closely related to such forms as *C. compressa* Ulrich and *C. astartæformis* Salter.

Formation and Locality: Lower and middle beds of the Cincinnati group, Cincinnati, Ohio.

Genus PYRENOMŒUS, Hall.

Pyrenomœus, Hall, 1852, Pal. N. Y., vol. ii, p. 87.

I refer two species provisionally to this little known genus. They agree in all respects with the published characters of *P. cuneatus*, Hall, the type of the genus, except that the anterior muscular scar is not strong, being on the contrary even less distinct than the posterior one. So far as the muscular impressions can be made out they seem to be as in the most of the *Nuculidæ*. Still, I have no idea that they really belong to that family of shells, the hinge being thin and almost certainly without denicles, while the test is very delicate and polished externally. Stoliczka, in his great work on the Cretaceous Pelecypoda of Southern India," places the genus with the *Solenomyidæ*. This arrangement seems to me entirely unwarranted, the short, nuculoid form of the shell being totally unlike the elongated form so strictly adhered to by the typical members of that family. All other authors who have had occasion to refer to *Pyrenomœus* have placed the genus more or less doubtfully with the *Nuculidæ*, and here I would leave it till something definite is learned of its hinge, when I believe we will have reason for the erection of a new family.

Pyrenomœus decipiens, n. sp.

Plate 51. Figs. 7 and 8.

Shell from 12 mm. to 15 mm. long, 9.8 mm. to 11.5 mm. high, nuculoid in shape, narrowest posteriorly, strongly convex, with prominently rounded umbones situated between one-third and one-fourth of the entire length from the anterior extremity. Antero-cardinal region slightly compressed and subangular in outline; upper half of anterior margin nearly vertical, base regularly convex; posterior margin oblique, scarcely truncate, sharply rounded below. Umbonal ridge rounded, inconspicuous; an obscurely defined line or narrow ridge traverses the middle of the cardinal slope posteriorly from the beak. Test very thin, the surface polished and marked by very fine concentric lines, of which the strongest only are visible to the unassisted eye. A small heart-shaped ligamental area or lunette in front of the beaks. Hinge very thin, as far as observed, without teeth. Anterior muscular scar and pallial line not shown by any of the casts of the interior seen; we may therefore assume that they are very faint; posterior scar scarcely defined, rather large, occupying the greater part of the post-cardinal slope.

The casts of this shell look very much like testiferous examples of an undescribed associated species of *Ctenodonta*. The latter is usually identified by Cincinnati collectors with Hall's *Tellinomya levata*. Testiferous specimens of the two species are no more likely to be confused than are casts of the interior. In the first case the surface of the shell is not polished in the *Ctenodonta*, while in the second the surface of the casts of the *Pyrenomœus* are more evenly rounded and the muscular scars much less distinct.

Formation and Locality: Middle beds of the Cincinnati group. Four specimens only have been seen and these were collected on Mount Auburn in the city of Cincinnati, from strata lying about 400 feet above the bed of the Ohio river.

Pyrenomœus subcuneatus, n. sp.

Plate 51. Fig. 6.

Shell about 11 mm. long, 7 mm. high, and 4.5 mm. thick, cuneate behind, rounded, though not quite regularly, in front; base rounded, cardinal outline sloping down on each side from the beaks which are situated about one-third of the length behind the anterior extremity. Posterior cardinal slope abrupt. Surface polished, marked with very fine concentric striæ and a few stronger irregular folds. The specimen figured exhibits traces of several radiating lines in the post-cardinal region.

There are several Lower Silurian shells that resemble the species under consideration, but I cannot say that the resemblance is in any case very close. In none of them is the posterior end so cuneate, nor is the surface in any except the preceding species polished. *P. decipiens* is a higher shell and shorter anterior to the beaks.

Formation and Locality: Lowest beds of the Cincinnati group, river quarries, Covington, Kentucky.

Family LYRODESMIDÆ, Ulrich.

Genus LYRODESMA, Conrad.

(Ann. Geol. Rep. N. Y., p. 51; 1841.)

Lyrodesma inornatum, n. sp.

Plate 50. Figs. 10 and 12.

Shell not known to exceed 18 mm. in length, transversely subovate, compressed convex, the three dimensions length, height and thickness respectively to each other as nine and seven is to four. Anterior margin regularly curved, base broadly convex, posterior margin slightly oblique, strongly rounded and most prominent below, gently curved and sloping forward above to the subangular extremity of the short hinge line. Beaks rather small, moderately prominent, situated a little in front of the center; cardinal slope compressed, slightly alate; umbonal ridge very moderately developed, the greater part of the surface being rather evenly convex. Surface nearly smooth, without radial lines on the cardinal slope, in the best specimens exhibiting only a small number of obscure concentric lines of growth. Eight transversely striated and radially arranged cardinal teeth in each valve, the anterior one usually not quite distinct from the dorsal edge of the valves. Muscular and pallial impressions not observed.

This species agrees with *L. planum* Conrad, in the number of its cardinal teeth and in wanting the post-cardinal striæ which are usually present in species of the genus. They are however readily separated by differences in their outlines, *L inornatum* being shorter (relatively higher) and more nearly ovate. Hall's *L. cincinnatiense* presents considerable resemblance in the way of outline, yet is really quite a distinct species, having a shorter hinge line, only six cardinal teeth, an angular umbonal ridge, and distinctly striated post-cardinal slopes.

Formation and Locality: Middle beds of the Cincinnati group, Covington, Kentucky, and Cincinnati, Ohio.

Lyrodesma grande, n. sp.

Plate 50. Fig. 13.

Of this large species I have seen only the cast of the interior figured on plate 50. While I cannot doubt that it really belongs to *Lyrodesma*, it is still a fact that there are features in which it differs from all the previously known forms of the genus. In the first place it is much larger than any of the others, and unusually short, while the plate bearing the cardinal teeth seems to have filled the entire rostral cavity, as that practically no beaks are to be distinguished on the cast. The muscular scars also exhibit peculiarities, the anterior one being very elongate and the posterior one of unusually large size. Having no strong umbonal ridge (the surface of the cast is almost uniformly compressed-convex) the affinities of the species seen to be nearest *L. inornatum*. Compared with that species it is found to differ in having the anterior end relatively narrower, the basal margin more obliquely rounded, and the hinge line shorter and not alate posteriorly. From *L. cincinnatiense* Hall, it is sufficiently distinguished by its great size and in wanting a distinct umbonal ridge.

Formation and Locality: Middle beds of the Cincinnati group, Cincinnati, Ohio.

Lyrodesma subplanum, n. sp.

Plate 47. Fig. 8.

Compare *Lyrodesma planum*, Conrad, 1841, Ann. Geol. Rep. N. Y., p. 51.

The outline of this shell is very much like that of *L. planum* Conrad, as figured by Hall in 1847 (Pal. N. Y., vol. i, pl. 82, figs. 11*a*, 11*b*). As represented by Hall, that species is longer, without radiating lines on the post-cardinal slope, and with the umbonal ridge not nearly so strong.

If the published figures and description of Conrad's species do it justice, the Cincinnati shell under consideration is certainly distinct.

The outline is quite different from that of any of the other species of the genus occurring in the Cincinnati rocks. Of Trenton forms certain varieties of *L. acuminatum* Ulrich, approach it rather closely, but, so far as observed, the post-cardinal angle never projects as far beyond the line of the umbonal ridge as it does in *L. subplanum*.

Formation and Locality: Near the base of the Cincinnati group, in strata exposed in the bank of the Ohio river at Covington, Kentucky.

Lyrodesma conradi, n. sp.

Plate 47, Fig. 9.

Shell a little oblique, transversely subovate, somewhat the highest across the middle of the posterior end; length 15 to 22 mm., height 11.5 to 15 mm., thickness about half the height; just beneath the middle of the slightly oblique posterior margin, the outline is a little produced and more narrowly rounded than elsewhere. Valves moderately convex, the posterior umbonal ridge rounded, not a prominent feature, the beaks small, situated just within the anterior third of the length. Surface marked by very fine, closely arranged, sharp concentric lines, crossed on the posterior cardinal slope by about ten radiating striæ. Hinge with seven teeth of the usual type in each valve. Adductor scars distinct, the posterior one rather small and situated a very short distance beneath the submarginal pedal muscle impression. Pallial line with a small though undeniable posterior sinus.* A peculiar feature of internal casts is the broad and shallow furrow shown in the figure just in front of the umbonal ridge.

This species resembles *L. inornatum* but is less broadly rounded posteriorly and has a stronger umbonal ridge. Casts of the exterior or testiferous specimens may be distinguished at once by their surface markings, that species being, as its name indicates, smooth and entirely without the posterior rays. The surface markings ally it to *L. subplanum* and *L. cincinnatiense*, but the first of these species is longer and quite differently outlined, while in the latter the umbonal ridge is very sharp, the posterior end angular basally, and the beaks more centrally situated.

Formation and Locality: In the lower 200 feet of the Cincinnati group, at Cincinnati, Ohio, and localities in Kentucky opposite that city.

*The cast illustrated on plate 47 is a recent acquisition, and since its discovery I have reexamined the other species accessible to me and found that in every case—they are not many, it must be admitted—where the posterior part of the pallial line could be determined, it was similarly sinuate.

Genus TECHNOPHORUS, Miller.

Technophorus punctostriatus, n. sp.

Plate 47 Figs. 10-12.

Shell small, moderately convex, alated posteriorly, the height and length nearly as two is to three. Cardinal margin long, nearly straight, in front passing rather regularly into the rounded anterior margin, behind drawn out into a small, compressed, triangular wing, the acuminate extremity of which projects slightly beyond the post-basal angle; ventral margin nearly parallel with the dorsal, straight in the middle and behind, curving regularly upward anteriorly; posterior margin biconcave, the upper concavity less oblique and twice as long as the lower. Beaks small, projecting very little in both the shell and in casts of the interior, situated, in specimens of the usual size, only about one tenth of the entire length of the shell in front of the middle. Two strong and sharp ridges extend in a strongly curved direction from the beak across the posterior half of the valves to the lower part of the posterior margin. With the exception of the posterior wing, the surface is marked with regular raised concentric lines, separating series of small punctæ. The latter may be arranged in quincunx or in lines radiating from the beaks. Three or four of the concentric lines occur in the space of 1 mm. The posterior wing is marked by similar lines but here they are straight and oblique, following a direction at right angles to a line drawn from the post-cardinal angle to the antero-basal margin. Of internal characters we know only that the clavicle was short and blunt, yet very strong, and that the cavity immediately in front of it contains a small and faintly defined muscular impression.

This small species is decidedly like the *T. subacutus*, Ulrich, from the lower Trenton of Minnesota, yet I have no doubt that they are specifically distinct. At present we know that species only from a cast of the interior. Comparing this with casts of the present shell we find that in the earlier form the beaks are more prominent and situated farther forward, the cardinal outline is different and the posterior ridges much less distinct. In the associated *T. faberi*, Miller, the posterior wing is shorter and the surface markings consist, so far as known, of very fine concentric lines only. It is besides a larger shell.

Formation and Locality: Middle beds of the Cincinnati group, Covington, Kentucky, where it occurs at an altitude of from 300 to 350 feet above the bed of the Ohio River.

Technophorus yoldiiformis, Ulrich.

Plate 47. Figs. 13 and 14.

Nuculites yoldiaformis, Ulrich, 1879, Jour. Cin. Soc. Nat. Hist., vol. ii, p. 24.

Though not entirely satisfied with the present generic arrangement of this peculiar species, I am still convinced that it is nearer the truth than was the original placement. The shell is more elongate than any of the other species now referred to *Technophorus*, while the clavical is not only longer and more slender, but much more oblique as well.

Formation and Locality: Lower beds of the Cincinnati group, Covington, Kentucky.

Family CYCLOCONCHIDÆ, Ulrich.

Genus CYCLOCONCHA, Miller.

Anodontopsis, Meek, 1871, Amer. Jour. Sci. and Arts, 3d ser., vol. ii, p. 297; 1873, Pal. Ohio, vol. i, p. 140. (Not *Anodontopsis* of McCoy.)
Cycloconcha, S. A. Miller, 1874, Cin. Quart. Jour. Sci., vol. i, p. 231.

Shells rather small, rounded or ovate, subequilateral; valves equal, moderately convex, with small beaks and no umbonal ridge. Surface marked with very fine concentric lines and occasionally with obscure rays on the post-cardinal slope. External ligament occupying a narrow groove extending both anterior and posterior to the beaks. Hinge with one strongly defined, subtriangular cardinal tooth beneath the beak of the right valve, with a small pit just in front of it and a corresponding large pit and a small tooth in the left valve. Posterior lateral teeth long, two in the left valve and one, two or three in the right. Anterior lateral teeth similar to the posterior laterals only shorter. The large cardinal tooth (in the right valve) is usually divided into three radially disposed portions. Pallial line simple, muscular impressions well defined though not deep, the posterior slightly the larger, both with a small pedal muscle scar above and occupying the small spaces left between the adductor scars and the opposite extremities of the two sets of lateral teeth.

Type: *Cycloconcha mediocardinalis,* S. A. Miller.

Plate 51, Figs. 14-21.

I have not the slightest doubt of the generic identity of Dr Miller's type and the shell named *Anodontopsis? milleri* by Prof. Meek, and the one next described as a new species under the name of *Cycloconcha ovata.* I have given figures of the exterior and interior of these three species on plates 48 and 51, and am confident that no one can compare them without coming to the conclusion that they are congeneric. I will admit that while there are really three lateral teeth on each side in the right valves of *C. mediocardinalis* and *C. ovata* there is but one that strictly speaking may be called a tooth in *C. milleri.* Still, and this part was noticed also by Meek, the other two laterals are represented in that species in a rudimentary condition, there being a faintly raised line on the outer sides of the two furrows which received the two laterals of the left valve.

Meek's description of *Anodontopsis? milleri,* or *Cycloconcha milleri,* as it should now be called, is full and correct in all respects except when he says "there are no traces of an external ligament to be seen." My specimens show clearly a narrow dorsal groove between the edges of the valves which I believe to have lodged a ligament.

As to the use of McCoy's genus *Anodontopsis* for this group of shells, I would say only this, that before such a cause is justifiable it must be shown that the *type* of his genus really has the same kind of hinge and muscular impressions as is above ascribed to *Cycloconcha*. Meek's name *Orthodontiscus*, which he suggested might be used for the species *milleri* should it prove to be generically distinct from *Anodontopsis*, has no claim to recognition at the expense of Miller's name, since it was never defined nor used as a genus by anyone.

It is very difficult to determine the family relations of this genus. The hinge is quite different from all paleozoic shells, but agrees rather well with those of the recent genera *Cyrena* and *Crassatella*. At present however, we cannot say that this resemblance indicates natural relationship, since *Cycloconcha* is, so far as known, restricted to the Cincinnati group, and not a single shell is known from rocks succeeding that formation as high up as the Lias, that might be regarded as connecting the Lower Silurian genus with those recent genera. It may be that such connecting links may yet be discovered, if indeed they have not already been found and are misunderstood, but until we do know something better, I propose to classify *Cycloconcha* as a peculiar family by itself.

Cycloconcha ovata, n. sp.

Plate 48. Figs. 13-15.

Shell about 17 mm, long, 12.3 mm. high, and 7.2 mm. thick; outline, excepting the slightly prominent beaks, regularly oval; occasionally the posterior end seems to have been a little higher than the anterior. Surface covered with such fine concentric lines that unless viewed through a strong lens, it appears perfectly smooth. The only specimen on which these surface markings can be detected also shows in the middle of the posterior cardinal slope six or seven obscure lines radiating from the beak. Hinge strong, with the cardinal tooth of the right valve triangular, only a little oblique and distinctly triplicate. Posterior lateral teeth of same valve three in number, the central one the strongest. Anterior lateral teeth of right valve three, the middle one the most prominent, the upper one formed by the margin of the valve, the lower one curved, shorter, and not as prominent as the central one. In the left valve the cardinal tooth is about half the size of the cardinal tooth of the right valve and situated in front of the pit into which that tooth entered. Of lateral teeth there are four, two anterior and two posterior; both pairs strong and subequal. Muscular scars not satisfactorily observed. As exhibited in a cast of the interior they appear to be less distinctly impressed than in *C. milleri* Meek, sp.

Externally this species is very much like *C. milleri*, yet when carefully compared, several constant differences may be observed. Thus, the ends in that species are relatively narrower, and the cardinal margin slopes regularly down in both directions from the beaks. This is not the case in *C. ovata*, in which the dorsal outline is slightly sinuate on each side between the point of the beak and the two extremities of the hinge. Finally, the surface markings are more delicate in the present form. Internally the rudimentary character of the upper and lower pairs of the lateral teeth in the right valve of *C. milleri* is a sufficient differentation to constitute a specific variation. The oval instead of subcircular outline distinguishes the new species from *C. mediocardinalis*. In all other respects however the two species are exceedingly close.

Formation and Locality: Lower beds of the Cincinnati group, at several localities in the vicinity of Cincinnati, Ohio. The horizon is about 100 feet above the bed of the Ohio river at Cincinnati.

Family PHOLADELLIDÆ, Miller.

Genus RHYTIMYA, Ulrich.

[Final Rep. Geol. Sur. Minn., Vol. iii. (In press.)]

Rhytimya producta, n. sp.

Plate 56. Figs. 6-9.

Shell rarely exceeding 39 mm, in length. tapering slightly and extended posteriorly, constricted beneath the moderately prominent umbones; sulcus somewhat oblique, anterior part of shell slightly inflated; length equaling two and one half times the height at the beaks and three times the height of the posterior third. Cardinal outline very gently concave posterior to the beaks, nearly straight but sloping down about one-third of the height in front of them; anterior margin subrectangular in the middle, then curving gradually backward into the basal line; posterior margin narrowly though rather regularly rounded; ventral margin distinctly sinuate centrally or a little in advance of the center. Lunule very narrow. Surface marked concentrically, with ten or more sharp regular folds anterior to the beaks and less distinct as well as less regular wrinkles and striæ posterior to them. On the compressed post-cardinal region the surface markings are very obscure. The best specimens seen are casts of the interior and on only one of the molds of the exterior are any traces of the radiating series of minute granules perserved.

Formation and Locality: Middle beds of the Cincinnati group, about 325 feet above the bed of the Ohio river at Cincinnati, Ohio, and Covington, Kentucky. Not an uncommon fossil, but good specimens must be considered as rare.

Rhytimya byrnesi, Miller.

Plate 56. Figs. 4 and 5.

Orthodesma byrnesi, Miller, 1881, Jour. Cin. Soc. Nat. Hist., vol. iv, p. 76.

Dr. Miller's description of this species is not as complete nor as definite as we could desire, and his figures are not satisfactory. Add to this that the type specimen has been lost and that no others are known that have been strictly compared with the specimen upon which the species was founded, it is evident that some doubt must necessarily attach to all attempts at identifying the species. Yet I entertain considerable confidence in the correctness of the present attempt, for the reason that shortly after the appearance of Dr. Miller's description I had an opportunity of studying his type. I remember distinctly that I at once recognized in it a member of *Rhytimya** and one that was very near the species just described as *R. producta*. Dr. Byrnes' specimen preserved a good part of the test, but as it was exceedingly thin we may reasonably assume that casts of the interior would not look much unlike testiferous examples. Of course we cannot expect that they would preserve anything of the superficial spines.

The specimens here referred to the species are good casts of the interior found at Richmond, Indiana, in beds believed to be exactly equivalent to those at Weisburg, Indiana, from which Dr. Byrnes obtained his specimen. If my memory is not at fault, they agree with that example also in every essential character, so that the standing of the species may be, in the absence of the original type, with justice transferred to them.

Compared with *R. producta*, which *Rhytimya byrnesi*, as the species should now be called, resembles perhaps more than any other, it will be found to be relatively higher, especially in the posterior part where the height equals about four-ninths of the entire length instead of one-third. The anterior part of the shell again is not inflated, at any rate it is much less so than in *R. producta*, the mesial sulcus is shallower, wider and directed more obliquely backward, and the ventral margin less sinuate, indeed, it is almost straight. Finally, the convexity of the shell is less, the posterior margin is not so regularly rounded and the lunule a little wider. For further comparisons the reader is referred to several of the descriptions following.

Formation and Locality: Upper beds of the Cincinnati group, Weisburg and Richmond, Indiana.

Rhytimya œhana, n. sp.

Plate 56. Fig. 1.

Shell large, compressed convex, elongate-subrhomboidal, with subparallel dorsal and ventral margins, and obliquely truncate posterior

* This and other genera of Lamellibranchiata now being published for the first time, was outlined in 1881–82 and has been in manuscript since 1883.

margin; anterior end gently concave in front of the beaks, rounding regularly downward and backward from the obtusely angular antéro-cardinal extremity which is but little beneath the line of the hinge; ventral margin distinctly though broadly sinuate, mostly in front of the middle. Beaks of moderate prominence, incurved, situated about one-fourth of the length of the shell from the anterior extremity. Mesial sulcus distinct, broad, directed obliquely backward, the part of the shell lying in front of it slightly inflated, while posteriorly the surface of the valves rises very gently into a broadly convex umbonal ridge; cardinal slope concave, compressed and subalate posteriorly. Concentric surface markings very faint on the post-cardinal third, rather strong and irregular on the anterior and lower side of the umbonal ridge and in the mesial sulcus, becoming finer as they pass over the anterior swelling and finally gathered into strong folds with fine lines between them on the antero-cardinal slope. Radial markings not preserved on the specimen described.

Greatest length 55 mm.; posterior or greatest height 21 mm.; height at beaks 20 mm.; greatest thickness shown by the specimen described only 6 mm. for each valve. The convexity of the valves has doubtless been reduced by pressure. I estimate the entire normal thickness of the shell at about 15 mm.

This fine species, which it gives me pleasure to name for the discoverer, Mr. George Oeh, a liberal collector and careful student of the fossils of the Cincinnati group, is closely related to *R. byrnesi*, yet may be distinguished readily by its much greater size, more distinct mesial sulcus, and subtruncate posterior margin. *R. producta* is much smaller and narrower posteriorly.

Formation and Locality: Middle beds of the Cincinnati group, Cincinnati, Ohio, where it was found at an elevation of about 390 feet above the bed of the Ohio river.

Rhytimya mickleboroughi, Whitfield.

Plate 56. Figs. 14 and 15.

Orthodesma mickleboroughi, Whitfield, 1878, Jour. Cin. Soc. Nat. Hist., vol. i, p. 139.

This species is near *R. oehana*, but is a trifle longer, more produced posteriorly, less rounded in front, and more convex, especially on the umbonal ridge which is more prominent than in any other species of the genus.

An examination of the original type of this species shows that it is incomplete at the ends and that the abnormally short form which this imperfection itself would cause has been emphasized by compression. Whitfield's statement therefore that the valves are "twice as long as high" applies only to imperfect specimens like the one used by him and not to such as have retained the normal relations of those dimensions, in which the length is about three times the height. With this exception both his description and figure are exact. The specimen here illustrated on plate 55 has suffered in nearly an opposite direction so that it is more elongate than natural. But as at least nine-tenths of the specimens seen have been compressed in a similar manner the figures now given may justly be considered as highly characteristic of the shell as it is represented in collections.

Formation and Locality: Middle beds of the Cincinnati group at several localities in the vicinity of Cincinnati, Ohio.

Rhytimya convexa, n. sp.

Plate 56. Figs. 2 and 3.

Shell elongate, strongly convex, the outline narrowly subelliptical, converging slightly toward each end from the middle; height equaling nearly two-fifths of the length, thickness a little less than four-fifths of the height. Cardinal and basal margins gentle arcuate; anterior end curving obliquely backward from the subangular extremity of the hinge line, nearly vertical, however, in the upper half; posterior margin strongly rounded and most prominent in the lower half, oblique and somewhat straight in the upper. Beaks small, not very prominent, situated a little less than one-fifth of the entire length of the shell from the anterior end; posterior umbonal ridge subangular near the beaks, its convexity becoming less as it recedes from them; anterior umbonal ridge low, nearly vertical; sulcus rather shallow, not deep enough to cause a sinus in the basal margin. Concentric surface markings unusually strong on the posterior part of the valves, but anterior to the center they are precisely as in *R. oehana* and other species of the genus. Postero-ventral fourth of valves with series of large pustules arranged in a radial manner with respect to the beaks. Pustules about one millimeter apart measuring from center to center.

Excepting that the concentric furrows are stronger on the posterior half of the valves, the surface markings are about the same as in *R. mickleboroughi.* Further comparisons with that species show that *R. convexa* differs also in having a less prominent posterior umbonal ridge, less attenuate ends, a shallower mesial sulcus, and a convex instead of sinuate ventral margin. In *R. oehana* the valves are a little higher, the basal line gently sinuate, and the posterior margin more truncate. In *R. compressa* the valves are less convex, the post-cardinal angle sharper, and the mesial sulcus so little developed that it is practically wanting.

Formation and Locality: Middle beds of the Cincinnati group, Cincinnati, Ohio. It is found associated with *R. mickleboroughi* Whitfield, sp., but is a much rarer shell.

Rhytimya compressa, *n. sp.*

Plate 56. Fig. 13.

Shell of medium size, compressed-convex, elongate, the length two and one half times the greatest height. Beaks small, very little prominent, about one-fifth of the entire length behind the anterior extremity; umbonal ridges very inconspicuous; mesial sulcus scarcely distinguishable. Cardinal margin long, about seven-eighths of the entire length of the shell, straight posterior to the beaks, declining very little anterior to them; anterior end wide, sharply rounded above, uniformly curved in the middle and below; ventral margin gently but almost regularly convex throughout; posterior margin oblique, strongly rounded in the lower half, subtruncate in the upper; post-cardinal extremity obtusely angular. Concentric surface markings as usual for the genus. Radial markings not shown by the specimen figured which is the best seen. From the same block of shale, however, I obtained fragments of the posterior part of a *Rhytimya*, probably of this species, that are beautifully marked with closely arranged radial series of exceedingly small spines. In a cross-light the lines formed by them are just visible to the unassisted eye.

The slight convexity of the valves and the absence of a distinct mesial sulcus or constriction sufficiently distinguishes this species from all the other shells referred to *Rhytimya* save the next, *R. radialis*, which see.

Formation and Locality: Middle beds of the Cincinnati group, Cincinnati, Ohio, about 325 feet above the Ohio river.

Rhytimya radiata, n. sp.

Plate 56. Figs. 10-12.

This species is closely related to *R. compressa*, but seems to have been more convex, and is a smaller shell. There are slight differences in the outline, the posterior margin being less oblique, the basal line straight in the middle and for a short distance forward, and the anterior end more angular above. Of the surface markings the grano-lineate ornamentation is coarser, and the anterior concentric folds smaller. Finally the length is proportionally a little greater, the height being to the length as three is to eight instead of three to nine.

The mesial sulcus being very slightly developed the species is readily separated from *R. producta* and *R. œhana*. From the other species *R. radiata* differs in such obvious respects that comparisons are not necessary.

Formation and Locality: Lower beds of the Cincinnati group, Cincinnati, Ohio, and Covington, Kentucky; 100 to 150 feet above the bed of the Ohio river.

Genus PHYSETOMYA, n. gen.

Shell somewhat elongate, inflated anteriorly, tapering to a narrow or acute extremity posteriorly; base arcuate. Beaks situated a little in front of the middle, strongly incurved, not prominent though the umbones are full. A narrow escutcheon and an obscurely defined lunule. Hinge apparently edentulous; test very thin, muscular attachments not observed, probably very faint. Surface with concentric striæ and wrinkles of growth, strongest anteriorly, and fine radiating lines.

Type: *P. acuminata*, n. sp.

This genus is believed to be closely related to *Rhytimya*, Ulrich, and *Allorisma*, King, differing from both in the subcentral position of the beaks and tapering posterior end.

Pysetomya acuminata, n. sp.

Plate 49. Figs. 12–14.

Shell small, transversely elongate, inflated and rounded in front, tapering to an acute extremity behind; basal margin broadly arcuate on the whole, somewhat straightened for a short distance in front of the centre. Beaks strongly incurved, situated about 8 mm. behind the anterior extremity in a specimen 22 mm. long; umbones full, though a little depressed in the middle by an obscure flattening of the surface that extends vertically across the shell; posteriorly the umbo is drawn out into a strongly rounded ridge which, however, is defined on the upper side only by the abrupt descent to the hinge line. Escutcheon very narrow, extremity about two-thirds the length of the hinge posterior to the beaks; lunule obscurely defined, narrow. Surface markings consisting of rather irregular concentric furrows, very indistinct on the posterior cardinal slopes and a little the strongest on the anterior end. These are crossed, at any rate on the posterior half of the ventral slope, by fine radiating lines.

The characters of this shell are so distinctive that I cannot see how it might be confounded with any known Silurian lamellibranch.

Formation and Locality: Middle beds of the Cincinnati group, at Cincinnati, Ohio, where the specimen described was discovered by Dr. S. A. Miller.

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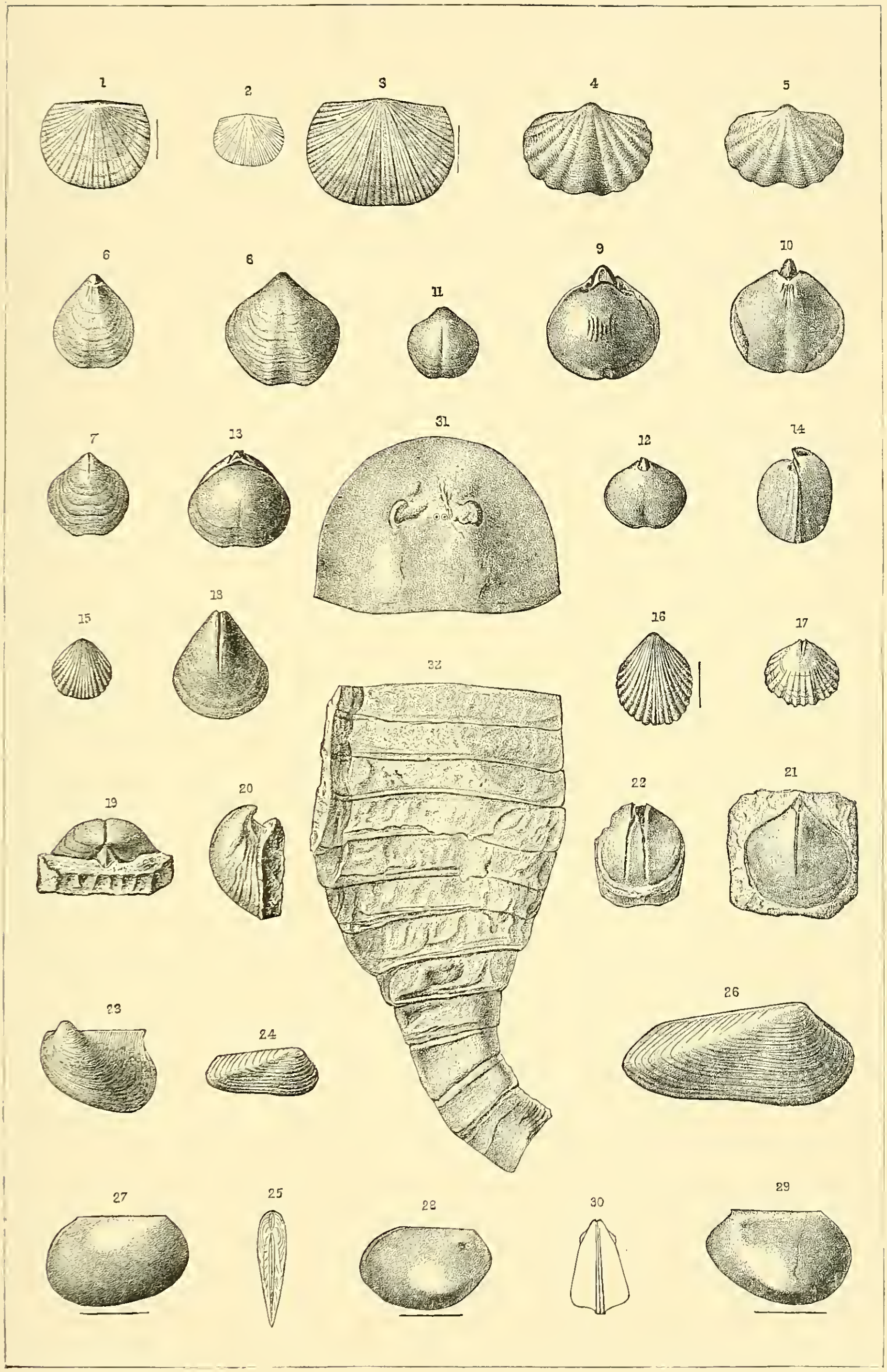
PLATE I.

ANNALS N Y ACAD. SCIENCES. VOL. V, PL V

(SILURIAN)

OHIO GEOL. SURVEY, SECOND ANN REPT.

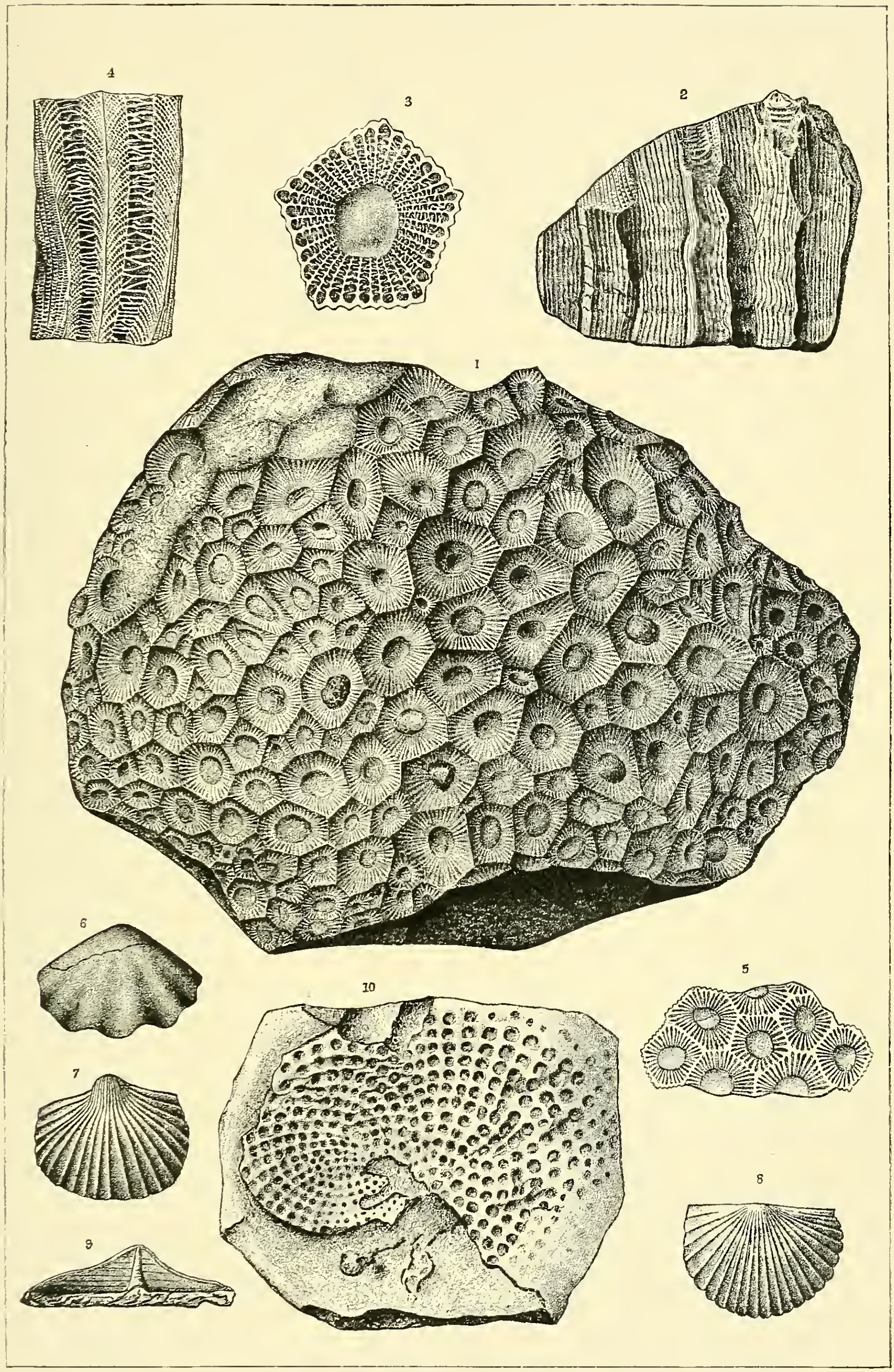


R. P. Whitfield Del

PLATE II.

PLATE II.

ANNALS N Y ACAD. SCIENCES VOL. V, PL. VI. (DEVONIAN) OHIO GEOL. SURVEY, SECOND ANN REPT.



L. P. Gratacap, Del.

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PLATE III.

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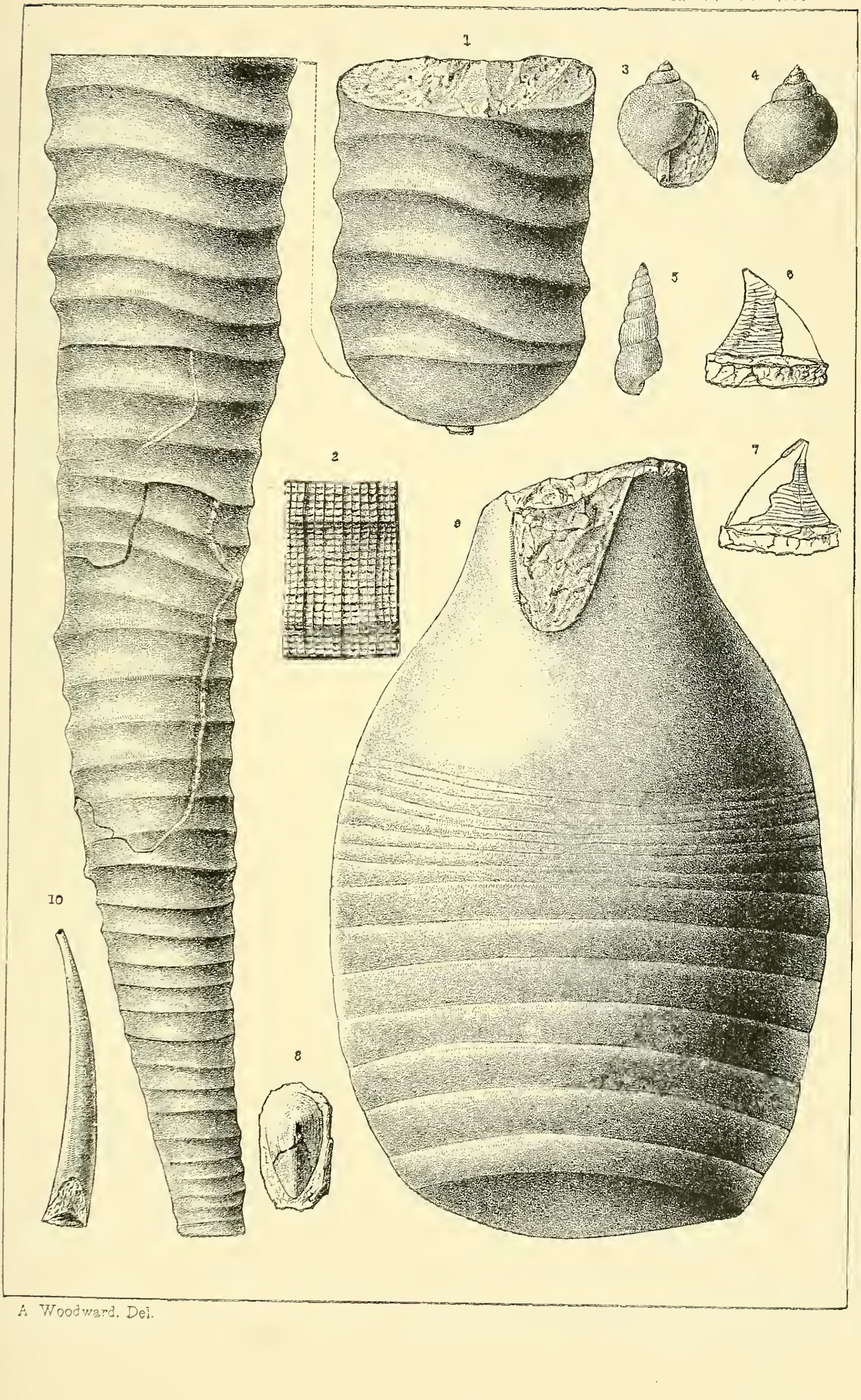
(DEVONIAN.)

OHIO GEOL. SURVEY.
SECOND ANN. REPT.



A. Woodward. Del.

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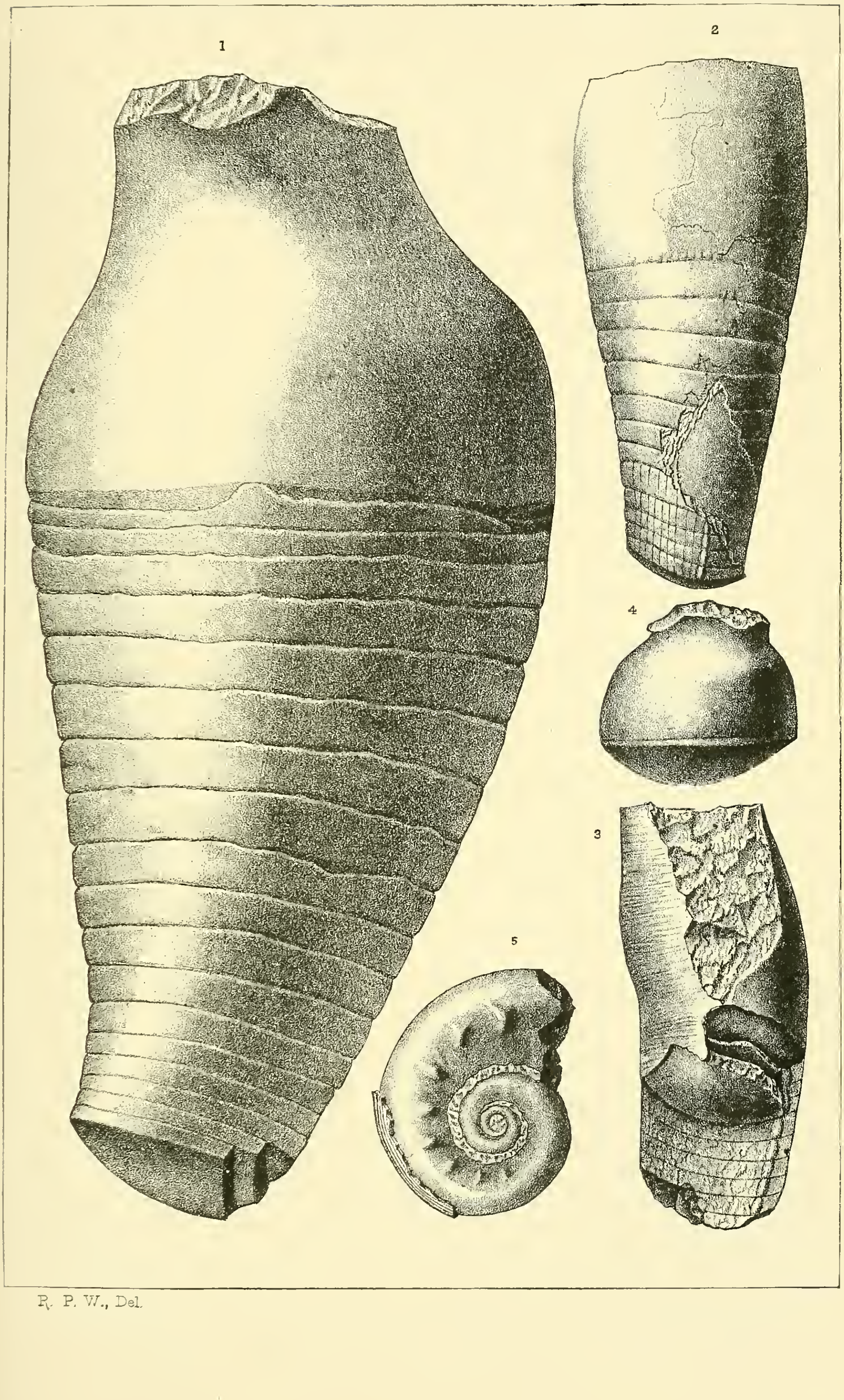
OHIO GEOL. SURVEY,
SECOND ANN REPT.



R. P. W., Del.

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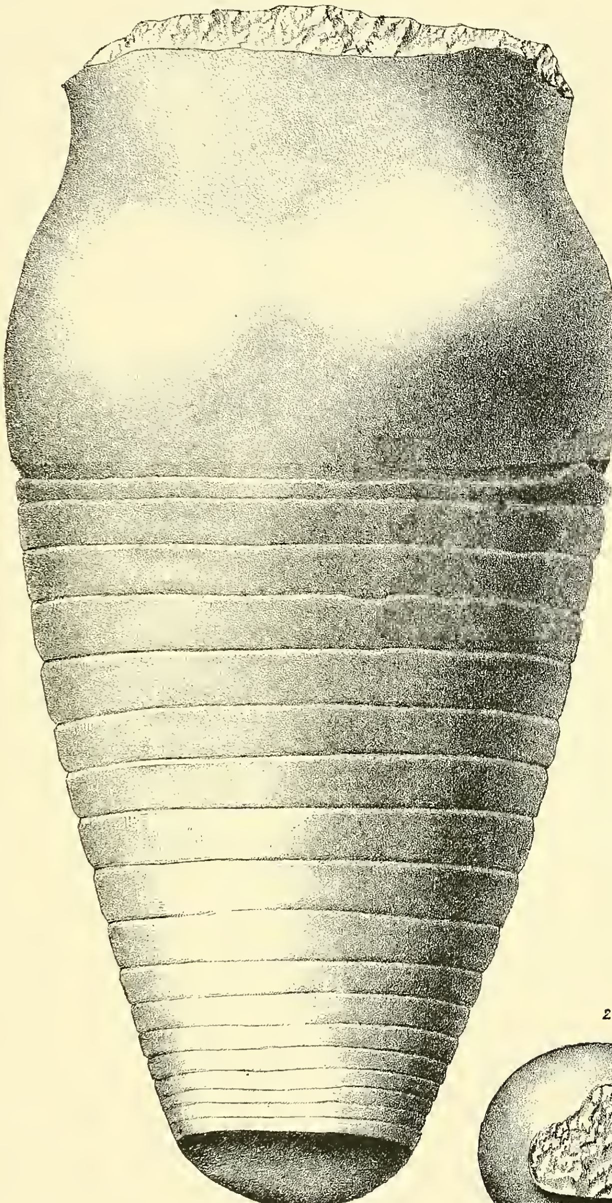
1



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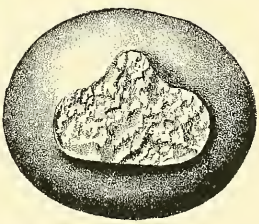

L. P. Gratacap, Del.

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PLATE VI.

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OHIO GEOL. SURVEY,
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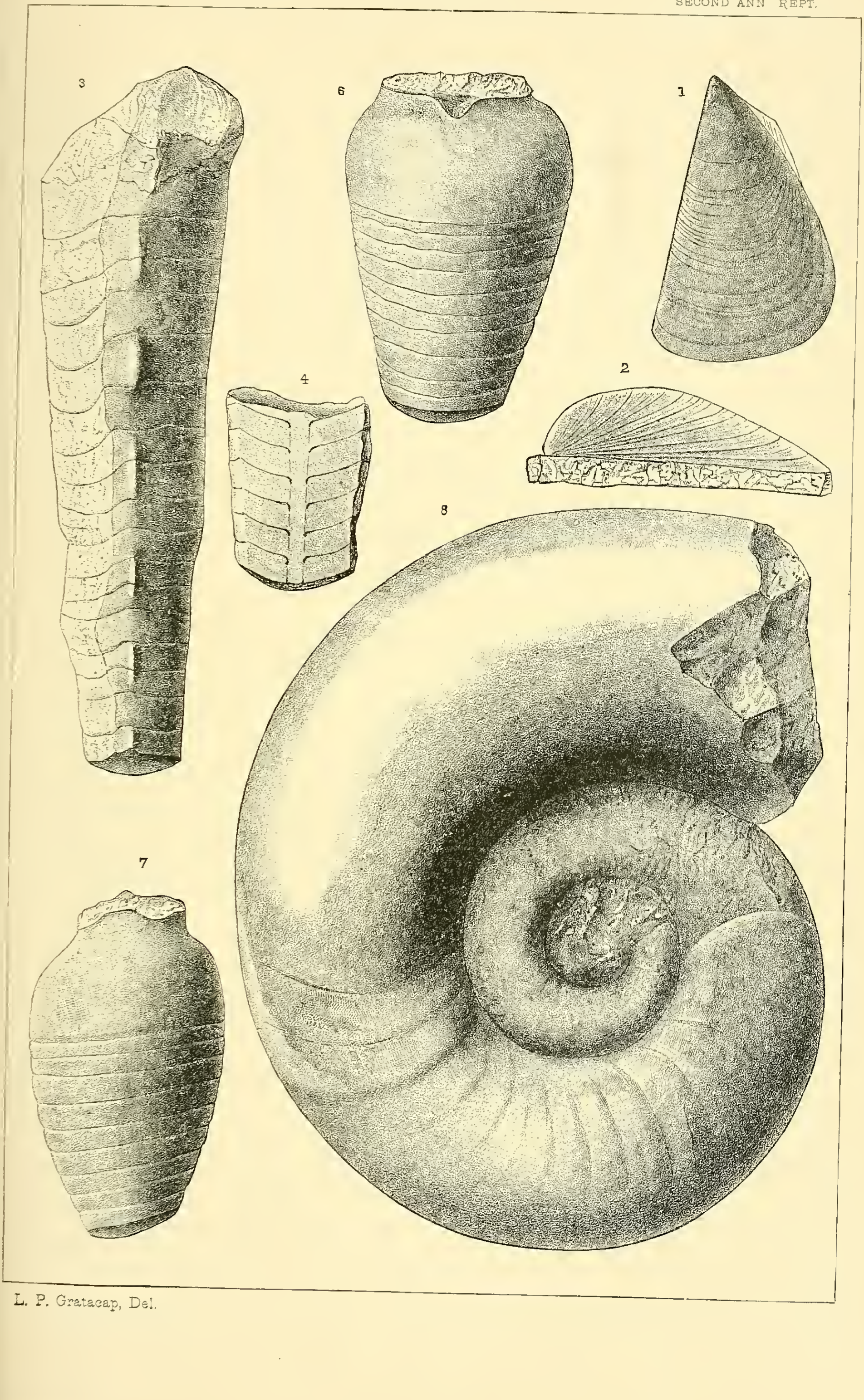

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PLATE VII.

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(DEVONIAN)

OHIO GEOL. SURVEY,
SECOND ANN. REPT.

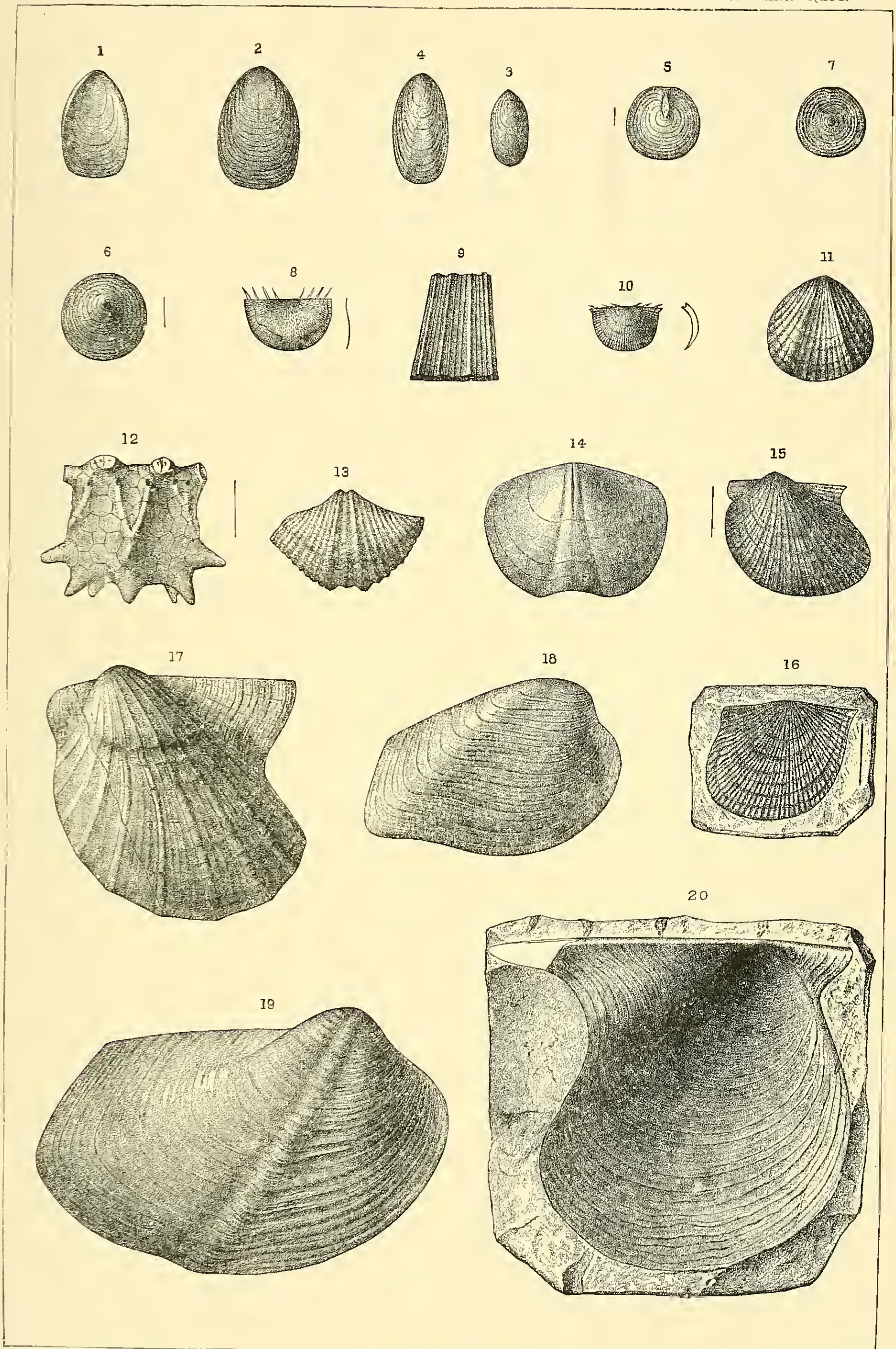

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PLATE VIII.

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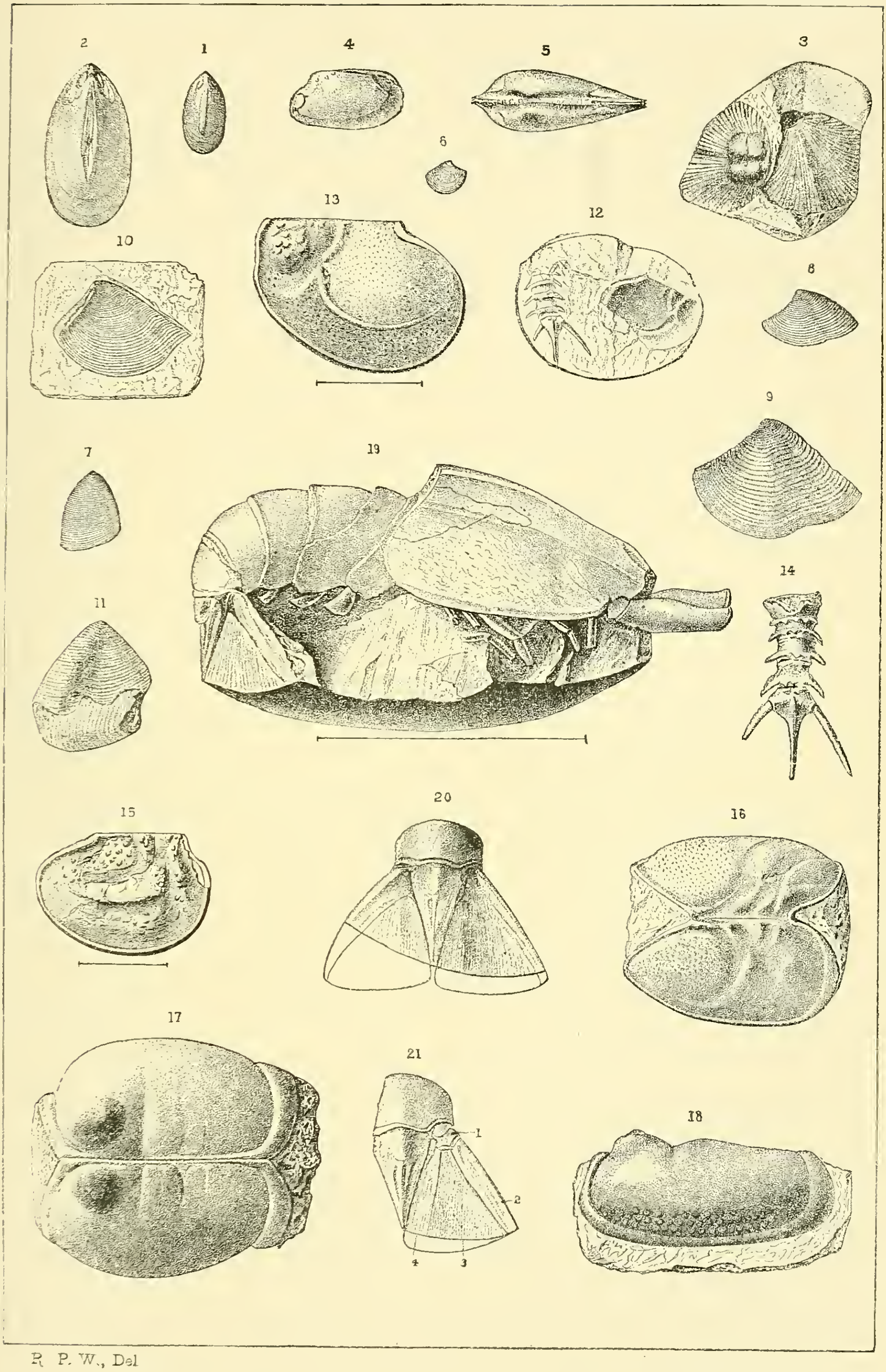
OHIO GEOL. SURVEY,
SECOND ANN. REPT.



R. P. W., Del.

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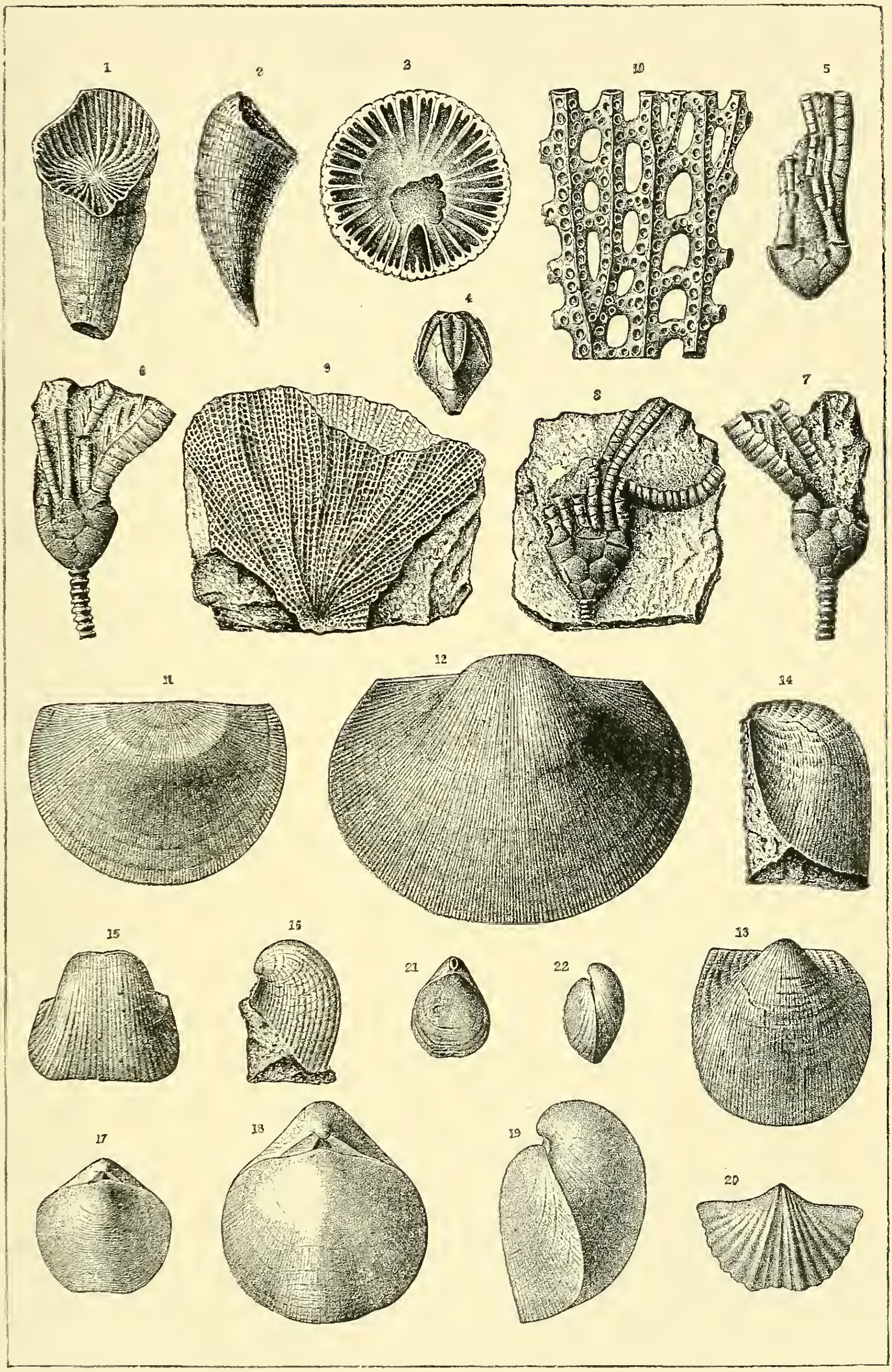
PLATE IX.

ANNALS N. Y. ACAD. SCIENCES. VOL. V., PL. XIII (CARBONIFEROUS.) OHIO GEOL. SURVEY, SECOND ANN. REPT.



A. Woodward, Del.

PLATE X.

PLATE X.

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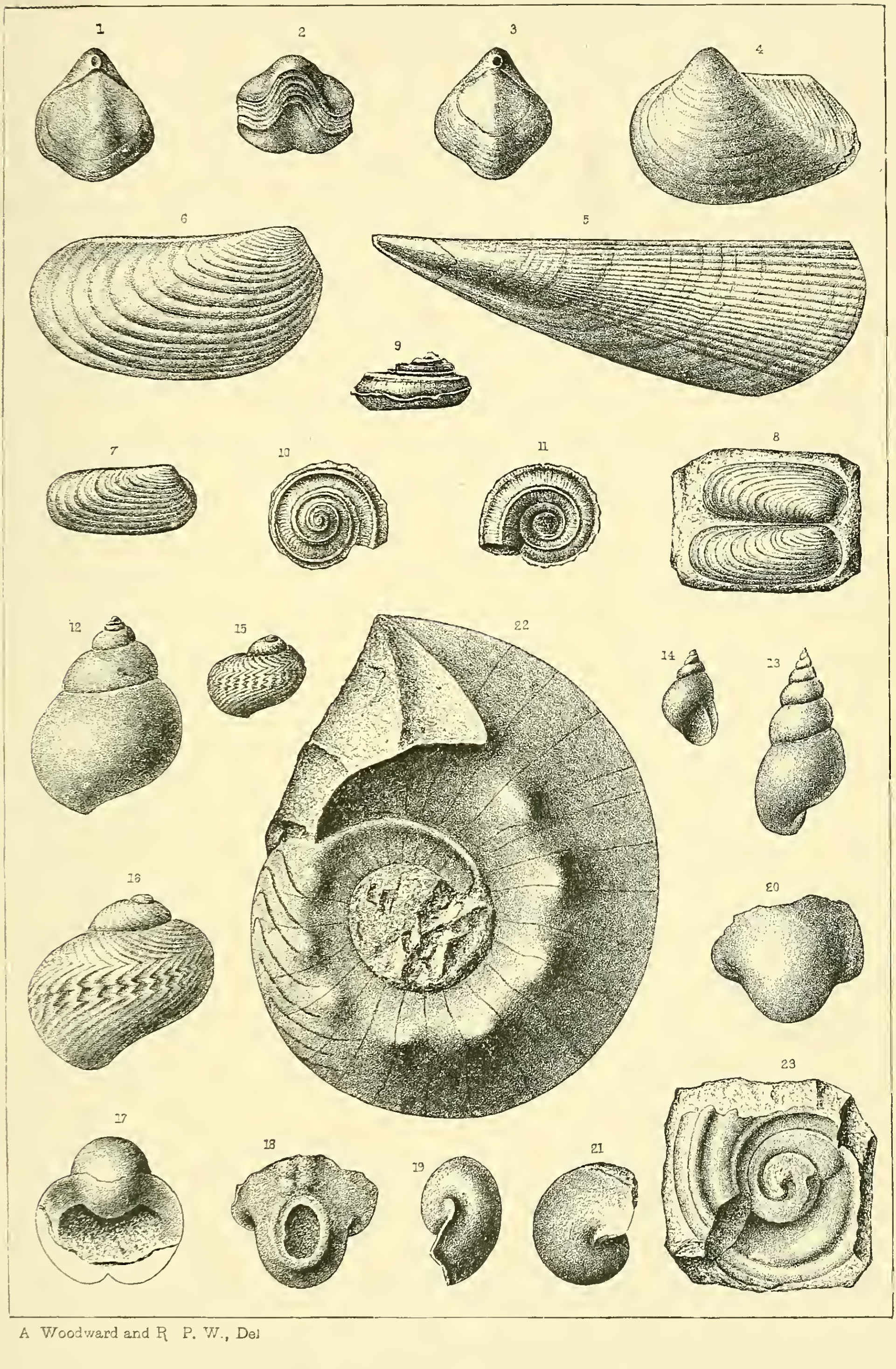

A Woodward and R P. W., Del

PLATE XI.

PLATE XI.

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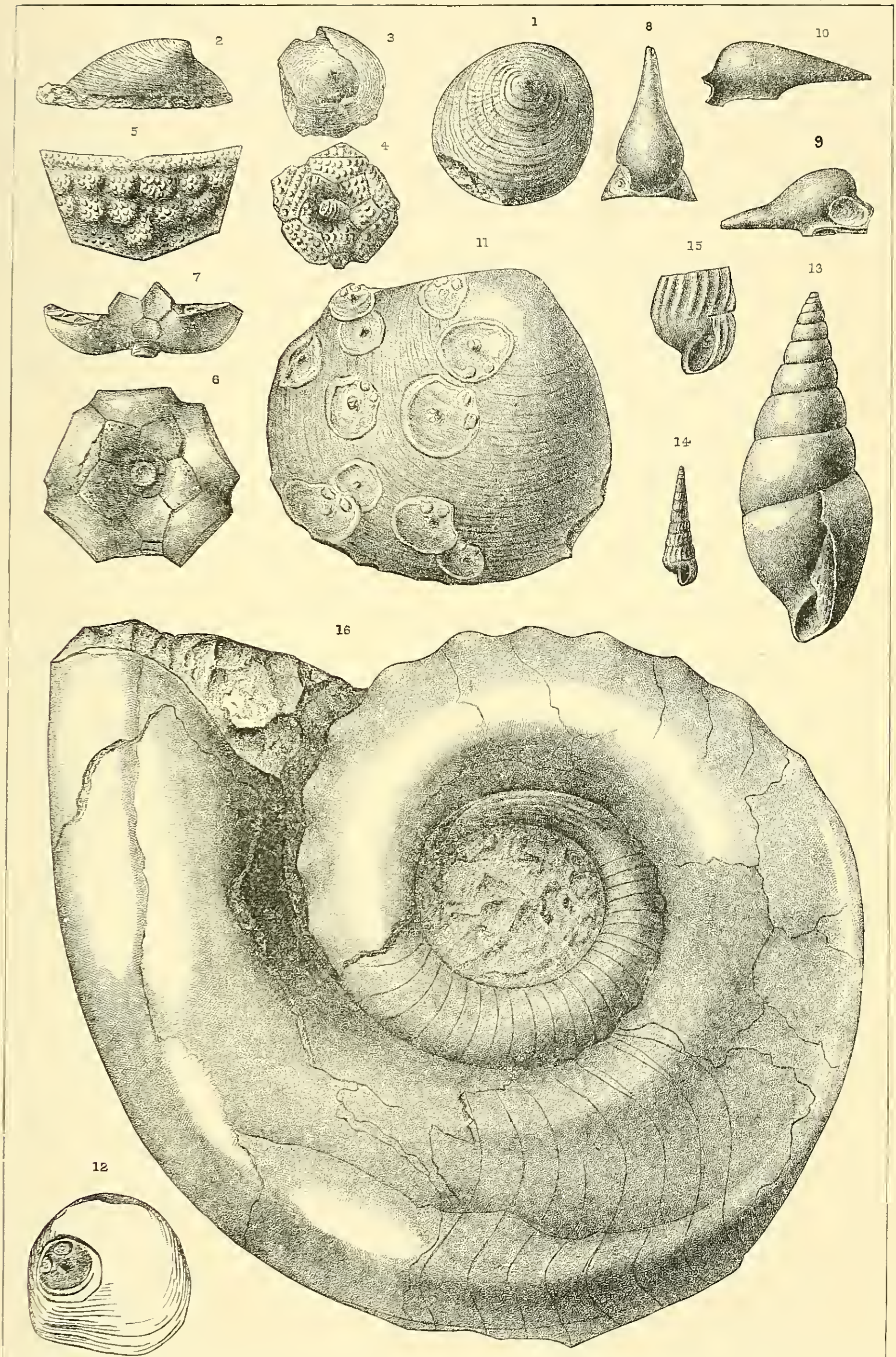

R P W , Del.

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(CARBONIFEROUS.)

OHIO GEOL. SURVEY,
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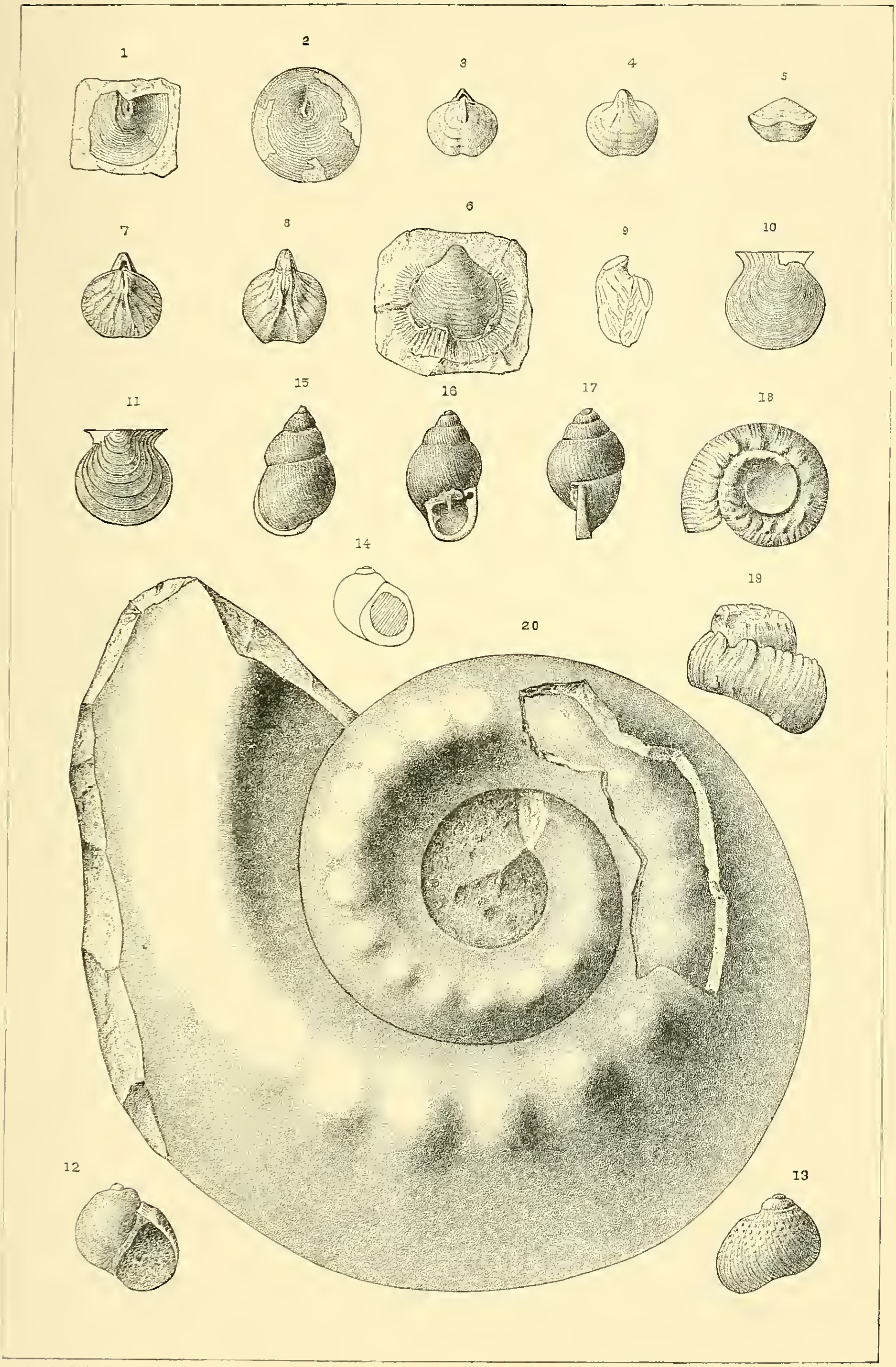

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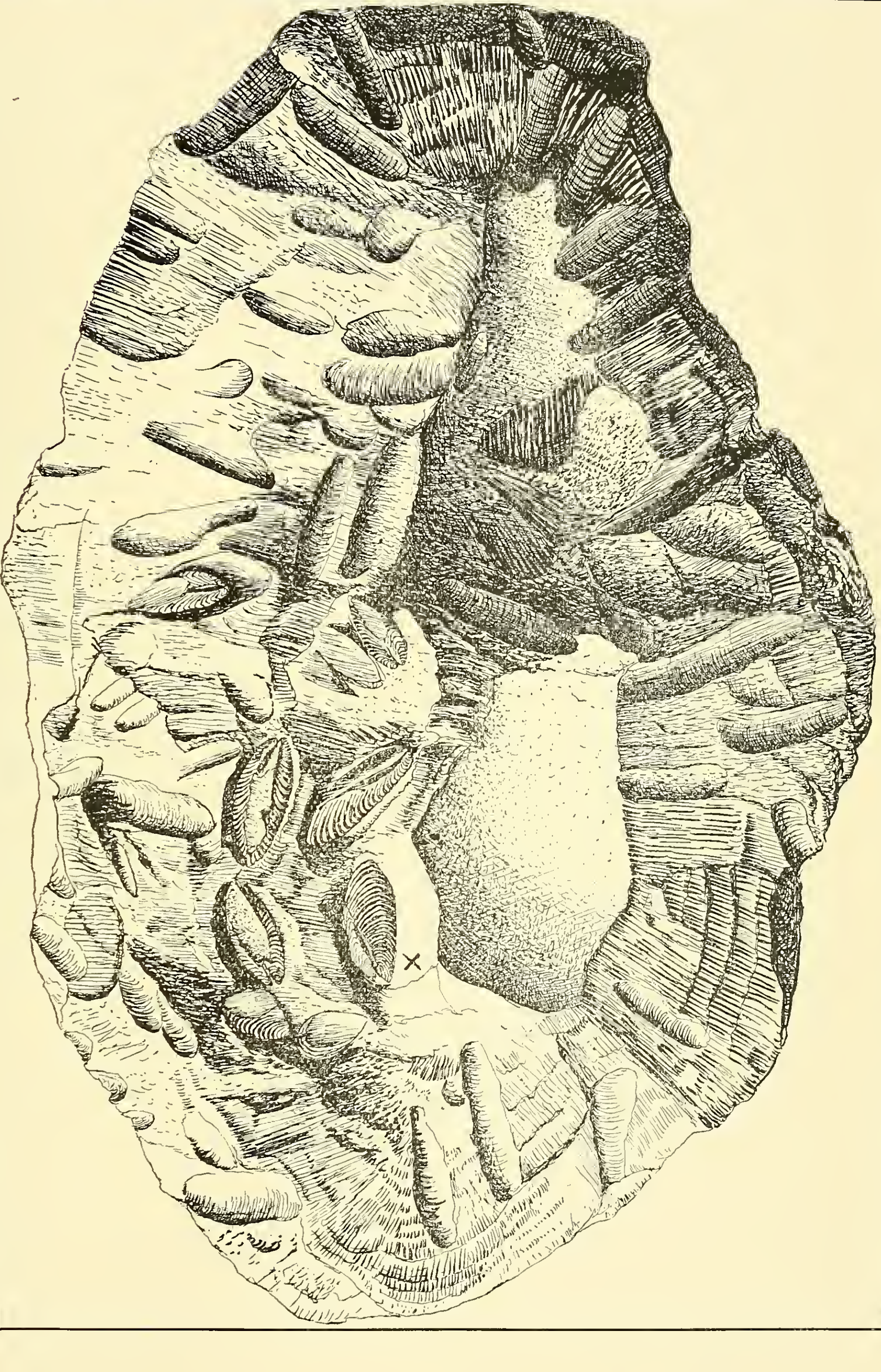

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Pygidium, enlarged two diameters.

Fig. 7. PRŒTUS MINUTUS Herrick.

7. Greatly enlarged. It is probable that this is a young specimen of Prœtus præcursor. Intermediate forms show that the length of the axial portion of the glabella varies with age. This specimen is almost microscopic. Moot's run.

Fig. 8. PHILLIPSIA SERRATICAUDATA Herrick.

8. Pygidium and its markings.

8*d*. Portion of head. Upper (Keokuk) layers of Waverly at Newark.

Fig. 9. PHÆTHONIDES IMMATURUS Herrick.

Pygidium. Probably immature or depauperate forms of P spinosus. This form occurs in the shales, while the typical specimens are from the lime concretions of the same strata, Cuyahoga shale, Cuyahoga Falls, 40 feet below the coal measure conglomerate. This form is generally labeled P. lodiensis by collectors.

Figs. 10–11. PHÆTHONIDES OCCIDENTALIS Herrick.

a. Portion of head, enlarged two diameters.

b. Pygidium, natural size. Kinderhook division (conglomerate I) Granville.

11. Hypostome of some trilobite, perhaps Phillipsia seraticaudata Herrick.

Fig. 12. PRŒTUS sp? (perhaps haldemani).

Shales near base of Waverly, one mile east of Harlem, Licking county.

Fig. 13. PRŒTUS (?).

Portion of head from the upper division.

Figs. 14–15. PRŒTUS AURICULATUS Hall.

14. Reduced one-half. Kinderhook freestone, near Granville.
15. Pygidium of unknown trilobite (perhaps Phæthonides from upper division Burlington) near Newark.

Fig. 16*a*. PRŒTUS PRÆCURSOR Herrick.

A rather immature specimen. Cuyahoga shale Lodi, Ohio.

Fig. 16*b–c*. PHÆTHONIDES SPINOSUS Herrick (?).

Pygidium apparently of this species from shales of Cuyahoga strata at Lodi. In the fourth volume of the Bulletin of Denison University these pygidia and the associated heads were recognized as a distinct species (Phillipsia? cousors) but the attempt to unite the characters of two genera should not have been made. We have since found the forms connecting such glabellæ with typical Prœtus præmaturus, which species is typically represented in the concretions at the same place. The pygidia can hardly be other than depauperate forms of P. spinosus of the same horizon.

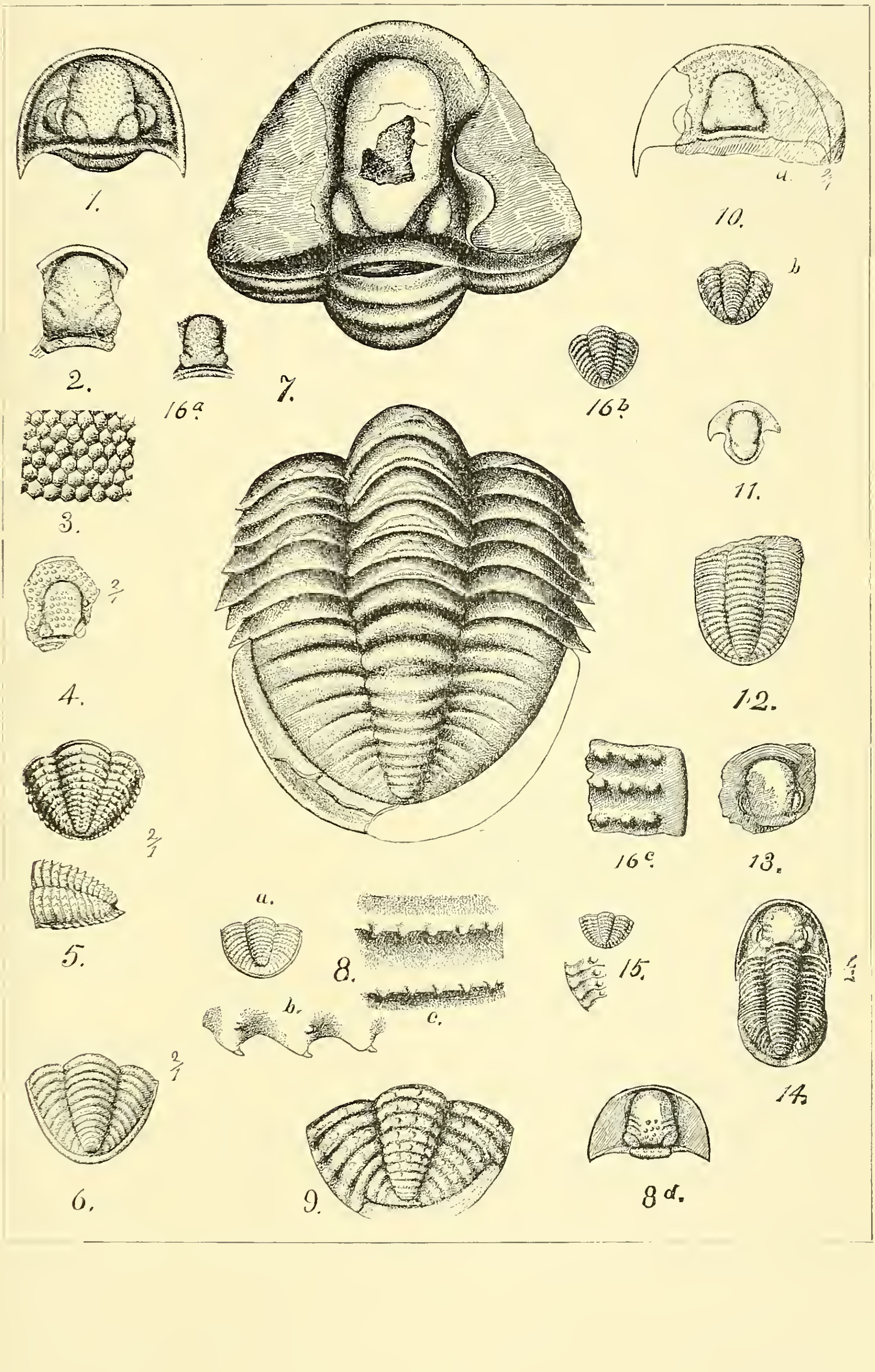
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PLATE XV.

PAGE.

Fig. 1. HEMIPRONITES CRENISTRIA.. 512

Ten feet above the Ohio river at Sciotoville. Cuyahoga shale at same horizon as Moots' run. This species is abundant throughout the Waverly in numerous varietal forms, deserving close study.

Fig. 2. SPIRIFER MARIONENSIS, Shumard.

Cuyahoga shales, Portsmouth, O It would appear that S. centronota, Winchell applies to the variety of this species which occurs in the northern part of the state and which has frequently (as by the writer) been identified with S. biplicatus. The latter is, however, restricted to the upper third of the Waverly and is a smaller species.

Fig. 3. HINGE VIEW OF SPIRIFER.

Sp. like S. altus) from Moot's run. (See Fig. 11.)

Fig. 3. SPIRIFER TENUISPINATUS, Herrick.

Cuyahoga shales, Moot's run.

Fig. 5. HEMIPRONITES.

Young individual from Moot's run.

Fig. 6. SPIRIFER, sp.

Keokuk division, Newark.

Fig. 7. SPIRIFER DELTOIDEUS, Herrick.

Conglomerate (Kinderhook) Granville.

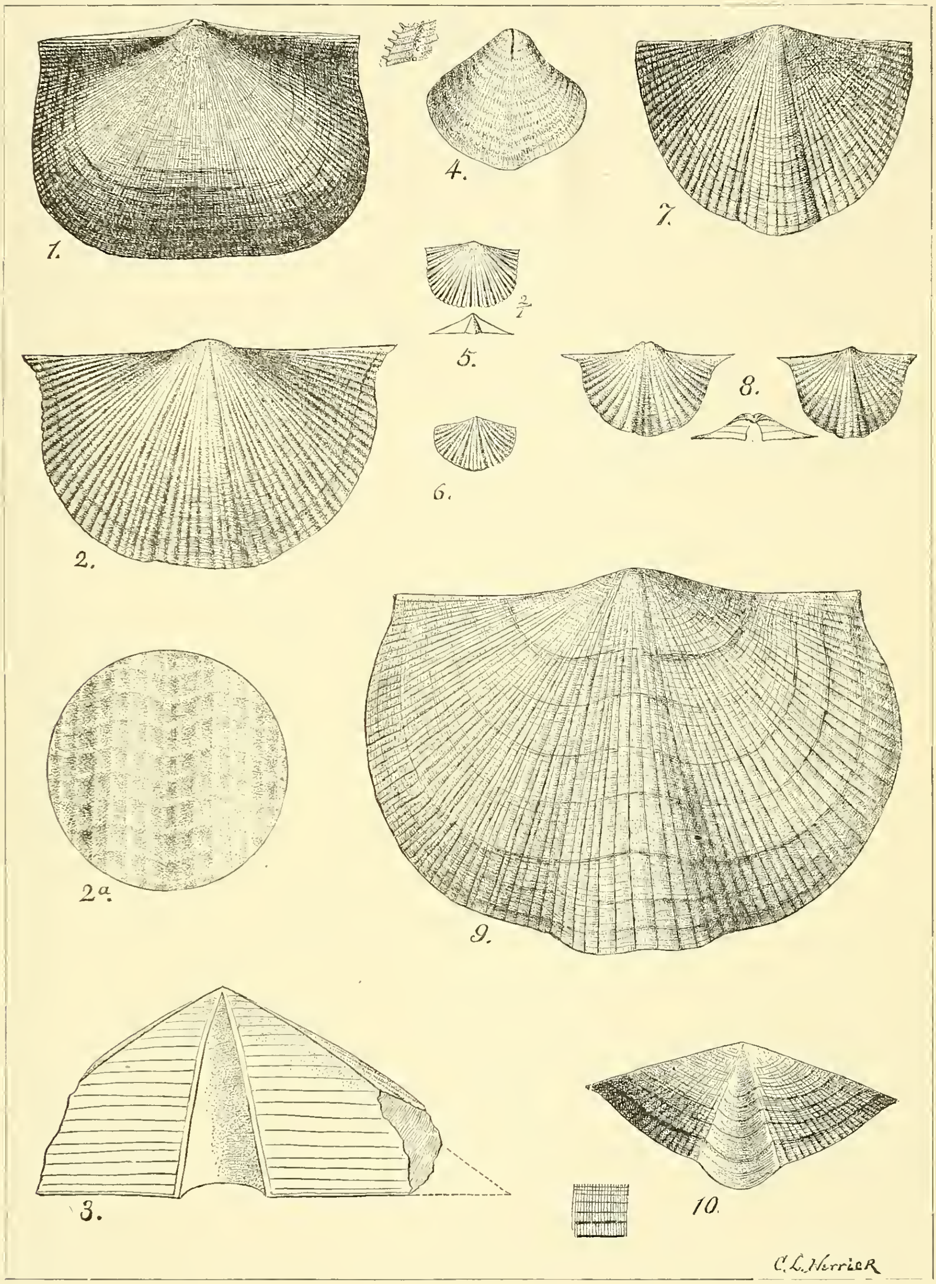
Fig. 8. SPIRIFER BIPLICATUS, Hall.

Upper layers, (Keokuk and Burlington) Newark, O.

Fig. 9. SPIRIFER STRIATIFORMIS, Meek.

Full-grown dorsal value. Upper layers, (Keokuk and Burlington) Newark, O.

Fig. 10. SPIRIFER (see Fig. 3.).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C. L. Herrick

PLATE XVI.

PAGE

Fig. 1. SPHENOTUS VALVULUS, Hall 514
Upper part of Cuyahoga shale 30 feet below conglomerate I.

Fig. 2. PROTHYRIS MEEKI, Hall.
Kinderhook, Shales below conglomerate II

Fig. 3. CTENODONTA HOUGHTONI, Stevens.
Cuyahoga shale.

Fig. 4. PALÆONEILO CURTA, Hérrick.
Kinderhook Freestone, Granville.

Fig. 5. DEXIOBIA OVATA, Hall.
Kinderhook, near conglomerate II, Newark.

Fig. 6. ORACARDIA CORNUTA, Herrick.
Cuyahoga shale, "Waverly shale" below conglomerate I.

Fig. 7. DEXIOBIA OVATA, Hall.
Kinderhook, Gann

Figs. 8–10. ORACARDIA CORNUTA, Herrick.
Kinderhook Freestone, Granville.

Fig. 11. NUCULANA sp.
Kinderhook, near conglomerate II, Gann.

Fig. 12. NUCULANA sp.
Kinderhook, Granville.

Fig. 13. NUCULANA SIMILIS, Herrick.
Below conglomerate I.

Fig. 14. PALÆONEILO CONSIMILIS, Herrick.
Base of Cuyahoga shale, Harlem, Delaware county

Fig. 15. PALÆONEILO IGNOTA, Herrick.
Cuyahoga shale, Moot's run.

Fig. 16. NUCULANA SACCATA, Winchell.
"Waverly shale," below conglomerate I.

Fig. 17. PALÆONEILO SULCATINA, Conrad.
Cuyahoga shale.

Fig. 18. PALÆONEILO (?) MARSHALLENSIS, Winchell.
This specimen is from the upper parts of the Wav rly but is found throughout the series with no obvious differences. It seems to be identical with Hall's Palæoneilo truncata and Winchell's Sanguinolites marshallensis.

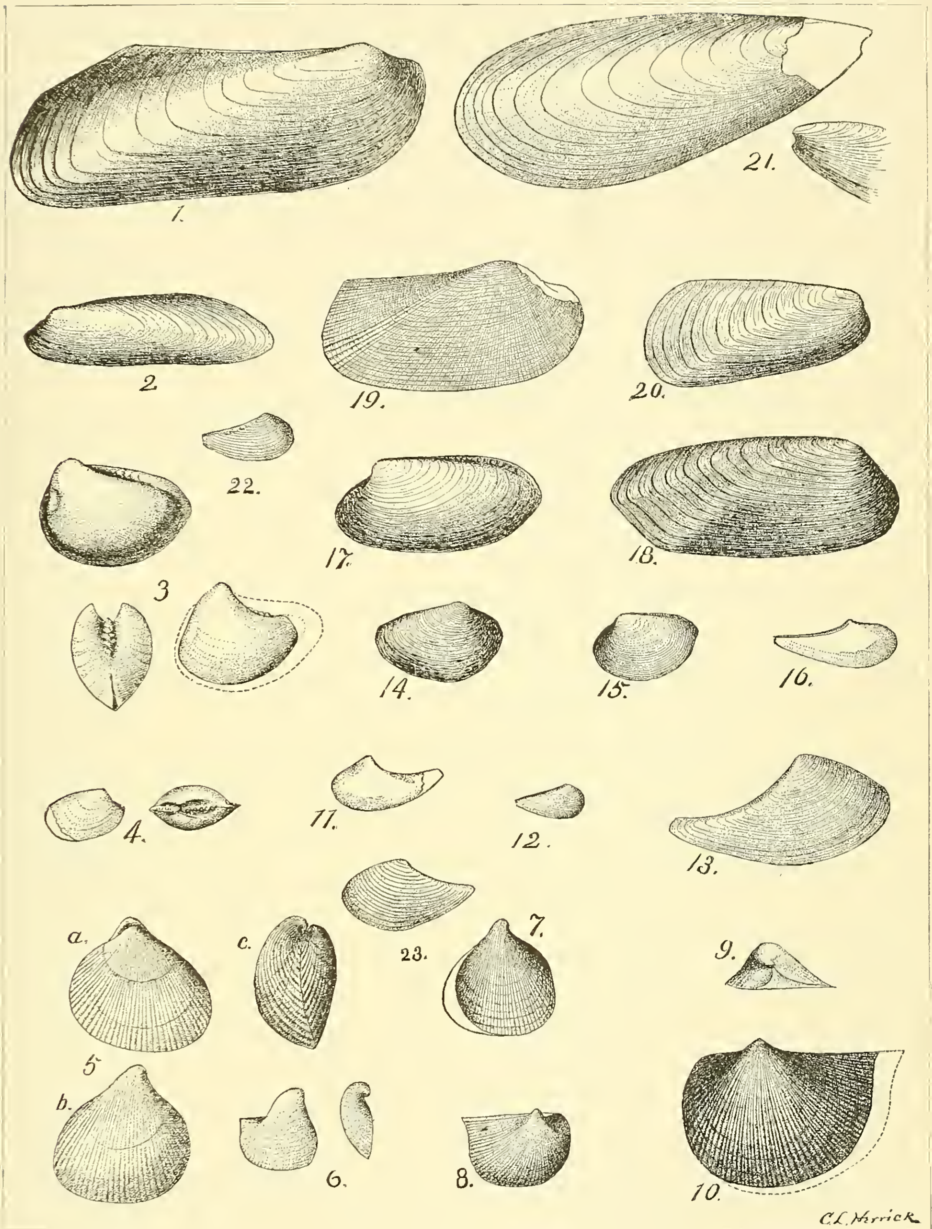
Fig. 19. MACRODON NEWARKENSIS, Herrick.
Burlington and Keokuk, Newark, O.

Fig. 20. SPATHELLA VENTRICOSA, Hall.
Keokuk. Freestone at Granville O.

Fig. 21. MYTILARCA FIBRISTRIATA, W. and W.
Cuyahoga shale. Moot's run.

Fig. 22. NUCULANA DIVERSA H (?).
Peninsula O.

Fig. 23. NUCULANA NUCULÆFORMIS, Stevens (?).
Burlington, Newark, O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C.L. Herrick

PLATE XVII.

PAGE

Fig. 1. SCHIZODUS PROLONGATUS Herrick..................... 512
Cuyahoga shale (upper portion or Wav rly shale) Licking c uuty.

Fig. 2. SCHIZODUS PALÆONILIFORMIS, Herrick.
Kinderhook Freestone; Licking county.

Fig. 3. SCHIZODUS HARLEMENSIS, Herrick.
Lower part of Cuyahoga shale. Near Harlem, Delaware county.

Fig. 4. SPHENOTUS (CYPRICARDIA?) sp.
Upper layers of Cuyahoga shale, Licking county.

Fig. 5. GRAMMYSIA FAMELICA, Herrick.
Upper layer of Cuyahoga shale, Licking county

Fig. 6. SCHIZODUS NEWARKENSIS, Herrick.
Burlington group, Newark. Ohio.

Fig. 7. MACRODON sp.
Cuyahoga shale, Moot's run

Fig. 8. CYPRICARDINIA SCITULA, Herrick.
Cuyahoga shale, Moot's run.

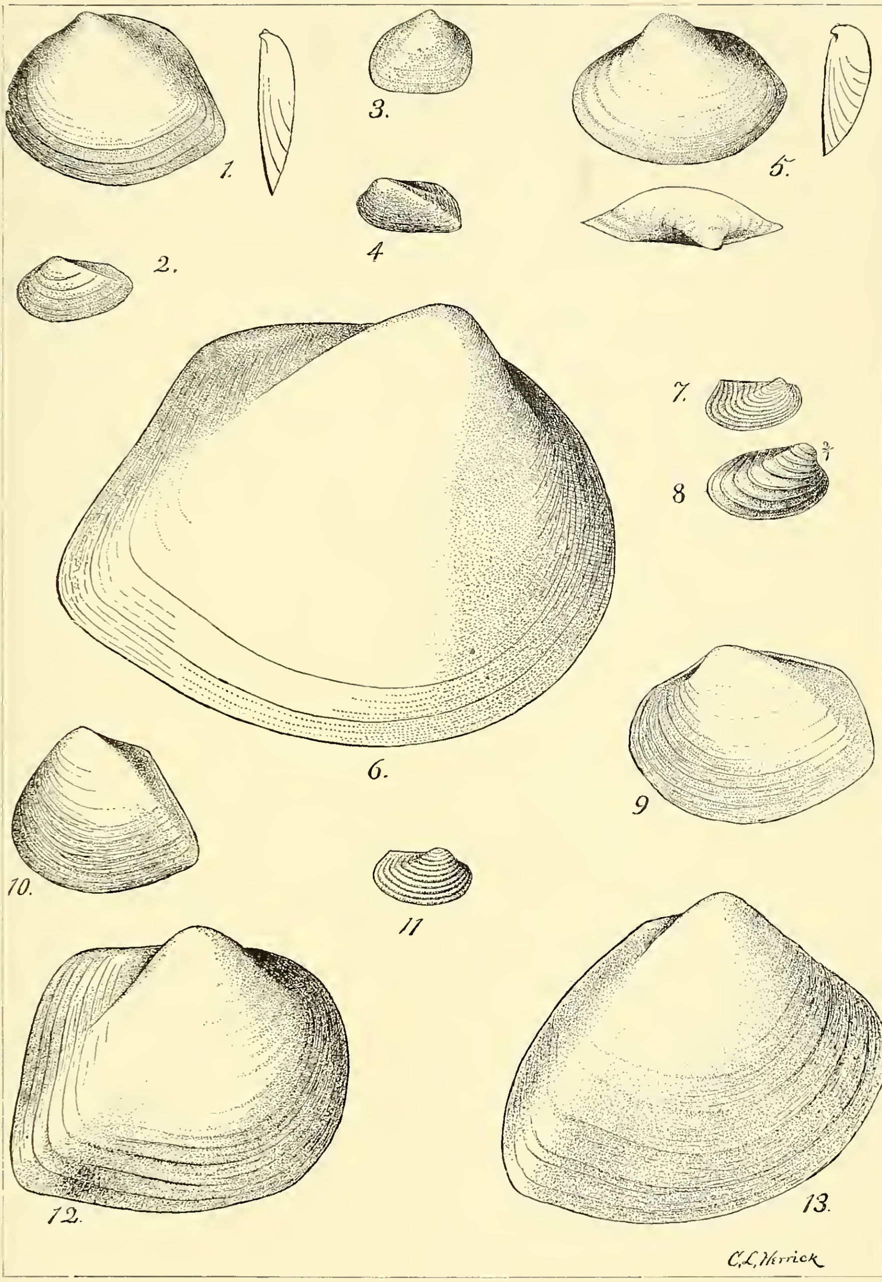
Fig. 9. MACRODON RESERVATUS, Hall.
Kinderhook, Granville, Ohio.

Fig. 10. SCHIZODUS TRIANGULARIS, Herrick.
Kinderhook, Granville, O.

Fig. 11. GRAMMYSIA? HANNIBALENSIS, Shumard.
Kinderhook Granville, Ohio.

Fig. 12. SCHIZODUS QUADRANGULARIS, Hall.
Kinderhook, Granville Ohio.

Fig. 13. SCHIZODUS TRIANGULARIS, Herrick.
Kinderhook, Granville, Ohio.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C.L. Herrick

PLATE XVIII.

PAGE.

Fig. 1. ORTHOCERAS RUSHENSIS (?) 512

Cuyahoga shale, upper layers (Waverly shale

Fig. 2. GONIATITES LYONI, Hall.

Kinderhook Freestone; Granville, Ohio.

Fig. 3. NAUTILUS sp.

Cuyahoga shale, Moot's run

Fig. 4. OPERCULUM?

Cuyahoga shale.

Fig. 5. EUOMPHALUS LATUS, Hall.

Kinderhook Freestone; Granville, Ohio.

Fig. 6. MURCHISONIA sp.

Cuyahoga shale, Moot's run.

Fig. 7. LOXONEMA sp.

Kinderhook, Granville.

Fig. 8. NAUTILUS sp.

Burlington, Newark.

Fig. 9. PLEUROTOMARIA STRIGILLATA, Herrick.

Kinderhook. Granville.

Fig. 10. PLEUROTOMARIA (FLEMINGIA) STULTA, Herrick.

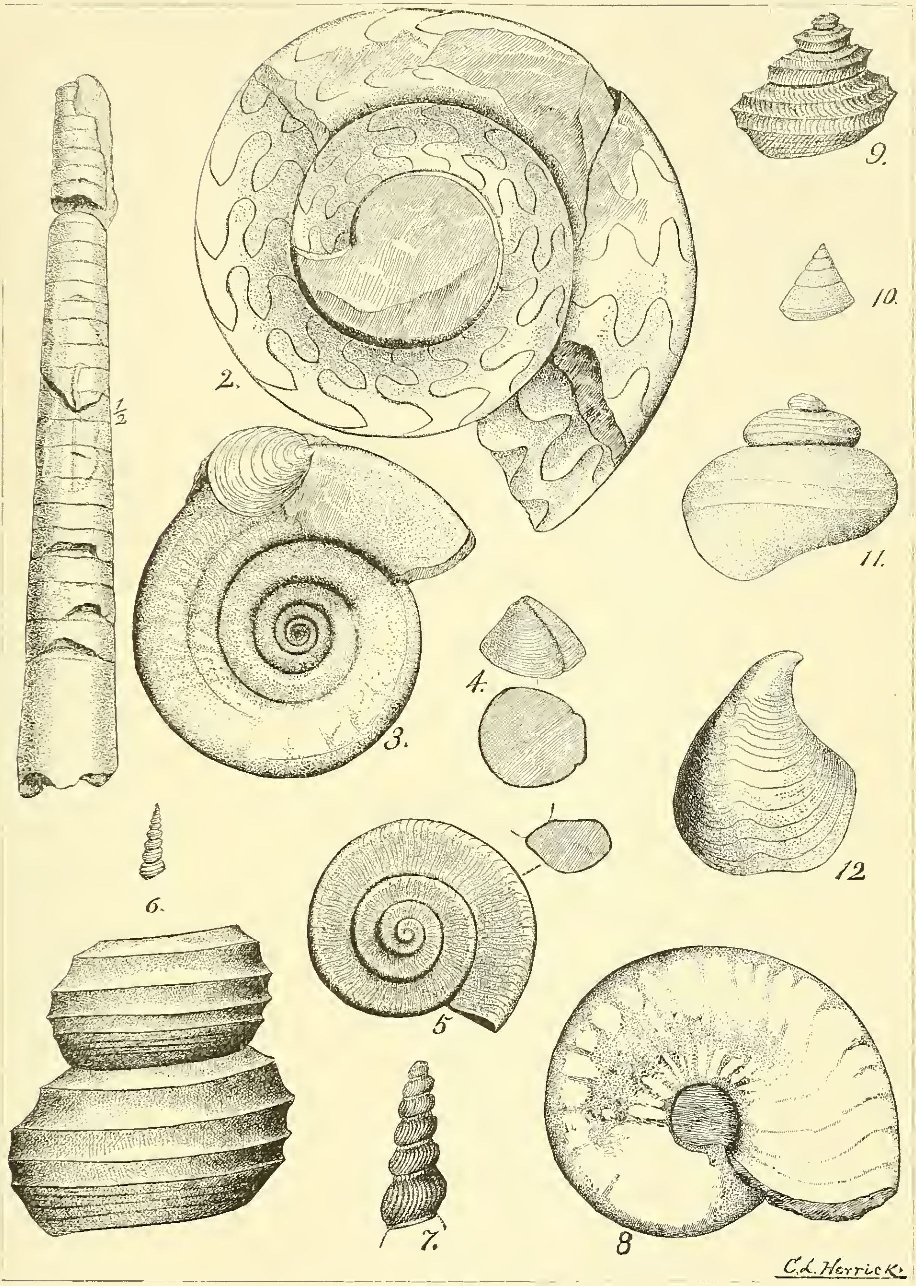
Kinderhook, Granville.

Fig. 11. PLEUROTOMARIA VADOSA, Winchell?

Near the base of the Cuyahoga shale, near Harlem.

Fig. 12. PLATYCERAS VOMERUM, Winchell?

Cuyahoga shale, Moot's run.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C.L. Herrick.

PLATE XIX.

PAGE.

Fig. 1. Platyceras lodiensis, Meek, var? 514
Cuyahoga shale, Bagdad, O.

Fig. 2. Conularia gracilis, Herrick.
Two specimens, Cuyahoga shale, Licking county.

Fig. 3. Conularia victa, White.
Burlington, Newark, O.

Fig. 4. Conularia micronema, Meek.
Kinderhook.

Fig. 5. Conularia newberryi, Meek.
Kinderhook.

Fig. 6. Zaphrentis?
Burlington or Keokuk, Rushville, Ohio

Fig. 7. Platyceras lodiense, Meek.
Cuyahoga shale.

Fig. 8. Cythere ohioensis, Herrick.
Keokuk. Rushville.

Fig. 9. Rhombopora ohioensis, Ulrich.
Cuyahoga shale.

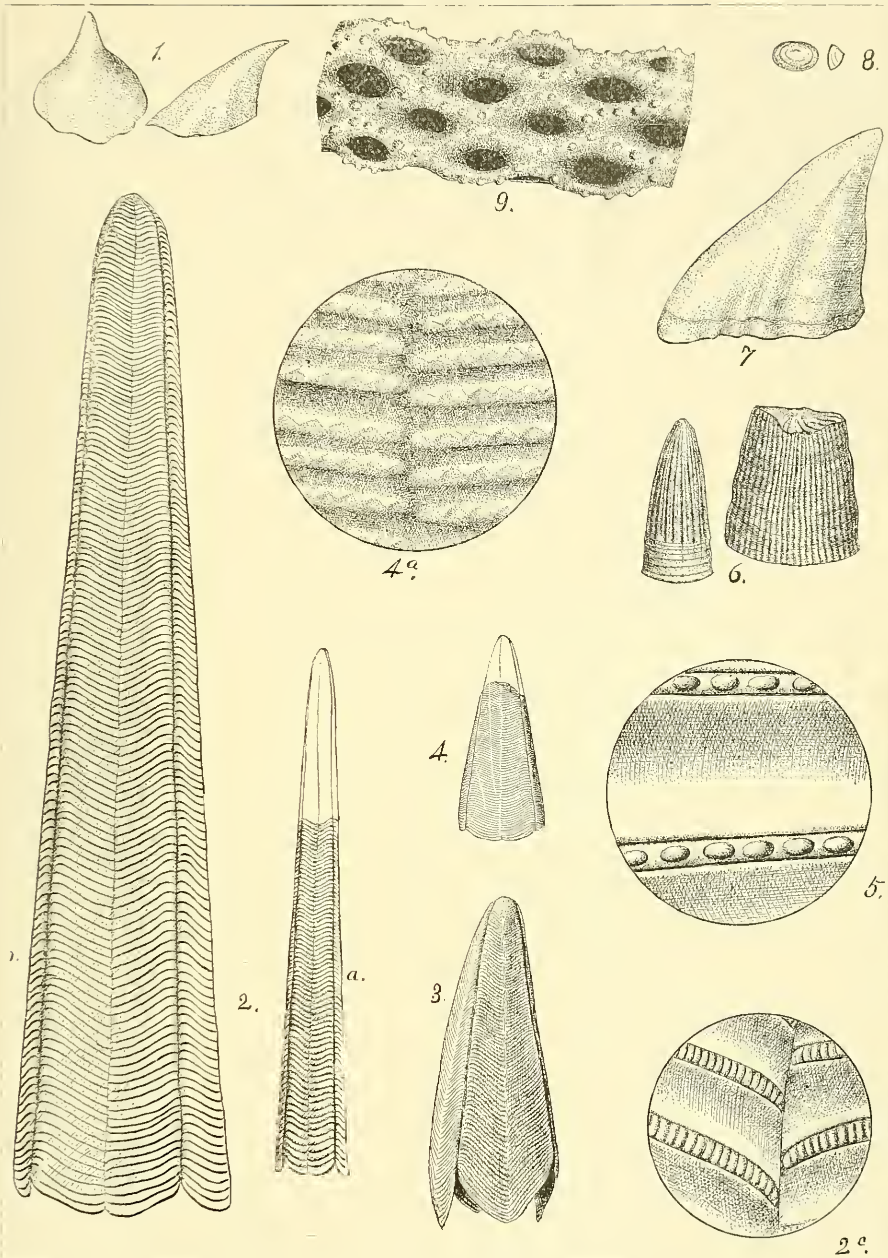
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PLATE XX.

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From Bedford shales at Central College.

Fig. 1. LINGULA MELIE, H. 507

Fig. 2. DISCINA, SP.

Fig. 3. MARTINIA UMBONATA, H.

Fig. 4. MACRODON HAMILTONIÆ, H.

Fig. 5. GONIATITES, SP.

Fig. 6. STROPHOMENA RHOMBOIDALIS.

From shales above Berea Grit.

Fig. 7. ATRYPA RETICULARIS.

Fig. 8. PALÆONEILO BEDFORDENSIS.

Fig. 9. MICRODON BELLISTRIATUS, Conr.

Fig. 10. ORTHIS VANUXEMI, H.

Fig. 11. BELLEROPHON HELENA.

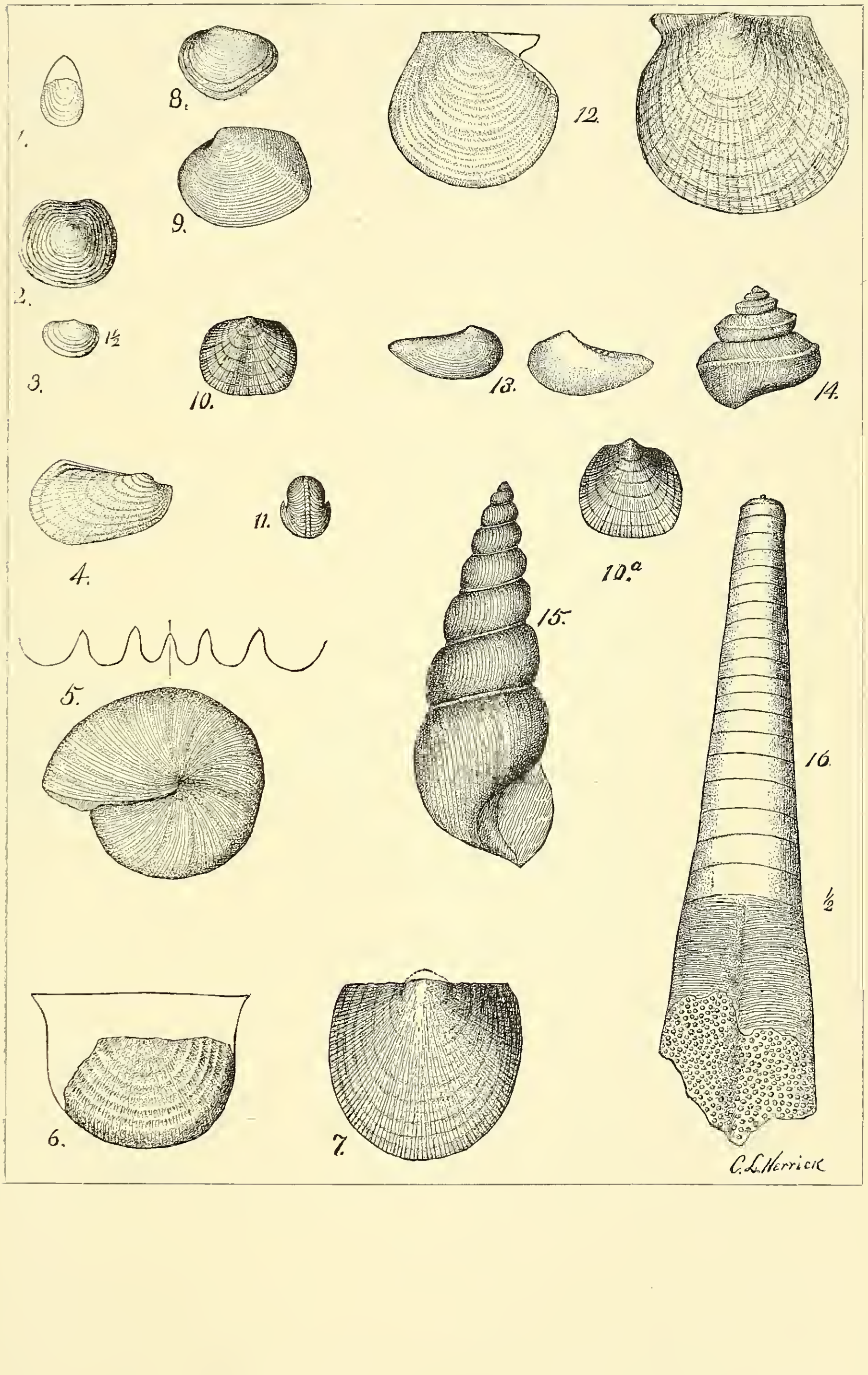
Fig. 12. PTERINOPECTEN, SP.

Fig. 13. NUCULANA DIVERSA, H.

Fig. 14. PLEUROTOMARIA SULCOMARGINATA.

Fig. 15. LOXONEMA DELPHICOLA.

Fig. 16. ORTHOCERAS, SP.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C. L. Herrick

PLATE XXI.

		PAGE
Fig. 1.	RHYNCHONELLA SAPPHO Hall. Kinderhook or base of Burlington	512
Figs. 2–3.	SPIRIFER WINCHELLI Herrick. Lower part of Burlington. Above conglomerate II.	
Figs. 4–7.	SYRINGOTHYRIS HERRICKI Suchert. Finderhook. Freestone at Granville.	
Fig. 8.	PLATYCERAS HERTZERI Meek. Cast, Kinderhook, Granville, O.	
Fig. 9.	ORTHIS VANUXEMI, VAR GRACILIS Herrick. Kinderhook, Granville.	
Fig. 10.	CRYPTONELLA EUDORA Hall. Kinderhook, Granville.	
Fig. 11.	PALAEONEILO ? MARSHALLENSIS Winchell. Kinderhook, Granville.	
Fig. 12.	UNIDENTIFED. Kinderhook or Burlington.	
Fig. 13.	SPIRIFERINA SOLIDIROSTRIS White. Burlington.	
Fig. 14.	HEMIPRONITES CRENISTRIA Phil. Kinderhook, Granville.	
Fig. 15.	SCHIZODUS CONEUS Hall. Kinderhook.	
Fig. 16.	UNIDENTIFIED CRINOID. Kinderhook.	
Fig. 17.	CTENODONTA HOUGHTONI Stevens. Kinderhook.	
Fig. 18.	RHYNCHONELLA sp.	

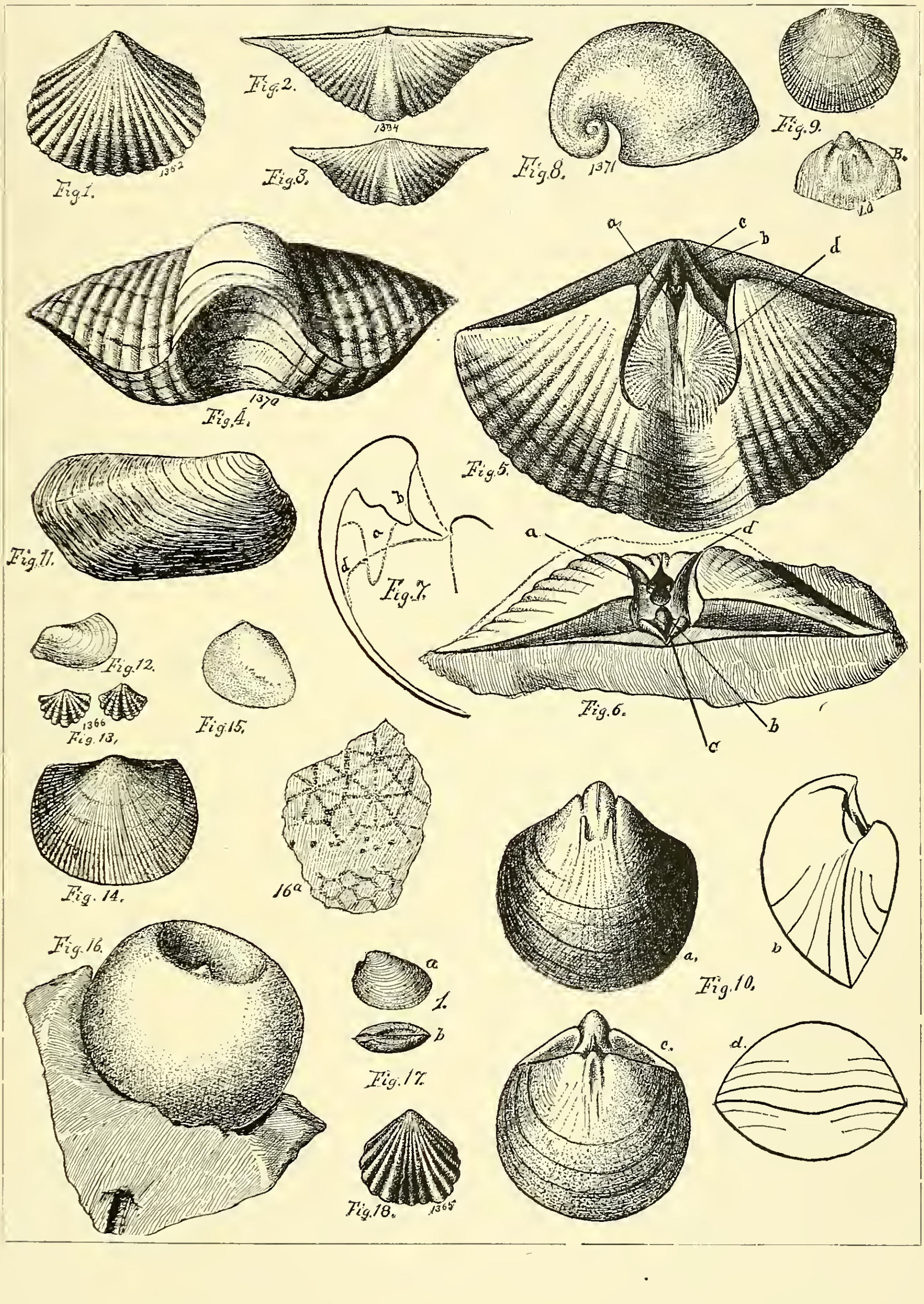
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PLATE XXII.

PAGE

Fig. 1. LINGULA (SCOTICA VAR.) WAVERLIENSIS Herrick........................... 508
In shale immediately above conglomerate II at Newark, O.

Fig. 2. LINGULA GANNENSIS Herrick.
Knox county, O., middle Waverly.

Fig. 3. VENTRAL VALVE OF SAME SPECIES.

Fig. 4. LINGULA MEMBRANACEA Winchell.
Sixty feet above conglomerate II, near Loudonville, O.

Figs. 5–6. LINGULA ATRA Herrick.
Ventral and dorsal valves. Near junction of the Cuyahoga with Little Cuyahoga river. Lowest part of Cuyahoga or Berea shales.

Figs. 7–8. LINGULA MEEKI Herrick.
Locality and position as above.

Fig. 9. LINGULA CUYAHOGA Hall.
Locality and position as above.

Fig. 10. LINGULA MELIE Hall.
Locality and position as above.

Fig. 11. ORBICULOIDEA NEWBERRYI Hall.
Locality and position as above.

Fig. 12. ORBICULOIDEA PLEURITES Meek.
Shale above conglomerate II, Newark, Gann and Loudonville.

Fig. 13. ORBICULOIDEA NEWBERRYI Hall.
Cuyahoga or Berea shale.

Fig. 14. CRENIPECTEN CANCELLATUS Herrick.
Cuyahoga shale, Moots' run and northern Ohio.

Fig. 15. PTERINOPECTEN LAETUS Hall.
Cuyahoga shale, Moots' run.

Fig. 16. PTERINOPECTEN CARINIFERUS Herrick.
A left valve without the usual sinus beneath the ear. Cuyahoga shale.

Fig. 17. ALLORISMA CUYAHOGA Herrick.
Flags below the lower falls of the Cuyahoga river, near base of the Cuyahoga shale.

Fig. 18. EDMONDIA SULCIFERA, Herrick.
Small specimen from Cuyahoga shale at Cuyahoga Falls.

Fig. 19. ENTOLIUM AVICULATUM H.
Cuyahoga shale. The two valves are almost in their natural relation, the upper one upper one having been broken away to show the interior of the opposite valve.

Fig. 20 EDMONDIA SULCIFERA Herrick.
Hinge view.

Fig. 21. ENTOLIUM AVICULATUE H.
Right valve.

Fig. 22. PTERINOPECTEN ASHLANDENSIS Herrick.
Cuyohoga shale, near Ashland.

Fig. 24. EDMONDIA SULCIFERA Herrick.
Cuyahoga shale. Licking county.

Fig. 25. SOLENOMYA (?) CUYAHOGENSIS Herrick.
Cuyahoga falls, 30 feet below conglomerate.

Fig. 26. MACRODON sp.
Cuyahoga shales.

Fig. 27. LYRIOPECTEN NODOCOSTATUS Herrick.
Cuyahoga shales. Licking county.

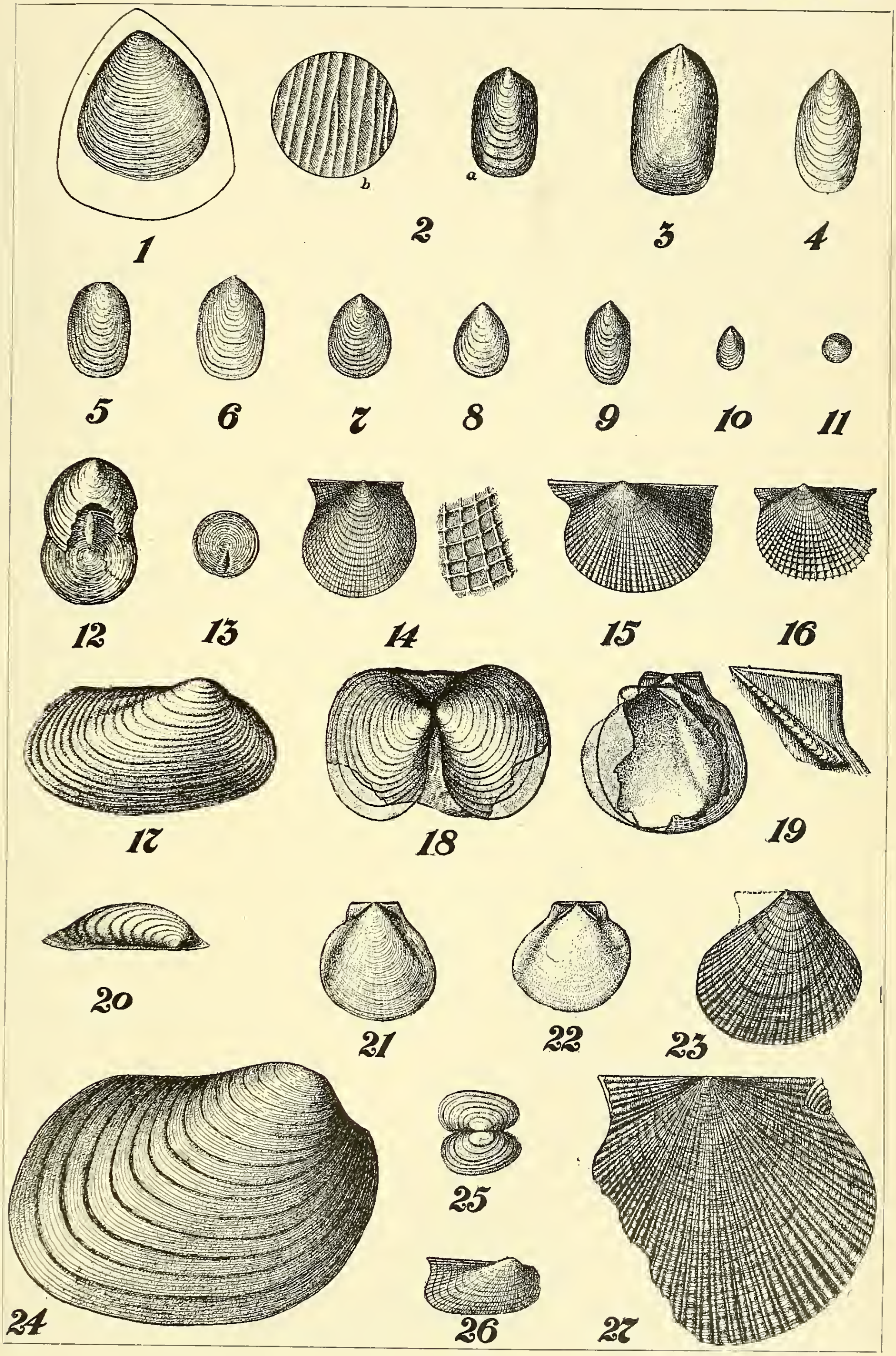
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PLATE XXIII.

PAGE.

Fig. 1–4. CRENIPECTEN (AVICULOPECTEN?) COOPERI, Depauperate form of, Herrick.......... 509

1–2. Allied species, as represented in the shales 50 feet below the conglomerate at Cuyahoga Falls.

3–4. Right and left valve of apparently the same species from the same place.

Fig. 5. AVICULA RECTA Herrick.

From same locality.

Fig. 6 NUCULA HOUGHTONI (?).

From same locality.

Fig. 7–8. CYPRICARDITES SP?

7. From the highest horizon of the Waverly at Rushville.

8. An interior view of the beak of a species of Syringothyris to show the form of the tube.

Fig. 9. PRODUCTUS RARICOSTATUS Herrick.

From the Cuyahoga shale at Moots' Run, Licking County. A variable form in some cases approaching P. lachrymosus. Found in shales and concretions.

Fig. 10. ATHYRIS ASHLANDENSIS Herrick.

Cuyahoga shale of Ashland and Licking counties.

Fig. 11. SPIRIFER DISJUNCTUS Hall.

From the Erie shale, to compare with the Waverly species.

Fig. 12. MARTINIA PREMATURA H.

Erie shale as above.

Fig. 13. PRODUCTUS NEWBERRYI, var. ANNOSUS Herrick

Lowest fossiliferous levels of Cuyahoga shale in Licking county.

Fig. 14. RHYNCHONELLA MARSHALLENSIS Winchell.

Very closely allied to R. sappho of the Chemung. The species occurs in the Cuyahoga division and continues with slight variations into the upper series.

Fig. 15. PRODUCTUS RUSHVILLENSIS Herrick.

Characteristic of a horizon nearly 100 feet above conglomerate II at Rushville, Newark and Loudonville.

Fig. 16. RHYNCHOSPIRA (?) ASHLANDENSIS Herrick.

Cuyahoga shale at Lyon Falls. (On the description of plates in vol. IV of the Bulletins of Denison University where this species was first mentioned it was called Heiorhynchus? richlandensis.)

Fig. 17. TEREBRATULA INCONSTANS Herrick.

Lodi, Moots' Run, Richland Co, etc., Cuyahoga shale.

Fig. 18. SANGUINOLITES NAIADIFORMIS Winchell.

Top of middle Waverly at Granville. The species is most abundant immediately beneath conglomerate I.

Fig. 19. ALLORISMA CONVEXA Herrick.

Middle Waverly in Licking county.

Fig. 20. ALLORISMA NOBILIS Dekoninck.

Middle Waverly in Licking county.

Fig. 21. GONIODON (PALÆONEILO? OHIOENSIS Herrick.

Cuyahoga shale, Moots' Run.

Fig. 22. SPHENOTUS CONTRACTUS W. W.

Cuyahoga shale at Moots' Run.

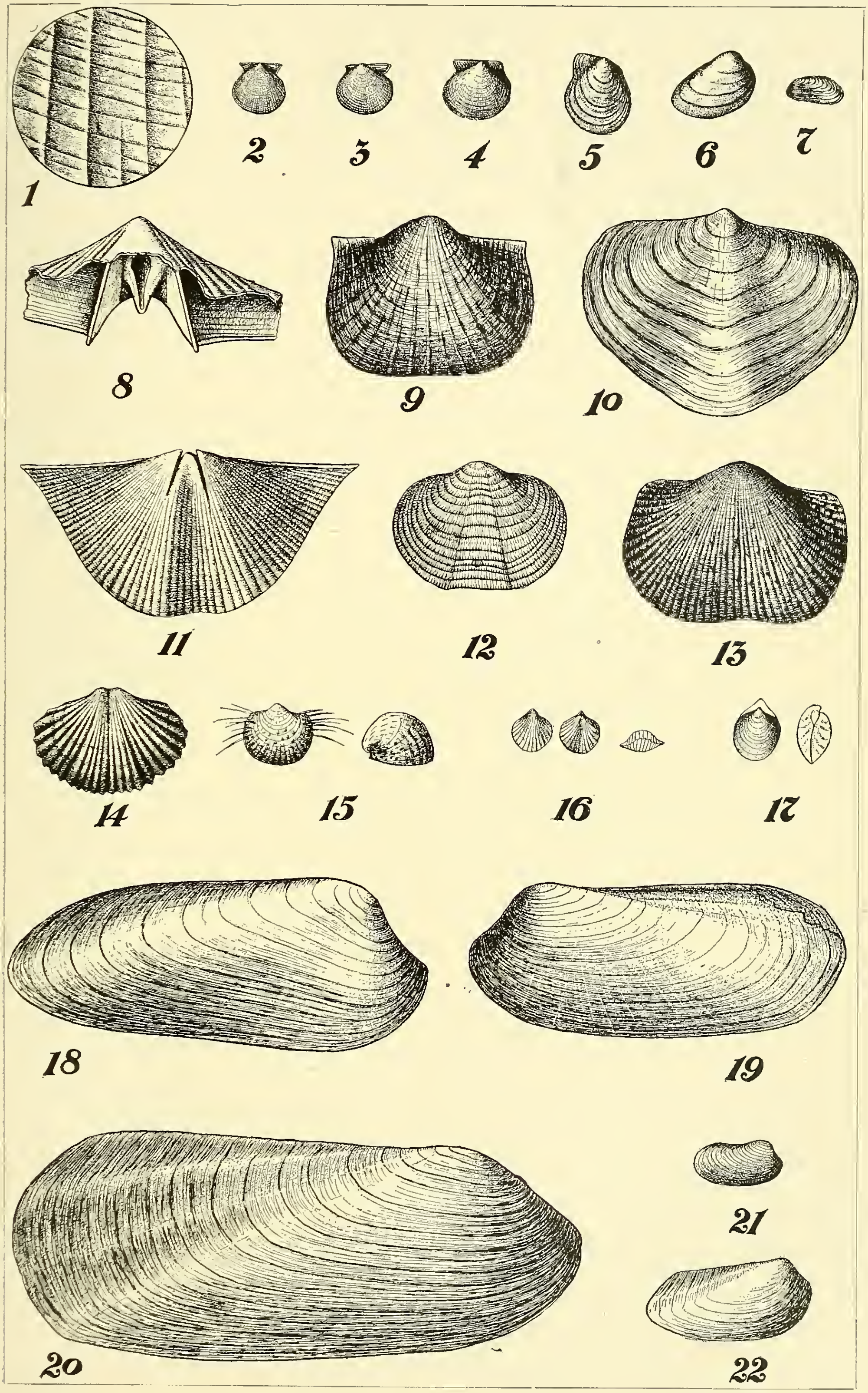
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PLATE XXIV.

PAGE.

Fig. 1. LEIOPTERIA (LEPTODESMA) ORTONI, Herrick.................................. 512
Upper part of Cuyahoga shale, ("Waverly shale,") Licking county.

Fig. 2. AVICULA SUBSPATULATA, Herrick.
Division III, (Burlington) Newark.

Fig. 3. CRENIPECTEN CRENISTRIATUS, Meek.
Same position and locality as the last.

Fig. 4. CRENIPECTEN CAROLI, Win. (?).
Kinderhook (Div. II.) Gann.

Fig. 5. STREBLOPTERIA SP.
Locality and position like the last.

Fig. 6. STREBLOPTERIA SP?.
Division III (Burlington group) Newark. There is apparently a complete series of transitions from Streblopteria media of the Cuyahoga shales to S. gracilis of the Kinderhook and the present form.

Fig. 7. GRAMMYSIA OVATA, Herrick.
Upper part of Division II (Burlington group), Newark.

Fig. 8. LEIOPTERIA HALLI, Herrick.
Kinderhook group (Freestone of Division II), Granville.

Fig. 9. LEIOPTERIA SP?
Location and position as above.

Fig. 10. LEIOPTERIA (variety of) ORTONI, Herrick.
Freestone of Kinderhook group.

Fig. 11. LEPTODESMA SCUTELLA, Herrick.
Location and position as above.

Pig. 12. LEIOPTERIA ORTONI, Herrick
Three views of the cast. Cuyahoga shale.

Fig. 13. UNIDENTIFIED LAMELLIBRANCH.
Cuyahoga shale.

Fig. 14. STREBLOPTERIA SQUAMA, Herrick.
The generic position is doubtful. Cuyahoga shale (Waverly shale), immediately below conglomerate I. Granville.

Fig, 15. STREBLOPTERIA GRACILIS, Herrick.
Kinderhook or Burlington division.

Figs. 16–17. STREBLOPTERIA MEDIA, Herrick
Figs. 16–17. Cuyahoga shales. Moot's run.

Fig. 18. POSIDONOMYA (STREBLOPTERIA) FRAGILIS, Herrick.
Cuyahoga shales, Moot's run.

Fig. 19. LIMATULINA? OHIOENSIS, Herrick.
Division III (Burlington group), Licking county.

Fig. 20.

Fig. 21. MODIOLA WAVERLIENSIS, Herrick.
Division II.

Fig. 22. MYALINA MICHIGANENSIS, Win.
Division II Kinderhook).

Fig. 23. GONIODON (PALEONEILO) OHIOENSE, Herrick.
Cuyahoga shale.

Fig. 24. PTERINOPECTEN CARINIFERUS, Herrick.
Right valve. Cuyahoga shale. Moot's run.

Fig. 25. Unidentified.
Cuyahoga shale

Fig. 26. ENTOLIUM AVICULATUM, Schum.
Two specimens of the left valve. Cuyahoga shale. Moot's run.

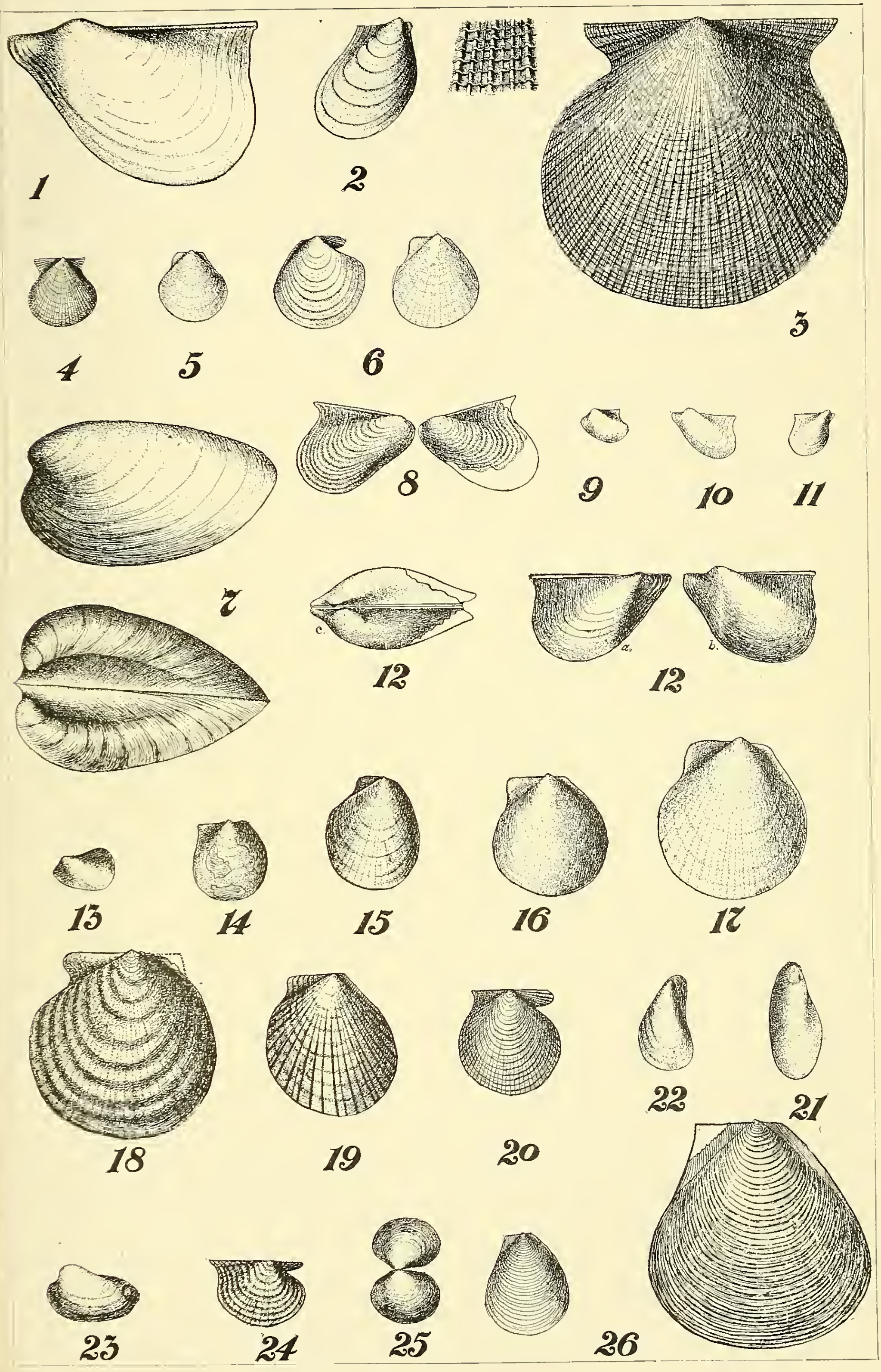
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PLATE XXV—Concluded.

Fig. 18. BELLEROPHON (BUCANIA) EXIGUUS Foerste... 548

18. *a*. View from above. *b*. Side view. The umbilicus here is very small. H. O. Marl.

Fig. 18. BELLEROPHON (BUCANIA) OPERTUS Foerste................................ 548

18. Not the type; the umbilicus in the cast is larger than in *B. exiguus*. *c*. Lateral view. *d* View almost from in front. H. O. Marl.

Fig. 19. BELLEROPHON FISCELLO-STRIATUS Foerste.................................... 548

19. *a*. Lateral view, the inner margin of the whorl not well shown, though the umbilicus is large. *b*. Front view. *c*. Upper view. *d*. View showing sinuous outer lip of aperture. *e*. A little of the carina and part of the adjacent striæ, enlarged. S. H. O. Stolz's quarry.

Fig. 20. ORTHIS (HERBERTELLA) DAYTONENSIS Foerste............................ 575

20. *a*. Pedicle valve. *b*. Interioı of the same. C. O.

Fig. 21. ORTHIS (HERBERTELLA) DAYTONENSIS Foerste............................ 575

21. A lateral view showing outlines of a perfect shell. C. O.

Fig. 22. PLATYCERAS (PLATYSTOMA) NIAGARENSE Hall.............................. 553

22. A mature specimen. *a*. Side view. *b*. Top view of spire. B. O.

Fig. 23. ACIDASPIS ORTONI Foerste.. 522

23. Glabellar regions not correctly shown, and the spines of the free cheek should be a little longer. B. O.

Fig. 24. CALYMENE VOGDESI Foerste.. 526

24. Smaller specimens from the limestone. S. H. O

Fig. 25. CALYMENE VOGDESI Foerste.. 526

25. The type. C. O.

Fig. 26. LICHAS BREVICEPS Hall...... 529

26. *a*, *b*. Two glabellæ. *c*. Surface enlarged. These specimens have lobes of considerable size in the occipital furrow not well shown in the figure beneath the lateral lobes of the glabella. This distinction belongs to variety *Clintonensis*. S. H. O. *d*. Pygidium. S. H. O. *e*. Part of a glabella, B O., belonging all to the same variety.

PLATE XXV.

NOTE.—The letters at the close of each description of the figures indicate the locality at which the specimen figured was found, as follows: S. H. O.—Soldiers' Home; F. O.—Fauver's; H. O.—Huffman's; B. O.—Brown's; C. O.—Centreville; T. F. O.—Todd's Fork; F. H. O.—Fair Haven; E. O.—Eaton, Ohio; H. I.—Hanover, Indiana; C. A.—Collinsville, Alabama; C. T.—Cumberland Gap, Tennessee.

PAGE.

Fig. 1. ORTHOCERAS (CYCLOCERAS) INCEPTUM Foerste.......... 543

1 *a.* Views of the carina after the action of strong weathering, removing part of the cast. The rows of pits illustrated in the two figures to the right are too regular and were the result of weathering; they represent no real structure of the shell. *b.* Views, showing position of the siphuncle. *c.* A longitudinal section, showing the cylindrical siphuncle at the centre, and accidental concretionary material around the same. H. O. Marl.

Fig. 2. MERISTELLA UMBONATA Billings.......... 590

2 *a.* Lateral view. *b.* View of the brachial valve. S. H. O.

Fig. 3. PLATYCERAS (PLATYSTOMA) NIAGARENSE Hall.......... 553

3 *a.* Ordinary, immature form *b.* Form approaching variety *plebium.* S. H. O.

Fig. 4. EICHWALDIA RETICULATA Hall.......... 594

4. *a.* Brachial valve. *b.* Pedicle valve. F. O.

Fig. 5. PLECTAMBONITES TRANSVERSALIS Wahlenberg.......... 566

5. Variety *reversata*, Foerste. *a.* Pedicle valve. *b.* Outline, showing curvature of the shell. S. H. O.

Fig. 6. ATRYPA MARGINALIS Dalman.......... 591

6. A young brachial valve H. O. Marl.

Fig. 7. ORTHIS (PLATYSTROPHIA) BIFORATA Schlotheim.......... 579

7. Of the form with many plications in sinus and in fold, called *reversata*; pedicle valve. S. H. O.

Fig. 8. ORTHIS (PLATYSTROPHIA) BIFORATA Schlotheim.......... 579

8. Of the form with two plications in the sinus and three on the fold, called *Daytonenensis*; pedicle valve. S. H. O.

Fig. 9. ATRYPA MARGINALIS Dalman.......... 591

9. Pedicle valve. S. H. O.

Fig. 10. ORTHIS (RHIPIDOMELLA) HYBRIDA Sowerby.......... 584

10. *a.* Brachial valve. *b.* Lateral view, drawn to show outline only. S. H. O.

Fig. 11. ORTHIS (DALMANELLA) ELEGANTULA Dalman.......... 581

11. *a.* Brachial valve. *b.* Lateral view, drawn to show outline only. S. H. O.

Fig. 12. ORTHIS (ORTHIS) CALLIGRAMMA Dalman.......... 572

12. Of a type nearest to the typical forms of Hall and Clarke's redefinition of the genus Variety *eu-orthis.* *a.* Brachial valve. *b.* Pedicle valve. S. H. O.

Fig. 13. ORTHIS (HERBERTELLA) DAYTONENSIS Foerste.......... 575

13. *a.* Brachial valve. *b.* Lateral view, drawn to show outline of brachial valve only. *c.* A few of the radiating plications. *d.* The same slightly enlarged S. H. O.

Fig. 14. PTERINEA BRISA Hall.......... 557

14. Fragments of the left valve. S. H. O.

Fig. 15. ORTHIS (HERBERTELLA) FAUSTA Foerste.......... 573

15. *a.* Brachial valve. *b.* Pedicle valve. *c.* Lateral view, drawn to show outline of shell only. *d.* A few of the plications, slightly enlarged. S. H. O. Carrollton Pike quarry.

Fig. 16. ORTHIS (HERBERTELLA) FAUSTA Foerste.......... 573

16. *a.* Brachial valve *b* Plications slightly enlarged. S. H. O. Carrollton Pike quarry, now abandoned, half way between Geo. Young's present quarry and the Germantown pike.

Fig. 17. Orthis (DALMANELLA) ELEGANTULA Dalman.......... 581

17, Variety *parva*, probably only young specimens of the species. *a.* Pedicle valve. *b.* Lateral view of the same S. H. O.

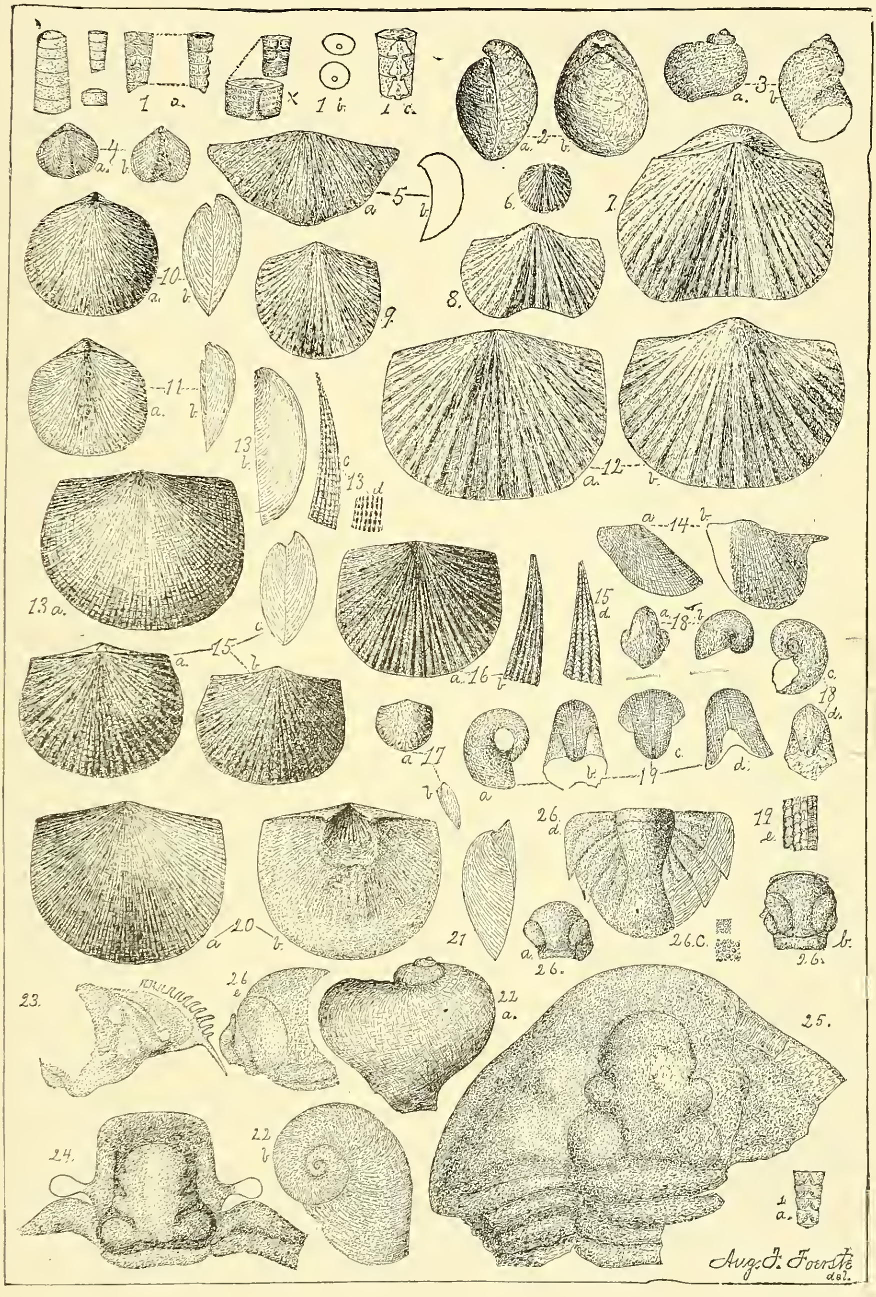

Aug. F. Foerste del.

PLATE XXVI.

PAGE.

Fig. 1. ILLÆNUS MADISONIANUS, Whitfield.. 526

1. Var. *elongatus*; *a*, pygidium; *b*, lateral view of the same. H. O.

Fig. 2. ILLÆNUS MADISONIANUS, Whitfield.. 526

2. Var. *depressus*; *a*, pygidium; *b*, lateral view of the same. S. H. O. Stolz's quarry.

Fig. 3. PHACOPS TRISULCATUS, Hall.. 529

3. Glabella. S. H O.

Fig. 4. ILLÆNUS DAYTONENSIS, Hall and Whitfield.. 525

4. *a*, pygidium; *b* lateral view of the same. S. H. O.

Fig. 5. PROETUS DETERMINATUS, Foerste.. 523

5. Glabella. S H. O.

Fig. 6. ILLÆNUS DAYTONENSIS, Hall and Whitfield.. 525

6. Free cheek, seen obliquely from below. S. H. O,

Fig. 7. ILLÆNUS DAYTONENSIS, Hall and Whitfield.. 525

7. *a*, glabella. side view, with free cheek belonging to a smaller individual; *b*, glabella, from above; *c*, posterior view of glabella. S. H. O.

Fig. 8. TELLINOMYA (NUCULA?) MINIMA, Foerste.. 563

8. *a*, view of anterior lunule; *b*, lateral view, (the markings on this cast near the beak are probably accidental); *c*, view of posterior lunule, showing a median line or ridge along the cast; branch posteriorly on either side. H. O. Marl. Enlarged.

Fig. 9. ILLÆNUS AMBIGUUS, Foerste.. 525

9. *a*, pygidium; *b*, lateral view of another specimen. S. H. O.

Fig. 10. ILLÆNUS AMBIGUUS, Foerste.. 525

10. *a*, lateral view of glabella, with movable cheek of another specimen; *b*, posterior view of glabella; *c*, glabella. S. H. O.

Fig. 11. ILLÆNUS INSIGNIS? Hall; or Ill. ambiguus? Foerste.. 525

11. Free cheek. S. H. O.

Fig. 12. CYPRICARDITES CASWELLI, Foerste.. 561

12. *a*, right valve; *b*, upper view along hinge line, beak too far forward. S. H. O. Coll. of George Caswell.

Fig. 13. STRICKLANDINIA TRIPLESIANA, Foerste.. 594

13. *a* pedicle valve; *b*, lateral view. S. H. O.

Fig. 14. STRICKLANDINIA TRIPLESIANA, Foerste.. 594

14. Brachial valve. S. H. O.

Fig. 15. CYCLONEMA BILIX, Conrad.. 551

15. This belongs to the form with a low spire, and transverse striæ, the revolving striæ being present only toward the lower side of the last whorl; a poor drawing. S. H. O.

Fig. 16. CASTS OF THE UMBILICUS OF RHAPHISTOMA AFFINE..

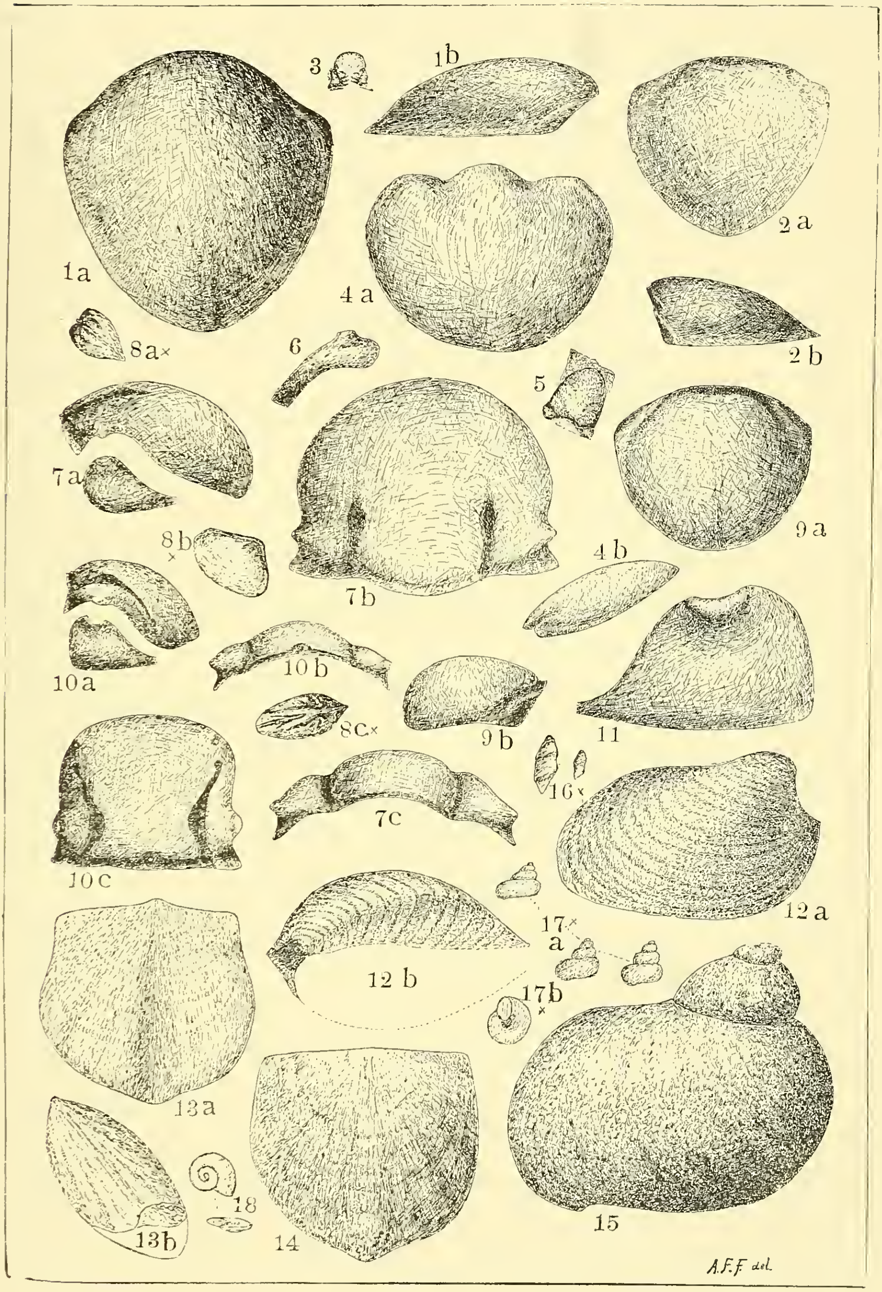
16. Similar casts of the umbilicus of Bucania can be distinguished only by means of their symmetry, on either side of a median plane. H. O. Marl.

Fig. 17. CYCLORA ALTA, Foerste.. 552

17. *a*, side views; *b*, basal view; all of casts magnified. H. O, Marl.

Fig. 18. RAPHISTOMA AFFINE, Foerste.. 550

18. A view from above and one from the side. H. O. Marl.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1b
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2a
4a
8a×
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2b
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7a
7b
9a
8b ×
4b
10a
10b
11
8c×
9b
16×
7c
10c
12a
17×
a
12b
17b ×
13a
15
18
13b
14
A.F.F del.

PLATE XXVII—Concluded.

PAGE.

Fig. 22. DALMANITES WERTHNERI Foerste 530

22. Head. S. H O.

Fig. 23. DALMANITES WERTHNERI Foerste 530

23. Pygidium. S. H. O.

Fig. 24. DALMANITES WERTHNERI Foerste 530

24. A specimen preserving a part of the body. S H. O.

Fig. 25. DALMANITES WERTHNERI Foerste 530

25. An eye magnified. S. H. O.

Fig. 26. ENCRINURUS PUNCTATUS Wahlenberg 531

26. Pygidium used as type of *E. Thresheri*. S. H. O. In cabinet of Mr. B. B. Thresher

Fig. 27. DICTYONEMA PERTENUE Foerste 600

27. A frond; b, part of the same magnified showing also the distance at which the pores are situated. S. H. O.

Fig. 28. DICTYONEMA SCALARIFORME Foerste 600

28. A frond. S. H. O.

Fig. 29. DICTYONEMA SCALARIFORME Foerste 600

29. A part of the latter magnified. S. H. O.

Fig. 30. PTERINEA BRISA Hall 557

30. Left valve. B. O.

Fig. 31. STROPHOMENA (ORTHOTHETES) TENUIS Hall 568

31. A brachial valve. S. H. O.

Fig. 32. STROPHOMENA (ORTHOTHETES)TENUIS Hall 568

32. A pedicle valve. S. H. O.

Fig. 33. BELLEROPHON (BUCANIA) TRILOBATUS Sowerby 549

33. Two views. H. O. Marl.

Fig. 34. STROPHOMENA (ORTHOTHETES) HANOVERENSIS Foerste 567

34. A pedicle valve referred to this species, forms of this type are moderately convex, and the posterio-lateral angles are not produced so prominently beyond the sides of the valves as in the figure, which obtained its character from the accidental manner in which it was exposed in the rock. T. F. Q.

Fig. 35. STROPHOMENA (STROPHONELLA or AMPHISTROPHIA possibly) PATENTA Hall 569

35. Pedicle valve, beginning to be reflexed at the margin. S. H. O.

Fig. 36. STROPHOMENA PATENTA Hall 569

36. Pedicle valve, already quite reflexed anteriorly, but not a nature specimen. F. O.

Fig. 37. STROPHOMENA PATENTA Hall 569

37. Brachial valve, young specimen, not at all bent towards margin. S. H. O.

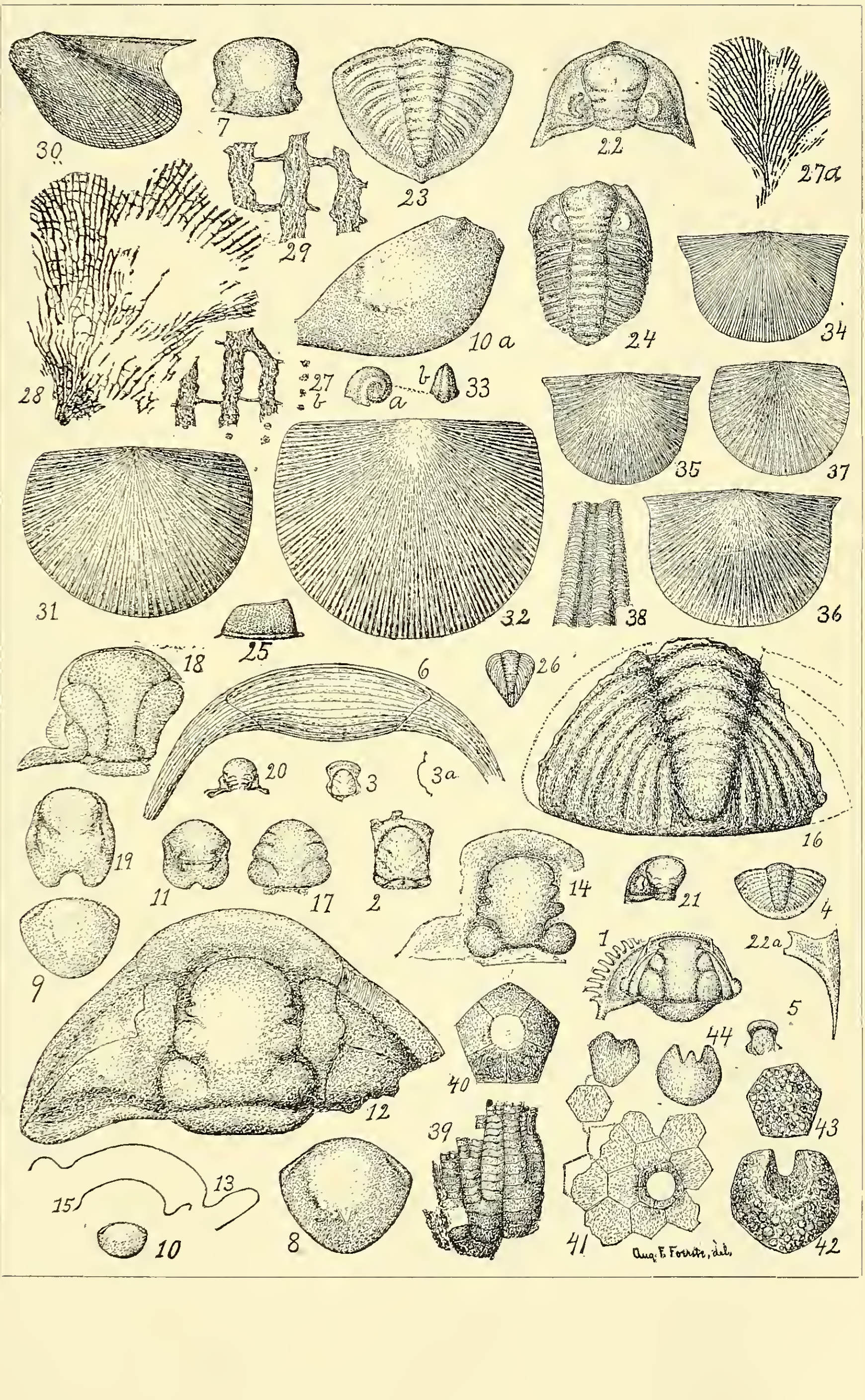
Fig. 38. STROPHOMENA (ORTHOTHETES) TENUIS Hall 568

38. A portion of a few plications enlarged. S. H. O.

Fig. 39–41. CRINOIDAL REMAINS.

39. Basal part of several arms. C. O. 40 and 41. Base of calyx, Reeds Hill, Ohio. 42 and 43. Plates of calyx. S. H. O. 44. Specimen of unknown relations. S. H. O.

PLATE XXVII.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Aug. F. Foerste, del.

PLATE XXVIII.

PAGE.

Fig. 1. PHYLLOPORINA ANGULATA Hall ... 600

A small form for which the specific name *Ph. Daytonensis* was suggested by Hall and Whitfield. Fig. 4, Plate V, Ohio Pal., should show four rows of cells on the branches. S. H. O,

Fig. 2. HEMITRYPA ULRICHI Foerste ... 599

Part of the infundibuliform frond. B. O.

Fig. 3. CLATHROPORA FRONDOSA Hall ... 598

Lower part of a frond separated along the epithecal membrane. S. H. O.

Fig. 4. CLATHROPORA CLINTONENSIS Hall and Whitfield ... 598

Lower part of a frond, separated along the epithecal membrane; both in this specimen and the last the line of articulation with the basal segment is shown S. H. O.

Fig. 5. PTILODICTYA WHITFIELDI Foerste ... 598

A typical specimen of this species (now distinguished from *Pt. expansa*, Hall and Whitfield,) parted along the epithecal membrane. T F. O.

Fig. 6. PHÆNOPORA MAGNA Hall and Whitfield ... 599

A fragment showing the surface; the monticules are usually lower and broader. S. H. O.

Fig. 7. PHÆNOPORA FIMBRIATA James ... 599

A typical frond parted along the epithecal membrane. S. H. O

Fig. 8. PACHYDICTYA EMACIATA Foerste ... 599

Showing surface. S. H. O.

Fig. 9. PACHYDICTYA BIFURCATA (Van Cleve) Hall ... 599

Part of a very large specimen. S. H. O.

Fig. 10. PACHYDICTYA BIFURCATA VAR INSTABILIS Foerste ... 599

One of the extreme forms. with more than one row of monticules on the branches. B. O.

Fig. 11. PACHYDICTYA TURGIDA Foerste ... 599

The distinctions between this form and the next are not yet well understood. S. H. O.

Fig. 12. PACHYDICTYA OBESA Foerste ... 599

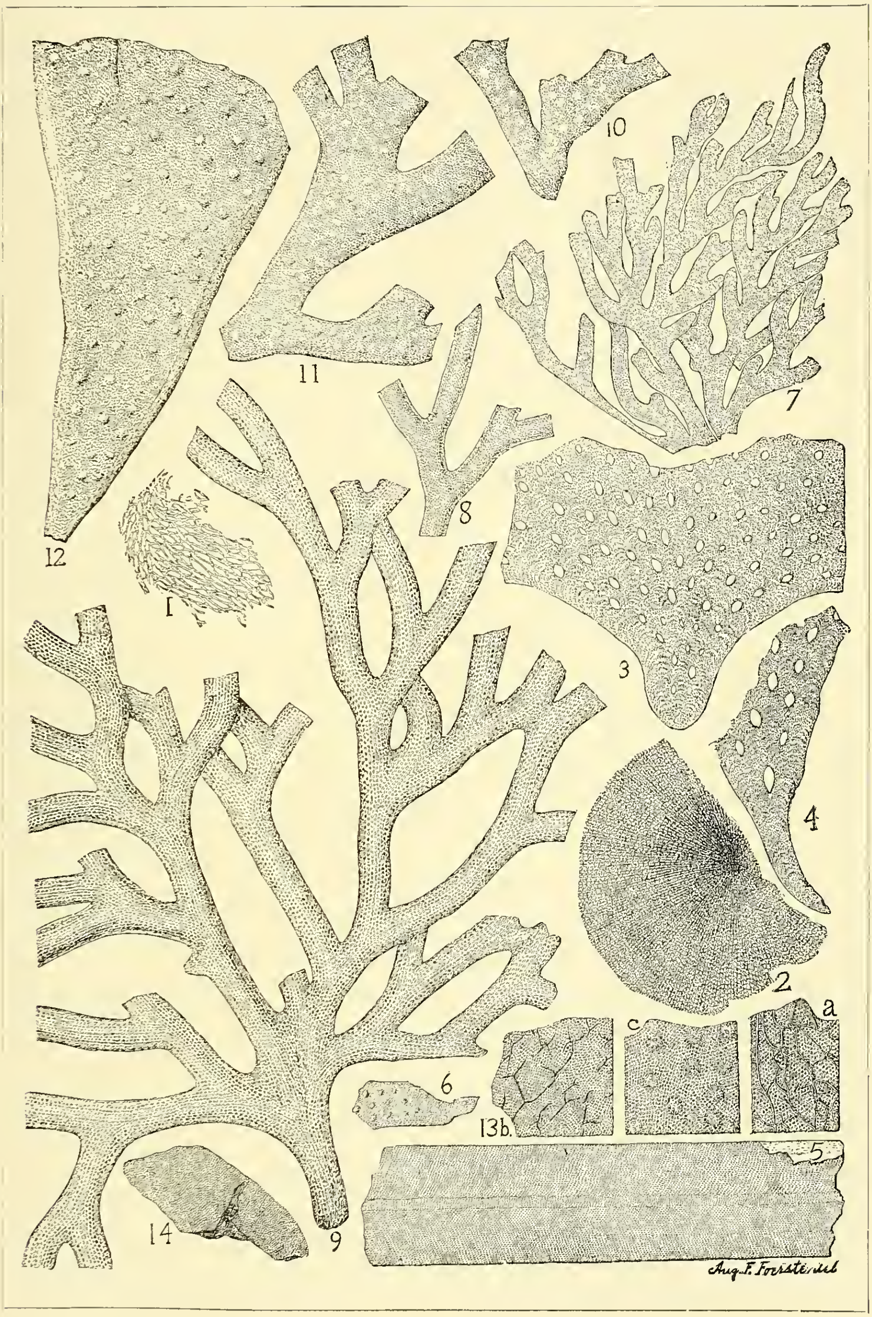
Specimens of this species usually have the fronds broader and strongly undulate S. H. O.

Fig. 13. RHINOPORA VERRUCOSA Hall ... 599

a, the form of preservation called *Rh. venosa*, Spencer; C. O. *b*, the same weathered leaving only the grooves, called then *Ph. frondosa*, Hall and Whitfield; C. O. *c*, areas with more distant cells more or less regularly disposed are not infrequent, and are usually associated with the " frondose " phenomena. occurring then at the intersections of " veins " S. H. O.

Fig. 14. ASPIDOPORA PARMULA Foerste ... 600

A fragment; H. O. The perfect fronds are thin, discoid, curved so as to be moderately covex above, about 25 inches in diameter, the cells form diagonal intersecting and concentrically arranged rows. H. O. Marl.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c
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13b.
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Aug. F. Foerste del.

PLATE XXIX.

Fig. 1. PHÆNOPORA EXPANSA Hall and Whitfield 598

A frond parted along the epithecal membrane. S. H. O

Fig. 2. PHÆNOPORA MAGNA Hall and Whitfield 599

Fronds parted along the epithecal membrane. S. H. O,

Fig. 3. PHÆNOPORA MULTIFIDA (Van Cleve) Hall........ 599

A frond parted along the epithecal membrane, collection of Geo. Caswell. S. H. O.

Fig. 4. HOMOTRYPA CONFLUENS Foerste.. 600

a, Branch of usual size. *b*, Gnarl formed by coalescence of several branches. S. H. O.

Fig. 5. CALLOPORA MAGNOPORA Foerste 600

A branch starting to divide or branch at the top. C. O.

Fig. 6. LIOCLEMELLA OHIOENSIS Foerste.. 600

Two branches of quite large size for this species. C. O.


Fig I.
Fig III.
Fig. V.
Fig. II. b.
Fig. IV b.
Fig. IV a.
Fig II a.
Fig. VI.
Fig. II. c.
Aug. F. Foerste. del.

PLATE XXX.

PAGE.

Figs. 1–4 STRICKLANDINIA PLANUS Foerste.

1–3–4. Casts of pedicle valves.

2. Cast of brachial valve.

2. *a*. Reconstructed interior of the brachial valve. Collinsville, Alabama.

Fig. 5. SPIRIFERA (CYRTIA) ROSTELLUM Hall.

5. Cast of pedicle valve and a line indicating its convexity. Collinsville, Alabama.

Fig. 6. SPIRIFERA PLICATELLA var. RADIATA Sowerby.

6. Brachial valve Cumberland Gap Tenn.

Fig. 7. CORNULITES DISTANS Hall 532

7. Collinsville, Alabama.

Fig. 8. CORNULITES SERPULARIUS var. CLINTONI, Hall.

8. Collinsville. Alabama.

Fig. 9. PLECTAMBONITES TRANSVERSALIS, var. ALABAMENSIS Foerste.

9. Cast of pedicle valve, and a line indicating its convexity. Collinsville, Alabama.

Fig. 10–12. EUOMPHALUS SINUATUS? Hall.

10. View of the spire conjecturally completed from the curvature of the fragment found.

11. An entirely conjectural figure of a side view based on the slight elevation of the spire indicated by the fragment found, but serving to indicate the actual position of the sinus at *a*; *a* is a view of the sinus, the position of which is indicated in figs. 10 and 11.

12. A view from the umbilical side of a part of the fragment found. Collinsville, Alabama. It is an Euomphalus but probably not *E. sinuatus*.

Fig. 13. PLECTAMBONITES TRANSVERSALIS, var. PROLONGATA Foerste 566

13. Pedicle valve and a line indicating the convexity of the same. Wildwood station, Georgia

Fig. 14. PLEUROTOMARIA LABROSA var. OCCIDENS, Hall.

14. Collinsville, Alabama.

Fig 15. CYCLONEMA BILIX, Conrad 551

15. Brown's Quarry, near New Carlisle, Ohio.

Fig. 16. CONULARIA NIAGARENSIS Hall 547

16. Todd's Fork, Ohio.

Figs. 17–18. PENTAMERUS OVALIS Hall.

17. A finely preserved cast of a brachial valve.

18. A cast of a pedicle valve. Collinsville, Alabama.

Fig. 19. PTERINEA.

18. Collinsville, Alabama.

Fig. 20. ILLÆNUS, perhaps I. IOXUS Hall.

20. Fragment of a glabella; possible outlines indicated. Collinsville, Alabama.

Fig. 21. LOXONEMA (cf HOLOPELLA) SUBULATA? Conrad 556

21. The striæ partly preserved on the last coil. Todd's Fork, Ohio.

Fig. 22. STROPHOMENA (AMPHISTROPHIA?) PATENTA Hall 569

22. Fragment, brachial valve, its original outlines restored. Collinsville, Alabama.

Figs. 23–24. RHYNCHONELLA JANEA Billings.

23 *a*. Inner cast of a brachial valve.

23. *b*. Inner cast of a pedicle valve.

24. Side view of an inner cast Collinsville Alabama.

Fig. 25. ORTHOCERAS (CYCLOCERAS) NOVA-CARLISLENSE Foerste 545

25. A section of the siphon. Brown's Quarry near New Carlisle, Ohio.

Fig. 26. ORTHOCERAS (KIONOCERAS) CRAWFORDI Foerste 546

26 A vertical section showing the siphon. Soldiers' Home near Dayton, Ohio.

PALEONTOLOGY XXX.

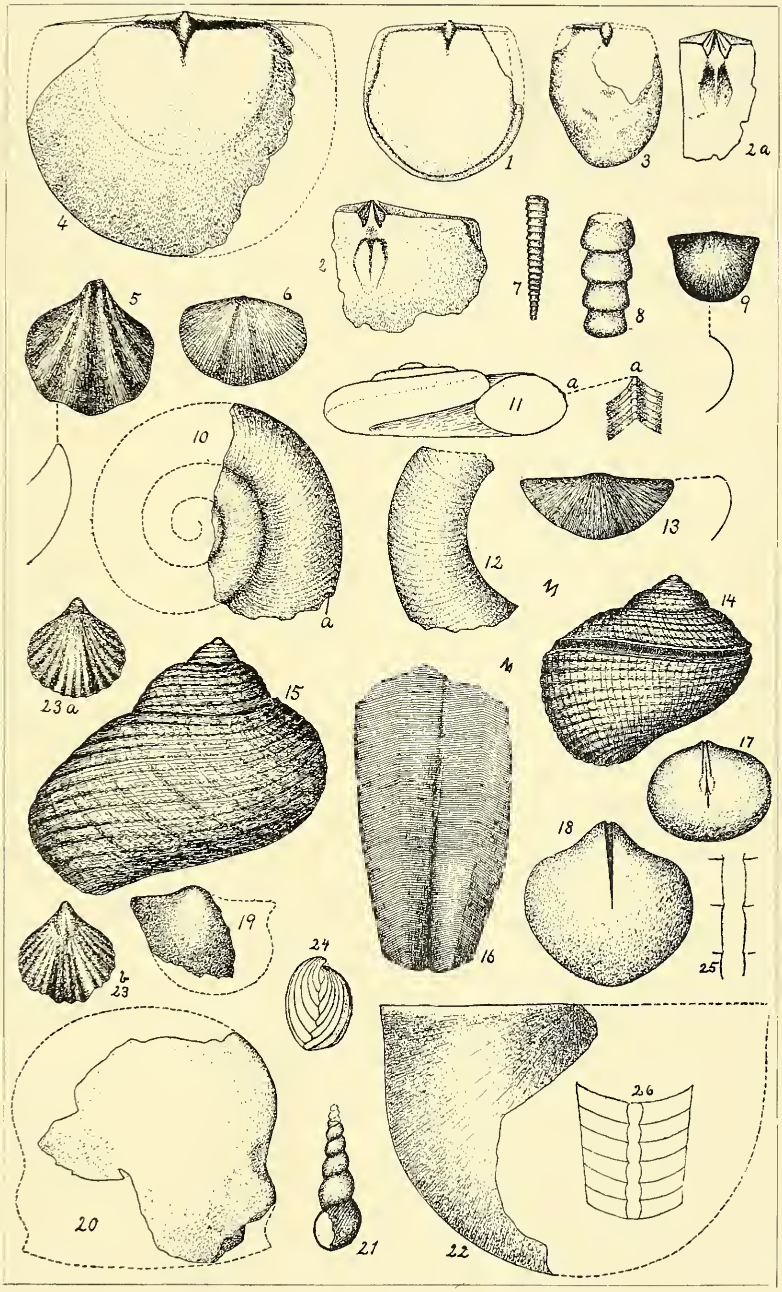


PLATE XXXI—Concluded.

PAGE.

Fig. 22. A glabella of CYPHASPIS CLINTONENSIS, Foerste............................ 524

Cumberland Gap, Tennessee.

Figs. 23-24. RYNCHONELLA DECEMPLICATA Sowerby?

23. A brachial valve and a side view of the same.
24. Perhaps a young form of this species. Cumberland Gap, Tennessee.

Fig. 25. STROPHOMENA (STROPHEODONTA?) CORRUGATA Conrad.

The elongated form figured first by Hall under this species, but not the typical form of Conrad. Cumberland Gap, Tennessee.

Figs. 26-29. STROPHOMENA (STROPHEODONTA?) CORRUGATA var. PLURI-STRIATA Foerste.

More like that figured second by Hall under *S. corrugata*. It is not impossible that this may prove to be the typical form of Conrad.

26. Brachial valve and a line indicating its lack of convexity.
27. Pedicle valve with a line indicating its convexity. Cumberland Gap, Tennessee.
29. Pedicle valve of an unknown species and a line indicating its convexity. Cumberland Gap, Tennessee.

Fig. 30. PACHYDICTYA EMARCESCENS, Foerste... 599

30*a* Part of a frond, with a section showing its convexity.
30*b* A part of the same magnified. Eaton, Ohio.

Fig. 31. PACHYDICTYA FARCTA Foerste.. 559

31*a* Part of a frond with a section showing its convexity.
31*b* Part of the same enlarged. Eaton, Ohio.

Fig. 32. PACHYDICTYA (RHINODICTYA?) RUDIS Foerste................................ 599

32*a* Parts of two fronds with section showing their convexity.
32*b* A part of the left hand specimen enlarged Eaton, Ohio.

Fig. 33. PACHYDICTYA (RHINODICTYA?) RUDIS Foerste................................ 559

33*a* Parts of two fronds with sections showing their convexity.
33*b* A part of the left hand specimen enlarged. Eaton, Ohio.

PLATE XXXI.

PAGE.

Fig. 1. STROPHOMENA (ORTHOTHETES) HANOVERENSIS, Foerste............ 567
Pedicle valve and a line indicatiug its convexity. Hanover, Indiana.

Fig. 2. STROPHOMENA (AMPHISTROPHIA) PATENTA, Hall?....................... 569
Apparently a sickly form, brachial valve; and a line indicating its convexity. Hanover, Indiana.

Fig. 3. BELLEROPHON (BUCANIA) EXIGUUS, Foerste................................ 548
3. Side view.
3*a* Lines indicating the character of a sectiou transverse to Fig. 3. Hanover, Indiaua.

Figs. 4–5. ORTHIS CALLIGRAMMA, DALMAN var. DINORTHIS........................... 572
4. Cast of a pedicle valve.
5. Cast of a brachial valve. Hanover, Indiana.

Fig. 6. PLECTAMBONITES TRANSVERSALIS, var. ELEGANTULA Hall.............. 556
Pedicle valve and a line indicating its convexity. Hanover, Indiana.

Fig. 7. CYRTOLITES YOUNGI Foerste... 549
7*a* A magnified side view with a line indicating the real size of the specimen.
7. Lines showing the outlines of a sectiou vertical to Fig. 7*a* also maguified. Hanover, Indiana.

Fig. 8. ATRYPA MARGINALIS, var. MULTISTRIATA Foerste.......................... 591
Pedicle valve. Hanover, Indiana.

Fig. 9. ATRYPA MARGINALIS, Dalman... 591
9. Pedicle valve.
9*a* A brachial valve. Brown's Quarry, New Carlisle, Ohio.

Figs. 10–11. CORNULITES DISTANS Hall.. 532
10. Resembles a species of Tentaculites.
11. Both in the cast and in the exterior views, is a figure of a true Cornulites. Cumberland Gap, Tennessee.

Fig. 12. RHYNCHONELLA NEGLECTA Hall... 592
Pedicle valve. Hanover, Indiana

Fig. 13. RHYNCHONELLA ACINUS var. CONVEXA Foerste............................ 593
13*a* Brachial valve.
13*b* Pedicle valve.
13*c* Side view. Hanover Indiana.

Fig. 14. RHYNCHONELLA ACINUS Hall... 593
From the Niagara of Waldron, Indiaua, the most distinct form.
14*a* Brachial valve.
14*b* Pedicle valve.
14*c* Side view.

Figs. 15–16. LEPTÆNA (RAFINESQUINIA) OBSCURA, Hall?
15. Brachial valve and a line indicating its convexity.
16. Pedicle valve and a line indicating its convexity Cumberland Gap. Tenne see.

Fig. 17. HOLOPEA OBSOLETA var. ELEVATA, Foerste.
Cumberland Gap, Tennessee.

Figs. 18–19. LEPTOCŒLIA? HEMISPHERICA Sowerby.
18. Pedicle valve, with a line indicating its convexity.
19. Brachial valve with a line indicating its convexity. Cumberland Gap, Tennessee

Figs. 20–21. PHACOPS TRISULCATUS Hall... 529
20 A glabella.
21. A pygidium. Cumberland Gap, Tennessee.

PALEONTOLOGY XXXI.

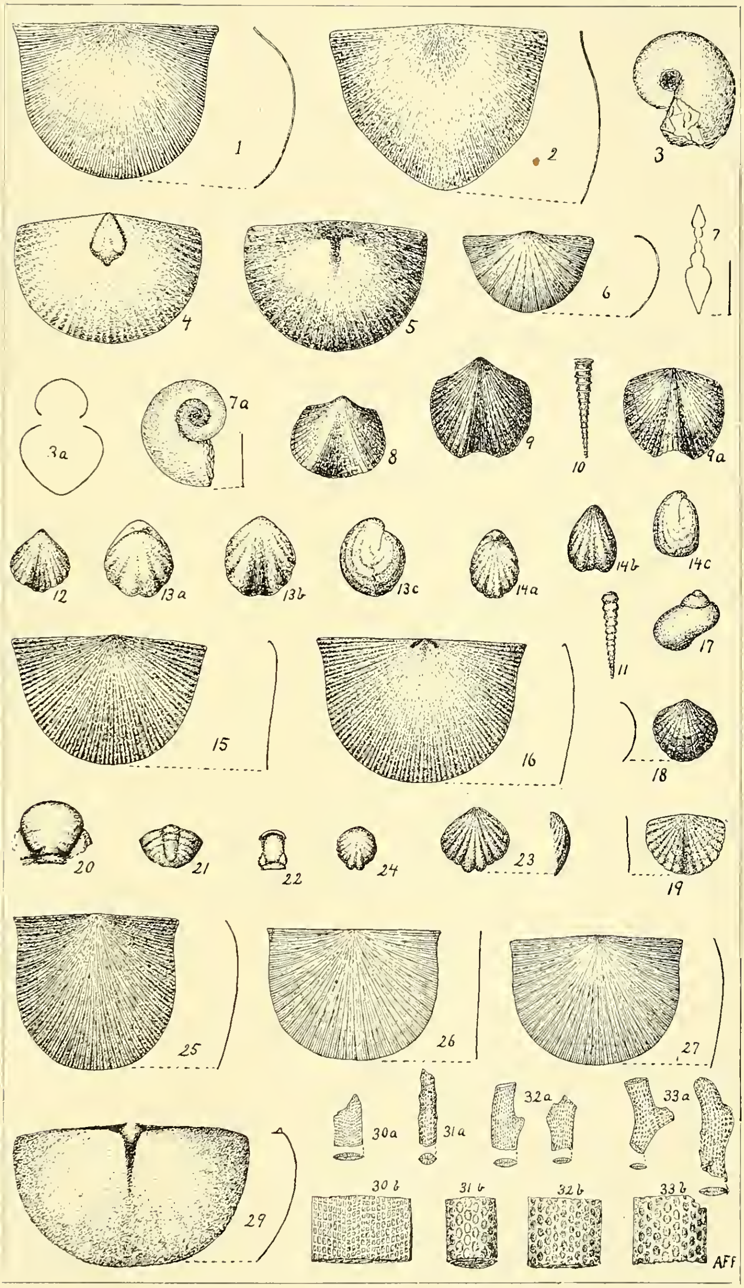


PLATE XXXII.

PAGE.

Figs. 1–2. ORTHOCERAS (EU-ORTHOCERAS?) RECTUM Worthen, var. JUNIUS... 539

2. A side view.

1. A specimen with a smooth exterior, perhaps of this species. Hanover, Indiana.

Fig. 3. ORTHOCERAS (SPYROCERAS?) JAMESI Hall and Whitfield............... 546

Side view, Todd's Fork, Ohio.

Fig. 4. ORTHOCERAS (EU-ORTHOCERAS) IGNOTUM Foerste..... 539

A vertical section through the siphon, with a transverse section indicating the position of the same. Hanover, Indiana.

Fig. 5. ORTHOCERAS (EU-ORTHOCERAS) VIRGULATUM Hall?...................... 543

A vertical section through the siphon. Soldiers' Home, Dayton, Ohio.

Fig. 6. ORTHOCERAS (EU-ORTHOCERAS) HANOVERENSE Foerste............... 543

The upper part of the figure, (Fig. 6*a*) represents a view of the cast of the interior of the shell; the lower part represents a vertical section of the same passing through the siphon.

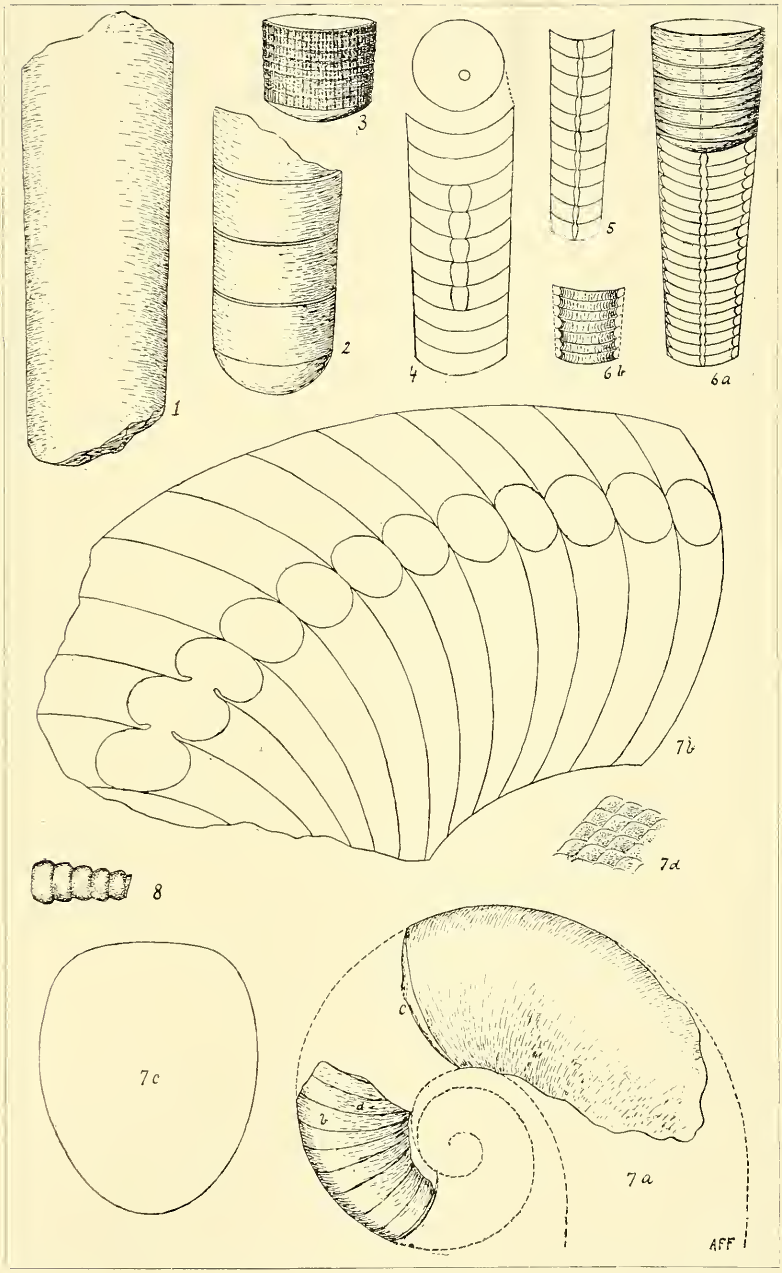
6*b* Represents a part of the other side of Fig. 6*a*, where it has been weather-worn. Hanover, Indiana.

Fig. 7. CYRTOCERAS (GLYPTOCERAS) SUBCOMPRESSUM Beecher........... 535

7*a* Is a side view of two fragments upon which this species is founded; the smaller, the type; the larger, a part of the living chamber, placed in the position it was supposed to have once occupied; the character of the remainder of the coil was conjecturally indicated. The diameter of t e whole is reduced to one-fourth. Recent observations have led us to believe that the rate of expansion of the shell is much more abrupt, and that the appearance of the coil might be more intermediate between that of Crytoceras and Gyroceras; fig. 7*b*, a vertical section through the type showing the character of the siphon; fig. 7*c*, a transverse section of the living chamber near the last septum reduced to one-half the diameter; fig 7*d*, showing the character of the surface markings of the type at *d*, in fig. 7*a*, but representing the same far more distinctly than warranted by the actual state of preservation. B O.

Fig. 8. CORNULITES SERPULARIUS var. CLINTONI, Hall.

Collinsville, Alabama.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7 d
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7 c
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7 a
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PLATE XXXIII.

PALEONTOLOGY XXXIII.

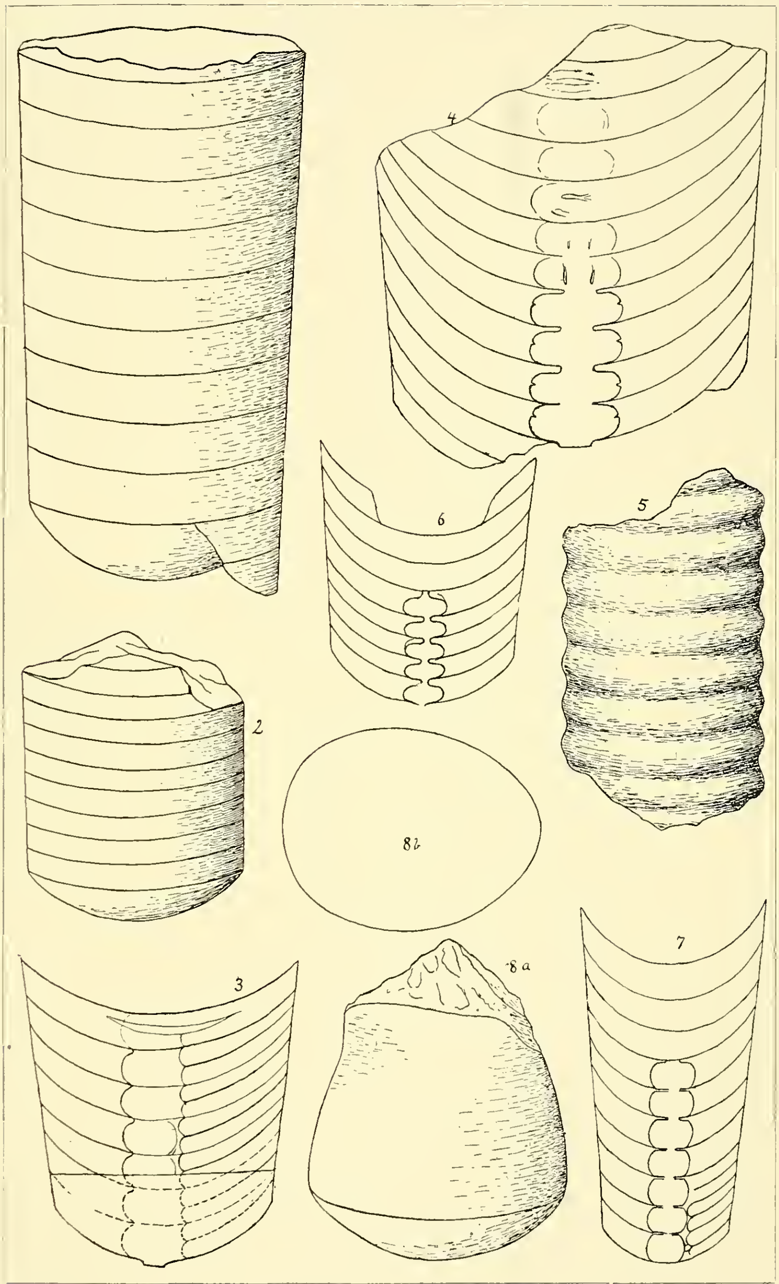

PLATE XXXIV.

PAGE.

Figs. 1–6. STREPTELASMA HOSKINSONI Foerste... 601

1–4. Various typical forms.

5. A very contorted form doubtfully referred here.

6. A transversely wrinkled form, perhaps an *Amplexus*, provisionally referred here. B. O.

Figs. 7, 12, 13. STREPTELASMA? GEOMETRICUM Foerste 601

7. The type specimen. S. H. O.

12. A similar form, Todd's Fork, Ohio.

13. A larger form referred here. S. H. O.

Fig. 8. CYATHOPHYLLUM? CALICULUM Hall... 601

8. Found at the roadside quarry east of the Soldiers' Home, Ohio.

Figs. 9–11. CYATHOPHYLLUM CELATOR var. DAYTONENSE Foerste.................... 601

9, 10. From S. H. O.

11. Probably from the same place, now in the cabinet at the Ohio State University

Figs. 14, 15. STREPTELASMA? OBLIQUIUS Foerste.. 601

14. Typical form.

15. Perhaps larger form of the same. H. I.

Fig. 16. LITUITES?

16. The living chamber with the recurved apertural end. Brown's Quarry, Ohio.

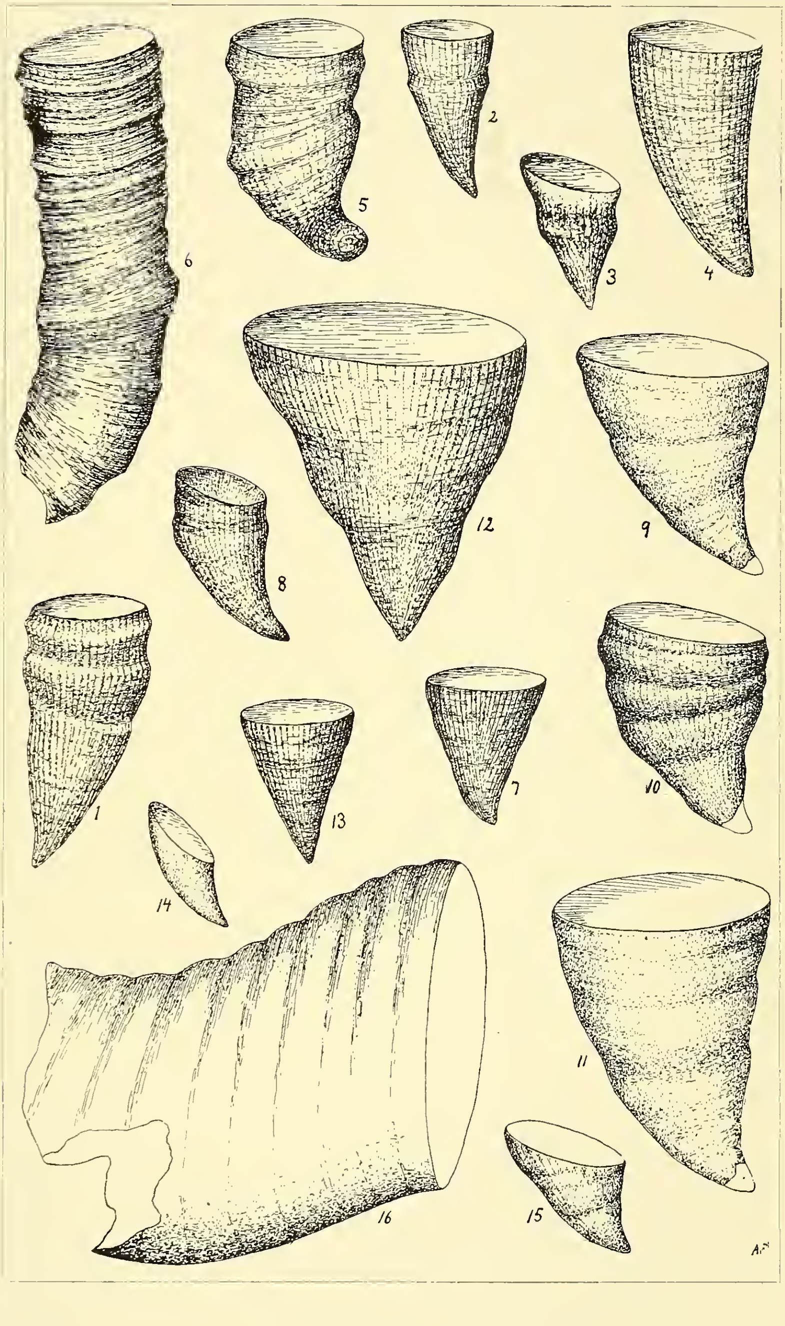
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PLATE XXXV.

PAGE.

Fig. 1. ORTHOCERAS (ACTINOCERAS) TURGIDO-NUMMULATUM, Foerste...... 538

1. S. H. O. Collection of Geo. Caswell.

Fig. 2. ORTHOCERAS (ACTINOCERAS).. 539

2. A form closely related to the last, but the septa more distant and the siphuncle more elongated. S H. O. Collection of Geo. Caswell A second specimen in my own collection shows a smooth surface.

Fig. 3. ORTHOCERAS (EU-ORTHOCERAS?) VIRGULATUM? Hall................ 534

3. The specimen figured resembles one identified by us on an earlier plate as this species, in having the same distant septa; but the siphuncle is wider, 1.1 mm. approaching in this respect the wider siphuncle of *O. ignotum*. S. H. O. Collection of Geo. Caswell

Fig. 4. ORTHOCERAS (ACTINOCERAS)... 538

4. A form closely related to O. lata-nummulatum, but the rate of expansion of the shell seems to be much greater; *a*, lateral view; *b*, view from below showing eccentric siphuncle; *c*, a section showing the large siphuncle. S. H. O. Collection of Geo. Caswell.

Fig. 5. ORTHOCERAS (EU-ORTHOCERAS) HANOVERENSE? Foerste............. 543

5. See text. S. H. O. Collection of Geo. Caswell.

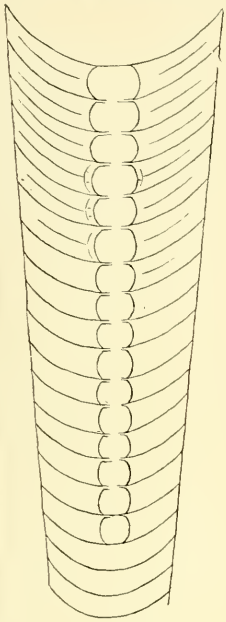


Fig. 1

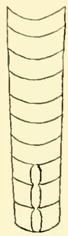


Fig. 3

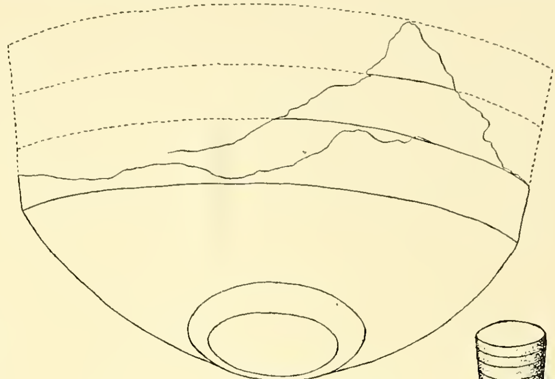


Fig. 4a

5

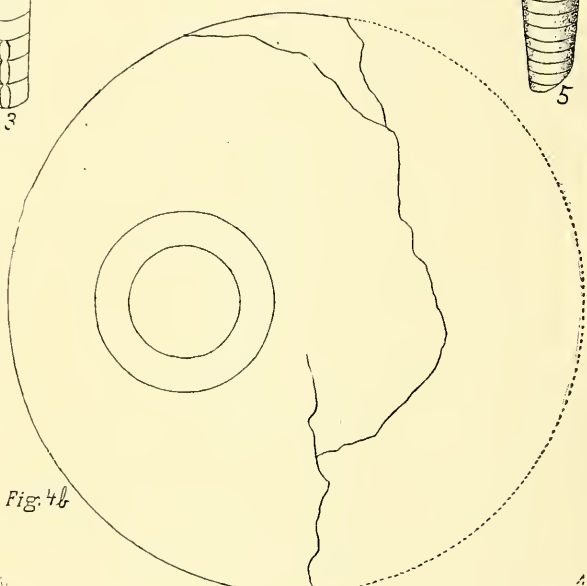


Fig. 4b

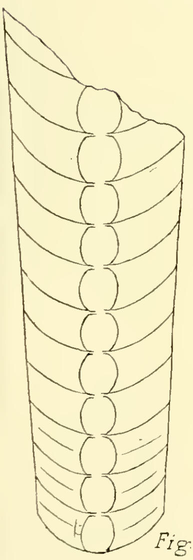


Fig. 2

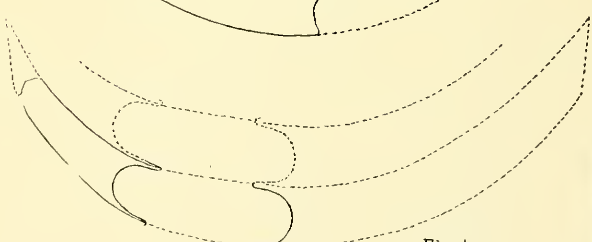


Fig. 4c

PLATE XXXVI.

PAGE.

Fig. 1. ORTHOCERAS (ACTINOCERAS) YOUNGI, Foerste.............................. 537

1. From the Orthoceras block, a large block full of fossils from a local deposit near the base of the Clinton at Huffman's quarry, south of Dayton. The block was accidentally saved by a quarryman who became interested in three large fragments of this species included in the block. Had some collector been at hand to explore the deposit it would have probably proved the richest locality so far discovered in the State for the rarer fossils. H. O.

Fig. 2. CYRTOCERAS CLINTONENSE, Foerste... 534

2. *a*, A rapidly curving fragment; *b*, a section of the siphuncle of the same; *c*, a transverse section. H. O. 2*e*, a less rapidly curving fragment believed to resemble a more matured stage of growth of the shell; *d*, a section of the siphuncle of the same. B. O. Ohio State Univ. collection.

Fig. 3. PTILODICTYA LANCEOLATA, Goldfuss, var. AMERICANA, Foerste....... 598

3. *a* One of the more lanceolate fronds with the median band and some of the stronger wrinkles of growth intentionally emphasized; *b*, a broader frond from the same locality, showing the more aberrent form of the species upon which the variety was founded. S. H. O.

Fig. 4. PTILODICTYA WHITFIELDI, Foerste... 598

Fig. 5. ORTHOCERAS (ACTINOCERAS) CLAVATUM, Hall............................ 538

5. *a*, A fragment showing the tapering of the species; *b*, a section of the upper end; *c* a section of the lower end; siphuncle. B. O. Ohio State Univ. collection.

Fig. 6. ORTHOCERAS (EU-ORTHOCERAS) IGNOTUM, Foerste..................... 538

6. *a*, *b*, *c*, Three separate fragments showing the characters of this species. H. O.

Fig. 7. GOMPHOCERAS ORTONI, Foerste.. 533

7. *a*, *b*, same as figs. 8 *a*, *b*, of plate 32, after more careful cleaning of the original specimen. The cleaning tools may have emphasized characters in the soft limestone, but every attempt was made to avoid that result. B. O. *c*. A specimen of Gomphoceras from the same quarry. B. O. Ohio State Univ. collection.

Fig. 8. ORTHOCERAS (DISCOSORUS) CONOIDEUM, Hall............................ 546

8. T. F. O Collection of Dr. Chas. Welch.

Fig. 9. ILLÆNUS, Glabella................................ 525

9. T. F. O. Collection of Dr. Chas Welch.

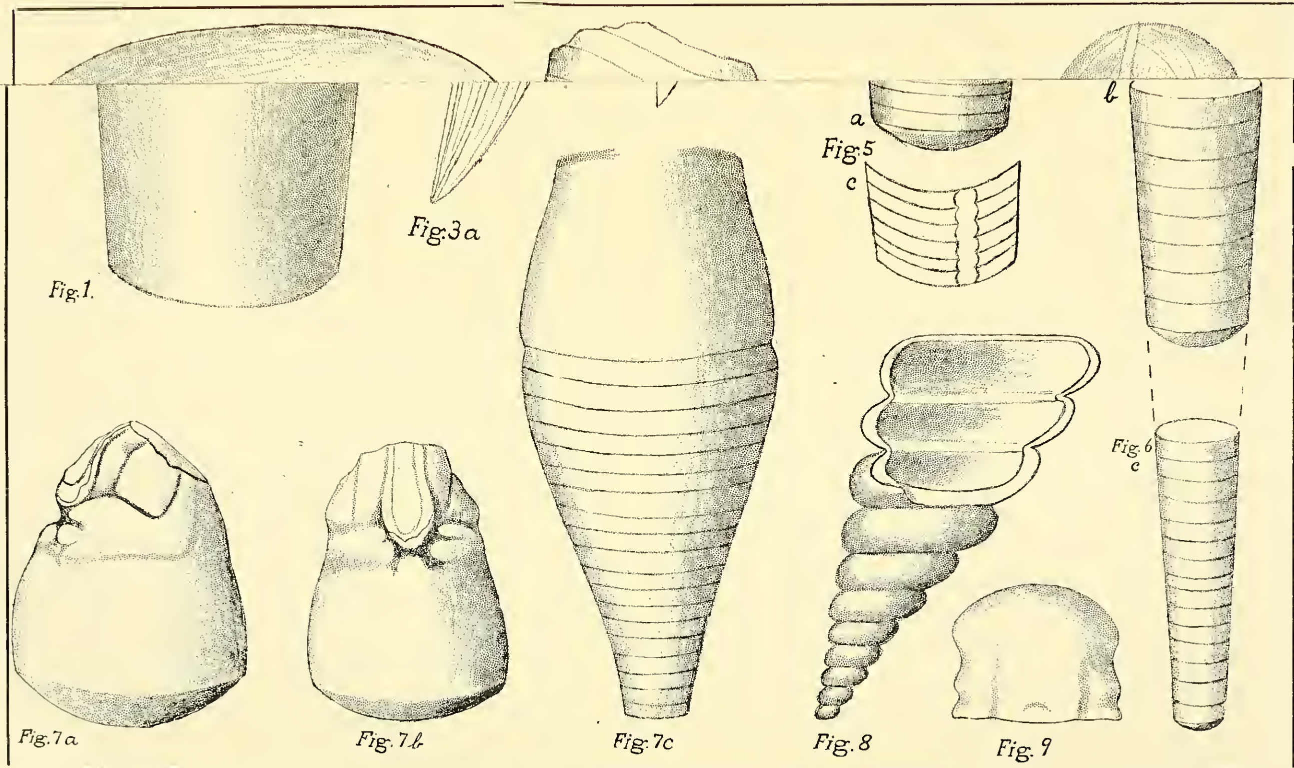


Fig. 1.
Fig. 3 a
a
Fig. 5
c
b
Fig. 6
c
Fig. 7 a
Fig. 7 b
Fig. 7 c
Fig. 8
Fig. 9

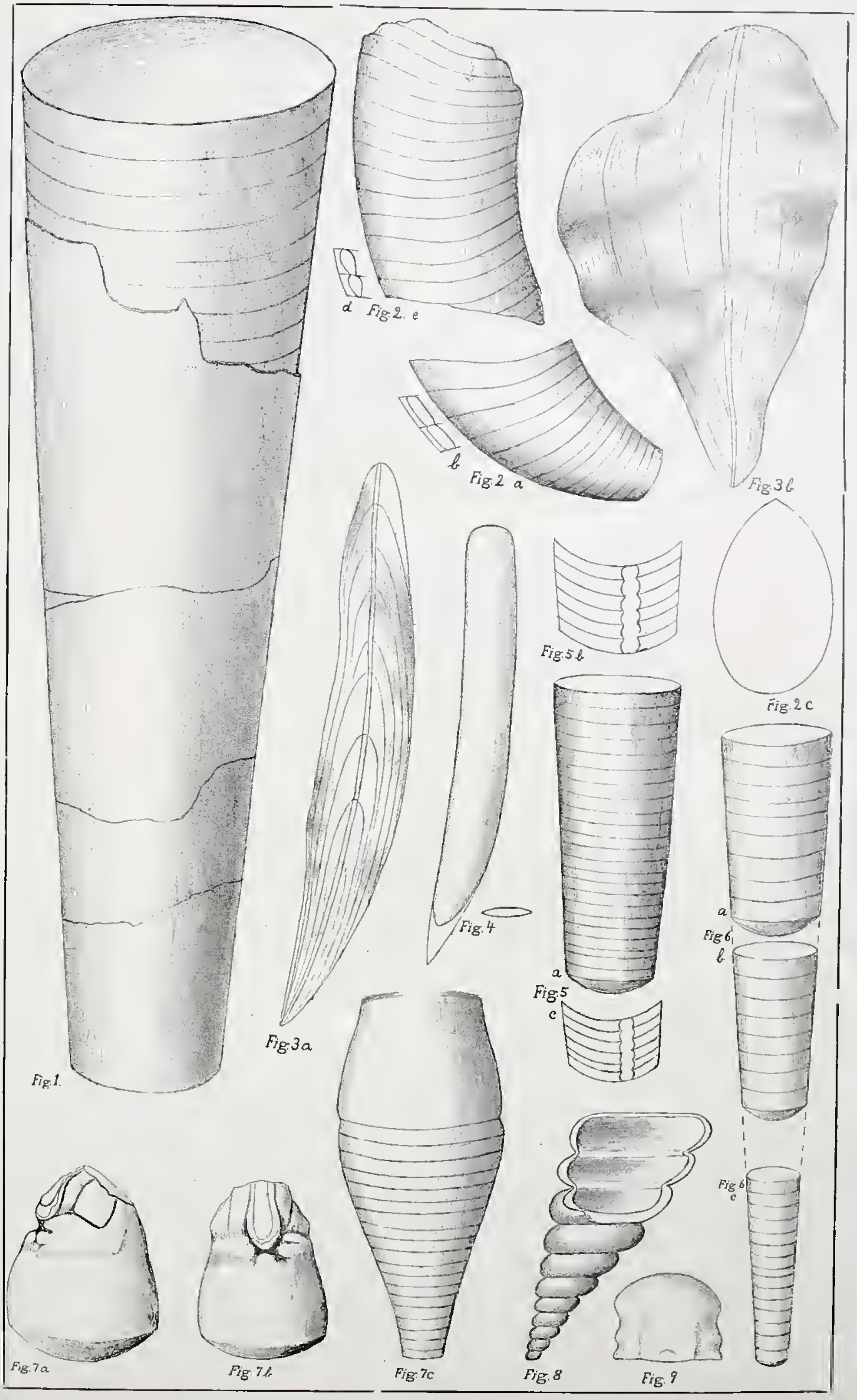


Fig. 1.
d Fig. 2. e
b Fig. 2 a
Fig. 3 b
Fig. 2 c
Fig. 3 a
Fig. 4
Fig. 5 b
a Fig. 5 c
a Fig 6 b
Fig 6 c
Fig. 7 a
Fig 7 b
Fig. 7 c
Fig. 8
Fig. 9

PLATE XXXVII.

PAGE.

Fig. 1. CYPRICARDITES CASWELLI Foerste 561

1. *a*, Lateral; *b*, front; *c*, hinge view. Same specimen as figs. 12 *a-b*. plate 25. S. H. O. Collection of Geo. Caswell

Fig. 2. NUCULITES (CLEIDOPHORUS) FERRUGINEUM Foerste.................... 564

2. *b*, Cast, natural size; *a*, magnified. T. F. O. Ohio State University collection.

Fig. 3. CRANIELLA CLINTONENSIS Foerste.. 565

3. *a*, Interior cast, the details are scarcely visible in the original specimen; *b*, an elevation of the same. T. F. O. Collection of Dr. Chas. Welch.

Fig. 4. TELLINOMYA ÆQUILATERA Hall.. 562

4. *a*, Cast of one valve magnified; *b*, curvature across the shell; *c*, curvature lengthwise with the shell, natural size. T. F. O. Collections of Dr. Chas. Welch; *d*, lateral; *e*, front; *f*, hinge view of *Tellinomya equilatera*, Hall, from the Coralline limestone of Schoharie, N. Y., copied from Pal. N. Y. Vol. II, Plate 75, Fig. 1 *b*, *d*, *c*.

Fig. 5. AVICULA WHITFIELDI Foerste.. 558

5. Cast of exterior. Same as *Cypricardites ferrugineum* of Hall and Whitfield, Pal. Ohio, Vol. II, Plate V, Fig. 11. Prepared from the original cast. The details near the posterior end of the hinge line are not well shown in the original, and at this point it would have been better if the drawing had been left more non-committal. Possibly the posterior margin was not incurved here but continued its convexity as far as the hinge line. T. F. O. Ohio State University collection.

Fig. 6. AVICULA.

6. Cast of interior with a little of the exterior preserved near the hinge. S. H. O. Collection of Geo. Caswell.

Fig. 7. MODIOLOPSIS SUBRHOMBOIDEA Simpson.. 560

7. *a*, Interior cast showing concentric striations and interior muscular impressions. H. O.; *b*, interior cast type; copied from Rep. Penn. Geol. Survey, Dictionary of Fossils of Pennsylvania, p. 411, Vol. I, Fig. V*a*., from Clinton shale, above fossiliferous ore, McKee's ore bank, northeast of McKee's house, Ferguson Valley, 7 miles northwest of Lewiston, Mifflin county, Pennsylvania.

Fig. 8. MODIOLOPSIS RHOMBOIDEA Hall.. 560

8. *a*, Interior cast, showing a strong anterior muscular scar. H. O. *b*, cast of interior, type, copied from Dictionary of Fossils of Pennsylvania, p. —, Fig. —, from the Upper Silurian at Arisaig, Nova Scotia.

Fig. 9. CYPRICARDINIA UNDULOSTRIATA Hall 561

9. *a*, Right valve. H O; *b*, left valve. S. H. O.; *c*, right valve, type, copied from Pal. N. Y. Vol. II, Plate 59, Fig. 6*a* from Niagara shale at Lockport, N. Y.

Fig. 10. TELLINOMYA ELLIPTICA Hall 562

10. Copied from Pal. N Y. Vol. II, Plate 30, Fig. 4*b*; from upper Clinton sandstone, south of Mohawk Herkimer Co., N. Y.

Fig. 11. MYTILARCA MYTILIFORMIS Foerste 559

11. *a*, Left valve; *b*, elevation along the anterior margin; *c*, elevation across the valve. T. F. O. Collection of Prof. E. W. Claypole.

Fig. 12. TELLINOMYA (NUCULA?) SOCIALIS Foerste.................................. 563

12. *a* Anterior; *b*, left valve; *c*, posterior view. H. O. Beavertown, Marl.

Fig. 13. TELLINOMYA (NUCULA?) MININA Foerste....................................... 563

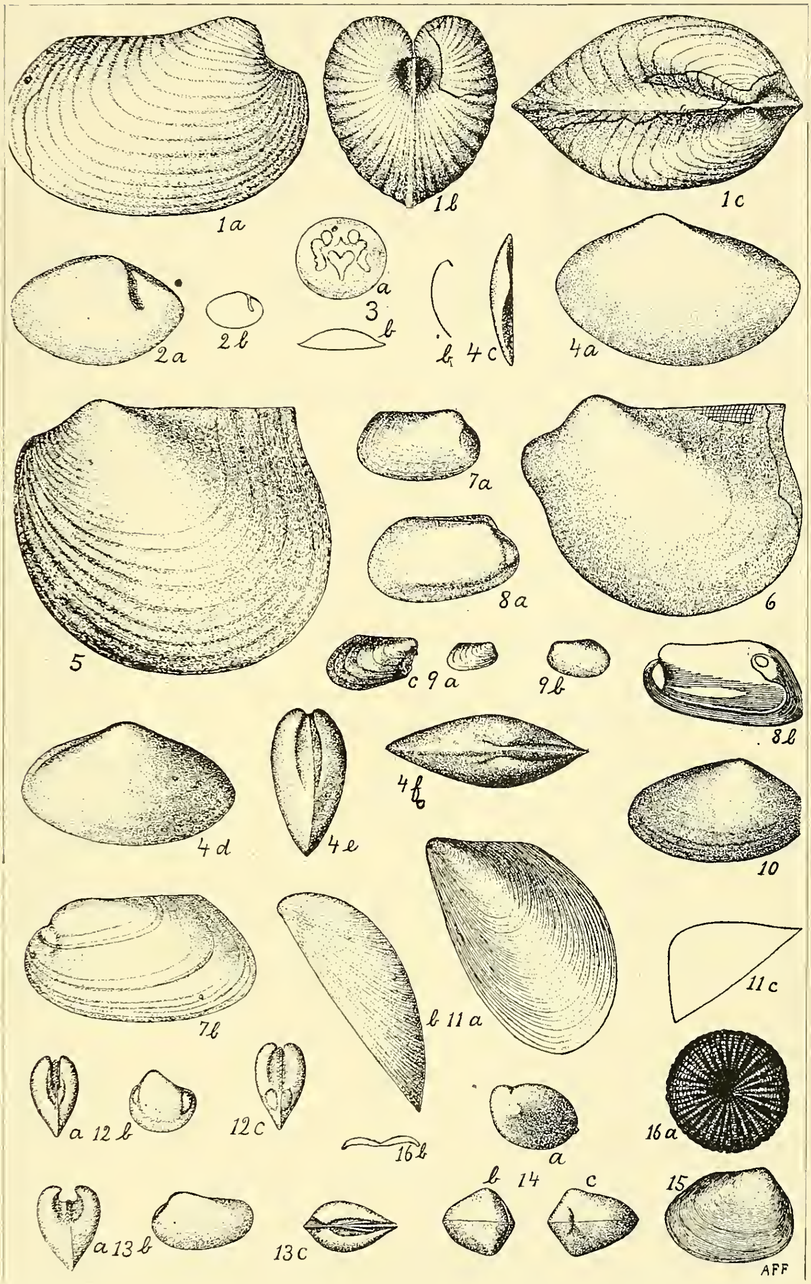
13. *a*, Anterior; *b*, left valve; *c*, hinge views, same as figs. 8*a-b-c*, of plate 25, type. H. O. Beavertown Marl.

Fig. 14. ELPE ULRICHI, Foerste.. 532

14. *a*, Left valve; *b*, anterior; *c*, hinge view. H. O. "Orthoceras block."

Fig. 15. TELLINOMYA (NUCULA?) CLINTONENSIS Foerste 563

15. Right valve. Collection of Prof. E. W. Claypole.


1a
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1c
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7b
11 a
b
11c
a 12 b
12c
16b
16a
a
b 14
c
15
a 13 b
13c
AFF

PLATE XXXVII*a*—Concluded.

PAGE

Fig. 17. CRANIA DUBIA, Fœrste.. 565

17. *a*, Shell from Soldiers' Home, O.; *b*, shell from Hanover, Ind.; no details of structure are visible in either case.

Fig. 18. CYCLOSPIRA SPARSI-PLICATA, Fœrste.. 593

18. *a*, Pedicle valve; *b*, lateral view

Fig. 19. ORTHIS FAUSTA, var. SQUAMOSA, Fœrste.. 574

19. *a*, Brachial valve; *b*, lateral outlines. Carrollton pike quarry, about half a mile west of the Soldiers' Home, on the south side of the pike.

Fig. 20. ORTHIS (DINORTHIS) CALLIGRAMMA, var. FISSIPLICATA, Fœrste 573

20. *a*, Pedicle valve; *b*, lateral outlines. Huffman's quarry, Ohio.

PLATE XXXVII*a*.

PAGE

Fig. 1. RAPHISTOMA AFFINE, Fœrste.. 550

1. *a*, Apical view, magnified two diameters; *b*, apertural view; *c*, umbilical view. In all three figures the details of the aperture are restored from fragments and by tracing out the outline in accordance with the striæ of growth. T. F. O. Cabinet of Dr. Chas. Welch.

Fig. 2. BELLEROPHON (BUCANIA) EXIGUUS, Fœrste.................................... 548

2. *a*, Posterior view; *b*, apertural view; *c*, umbilical view, the rapid expansion of the outer lip not well shown. In all three figures the outline of the outer lip has been restored from the course of the striæ of growth. T. F. O. Cabinet of Dr. Chas. Welch.

Fig. 3. BELLEROPHON (BUCANIA) OPERTUS, Fœrste.. 548

3. *a*, Posterior view; *b*, umbilical view. In both figures the outlines of the aperture are restored from the course of the striæ of growth. H. I.

Fig. 4. SUBULITES (POLYPHEMOPSIS) PLANILATERALIS, Fœrste.......................... 555

4. *a*, Natural size; *b*, the same magnified three diameters, apertural view; *c*, posterior view. S. H. O. Collection of Geo. Caswell.

Fig. 5. SUBULITES DIRECTUS, Fœrste.. 554

5. *a*, Apertural view; *b*, apical posterior of another specimen.. "Orthoceras block" near base of Clinton at Huffman's quarry.

Fig. 6. PLEUROTOMARIA FILITEXTA, Fœrste.. 550

6. *a*, Lateral view; *b*, apical view. "Orthoceras block," Huffman's quarry, O.

Fig. 7. STRAPAROLLUS (cf. ORIOSTOMA) INCARINATUM, Fœrste.......................... 552

7. *a*, Lateral view; *b*, apical view. "Orthoceras block," H. O.

Fig. 8. PLATYCERAS (PLATYSTOMA) NIAGARENSE, Hall, var. CLINTONENSE, Fœrste.. 552

8. Showing the loosening coil. Pennsylvania collection of Prof. E. W. Claypole.

Fig. 9. CYCLONEMA BILIX, var. VARICOSUM... 550

9. Apertural view. TF. O. Collection of Dr. Chas. Welch; the aperture restored from fragments in the writer's collection.

Fig. 10. ORTHOCERAS INCEPTUM, var. ACCELERATUM, Fœrste............................ 545

10. SH. O. Collection of Geo. Caswell.

Fig. 11. COLEOLUS CLINTONENSIS, Fœrste... 547

11. SH. O.

Fig. 12. CONULARIA BILINEATA, Fœrste.. 547

12. View of a portion of the small fragment, showing the bilineate character of transverse striæ, magnified about fifteen diameters. SH. O.

Fig. 13 ACIDASPIS BREVISPINOSA, Fœrste... 522

13. Huffman's quarry, Ohio.

Fig. 14. SPHAEREXOCHUS PISUM, Fœrste.. 528

14. *a*, View of glabella from above; *b*, lateral view. Niagara shales at Lockport, N. Y. Secured from Dr. E. N. S. Ringueberg.

Fig. 15. LICHAS PHLYCTAINOIDES? Green.. 529

15. A glabella, SH. O.

Fig. 16. ATRYPA LATI-CORRUGATA, Fœrste.. 591

16. *a*, *b*, *c*, Three lateral views to show the varying convexity of the shell, and the strength of the corrugations; *d*, view of the brachial valve. "Orthoceras block," Huffman's quarry.


1a
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PLATE XXXVIII.

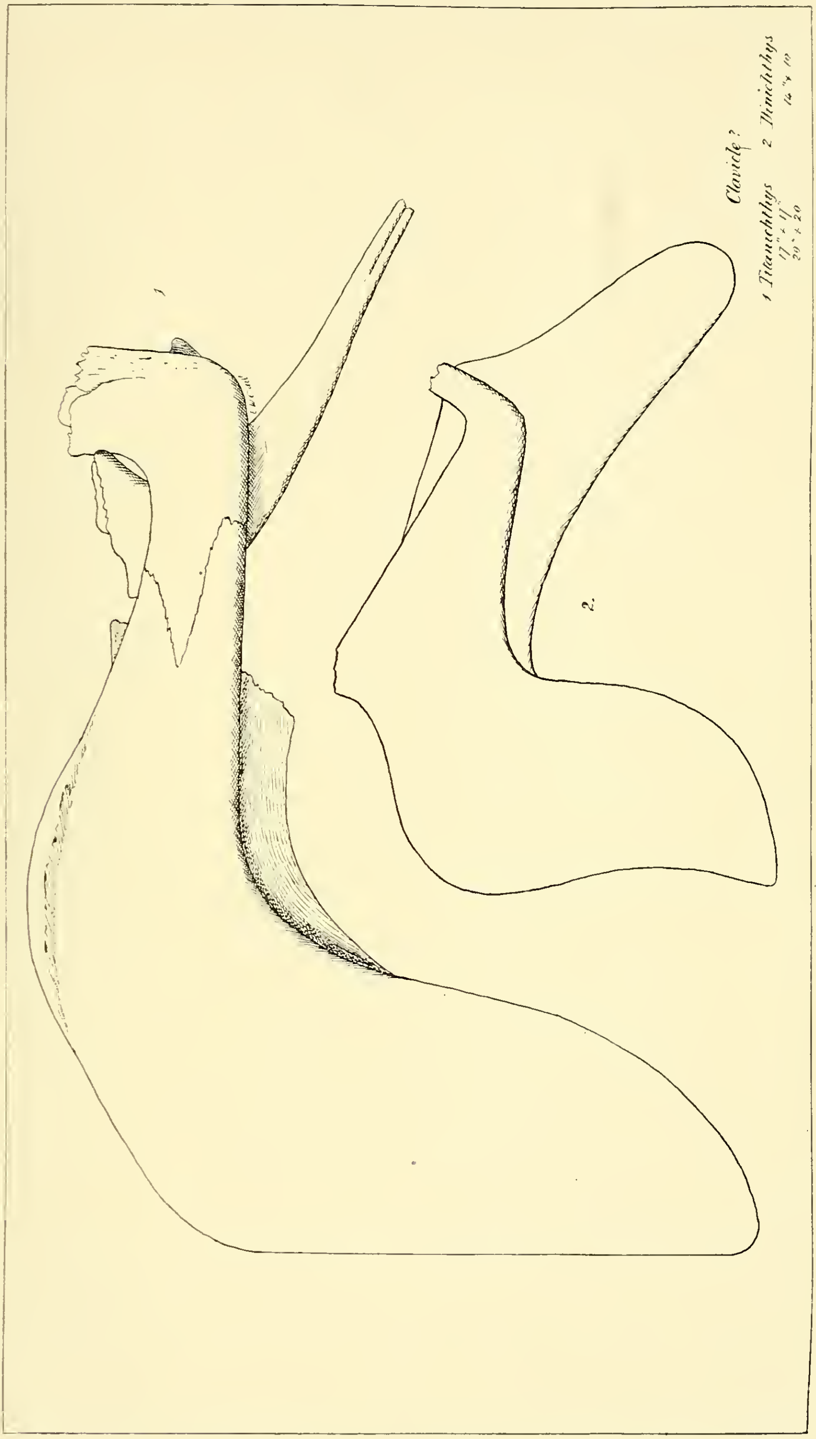
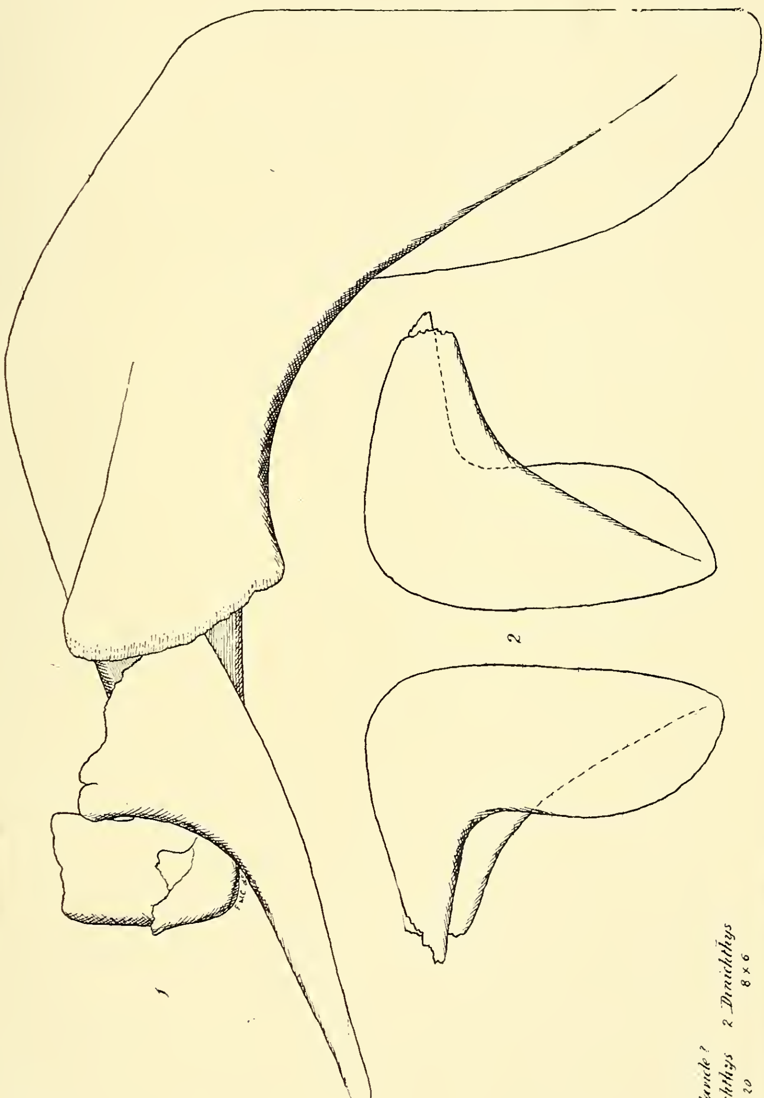

Clavicle?
1 Titanichthys 17" × 11" 20" × 20
2 Dinichthys 14" × 10
2.

PLATE XXXIX.

PAGE

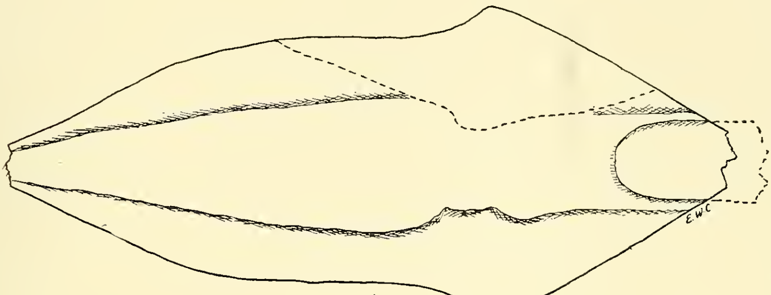
Supposed clavicular plate of Dinichthys or of Titanichthys, portion of the shoulder girdle. Opposite, (outer) aspect of that represented on Plate XXXVIII. The smaller figure represents a corresponding plate or bone of a somewhat smaller species from the Huron Shale of Delaware, O, found by the Rev. H. Hertzer........................ 609



Clavicle ?

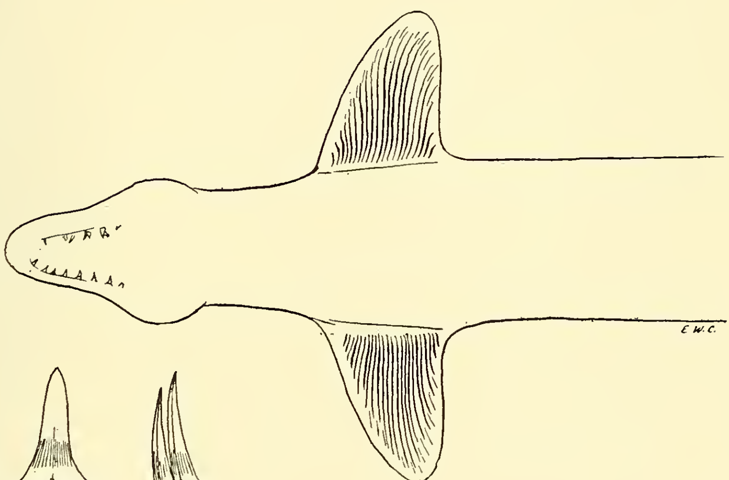
1 Titanichthys 20 × 20 *2 Dinichthys* 8 × 6

PLATE XL.



1

Titanichthys, sp? ventro-median plate? 20"



2

Monocladodus Clarki, a
63°

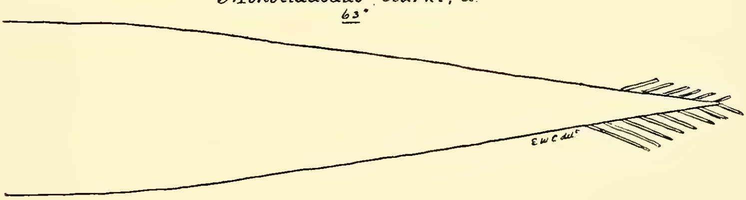


PLATE XLI.

PAGE.

Fig. 1. DINICHTHYS CLARKI... 607

Showing slender right mandible with thin flange of bone rising at back of the front tooth.

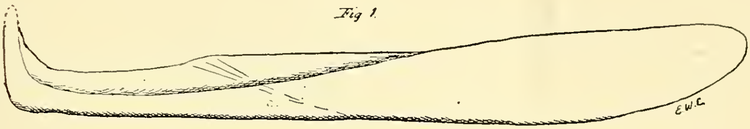
Fig. 2. COCCOSTEUS CUYAHOGÆ... 615

Part of right mandible, outside view; *a* shows the bases of three symphysial teeth.

Fig. 3. GORGONICHTHYS CLARKI... 614

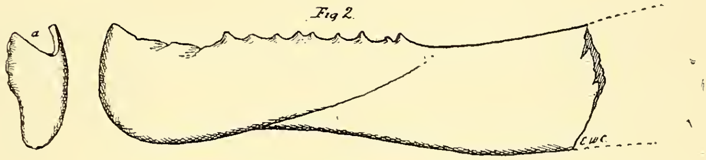
Outside view of right mandible showing groove worn by upper tooth in which it was lying when found; *a* shows the tooth of the upper jaw fitting on the double point of the mandible.

Fig 1.



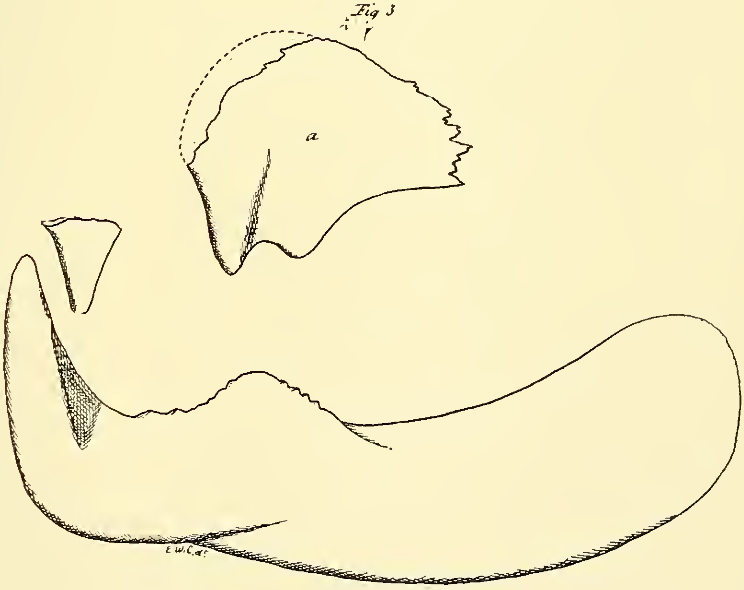
Dinichthys Clarki. Cl. inner face. 10.″

Fig 2.



Coccosteus ? Cuyahogae. Cl. 5.5″

Fig 3



Gorgonichthys Clarki. Cl. 25.″

PLATE XLII.

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14"

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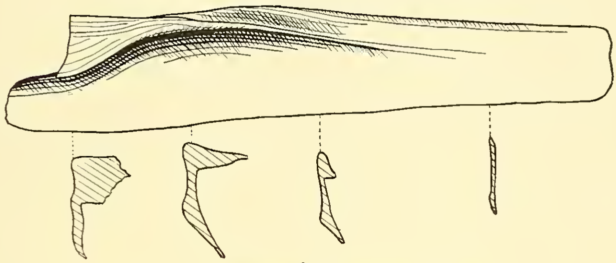
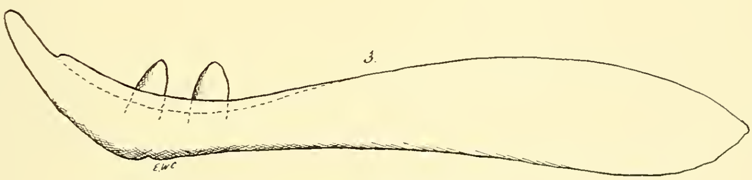


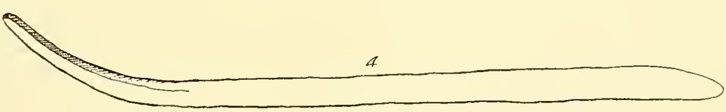
Titanichthys attenuatus, Wright

3.



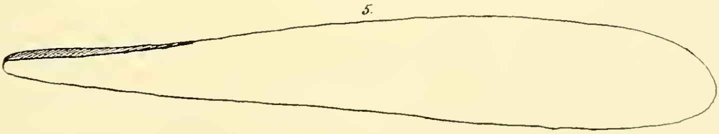
Titanichthys Clarki, Newb
26"

4



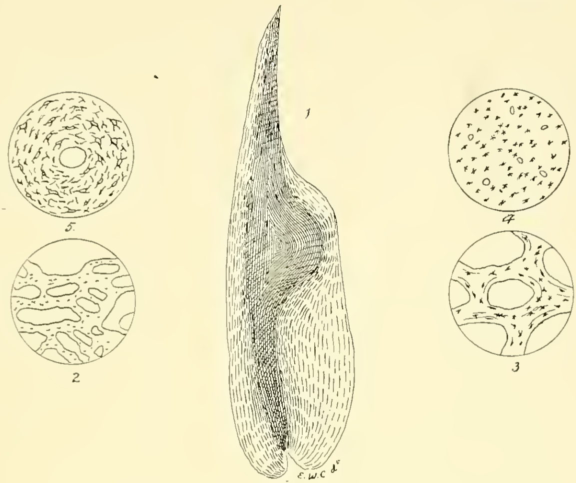
Titanichthys Agassizi, Newb
30"

5.

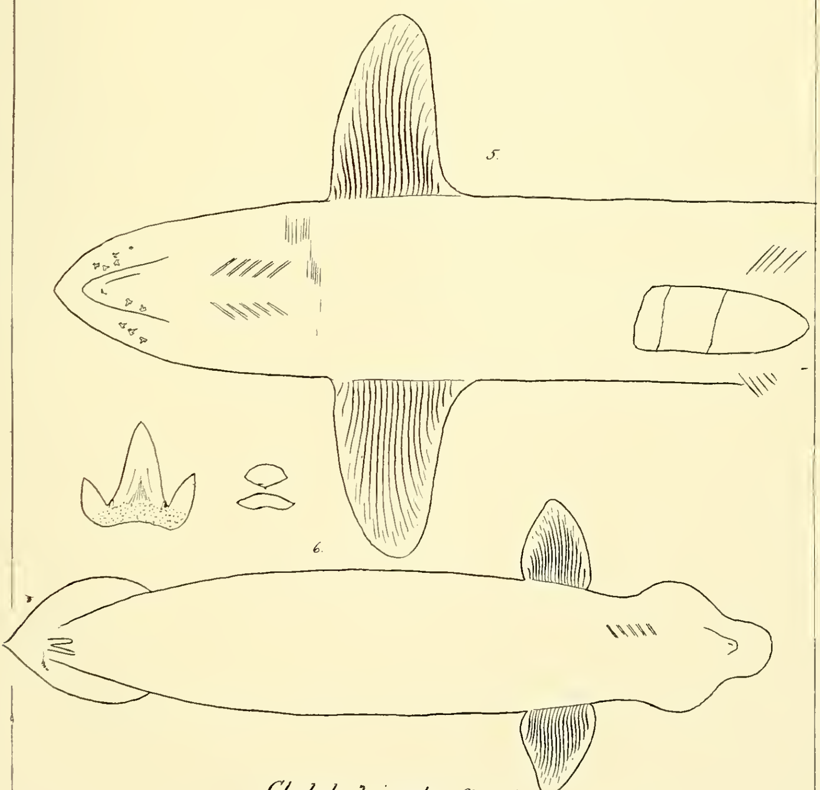


Titanichthys rectus, Cl
23"

PLATE XLIII.



Dinichthys Terrelli – Section of Mandible



Cladodus? sinuatus, Cl 28.

PLATE XLIV.

PAGE.

F gs. 1–9 ANTERIOR VENTRAL PLATES OF DINICHTHYS TERRELLI Newb ... 623

1 and 2. The space between these was filled with a ventro-median plate. Ventral surfaces.

3 and 4. Posterior ventrals (formerly called "jugulars").

5–7. Anterior and posterior ventral plates from another specimen.

6. Reversed view (dorsal side) of 7.

8. Inner (dorsal) view of anterior ventral from a third individual. The four sections are taken at the points where the letters correspond.

9. The same as Fig. 3 detached to show the overlapped spaces.

All figures drawn to the same scale and locality. Cleveland shale, Vermilion River and Lake Shore, Lorain Co., Ohio.

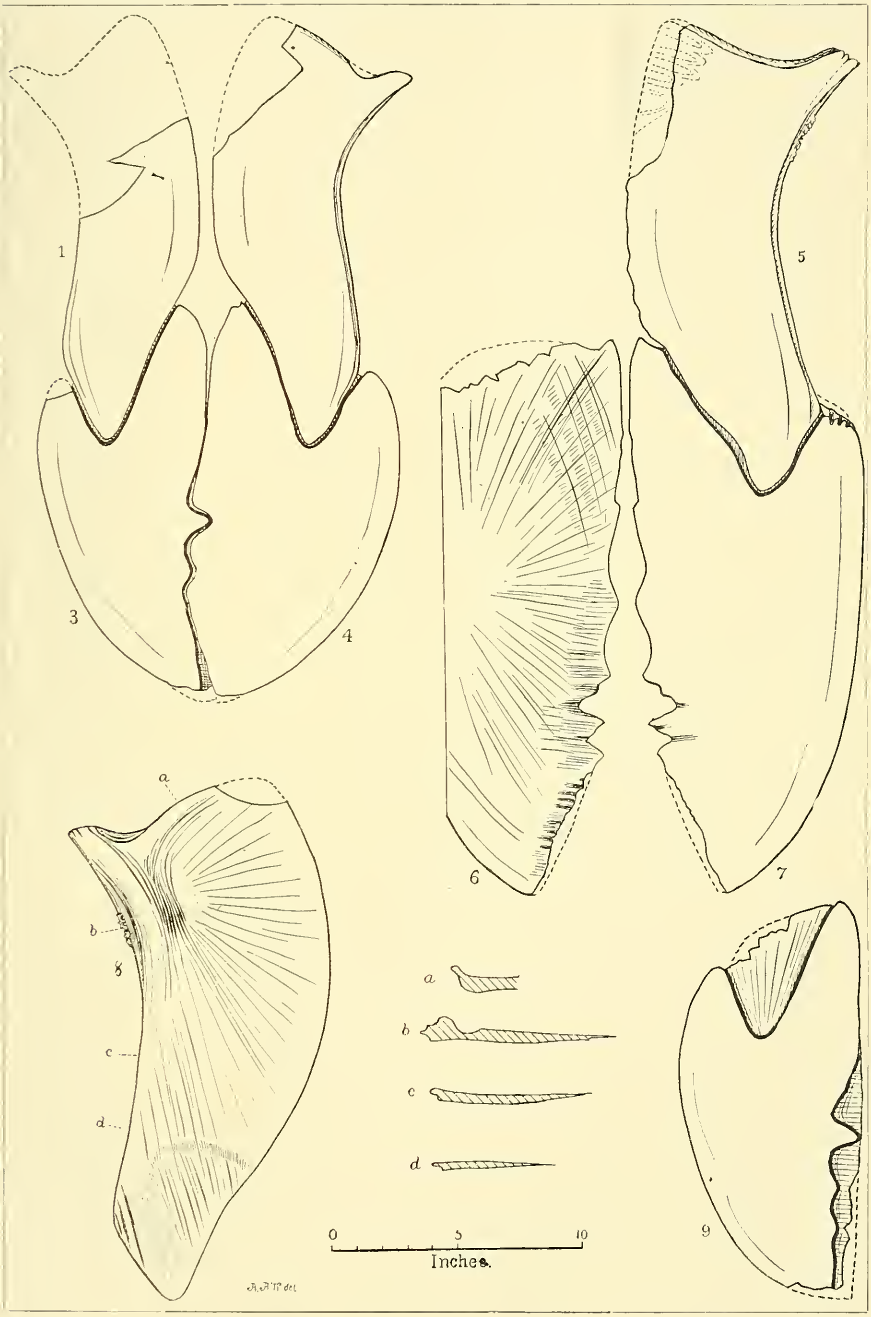

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PLATE XLV.

PAGE.

Figs. 1–2. BYSSONYCHIA PRÆCURSA, n. sp. 633

1. Cast of the interior of a right valve of the usual size. The hinge line often is longer.

2. Anterior view of same and of a left valve belonging to the Illinois State Museum Loraine shales, Loraine, New York.

Figs. 3–4. BYSSONYCHIA RICHMONDENSIS, n. sp. 632

Anterior and lateral views of a cast of the interior of the average size and proportions. Near top of Cincinnati group, Richmond, Ind.

Figs. 5–7. BYSSONYCHIA CULTRATA, n. sp. 632

5. Right valve of the usual size. The specimen preserves some of the test but is mostly a cast of the interior.

6 and 7. The anterior portion of the hinge of a left and a right valve, showing the cardinal teeth and the channel-like ligamental area. Upper beds of the Cincinnati group. Waynesville, Ohio.

Figs. 8–9. BYSSONYCHIA ACUTIROSTRIS, n. sp. (See also Plate 46, Fig. 10) 634

8. The hinge and the upper part of the anterior margin of a small testiferous specimen, x 2. The figure shows the small cardinal teeth, ligamental area and the plicated character of the margin of the byssal opening. Posterior lateral teeth seem to be wanting in this species.

9. Anterior view of same specimen, natural size. Middle beds of the Cincinnati group, Cincinnati, Ohio.

Figs. 10–12. BYSSONYCHIA OBESA, n. sp. 630

10–12. Three views of a cast of the interior of medium size, showing the usual rounded form, the depression surrounding the small byssal opening, and other characters of the species. Some specimens are proportionally a little higher. Upper beds of the Cincinnati group, Richmond, Indiana.

Figs. 13–15. BYSSONYCHIA SUBERECTA, n. sp. 634

13. An imperfeet testiferous right valve of the average size showing the erect form, and the wide angle formed by the hinge line and the anterior margin.

14. The anterior part of the hinge of a left valve.

15. Anterior views of the two valves. Upper beds of the Cincinnati group. Versailles Indiana.

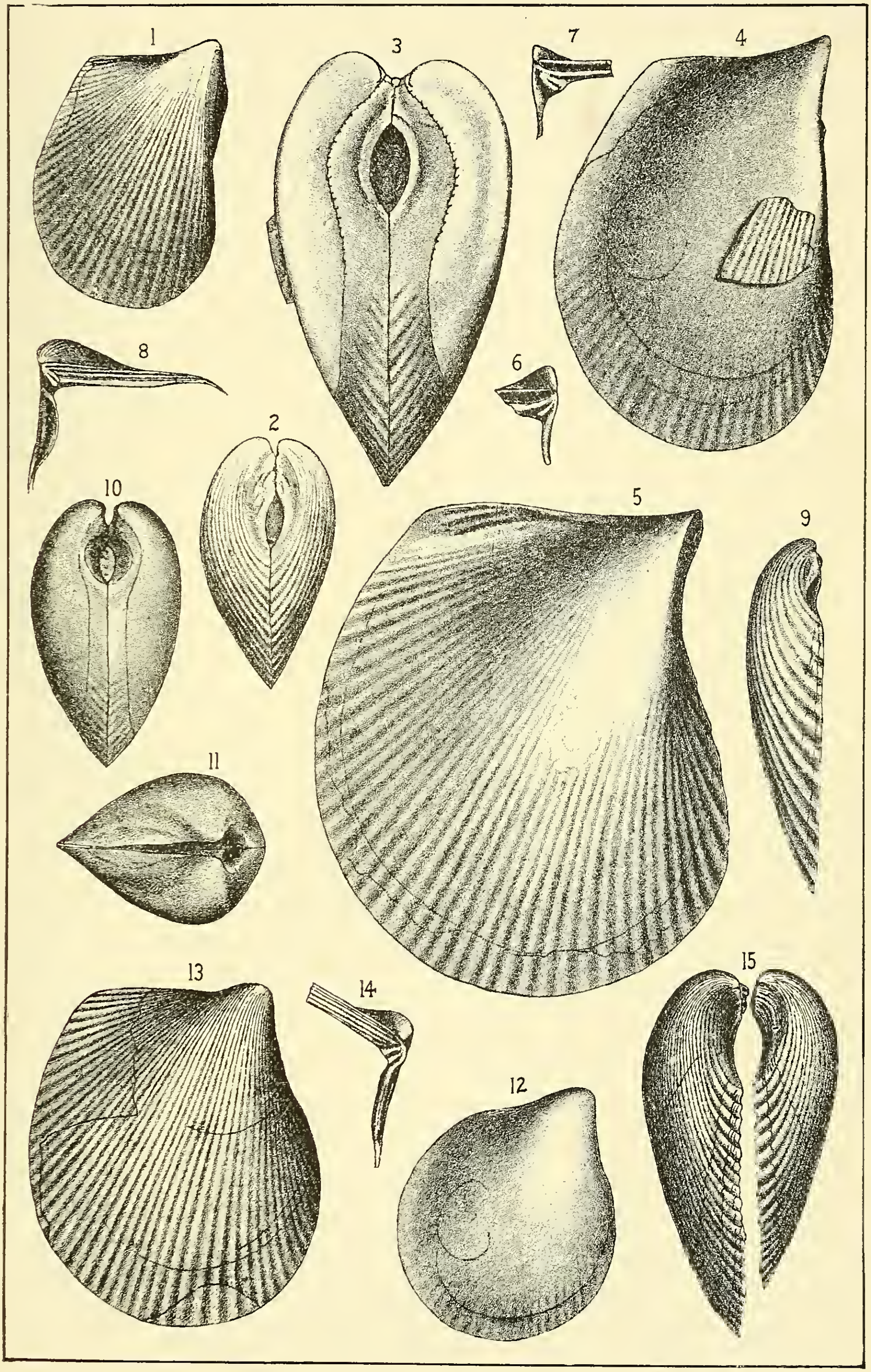

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PLATE XLVI.

PAGE.

Fig. 1. ANOMALODONTA ALATA, Meek, sp.. 638

Interior of a right valve as shown in a gutta-percha impression of a cast of the interior, from the Cincinnati group, near Morrow, Ohio. Specimens of this species often have the wing more extended than is shown in this figure.

Figs. 2–3. ANOMALODONTA PLICATA, n. sp.. 638

Two views of a cast of the interior of a right valve. Middle beds of the Cincinnati group, Covington, Kentucky.

Figs. 4–5. BYSSONYCHIA IMBRICATA, n. sp. 635

The left side and a front view of the largest specimen seen. It is a cast of the exterior. Middle beds of the Cincinnati group, Cincinnati, Ohio.

Figs. 6–9. BYSSONYCHIA GRANDIS, n. sp.. 631

6 and 7. The left side and an anterior view of an imperfect and slightly distorted cast of the exterior. Upper beds of the Cincinnati group, Oxford, Ohio.

8. Cast of the interior of a left valve, preserving the outline perfectly. The convex region beneath the umbones, however, has been planed away by exposure to the weather; Clarksville, Ohio.

9. Anterior view of same showing the broad depression around the byssal opening, and other features of the species.

Fig. 10. BYSSONYCHIA ACUTIROSTRIS, n. sp. (See also plate 45, Figs. 8 and 9) 634

A small testiferous right valve. The drawing is not exactly true to nature. The back should be a little narrower and the upper fourth of the anterior margin more distinctly concave. (About as in Fig. 3 on plate 47.)

Figs. 11–14. CTENODONTA PERMINUTA, n. sp.. 680

Right and left sides of four casts of the interior, x 6, showing slight variations. Cincinnati group, Cincinnati, Ohio.

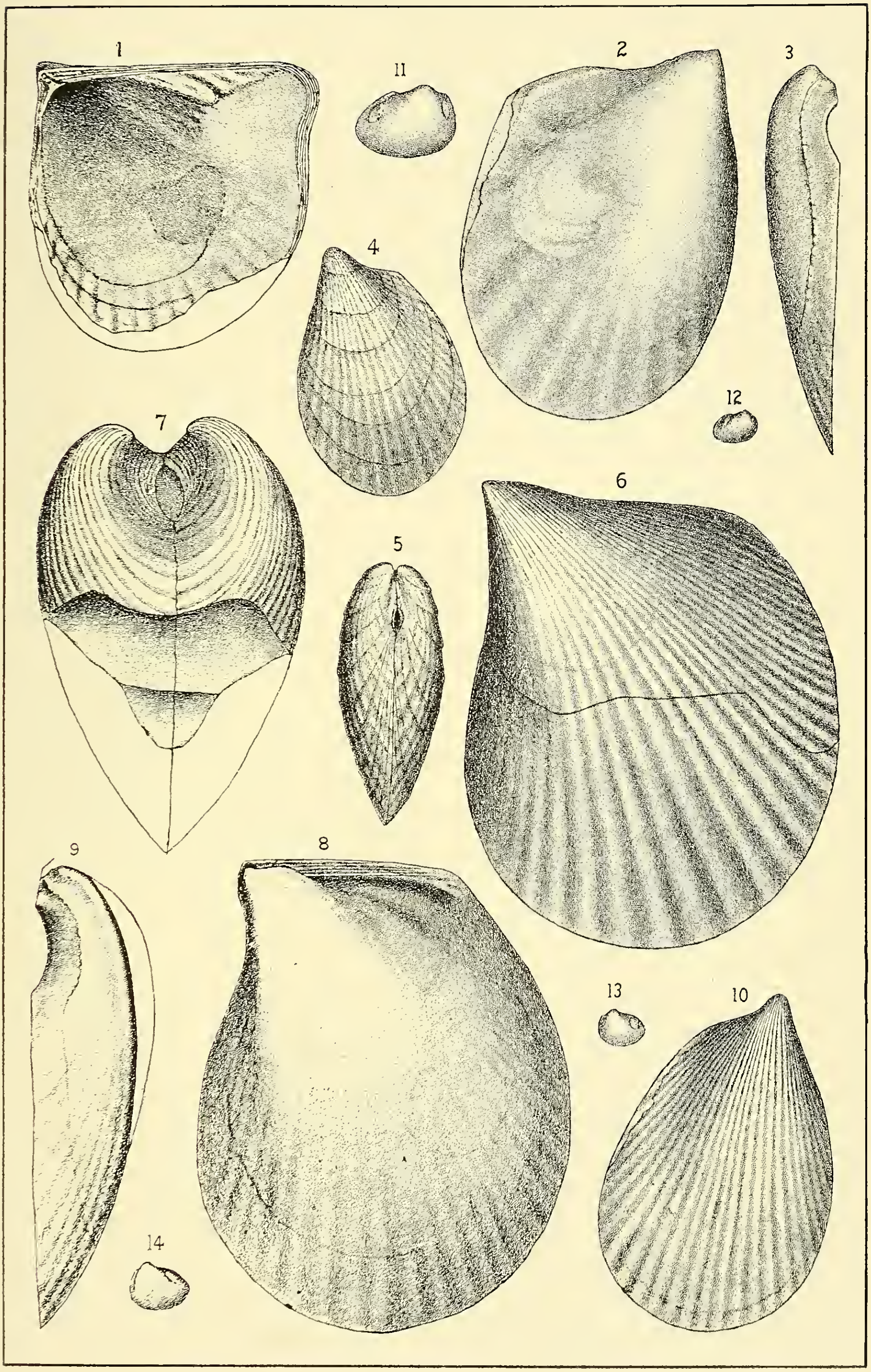
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PLATE XLVII.

PAGE

Fig. 1. ERIDONYCHIA APICALIS, n. sp....... 639

Interior of a left valve as shown in a gutta-percha impression of a cast of the interior. Middle beds of the Cincinnati group, Newport, Kentucky.

Fig. 2. ERIDONYCHIA PAUCICOSTATA, n. sp....... 640

An average left valve of this species. Middle beds of the Cincinnati group, Covington, Kentucky.

Fig. 3. ERIDONYCHIA CRENATA, n. sp....... 640

A left valve showing the greatly attenuated beaks and the wavy character of the ventral outline. Upper beds of the Cincinnati group, Waynesville, Ohio.

Figs. 4–5. BYSONYCHIA? BYRNESI, n. sp....... 635

4. Gutta-percha impression of a natural mold of the exterior of a right valve. The outline of this specimen is a little unusual in the post-dorsal region.
5. A left valve of the usual size and form. Lower beds of the Cincinnati group, Covington, Kentucky.

Fig. 6. OPISTHOPTERA LATICOSTATA, n. sp....... 646

The right side of a somewhat imperfect cast of the exterior. Upper beds of the Cincinnati group, near Waynesville, Ohio. Collection of the Ohio State University.

Fig. 7. OPISTHOPTERA AMPLA, n. sp....... 647

View of the imperfect specimen described. It is a cast of the interior of a left valve. Middle beds of the Cincinnati group, Cincinnati, Ohio.

Fig. 8. LYRODESMA SUBPLANUM, n. sp....... 683

Partial cast of the interior of a large right valve. Lower beds of the Cincinnati, group, Covington, Kentucky.

Fig. 9. LYRODESMA CONRADI, n. sp....... 684

Sharply defined cast of the interior, showing the muscular scars and the sinuate pallial line very clearly. Lower beds of the Cincinnati group, Covington, Kentucky.

Figs. 10–12. TECHNOPHORUS PUNCTOSTRIATUS, n. sp....... 685

10. Right valve of the natural size.
11. Cast of the interior of a left valve.
12. The original of Fig. 10 magnified two and one-half diameters to show the regular puncto-lineate surface marking. Middle beds of the Cincinnati group, Covington, Kentucky.

Figs. 13–14. TECHNOPHORUS YOLDIIFORMIS, Ulrich....... 685

13 The original type of this species, x 2. The specimen is preserved in soft shale as a partial cast of the interior.

14. The same valve together with a right valve found in the same block of shale. Lower beds of the Cincinnati group, Covington, Kentucky.

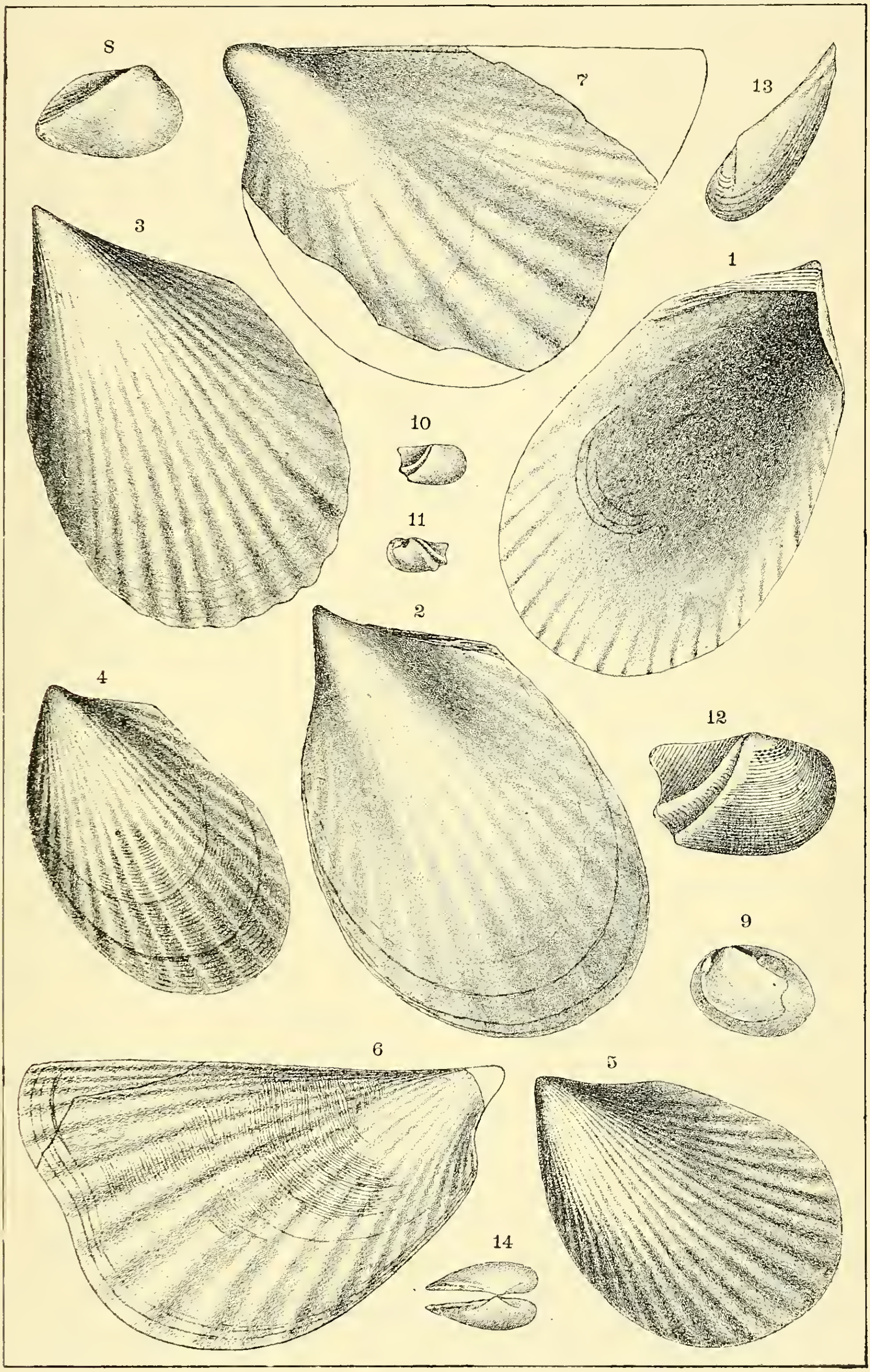
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PLATE XLVIII.

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Figs. 1–3. BYSSONYCHIA ALVEOLATA, n. sp. 631

Three views of a right valve of this species. In two of the views the opposite valve is restored except the radii. Middle beds of the Cincinnati group, Cincinnati, Ohio.

Figs. 4-6. ALLONYCHIA OVATA, n. sp. 641

4. A valve, somewhat weathered, showing, however, all the essential features of the species. Middle beds of the Cincinnati group, Covington, Kentucky.
5. The upper part of an inner view of the same specimen, showing the high ligamental area and other characters.
6. Anterior view of same.

Fig. 7. ALLONYCHIA JAMESI, Meek, sp. 641

An excellent cast of the interior of a right valve of this species. Middle beds of the Cincinnati group, Cincinnati, Ohio.

Figs. 8–9. ALLONYCHIA SUBROTUNDA, n. sp. 642

Lateral and anterior views of the specimen described. Middle beds of the Cincinnati group, Cincinnati, Ohio.

Figs. 10–11. CTENODONTA CINGULATA, Ulrich 680

10. Exterior of a silicified right valve.
11. Interior of same, x 2.

Fig. 12. CYCLOCONCHA MEDIOCARDINALIS, Miller 686

A right valve showing the hinge. Lower beds of the Cincinnati group, Cincinnati, Ohio.

Figs. 13–14. CYCLOCONCHA OVATA, n. sp. 687

13. A finely preserved left valve.
14. Hinge of a right valve, x 2.
15. Hinge of a left valve, x 2. Lower beds of the Cincinnati group, near Cincinnati, Ohio.

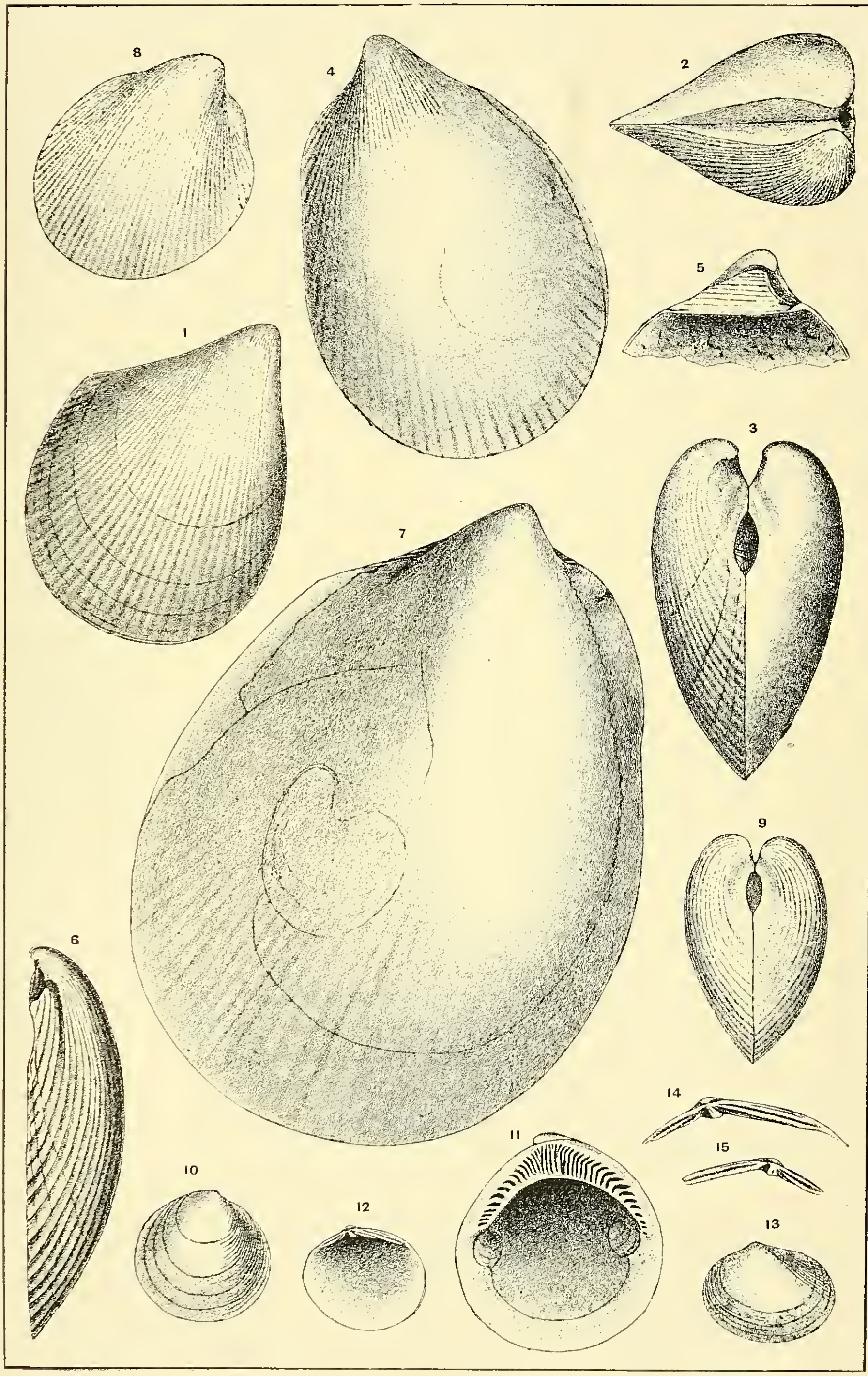
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PLATE XLIX.

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Figs. 1–5. OPISTHOPTERA CASEI, Meek and Worthen.. 643

1. Gutta percha impression of a natural mold of the exterior of a large left valve. Upper beds of the Cincinnati group, Marion county, Kentucky.

2–4. Three views of a nearly perfect cast of the interior of a small shell. Richmond, Indiana.

5. The left side of a larger cast of the interior from the same locality. The specimen is imperfect posteriorly but shows the muscular scars and pallial line very distinctly.

Figs. 6–8. OPISTHOPTERA OBLIQUA, n. sp.......................... 646

6. Dorsal view of the largest and best cast of the interior seen. Upper beds of the Cincinnati group, Richmond, Indiana.

7. The right side of same with some remains of the radial striæ. Generally the surface markings are not distinguishable on the casts.

8. Anterior view of same.

Figs. 9–11. OPISTHOPTERA ALTERNATA, n. sp.. 644

9. Left side of a small cast of the exterior. The specimen is slightly distorted. (See p. 645, fig.— *e.*)

10. Anterior view of same x2, showing the byssal opening and bifurcating costæ.

11. Anterior view of a large cast of the exterior believed to belong to this species. The surface markings in this specimen are much as in figure 15 of this plate, and it is possible that it is really a distorted example of O. FISSICOSTA. Upper beds of the Cincinnati group, Waynesville, Ohio.

Figs. 12–14. PHYSETOMYA ACUMINATA, n. gen. et sp.. 693

Anterior, cardinal and lateral views of the specimen described. Middle beds of the Cincinnati group, Cincinnati, Ohio.

Fig. 15. OPISTHOPTERA FISSICOSTA, Meek.. 643

Gutta percha impression from a natural mold of the exterior of a right valve, showing the form of the shell and the fissicostate surface markings. Upper beds of the Cincinnati group, Clarksville, Ohio.

Fig. 16. OPISTHOPTERA NOTABILIS, n. sp.................. 648

Gutta percha impression from a natural mold of the exterior of a left valve. The specimen is imperfect at the posterior extremity of the wing. Middle beds of the Cincinnati group, Cincinnati, Ohio.

Figs. 17–20. PROTHYRIS sp (compare P. meeki, Winchell).

17–28. Three views of a large specimen.

20. Left side of a smaller example.

These two and other specimens were found by myself several years ago on the hill quarry dumps west of Covington, Kentucky. How they came there is not known, but I have satisfied myself that they do not belong to the Cincinnati group. As the species is closely related to if not identified with Winchell's *P. meeki*, and as the shells were evidently imbedded originally in a fine-grained, bluish-gray sandstone, it is not improbable that they belong to the Waverly of Ohio.

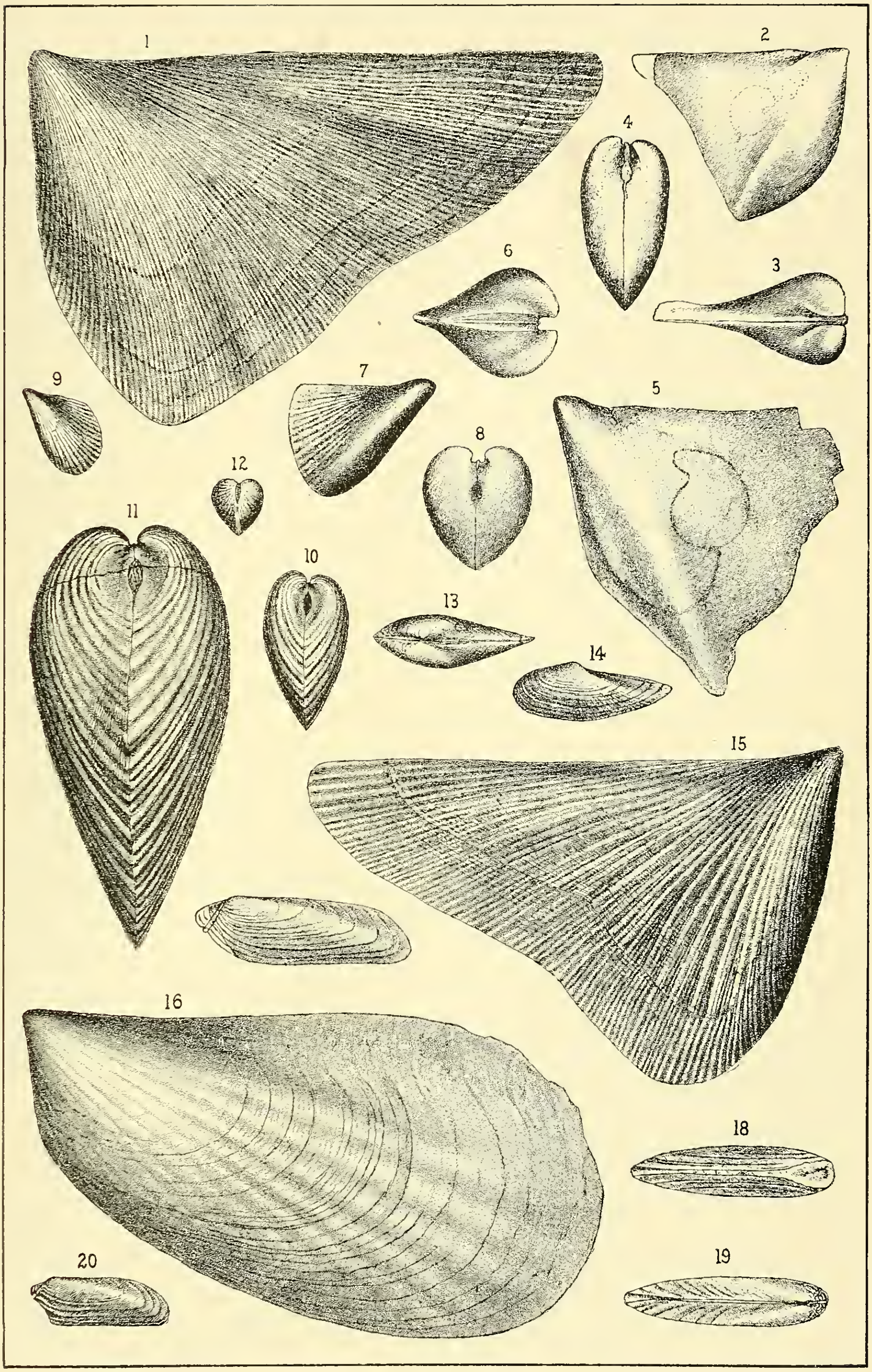
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PLATE L.

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Figs. 1–4. ANOMALODONTA GIGANTEA, Miller... 637

1. Very good cast of the interior of a left valve, showing the large posterior adductor muscle scar, the pallial line, and the impression of a pedal muscle a short distance behind the beak. The pallial line continues uninterruptedly, as in all the genera of the family, to the inner side of the beak, and there is no anterior adductor scar unless it be a very small one in the rostral cavity. The ligamental area is wanting in the specimen, but has been restored, perhaps too narrowly, in the drawing.
2. Anterior view of an unusually complete testiferous example, showing the abruptly impressed byssal opening.

3 and 4. Internal views of the original types of the genus and species, kindly loaned by Dr. S. A. Miller. Figure 3 shows about one half of the anterior margin and nearly all of the hinge of an old right valve, while figure 4 shows the greater part of a left valve. Upper beds of the Cincinnati group, Versailles, Indiana.

Figs. 5–9. ANOPTERA MISENERI, n. gen. et. sp... 650

5 and 6. Dorsal and lateral views of a cast of the interior.

7 and 8. Anterior and lateral views of another cast of the interior. Both specimens show the pallial line very distinctly, and rather faint impressions of the posterior adductor muscles. Upper beds of the Cincinnati group, Richmond, Indiana.

9. Gutta percha impression from a natural mold of the exterior of a small left valve in the base of a parasitic bryozoan. The mold is imperfect at the apex. Clarksville, Ohio.

Figs. 10–12. LYRODESMA INORNATUM, n. sp... 682

10. A small right valve.
11. A larger right valve that may be considered as of the average size. This species is without the radiating striæ usually found on the posterior cardinal slope in shells of this genus.
12. Hinge of a right valve, natural size. Middle beds of the Cincinnati group, Covington, Kentucky.

Fig. 13. LYRODESMA GRANDE, n. sp... 683

The left side of a complete cast of the interior. Middle beds of the Cincinnati group, Cincinnati, Ohio.

Figs. 14–15. CTENODONTA RETRORSA, n. sp... 679

Lateral and cardinal views of a cast of the interior. Middle Trenton, near Burgin, Kentucky.

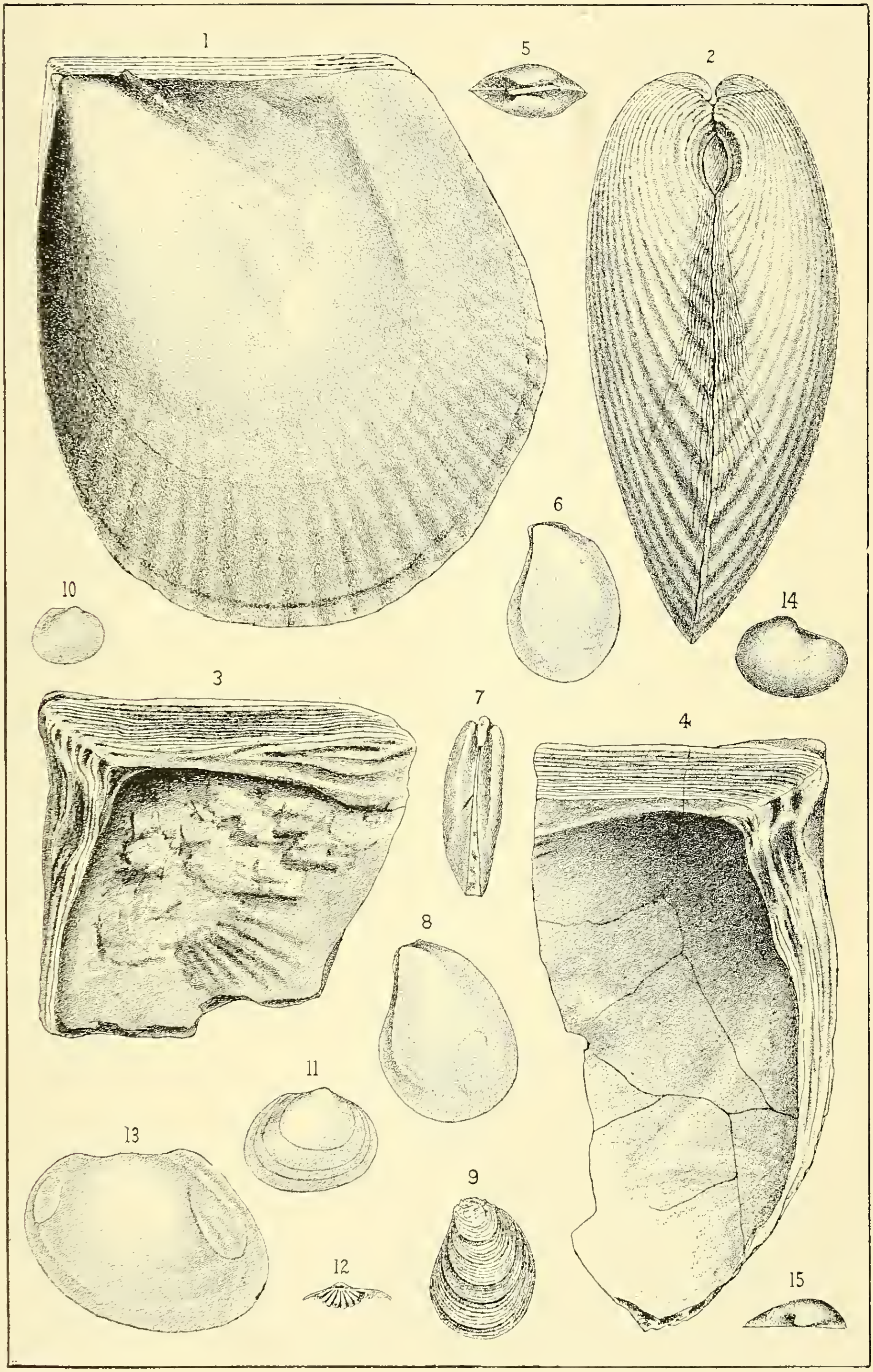
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PLATE LI.

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Figs. 1–3. PSILONYCHIA PERANGULATA, n. sp............. 649

1. Left valve with some of the test weathered away so that the posterior muscular impression is exposed to view. Middle beds of the Cincinnati group, Cincinnati, Ohio.
2. Anterior view of same.
3. Hinge of same.

Figs. 4–5. CLIONYCHIA EXCAVATA, n. sp..................... 651

Lateral and anterior views of a cast of the interior The thickness of the specimen has doubtless been reduced by pressure and I believe to an amount not less than shown in figure 5. Upper beds of the Cincinnati group, Richmond, Indiana.

Fig. 6. PYRENOMŒUS SUBCUNEATUS, n. sp.. 682

A left valve of this species. Lower beds of the Cincinnati group, Covington, Kentucky.

Figs. 7–8. PYRENOMŒUS DECIPIENS, n. sp.. 681

7. A good cast of the interior of a left valve, showing the usual form of casts and preserving more distinct traces of the muscular scars than any other specimen seen.
8. Testiferous example. The raised line in the middle of the posterior cardinal slope is natural, but the concentric striæ are too fine to be successfully represented of the natural size. Middle beds of the Cincinnati group, Cincinnati, Ohio.

Figs. 9–10. MODIOLODON TRUNCATUS, Hall sp. 656

9. The left side of a cast of the interior belonging to the collection of Mr. George Asherman. This is the usual form of the species as it occurs in the middle beds of the Cincinnati group near the tops of the hills at Cincinnati, Ohio.
10. The right side of an internal cast of a variety occupying a higher position in the Cincinnati group, and found associated with the next species at Versailles, Indiana. In this variety the anterior end is wider than in the more typical form of the species represented in figure 9.

Figs. 11–13. MODIOLODON SUBOVALIS, n. sp. 655

11 and 13. The right side and a cardinal view of a good cast of the interior.

12. The left side of a larger cast of the interior. Upper beds of the Cincinnati group, Versailles, Indiana.

Figs. 14–21. CYCLOCONCHA MILLERI, Meek sp.. 686

14. A large right valve preserving faint radiating lines on the posterior cardinal slope.

15 and 16. Two views of a smaller testiferous example.

17. The hinges of three small right valves, x2, showing a gradual change in the cardinal teeth with age.

18. Hinge of a fully grown right valve x2.

19–21. Hinges of three left valves, x2. Upper beds of the Cincinnati group, Versailles, Indiana.

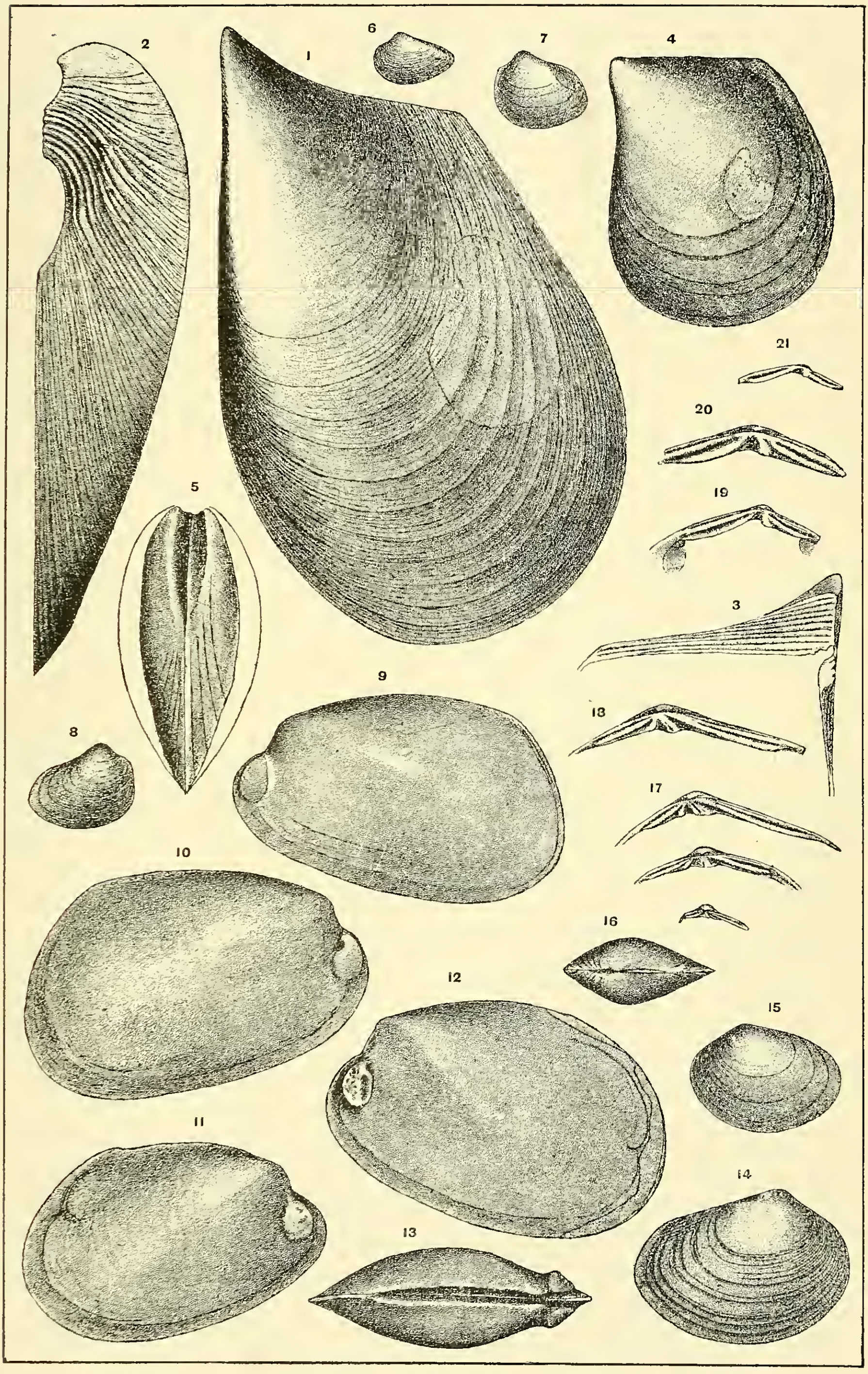
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PLATE LII.

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Figs. 1–2. PSILOCONCHA GRANDIS, n. sp. 665

The left side and a dorsal view of an excellently preserved cast of the interior. Upper beds of the Cincinnati group, Waynesville, Ohio.

Figs. 3–4. PSILOCONCHA ELLIPTICA, n. sp. 667

3. A testiferous example of a right valve.
4. The right side of a cast of the interior, showing muscular scars and pallial line. Upper beds of the Cincinnati group, Clarksville, Ohio.

Figs. 5–7. PSILOCONCHA SUBOVALIS, Ulrich 666

5. Imperfect left valve from the lower beds of the Cincinnati group. Collection of Mr. George Asherman.
6. A small specimen from the same horizon near Covington, Kentucky.
7. Right side of the original type of the species. Middle beds of the Cincinnati group, Morrow, Ohio.

Figs. 8–9. PSILOCONCHA MINIMA, n. sp. 669

The right side of the specimen described. It is a sharply marked cast of the interior and shows the anterior muscular scar but no trace of either the posterior scar or the pallial line. Lower beds of the Cincinnati group, Covington, Kentucky.

Fig. 10. PSILOCONCHA TENUISTRIATA, n. sp. 668

The right side of an imperfect testiferous example, x2. On a small space beneath the beak, I have attempted to give an idea of the extreme delicacy of the concentric lines. Lower beds of the Cincinnati group, Covington Kentucky.

Figs. 11–12. PSILOCONCHA INORNATA, n. sp. 667

11. Cast of the exterior of a right valve.
12. A specimen retaining both valves in position, the upper one showing the normal convexity of the valves. Middle beds of the Cincinnati group, Cincinnati, Ohio.

Figs. 13–14. PSILOCONCHA SUBRECTA, n. sp. 667

The left side and a dorsal view of a cast of the exterior. Upper beds of the Cincinnati group, Waynesville, Ohio.

Figs. 15–16. PSILOCONCHA SINUATA, n. sp. 668

Casts of the exterior of a right and a left valve Middle beds of the Cincinnati group, Cincinnati, Ohio.

Figs. 17–19. COLPOMYA CONSTRICTA, n. sp. 659

17 and 18. Interiors of a left and right valve, showing the hinge and muscular impressions. These two figures suffered somewhat in the reproduction.
19. Exterior of a large right valve. Uppermost beds of the Trenton group, Frankfort, Kentucky.

Figs. 20–21. MODIOLODON OBTUSUS, n. sp. 654

Impressions of the exterior of a left and a right valve of the typical form of this species, both showing traces of the anterior muscular scar. Middle beds of the Cincinnati group, Cincinnati, Ohio.

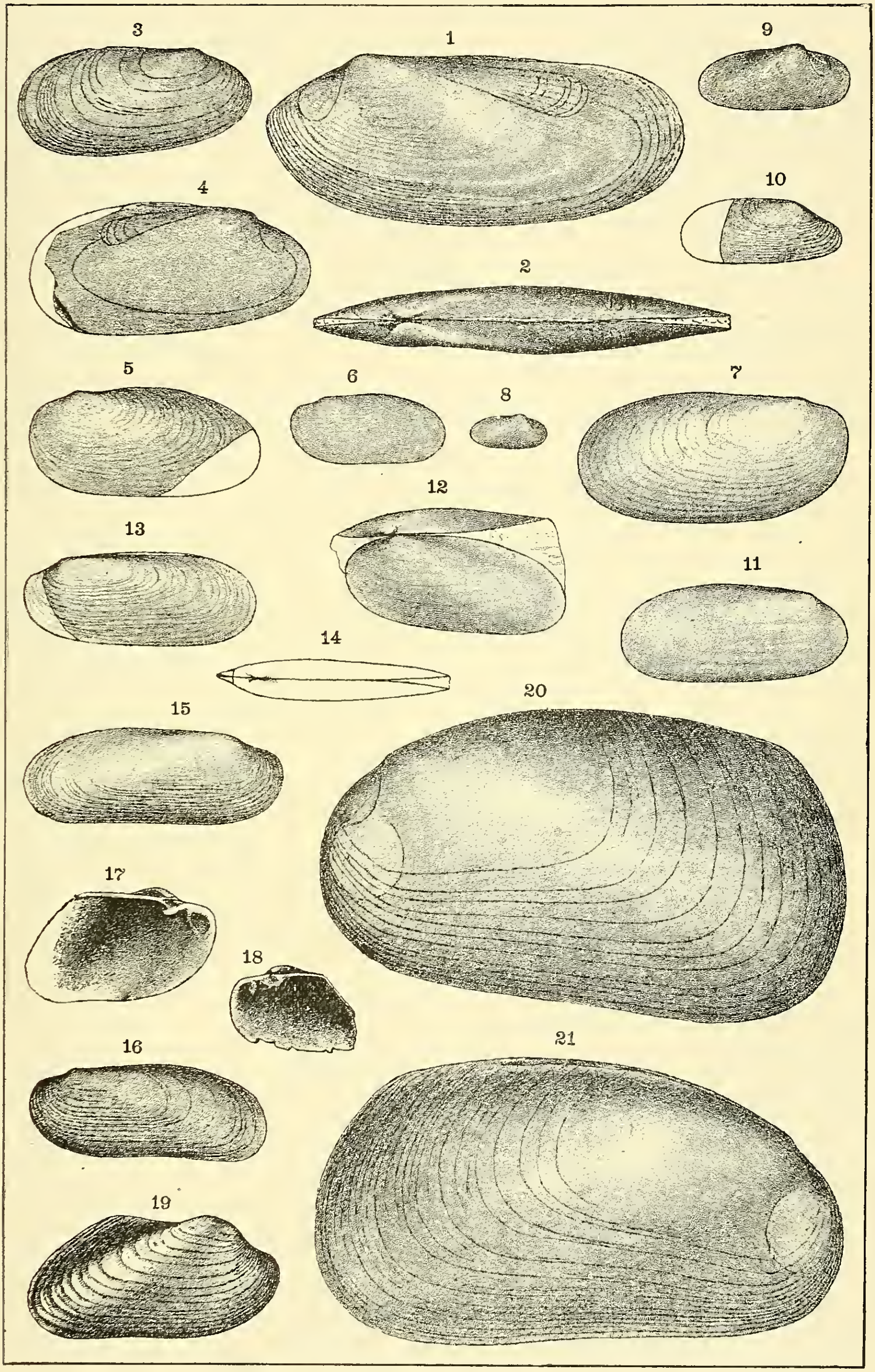
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PLATE LIII.

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Figs. 1–2. MODIOLODON OVIFORMIS, var AMPLUS, n. var........ 653

1. The left side of a nearly perfect cast of the interior.
2. Mold of the exterior of a right valve. Trenton group, Frankfort, Kentucky.

Figs. 3–4. MODIOLODON DECLIVIS, n. sp.. 654

The right side and a cardinal view of a cast of the interior of the average size. Upper beds of the Cincinnati group, Richmond Indiana.

Figs. 5–6. MODIOLODON SUBRECTUS, n. sp.................. 653

The left side and a dorsal view of a small but characteristic cast of the interior of this species. Upper beds of the Cincinnati group, Richmond, Indiana.

Figs. 7–8. MODIOLODON OVIFORMIS, Ulrich... 652

7. A perfect impression of the interior of a left valve. The specimen is of the usual size and from the Trenton at Frankfort, Kentucky.
8. Gutta percha impression from the preceding to show the character of the hinge, the anterior adductor scar and the pallial line.

Figs. 9–18. ORTONELLA HAINESI, Miller sp.. 670

9. The right side of a perfect though rather small specimen of the typical form.
10. Antero-dorsal view of same, showing the lunule and escutcheon.
11. Interior of a left valve.
12. Almost entire mold of the interior of a right valve, showing impressions of the posterior lateral teeth.
13. The left side of a large and complete cast of the interior.

14 and 15. The right side and an antero-dorsal view of a small cast of the interior belonging to a variety that is shorter than the typical form.

16. A small cast of the next variety.

17 and 18. The right side and a dorsal view of an excellent cast of the interior of an unusually long variety. The small pedal muscle scars are shown very distinctly in figure 18. Upper beds of the Cincinnati group. Richmond, Indiana.

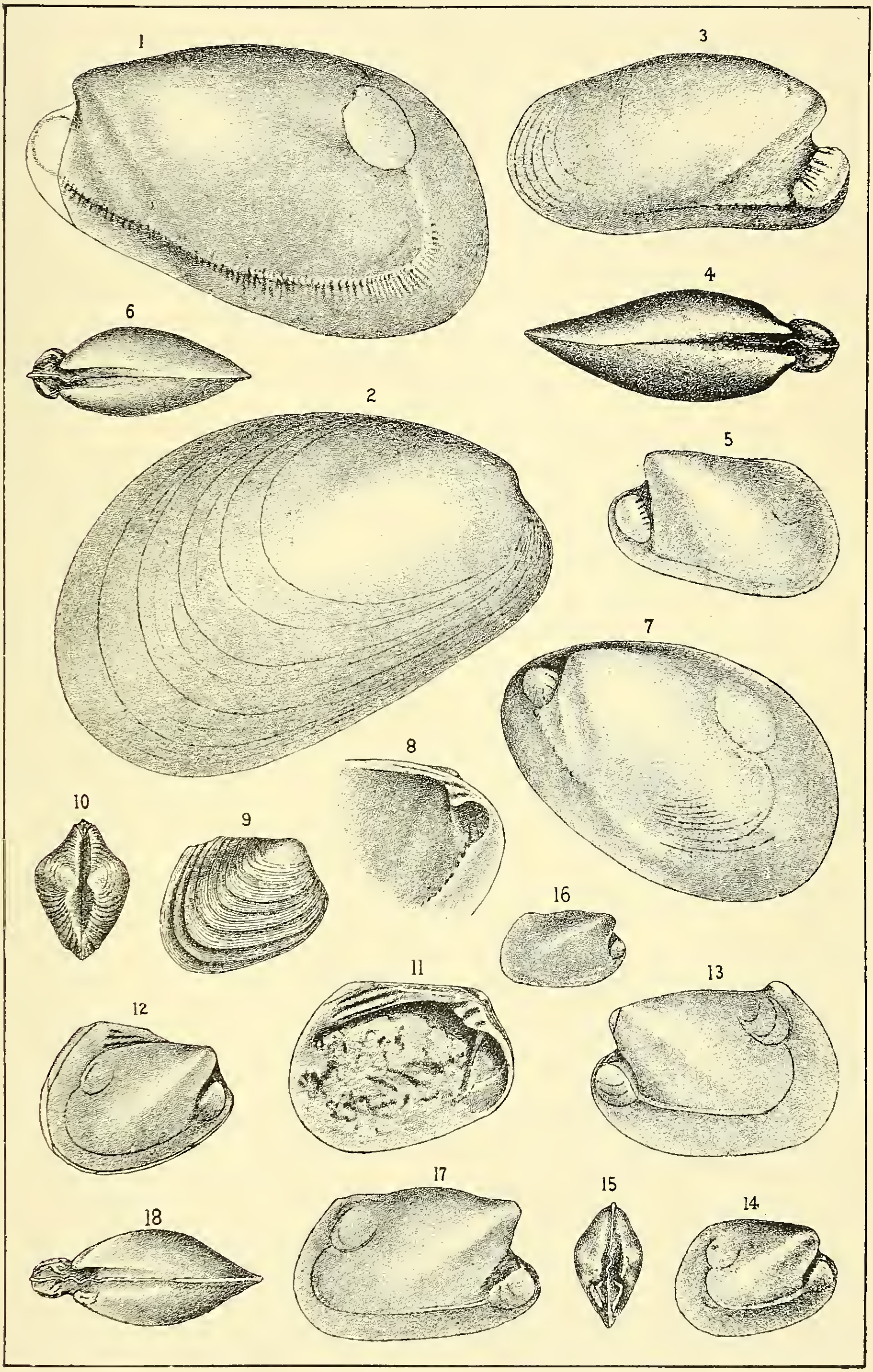
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PLATE LIV.

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Figs. 1–3. ISCHYRODONTA UNIONOIDES, Meek sp. 677

1. Interior of a large right valve showing the hinge and the anterior adductor and pedal muscle scars. Also the left side of an unusually well preserved cast of the interior.
2. Entire impression of the inner side of a right valve, showing the anterior muscular scar and the impression of the subcardinal rib that supported the internal ligament.
3. A testiferous example of a right valve of less regularly ovate shape than usual. Middle beds of the Cincinnati group, Covington, Kentucky.

Figs. 4–9. ISCHYRODONTA MODIOLIFORMIS, n. sp. 676

4. Rather small example preserved in part as a mold of the exterior. In this specimen the outline, especially in the basal region, differs somewhat from the usual form of the species.
5. Sharply marked cast of the interior showing the muscular scars and the pallial line.
6. The right side of a large and nearly perfect cast of the interior.
7. Left side of a cast in which the hinge is longer than usual.
8. Dorsal view of same.
9. From a gutta percha impression of a natural mold of the exterior, showing the surface markings, x2, as they appear in the central part of the posterior half of the left valve Upper beds of the Cincinnati group, Richmond, Indiana.

Figs. 10–11. ISCHYRODONTA MISENERI, n. sp. 675

10. Antero-cardinal view of a testiferous specimen.
11. Right side of same showing the usual size and form of this species. Upper beds of the Cincinnati group, Richmond, Indiana.

Figs. 12–15. ISCHYRODONTA OVALIS, Ulrich 674

Four views of the original type of this species. Uppermost beds of the Cincinnati group, near Richmond, Indiana.

Figs. 16–19. ISCHYRODONTA DECIPIENS, n. sp. 673

16–18. Three views, respectively inner, antero-cardinal, and outer, of a nearly perfect right valve.

19. Interior of the largest left valve seen. The specimen is slightly weatherworn. Upper beds of the Cincinnati group, near Richmond, Indiana.

Figs. 20–21. ISCHYRODONTA ELONGATA 675

20. Small specimen preserved as a mold of the exterior. Upper beds of the Cincinnati group, Richmond, Indiana.
21. Left side of the original type of the species. The specimen is an excellently defined cast of the interior, from Oxford, Ohio.

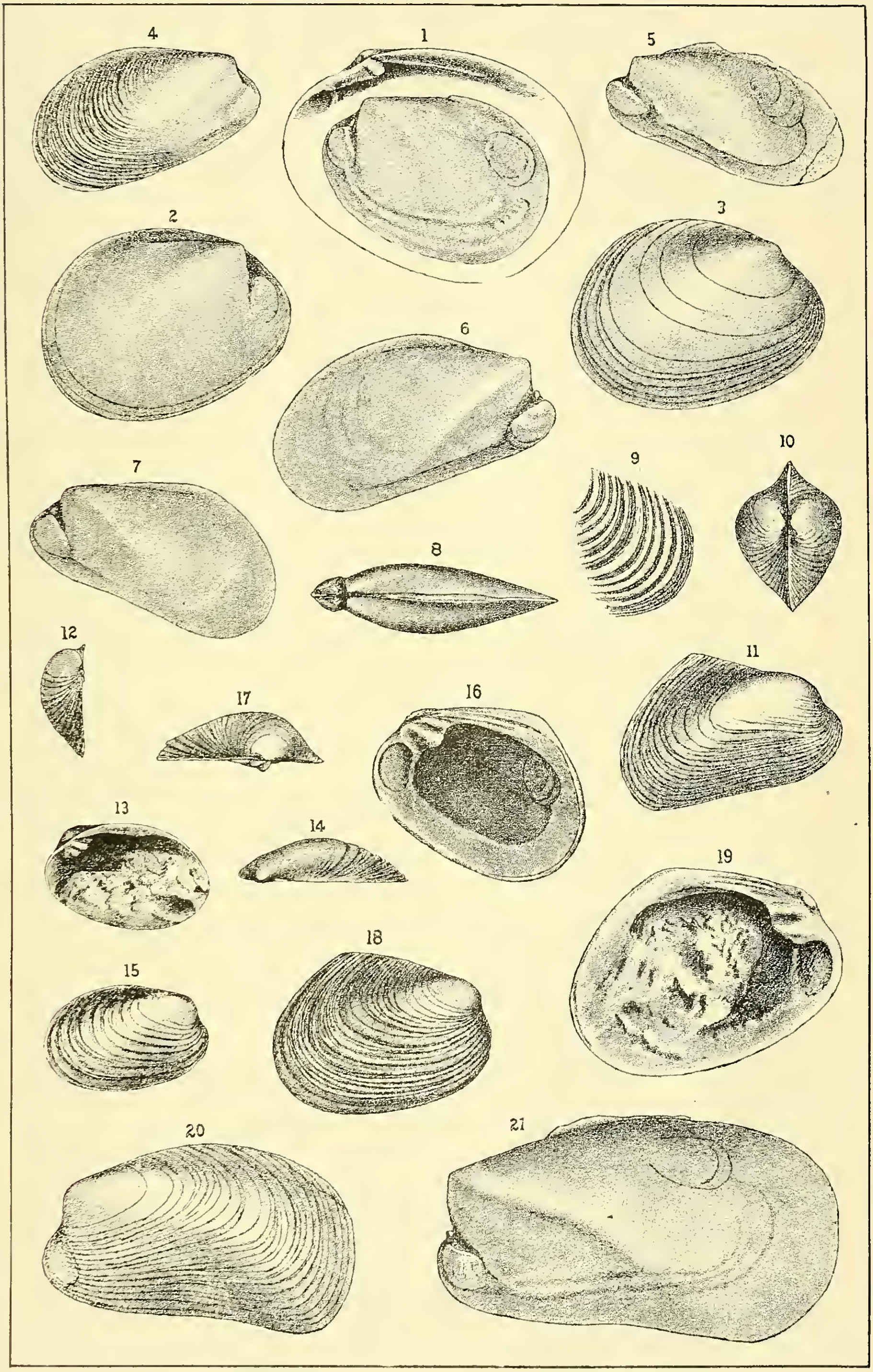
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PLATE LV.

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Figs. 1–5. CYMATONOTA TYPICALIS, n. sp.. 662

1. Left side of a nearly complete cast of the exterior. The specimen is a large one but its thickness has been somewhat reduced by pressure.
2. Dorsal view of same in outline, to show gaping extremities and the oblique dorsal furrows.
3. Dorsal view of an incomplete cast of the exterior. The length of this specimen has been reduced by pressure, bringing the dorsal furrows a little closer together than is normal for the species.

4 and 5. The left side and a dorsal view of au incomplete but otherwise well preserved cast of the interior, showing faint traces of the anterior muscular scar. Upper beds of the Cincinnati group, Waynesville, Ohio.

Figs. 6–7. CYMATONOTA SEMISTRIATA, n. sp.. 663

6. The anterior half of the left side of a nearly complete cast of the exterior, x2, showing the fine, equal, threadlike surface markings of this part.
7. The entire left side of same, natural size. The length of the specimen has been reduced probably from the outline restored in the figure. Upper beds of the Cincinnati group, Clarksville, Ohio.

Figs. 8–9. CYMATONOTA RECTA, n. sp.. 662

8. Cast of the interior of a small left valve, preserved in a limestone matrix. A few of the concentric lines on the flanks of the shell should be stronger than represented in the figure. Middle beds of the Cincinnati group, Newport, Kentucky.
9. Cast of the exterior of a large left valve, preserved in soft shale. Cincinnati, Ohio.

Figs. 10–11. CYMATONOTA CONSTRICTA, n. sp.. 664

The left side and a dorsal view of a nearly perfect cast of the interior, showing the gaping extremities, the obtuse anterior end, and the constriction of the shell beneath the beaks. Upper beds of the Cincinnati group, Butler county, Ohio.

Figs. 12–14. CYMATONOTA ATTENUATA, n. sp.. 664

12 and 13. The right side and a dorsal view of a small specimen, preserving very nearly the shape regarded as normal.

14. A peculiarly distorted large specimen believed to belong to this species. Upper beds of the Cincinnati group, Waynesville, Ohio.

Figs. 15–16. CORALLIDOMUS CONCENTRICUS, Whitf.. 493

The right side and a dorsal view of a partial cast of the interior of this boring shell; natural size. The specimen shows a gape between the edges of the valves at each end, and a strong anterior muscular scar precisely as in MODIOLOPSIS and ORTHODESMA.

Figs. 17–18. CYMATONOTA PRODUCTIFRONS, n. sp.. 665

The right side and a dorsal view both restored—of a slightly distorted cast of the exterior. The unusual length of the anterior end is the principal peculiarity of the species. Lower beds of the Cincinnati group, Covington, Kentucky.

Figs. 19–20. ORTHODESMA PARVUM, n. sp.. 660

The left side and a dorsal view of the type specimen. It is a nearly complete cast of the interior. Middle beds of the Cincinnati group, Cincinnati, Ohio.

Figs. 21–22. ORTHODESMA SUBANGULATUM n. sp.. 660

The left side and a dorsal view of a cast of the interior. Upper beds of the Cincinnati group, Richmond, Indiana.

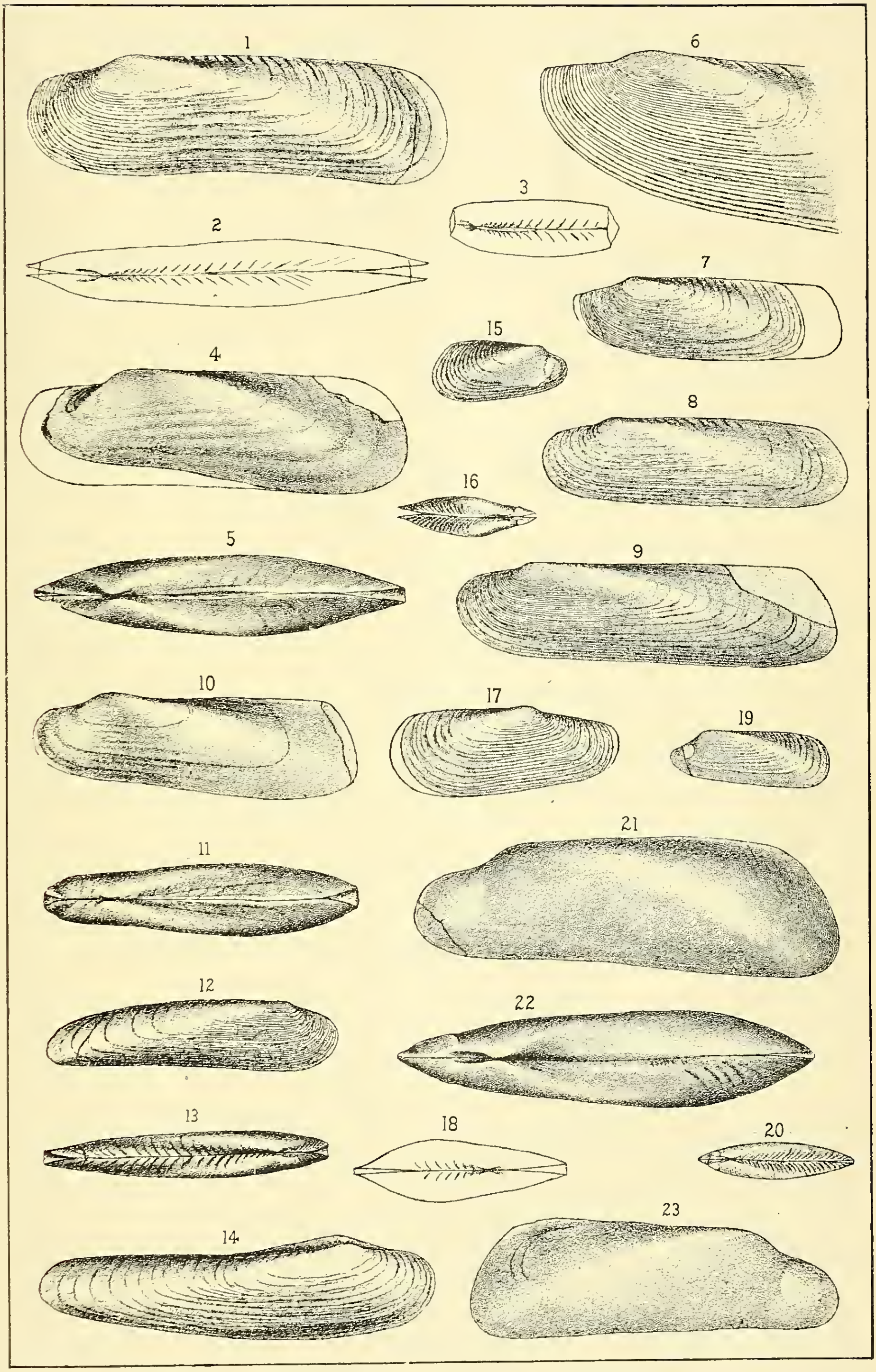
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PLATE LVI.

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Fig. 1. RHYTIMYA ŒHANA, n. sp.. 689

View of the specimen described. Middle beds of the Cincinnati group, Cincinnati, O.

Figs. 2–3. RHYTIMYA CONVEXA, n. sp.. 691

Right side and cardinal views of a large and well preserved example. The original shows remains of radial series of pustules on the post-ventral slopes, but their significance was not appreciated until it was too late to change the drawing. Middle beds of the Cincinnati group, Cincinnati, Ohio.

Figs. 4–5. RHYTIMYA BYRNESI Miller, sp.. 689

Left side and dorsal views of a large cast of the interior. In figure 5 the linear depress on each side of the hinge line has been reproduced too much like an escutcheon Upper beds of the Cincinnati group, Richmond, Indiana.

Figs. 6–9. RHYTIMYA PRODUCTA, n. sp.. 688

6 and 7. Right side and dorsal views of the largest specimen seen. Middle beds of the Cincinnati group, Mt. Sterling, Kentucky.

8. Right side of another specimen preserving more of the concentric lines.

9. An unusually short but otherwise typical example. This and the preceding one are from Cincinnati, Ohio.

Figs. 10–12. RHYTIMYA RADIATA, n. sp.. 692

10 and 11. Two specimens preserved in soft shale and retaining the outline and surface markings. Lower beds of the Cincinnati group, Covington, Kentucky, and Cincinnati, Ohio.

12. A small part of the ventral slope x3, to show the grano-lineate ornamentation.

Fig. 13. RHYTIMYA COMPRESSA, n. sp.. 692

A right valve, imperfect at the posterior end but otherwise in a good state of preservation. Middle beds of the Cincinnati group, Cincinnati, Ohio.

Figs. 14–15. RHYTIMYA MICKLEBOROUGHI, Whitfield.. 690

Left side and cardinal views of a specimen showing the usual characters of the species. The height has been reduced by pressure to perhaps four-fifths of what it was originally. Middle beds of the Cincinnati group, Cincinnati, Ohio.

Figs. 16–17. *WHITEAVESIA CINCINNATIENSIS, Hall and Whitfield.. 656

16. A large and nearly perfect cast of the interior of a right valve, showing the true form of the species, the anterior muscular scar, traces of the posterior scar, and unusually distinct rays on the ventral slope. The latter as a rule are very obscure, while the exterior of the shell generally exhibits faint radiating lines on the cardinal slopes which in rare cases may be distinguishable even on casts of the interior.

17. Hinge of a right valve, showing its simple character. Lower beds of the Cincinnati group, Covington, Kentucky.

Figs. 18–20. WHITEAVESIA KENTONENSIS, n. sp.. 658

18. A large left valve, imperfect anteriorly and unusually high posteriorly. The specimen preserves small patches of the shell.

19 and 20. Two views of a small cast of the interior, showing the usual characters of the species. Lower beds of the Cincinnati group, Covington, Kentucky.

Figs. 21–22. WHITEAVESIA PHOLADIFORMIS, Hall sp.. 658

21. The greater part of the hinge of a left valve.

22. Hinge of a right valve, imperfect at both ends.

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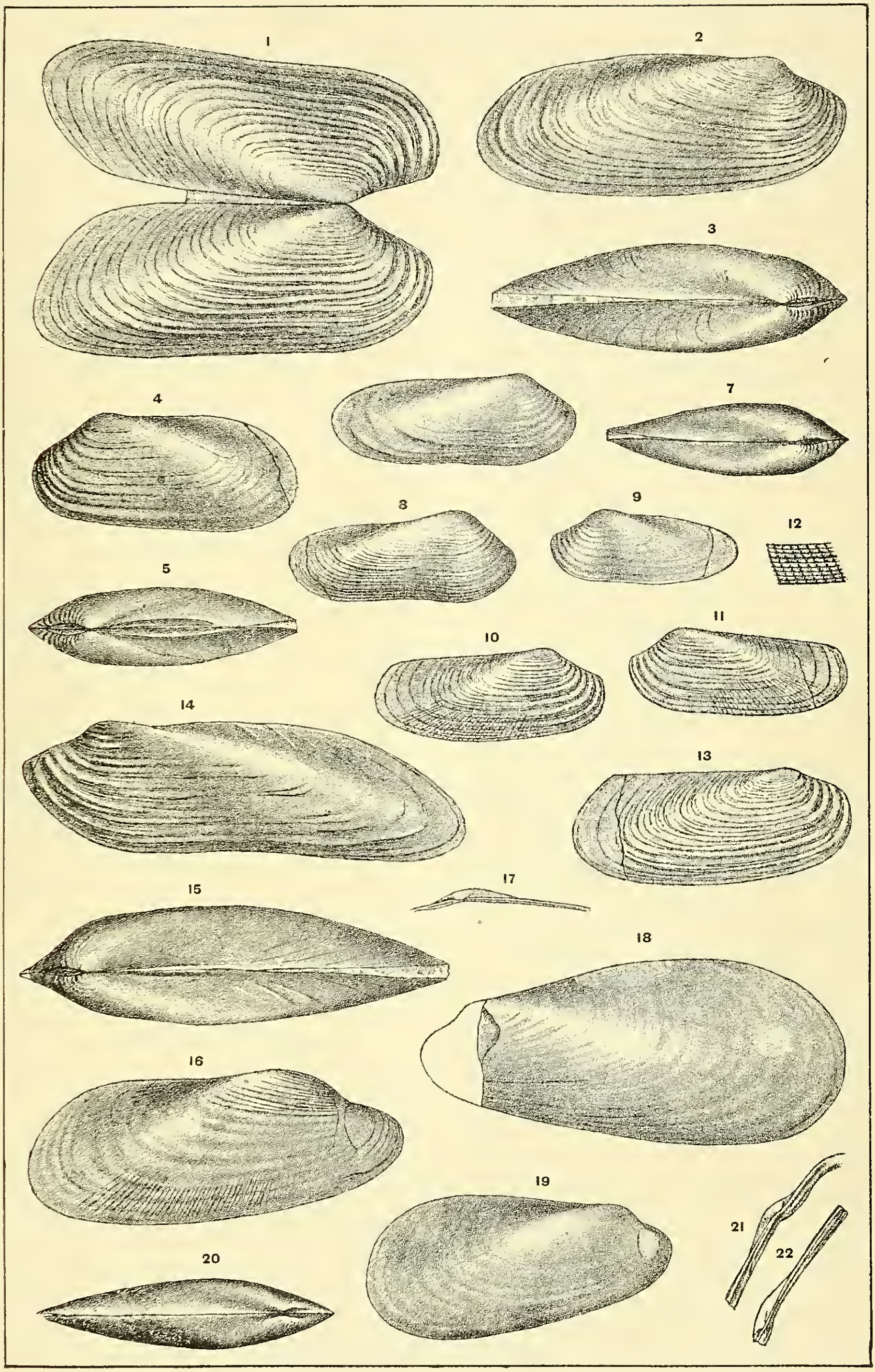
*In the text the genus for this and the next two species reads *Actinomya*. This name having been preoccupied a few years ago by Mayer for a Cretaceous genus of shells, it cannot be used for these Lower Silurian types. The name *Whiteavesia* is therefore proposed instead. I am not sorry for the change, since it affords me an opportunity of expressing my high appreciation of the paleontological labors of Prof. J. F. Whiteaves of the Canadian Geological Survey.

E. O ULRICH.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