PART II.

PALEONTOLOGY.

PRINCIPLES OF PALEOZOIC BOTANY

AND THE

FAUNA OF THE COAL MEASURES.
INTRODUCTION

In former years the object of a Geological Survey was limited to explorations of the mineral riches of the land and to the study of the fossil remains, which, found in the rocks, serve as guides for the determination of Geological Periods, or Formations. Now that the field which the human mind is called to explore has been widely expanded by discoveries of every kind, giving origin to many new industries, Geological Surveys are called upon to give an account of all that may be valuable to the inhabitants of a country and of all that may interest the world at large. The characters of the land, its chemical components, its adaptation to culture, the divers kinds of minerals, the plants and animals of the present epoch as well as those which have lived in former periods, the remains left by former races of human beings, those of animals and vegetables left in the strata composing the crust of the earth; all have to be carefully studied and recorded. For if the present inhabitants have the need and the right to know about the material value of their land, the world at large has a right to know all that pertains to natural history, in order to gather the facts that constitute the history of the world from its origin, through the different periods of its existence.
In my efforts of the past years, I included as a contribution to science, a description of some of the fossil remains of animals especially marine shells, corals, etc., found in the rocks of Indiana and serving as characters to recognize the succession of the Geological Formations of the State. This part has been generally received with great favor. As the greatest riches of the minerals of Indiana, lie in its coal beds which are entirely composed of plants, I have thought it advisable to give an exposition of the vegetable remains, which found in connection with coal beds, indicate the nature of their compounds. The plants of the coals of North America have been already described in many valuable works or Geological Reports, especially in those of Pennsylvania, Illinois, Arkansas, Ohio, etc. And, therefore, the number of new or not yet known species is probably limited, and few could be furnished from Indiana. But until now, we have no kind of book servicable to direct the study of the fossil plants, no manual of the Principles of Vegetable Paleontology which, in my opinion, would be very useful to the students of all the Scientific Institutions of our State and country.

The only man deeply versed in that part of Natural History, is Prof. Leo Lesquereux, of Columbus, Ohio, who, as an intimate friend and fellow-citizen of Professor Agassiz, was encouraged by him to come to America, and who, since his arrival here in 1848, has given the most of his time to the study of the fossil plants of North America. His studies published in numerous State and Government Reports fill many volumes, and as a Paleontologist, Lesquereux is as widely known in Europe as he is in this country. I have, therefore, proposed to him to prepare for this Report, a Manual on the Principles of Vegetable Paleontology, and I now offer it to the State as a work which will be of great value to the students and colleges of Indiana, and to those of the United States, and which at the same time may be read with pleasure and profit by all persons interested in the coal beds. It will enable every one to study and analyze the beautiful specimens of fossil plants abundantly found in our Coal Measures.

The work forcibly limited to the plants of the Paleozoic times has been prepared with the greatest care. It illustrates in beautiful plates the characters of the plants which facilitate the understanding of the descriptions. I consider it, therefore, as a
publication that will greatly enhance the value of the Geological Reports of Indiana.

The foregoing Vegetable Paleontology is followed by descriptions and figures of the characteristic animal remains of the same period, by Dr. C. A. White, Paleontologist of the United States Geological Surveys, of the Smithsonian Institute, and former State Geologist of Iowa.

The best specimens have been selected for this purpose by Dr. White, and the work has been done with his usual fidelity and ability. These shells, etc., designate the horizon of stone coal—of the Coal Measures—they are not found except within a short distance above or below Coal seams; hence are indicators of minerals to be expected, as emphatic and plain as if the rocks in which they are found were labeled in black letter English.

The drawings of the animals, shells, corals, etc., are by Dr. McConnel, of Washington City, and will bear comparison with similar work prepared in any age, State, or Nation.

The State Geologist admits that he is glad to present this work, and its illustrations, prepared by the best experts in the Special Departments of Science, to the citizens of Indiana—to some extent a contribution to science throughout the world.

JOHN COLLETT,
State Geologist.
PRINCIPLES OF PALEOZOIC BOTANY.

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PRINCIPLES

OF

PALEOZOIC BOTANY.

BY LEO LESQUEREUX.

§1. EXPOSITION.

Vegetable or phyto palaeontology (phuton, a plant, palæios, ancient, logos, word), a branch of science intimately related to geology, considers the vegetation of our globe during the different epochs anterior to the present times, directing its researches and study to the plants which, found in a fossil state, are known to have inhabited the earth or the sea from the first apparition of vegetation until now. This, of course, implies the well known fact that this world of ours has not remained the same since its origin; that it has been subjected to great and gradual changes; that the plants which inhabited it in former times are not the same as those of the present.

It is the history of the ancient vegetation that vegetable palaeontology is trying to decipher and interpret. From mere fragments of wood, bark, and leaves, all transformed into stone or imbedded in the rocks, palaeontology is able to gradually reconstruct some kinds of plants, and to discover not only their nature by a more or less distinct relation to the vegetables living now, but the physical circumstances which have fostered their growth. It thus explains the atmospheric variations of the long series of ages preceding the advent of man, and is able, at the same time, to trace, in connection with animal palaeontology, the succession of the series of layers which constitute the crust of the earth, and the relative age of each of them. Thus a mere leaf, or the mere fragment of a plant, indicates the age and nature of what is called a geological formation; a series of deposited materials, for example, like those interstratified with coal (the carboniferous), or those containing oil or other kinds of minerals.

I do not intend to give here a description of all the characters of the plants which are known to have inhabited the earth at different epochs;
still less could I now interpret the natural phenomena which have influenced successive modifications in the vegetable kingdom. I wish only to trace the first principles of a science which opens to the mind a most pleasant and attractive prospect and explains the work of the Great Creator of Nature in gradually building the habitation of man. Not as a work limited or dwarfed by fallacious theories of the human mind, but as it really is, an exposition of the sublime wisdom, the prescience and providence of the Great Architect, traced by the plants of the ancient ages or by their remains in the rocks, quite as evidently as his eternal, infinite, and divine essence is demonstrated by the Heavens.

II. THE CONSTRUCTION OF THE CRUST OF OUR EARTH, OR, IN GEOLOGICAL PARLANCE, THE FORMATIONS.

The most true and sublime passage written by Moses, in exposing his system of the cosmogony of the world, is that in the first and second verses of the first chapter of Genesis: "In the beginning God created the heaven and the earth. The earth was without form, and void; darkness was upon the abyss and the Spirit of God moved upon the face of the waters." The word move here implies action, work—the same sense as given to the words of Christ when he says: "My Father worketh hitherto and I work." (John v., 17.)

Like the innumerable bodies scattered in the heavens, some of them brilliant, some others darkened by a vail of opaque matter, our planet was originally a nucleus, a fiery furnace of molten matter, surrounded by a compact mass of vapors. These vapors, in coming near or in contact with the burning mass, were for a long time immediately dilated by heat, expanded and forced upward, so that no water could be permanently deposited upon the surface of the earth, and no ray of light could reach it. It was only after the surface had been gradually cooled, when, like a boiling semi-fused bed of lava, it had been upheaved at some places, traversed in various directions by wide undulations, eleft in deep fissures or crevasses and rendered somewhat solid, that the surrounding vapors could reach the earth like torrents of rain and fill more or less wide and deep basins where the waters were gathered. Thus land and water became separated; thus the rarified vapors of the atmosphere gave passage to light; thus the rain, falling on the still heated crust of the earth, began decomposing, loosening and scattering particles of matter, which, gathered by water, were transported by their course and spread at the bottom of the basins. Thus gradually the thickness of the crust was increased, the surface became gradually more cooled, the separation between land and water was more distinctly fixed, and, after a long period of time, the earth became prepared for the habitation of plants and animals.
Of course the earthy materials, either in the water or scattered on the surface of the primitive still heated rocks, were not fit for the life of highly organized beings. But, judging from what we see at the present times, vegetation has appeared in its most simple representatives as soon as the water could be permanently gathered into basins, or at a degree of heat slightly lower than that of the boiling point. In the hot springs of Arkansas and those of the Yellowstone, plants named Conferve, long, green, thread-like filaments, fill basins of water of a temperature of near 100° Cent., the point of ebullition where water is forcibly vaporized. Hence we can surmise that in the first layers of sediments of matter, transported and deposited by water, one may expect to find the first traces of plants preserved by fossilization. It is therefore from this point that we may begin explorations for the discovery of remains of plants and researches upon their nature and their gradual development.

Before coming to this, it is advisable to further consider the mode of increase in the thickness of the crust of the earth, the origin, the succession and distribution of the materials which have entered into its composition and the changes which have occurred in the gradual construction of the great building from its origin, when nothing could live in the water but a film of green coniferve, to its completion, when, as man's habitation, it became covered with a multitude of beings, plants and animals, all contributing to the advantage of the human race. The following short explanation is merely an exposition of the first principles of Geology.

§3. COMPOSITION OF THE CRUST OF THE EARTH.

The primitive rocks are composed of materials originally in fusion, either exposed after cooling from the nucleus of the earth or thrown out by eruptions of the volcanoes like lava. These rocks, like the first layers of materials deposited upon them, which were transformed either by heat in their contact with the molten mass (metamorphic rocks) or by amalgamation of their elements with those of the surrounding vapors, do not contain any remains of animals and plants. They constitute in their thickness and distribution the first group of stratified rocks, named by geologists the Archean or Azoic (a without, zoës life). This formation is necessarily omitted in the present remarks on the ancient vegetation of the earth, as it is only in the later strata or layers composed of deposits of transported materials that remains of organized beings have as yet been found.

The work of building up the thick crust of earth by successively deposited materials being continued at the present epoch, it is easy to have an idea of the means employed by nature for the construction of the more ancient layers, which serve as the base of the great edifice.
Atmospheric influences, the alternation of cold and heat, the winds, the rain, etc., tend to produce a continual disintegration of the rocks into more or less minute particles of matter, which, falling into the water, are transported by its movements, sometimes to long distances, and strewn either along the borders of the currents from streamlets to streams, then to the rivers which throw them and heap them in banks into the sea. The waves of the sea constantly driven by winds and currents against the shores, break and grind into powder even the hardest rocks, and the debris drifted around are deposited somewhere at the bottom, the heaviest nearest to the shores, forming banks of pebbles, sand, mud, or other materials. The ice also breaks the rocks by gradual disintegration or by the movement of the glaciers, and the crumbled debris is either transported by floating banks of ice, cast forth and scattered to the bottom of the sea, or is pushed upon the surface of the land, sometimes in wide deposits of rounded blocks, pebbles, gravel or sand. As the largest heaps of transported materials have been deposited in the sea by the course of the great rivers, or by the movement of the waves, most of the formations are marine and have the greatest thickness and the widest extent. But land has also contributed its share in the construction of the earth's crust, either directly by its vegetation, forming heaps of combustible mineral, coal, lignite, peat, humus, or layers of iron ore by the work of infusoria, minute beings observable only by the microscope; or indirectly by the accumulation of particles of matter deposited in fresh water basins, forming especially beds of clay, or by condensation of the elements held in solution in the water, and by atmospheric action transformed into lime, silex, etc. In the deposits of the sea, remains of marine animals and of marine plants are more or less abundantly found, while land and fresh water plants and animals are mixed in the clay and other land materials. We have thus already two distinct kinds of strata, representing first, the marine, and second, the fresh water formations.

The superposition of the layers of matter is a result of their mode of deposition. In the sea, the constant movement of the water, especially the currents, displace the materials at the bottom, transporting them and strewing them along their courses, heaping them in some localities, while they are taken from others which are left waste. The same action is seen in the bottoms of large rivers, where gravel, sand and mud are constantly displaced and deposited again here and there, new materials upon the old ones, and gradually pushed farther down by the movement of the water. Naturally it is near the mouths of large rivers like the Mississippi, the Nile, the Amazon, that the materials are more abundantly carried, and successively deposited near the land or farther into the sea, according to their size or density. There the currents vary each year, either in force and velocity, or in direction; and each year, also, the layers of drifted matter are differently distributed around and superposed.
One year sand comes along one of the branches of the river; later, the outlet is closed and for a time nothing may pass through the channel; it becomes a bayou whose bottom is gradually covered by a bed of dark mud composed of remains of plants, shells, etc. Later, in a period of very high water, the channels are opened again and over the first deposits of sand and mud a bed of gravel may be spread, thus producing alternate layers of different natures.

On another side, local swellings and depressions of the crust of the earth were extremely frequent and active in the first ages of the world, when the crust, still thin, was under the more direct influence of the internal heat. These local upward and downward movements, though much less marked now, are, however, observed in different countries where the shores are gradually upheaved, the sea receding from them, while at other localities they are gradually depressed, and thus invaded by the ocean. It is to these movements of the crust that are due formations covering wide surfaces, sometimes whole continents.

There has been on the surface of the earth a succession of local changes of level, sometimes persistent for ages, which have naturally greatly modified the local deposits, very thick at some places, totally absent at others, and have produced local differences in the nature of the layers, and in their direction or angle of stratification, which correspond to the angle of superposition.

The deposits successively made on the surface of the earth, either above or under water, and for a countless number of ages, have been gradually hardened and modified in their compound and transformed into beds of sandstone, limestone, clay, siliceous or ferruginous rocks, according to the elements of which they are composed. They have thus formed the so-called stratified rocks whose study is the province of geology.

§ 4. GEOLOGY, ITS PURPOSE AND ITS WORK.

Geology is a complex science. A thorough comprehension of it requires a knowledge of divers subjects which, separately considered, necessitate long and difficult study. For it has to search and determine the nature and relative position of the series of all the stratified rocks, which, if they were heaped at the same locality, would show a thickness of twenty miles or more. It has been said above that the age of the strata is attested by the remains of plants and animals which, either marine or of fresh water or of land origin, are found imbedded into the rocks. It will be seen hereafter that the beings which have at successive epochs inhabited the earth, either plants or animals, have become more and more highly organized from the oldest times to the present, and therefore geology is able to fix the characters and the relative age of the different layers from the study of the remains of organized beings discovered in them. This, of
course, necessitates for the geologist an acquaintance with animals and plants living at our time as points of comparison for the anatomy of fossil remains.

Geology has also to study the constituents of the rocks, by chemical analyses, in order to recognize the nature of their compounds, which, like some minerals, may be used for the advantage of man. Hence its domain is immense. It bears upon the interest of all the conditions of the existence of man, and though of difficult access, some of its more valuable and productive divisions are accessible to every man of intellect. For the analyses necessary for the determination of a bone, of a plant, or of any kind of mineral, are made by competent specialists, and therefore every one has the means of ascertaining the value of the discovered materials and the mode of pursuing the researches with advantage and pleasure.

From the characters of the remains of organized beings preserved in them, the strata of the earth have been divided into three great periods of time: First, the Paleozoic, which follows the Azoic or Archean; second, the Mesozoic (mesos—middle), and the Cenozoic (kainos—new or recent).

The Paleozoic time has three essential ages: The Silurian, or the age of invertebrate animals; the Devonian, the age of fishes; the Carboniferous, the age of plants. Each of the ages is subdivided into periods. The Mesozoic time, or reptilian age, has three periods—the Triassic, the Jurassic, and the Cretaceous. The Cenozoic has the Tertiary age, and at its end the Quaternary and the Era of Man.

In this memoir, and for the present, the vegetable paleontology of the Paleozoic times only has to be examined.

### §5. MODE OF PRESERVATION AND FOSSILIZATION OF VEGETABLE REMAINS.

Plants are fossilized for ages, and preserved: First, by entombment; second, by carbonization; third, by impressions or casts; fourth, by infiltration or impregnation of foreign substances generally held in solution by water.

a. Entombment or Burial.

Vegetable remains covered or surrounded by compact impermeable materials before their decomposition, have been sometimes preserved without any modification of their original structure. For example, leaves, flowers, or small fragments of plants are now found imbedded in pieces of amber. Subjected to microscopical examinations, remains of this kind are determined as easily as specimens of living plants. This process of fossilization is explained by that of the deposition or formation of amber. In some
cases, observable upon the peat bogs of the North, the resinous matter exudes, from the trunks of low conifers, in such profusion that the ground at their base is covered with a coating of resin. All the small fragments falling upon this matter are soon imbedded in it and secured against atmospheric influences. The northern part of Europe, during the tertiary period, was covered by vast forests of this kind, which have been buried along the shores of the Baltic Sea, where amber is now gathered.

In other cases, deposits of woods, like forests prostrated by some catastrophe, have been buried by the eruptions of volcanoes under layers of ashes and lava, or other impermeable matter. These vegetable deposits are now found in their original state, the wood perfectly preserved. Some of these beds of lignite, rendered accessible by shafts, are worked like coal mines, and the materials used for fuel. Deposits of this kind are rare, and as yet found like amber in tertiary formations.

But in older formations, even in the carboniferous, isolated fragments of wood, whose structure is still unimpaired, are sometimes found imbedded in very compact rocks. They have preserved, to a certain extent, their primitive nature, the flexible texture of the wood, the bark, even the epidermis.

b. Slow Burning or Carbonization.

Plants growing in swamps or damp places are shielded by immersion in water, or by great atmospheric humidity, against the rapid decay produced by the oxygen of air. The plants do not escape decomposition; but the process, rendered very slow under peculiar chemical modifications, is like that of the burning of wood in closed ovens for its transformation into charcoal. It is in that way that remains of a luxuriant vegetation, heaped each year upon the surface of the swamps, have been gradually transformed first into peat, as in the peat bogs of our tine; then into lignite, by a more prolonged action of the same process, which tends to render the matter gradually more compact; then into coal, from the deposits of vegetable materials of more ancient periods, and to anthracite when the gases have been driven out of the coal by heat.

The plants preserved in this way are generally so mixed and compressed that, after a time, losing their original forms, they constitute a more or less compact mass, and become indeterminable. The coal, for example, when cut in thin lamelle and examined with the aid of a microscope, exposes to view a fibrous or cellular compound, recognized as pertaining to vegetable tissue; but of course the determination of the characters of the plants which have entered into the composition is not possible. Sometimes, however, thin layers of charcoal, bearing impressions of leaf-scars, are observed between layers of compact coal. These impressions indicate the kind of trees from which they are derived, as Lepidodendron,
Stigmaria, or Stigillaria, or even this dry charcoal, as it is named, distinctly preserves the impressions of leaflets of ferns. These remains give a vague insight into the characters of the plants which have entered into the composition of the coal; but the representations are too vague, and rarely interesting to the paleontologist.

c. Impressions or casts.

This process of fossilization is the more interesting to the phyto-paleontologists, who owe to it the preservation of the outlines or surface of fragments of plants of every size. Vegetable remains, leaves, branches, trunks of trees falling into the muddy water of swamps or upon the sand at the bottom of ponds or slow rivers, have been gradually covered by the deposits of soft materials, mud, clay, sand, etc., which have prevented access of the oxygen of air. Gradually, however, the original texture and compounds of the plants have been destroyed, but the impressions of their surface have been moulded upon the imbedding matter, which after the process of hardening has preserved them, often so distinctly, that their characters, the shape, even the nerves of the leaves, the scars of the bark of trees, etc., are easily recognized. Those who have seen specimens of fossil plants taken from the roof of coal beds know how admirably nature has preserved her works; how beautiful are those branches of ferns or other plants with their leaves flattened and compressed as if they had been prepared by drying for an herbarium, with the veins, the minutest teeth, even the hairs of the leaflets distinct, as if the plants were still living.

The trunks and the stems, by this mode of petrification, are generally flattened to a more or less great degree; the original compounds of the plants have been gradually destroyed and replaced by the imbedding matter, sand or clay; but the bark with its surface or merely the impressions are left as distinct as if they had been sculptured upon the rocks. I say that in some cases the mere impressions of the surface are left without any trace of the bark. There is generally an intermediate thin pellicle of coal representing the bark of the trunks in sandstone; but it is reduced to powder and detached on the contact of the atmosphere; thus one finds, especially in sandstone, large trunks of trees, Lepidodendron, for example, forty to sixty feet long and two feet in diameter, whose scars of leaves are distinctly marked from the base to the top without any remains of organic matter to cover them.

Generally, the casts of the leaves show only one of their faces. It is the case in those of the coal, and as there is sometimes a difference in the characters of the upper and lower faces, this may cause some difficulty in the analysis and determination of the leaves. The difficulty is still more marked in casts of leaves of the Cretaceous, which, thick and coriaceous, have the impressions of both faces separated by a thin space, or a thin
crust of matter, in such a way that by cutting the specimens vertically we may get a double impression of the leaves, the upper strongly, deeply nerved, the lower with veins far less marked, or with a facies sometimes very different.

I may mention here, as indirectly referable to the same kind of fossilization, the preservation of vegetable fragments in iron-stone concretions. These concretions, especially abundant at Mazon Creek, Illinois, and near the Little Vermillion River, Indiana, are round or oval generally flattened pebbles, varying from one to forty cm. long or more, the nucleus being either a leaf or a fragment of plant or animal. The concretions are the work of infusoria, small animalcules, some species of which living in water charged with carbonate of iron, congregate around fragments of organic matter and gradually surround them with a thick coating of compact iron-stone or clay derived from their organism. In splitting these nodules in the plane of stratification, the imbedded bodies are found fossilized in a perfect state of preservation, and therefore, the most beautiful specimens have been obtained from these concretions, which are strewn in the roof clay, of some coal beds. The specimens are generally of small size; but they, sometimes, contain remains of delicate plants or animals, which, imbedded by the work of infusoria before decomposition, or while they were still fresh, have escaped the deterioration and destruction forcibly produced by oxygen in shale whose matter is less compact and has been more slowly deposited. Mazon Creek has thus supplied paleontologists with specimens of many species which have not been found elsewhere in the Coal Measures.

d. Fossilization by Infiltration.

In this kind of petrifaction, the vegetables impregnated by water having in solution some kind of mineral substances, like silex or lime, are gradually transformed into stone. Generally the impregnation does not destroy, nor even alter in any degree, the internal structure of the plants. The woody tissue remains unimpaired—only the bark is destroyed.

The anatomy of wood fossilized by this process is made, as for that of living trees, in cutting thin sections or plates both vertical and horizontal, which, reduced to thin slides by the work of the lapidary and polished, may then be studied under the microscope, exposing the tissue to its most delicate fibers or cells.

Trees have oftener been subjected to this kind of petrifaction while still standing than when prostrated. In Colorado, standing fossilized trees have often been formerly observed; they are now mostly destroyed by the work of collectors of specimens. Near the Yellowstone Park, there are whole forests of silicified trees imbedded in sandstone; but many of the standing trunks have been bared by disintegration and erosion by water of the matter in which they have been buried. Trees fossilized in that
way are, however, rarely found in their original integrity of size, for, as soon as separated from the imbedding matter, they break, mostly transversely, in fragments of various length, which are strewn on the surface or buried in the sand. Such are the trunks of tree-ferns abundantly found on Shade River, near Athens, Ohio. As shown by their fragments, the trees from which they are derived had mostly a diameter of 15 to 30 cm. Few are smaller, some much larger. An exactly cylindrical trunk of a tree-fern, a fragment measuring 60 cm. in diameter and of the same height, was dug out of a creek near Shade River and transported to the Museum of Comp. Anatomy of Cambridge, Mass. This mode of breaking is, however, not always the same, for near Gallipolis, O., there are some prostrated silicified trunks protruding from a bed of sandstone. They are solid in the whole exposed length, without appearance of transverse breakage, with this peculiarity, however, that a part of the wood has been fossilized into limestone, another part into silex, and this without distinct transverse separation. The parts silicified and petrified are here and there horizontally intermixed with other materials, as if the trees when prostrated had been impregnated in places by water containing different elements in solution.

The process of infiltration into the wood, of mineral matters soluble in water, presents so many apparent deviations from a common law that it can not be fully explained. At the present time, the water of some hot springs charged with carbonate of lime or other mineral substances in solution covers with a crust of hard deposits every kind of solid materials, organic or inorganic, which are immersed in their basins. The same phenomenon happens by the percolation of spring water charged with lime, made soluble by carbonic acid, upon leaves or other organic remains. The carbonic acid being set free by contact with air, the carbonate of lime is deposited. Materials of this kind named tufa are observed at different epochs. But the process is not a true petrification; it does not change into stone the compounds of the encrusted bodies, but only covers them with a hard stony deposit. The fossilization by infiltration is more like the impregnation of wood produced by aspiration of the inner texture, a kind of capillary suction, which forces a fluid matter to ascend and penetrate whole trunks when they are immersed in it by their base, or like the movement of the water ascending the inside of the stems of the flowers when their base is immersed.

It has been supposed that the water charged with minerals in solution was derived from hot springs in the vicinity of volcanoes and widely distributed over the surface of the land, a fact which might be corroborated by the silicified forest of the Yellowstone, but which is contradicted by the silicified trunks so abundant in the south of Ohio, where no trace of disturbances of surface resembling the influence of subterranean heat has ever been observed.
Marine plants have been sometimes, not preserved, but traced or delineated by infiltration. When deposited upon sand or permeable rocks, the cellular tissues, becoming softened or fluid by decomposition, impregnate the surface of the sand or of the rock, marking upon it some indistinct design or outline of the vegetable form. Of course the specimens bearing impressions of this kind are of little value, as they offer but a vague representation of the original forms of the plants.

6. HOW TO SEARCH FOR, AND COLLECT, SPECIMENS OF FOSSIL PLANTS.

The plants, like the animals of the ancient epochs, have left only fragments of their bodies in the numerous layers composing the crust of the earth. Not a single plant has been found preserved fossil in its full integrity with stems, leaves, flowers and fruits attached to their supports. Therefore, often, only one or two of their organs can be found. Thus, pieces of petrified wood, leaves especially, and hard fruits, are generally all that can be obtained for the study and the determination of a plant. Everybody knows how far different, even upon the same plant, are the organs which compose it. Taking only the leaves, for example; a single tree has them all more or less different, in shape and size, even in the disposition of the nerves (the nervation), which is of great importance for their determination. It is therefore easily seen that a paleontologist has more chance of coming to a better understanding of the characters of a plant in proportion to the number of specimens which represent it. If the collectors for show cabinets select especially specimens of fine appearances, the collections for study should always have as large a number of specimens known, or supposed to belong to the same species, as possible. Therefore, in cutting stones for specimens, great care must be taken to preserve all the vegetable fragments derived from the same piece of rock; or, when search is made in mines, it is always advantageous to select and compare plenty of specimens around the same place, in order to find, if possible, the different fragments which may belong to a plant or represent it. When large portions of plants, branches with their leaves and fruits, have fallen to the surface of the bogs and entered into decomposition, their parts gradually separate; first the leaves, then the fruits, then the small branches, and, after all, the large stems; but this separation generally leaves the different parts in proximity and therefore the researches upon the same place offer more chances of obtaining a whole subject, or a large portion of it; and it is not only the leaves of separate fragments which have to be studied, but their mode of attachment, the mode of division of the branches, the bark, the scars upon it, which are all of importance for determination.

No positive directions can be given on the probability of obtaining specimens in the rocks according to their different components. Limestone and
sandstone formed at the bottom of the seas, have mostly animal remains, sometimes mixed with marine plants. Even land plants, like floated trunks or branches, may be found in rocks of this kind. But this is very rare. Brackish shells are, however, mixed with remains of plants in the roof shale of some coal beds. For, sometimes, after the heaping of woody debris, the surface of the deposits has been slowly invaded by the water of inland straits or bayous, inhabited by shells, which have, of course, been gradually brought with it. As the surface of the bogs was for a time covered with some kinds of plants of the coal age which had continued their vegetation in the water or above it, supported by hillocks, at the base of the trunks, remains of plants and animals have been there mixed together. But generally the best specimens of fossil plants are found where plants have lived alone, and this is generally the case in the carboniferous formation. It is, therefore, by splitting in the line of stratification the schist or slates of the roof of the coal beds that the finest specimens of fossil plants are found in this country. For this, a hammer pointed on one side and sharpened on the other, like a small hatchet, is the more valuable instrument, even the only one needed. And whenever one interested in the discovery of specimens and in their collection has his habitation in the vicinity of a worked coal bed, or still better, when one is the proprietor of a seam of coal, he may easily interest the miners in researches and obtain very valuable specimens from them. A proprietor in Pennsylvania has thus procured from a single bed of coal, and with the assistance of his miners, an immense amount of materials, representing not less than one hundred and eighty species of coal plants.

§ 7. THE NUMBER OF FOSSIL PLANTS KNOWN FROM THE ANCIENT FLORAS OR WHICH HAVE BEEN FOUND AT LOCALITIES REPRESENTING THE SAME AGE, AND THEIR VALUABLE IN RELATION TO BOTANICAL SCIENCE.

The plants preserved fossil are always very few in comparison with those which were living at the time when some of them were imbedded in the mud, sand, or soft materials, to be thus guarded against decomposition. The present flora of the borders of a lake or swamp, represents a mere, generally unimportant part of the vegetation of a whole country. Of any local group of plants, a few only may fall as debris into the mud or the imbedding matter, and of the imbedded fragments, a limited number only are discovered by researches; for the discoveries are rare and depend on peculiar casualties, or on peculiar kind of works like quarries, tunnels, etc. The chances of obtaining a tolerably good representative of an ancient flora are thus very few, except perhaps for that of the carboniferous. It is, therefore, difficult to make a comparison between the floras of the ancient formations and that of the present epoch.
The number of fossil plants known until now from all geological formations does not represent more than six thousand species, while the flora of the present time, taken in its whole, would probably, if entirely known, comprise more than one hundred and fifty thousand species; the phanerogamous plants alone described until now amounting to eighty thousand species. The difference is enormous and at first sight seems to imply an immense superiority of the richness of the flora of this epoch over that of the ancient ones. If, however, the comparison is restricted, as it ought to be, to plants inhabiting local areas of reduced space, to the number of plants now growing at certain localities which may be supposed of a superficial extent equal to that where a number of fossil plants have been discovered, the differences will appear of far less importance. For example, a recent catalogue of the plants known as living in and around the District of Columbia, published in 1881 by the Department of the Interior, enumerates eleven hundred species of phanerogamous plants. Another catalogue of the species observed around Buffalo, in a circle whose radius is more than fifty miles, has twelve hundred and seventeen species; while a third catalogue, that of Yale College, enumerates twelve hundred and thirty-three species, growing within thirty miles of the College. From these enumerations, and from a number of others published of different localities, one may admit that in the United States, eleven to twelve hundred species, inhabit a surface of thirty square miles, or about fifty species per square mile.

Calculations of this kind are always hypothetical in a great degree, as the vegetation varies in different localities, according to the local circumstances, nature of the soil, temperature, etc. They may serve, however, to show that, against the assertion made to the contrary, the fossil floras of the ancient epochs are sometimes locally represented by a number of species indicating a richness of vegetation equal or surpassing that of our present time. In an introduction to a work on Paleontological Botany, considered in England as reliable authority,* it is asserted that each coal bed has had a very limited amount of species of plants contributing to its composition. "Their number, it is said, particularly in the ancient beds, is rarely more than eight to ten species. In other cases it is more considerable, but rarely above thirty or forty." In the coal beds of Cannelton, Penna., which is worked on a very limited area, one hundred and forty species have been described from a very large number of specimens obtained there by systematic researches. The specimens here positively indicate the components of the coal, for they are derived, not from the top shale, where the vegetation might have been modified by peculiar circumstances after the deposits of combustible materials, but from the bottom, a hard compact cannel shale passing above to Cannel coal by a gradual

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* Introduction to the study of Paleontological-Botany by Balfour, (1872).
diminution of the muddy matter originally deposited with the vegetable remains. In the nodules of Mazon Creek, Illinois, derived from a bed of soft clay overlying the coal of that locality, one hundred and fifty species have been obtained already; and from the same shale, above the coal of Morris, eight miles distant, where the same bed of coal is thick and worked, sixty more have been found, of which fifty have not been as yet observed in the concretions of Mazon Creek. Adding both numbers it is seen that from what is known now, two hundred species of plants have contributed to the composition of a single bed of coal, and this in an area of less than ten square miles. If we would add to this the species of plants discovered at Murphysborough, Illinois, and Clinton, Missouri, where the same bed of coal is worked, the number of species would amount to two hundred and fifty.

The formation of coal is comparable to that of the peat bogs of our time and both materials have been produced under peculiar circumstances, especially superabundance of humidity, and with peculiar kinds of plants. For, as far as can be judged from the observations made in France, there was at the carboniferous epoch a flora inhabiting dry land, different in its characters from that of the bogs, where the coal was in process of formation. At the present time the flora of the peat bogs, well known to be limited in its characters as in its habitat, is composed of one hundred to one hundred and fifty species of plants, according to the localities where peat bogs have been formed. Pursuing our comparison on this new ground we must recognize here in the flora of the carboniferous epoch a far greater richness than in the flora of the peat bogs of our time; for as yet, more than nine hundred species of plants are known from the carboniferous formation mostly found in connection with beds of coal.

And now, still taking for another point of comparison the plants which at the present epoch have been found in such a state, where either imbedded in clay, or entombed in lime deposits, or heaped and covered with sand, they may seem prepared for fossilization, we are still surprised to find an inferiority of the representatives of the present flora as compared with the ancient vegetable fossil remains. The leaves of a single swamp, found still recognizable in the muddy deposit, do not represent more than twenty species. In the tufa, produced by the deposits of carbonate of lime, I have never found more than a dozen species; this, however, in deposits of limited extent. Near the mouth of the Ohio River, between the Cumberland and Tennessee Rivers, there is a very thick accumulation of leaves and fruits, materials heaped along the borders like a wall, four to eight feet high, mixed with sandy mud and in a very good state of preservation. They represent of course, by floated remains, the present arborescent and bushy vegetation of the borders of the river, a number of species amounting to one hundred to one hundred and twenty-five, when certainly
from the heaped fragments no more than forty species could be determined.

Though great may have been the richness of the ancient floras, their study is rendered difficult by the deficiency of the fossil specimens. As it has been said above, the remains of plants of the ancient epoch are all more or less fragmentary. Of all, we have mere parts, representing one or two organs of the plants, all the others being destroyed. For this reason, the study of paleontology is not only discouraging, but its conclusions are uncertain and more or less unreliable. As it will be seen hereafter, however, there are often, even in the smallest fragment of a plant, some peculiar marks—characters, which indicate, if not its specific, at least its generic affinities; and certainly now, although still in its infancy, vegetable paleontology has procured, on the nature of the plants of the ancient epochs, on their relation to those living at our time, on the atmospheric circumstances which have governed the earth and influenced the vegetation at divers periods, data of such high value that it is now generally acknowledged as the faithful and reliable assistant of geology. Another important service rendered to science by paleontology is its positive exposition of the gradual development of the vegetable types, from the first apparition of the plants until now. This will be put in evidence in the following chapter.

§ 8. THE PRINCIPAL DIVISIONS OF THE VEGETABLE KINGDOM AND THEIR GENERAL DISTRIBUTION IN THE GEOLOGICAL PERIODS.

The plants inhabiting the earth, either on the land or in the water, are considered first in five principal divisions. First series. The Cryptogamous or acotyledonous cellular plants. Second. The vascular acotyledonous or Acrogerens. Third. The Gymnosperms (phænogamous). Fourth. The Monocotyledonous. Fifth. The Dicotyledonous. These great branches are subdivided into classes, orders, or families, genera and species. The most essential subdivisions only can be mentioned here.

First. The Cryptogamous or acotyledonous cellular are the Fungi (mushrooms) the Lichens, both land plants, of which few have been preserved, fossil, and the Algae, either marine or fresh water plants.

Second. The Cryptogamous vascular plants or acrogerens, omitting the Characeae and the mosses which are not represented in the old formations, have the Equisetaceae (the Horsetail family), the Filicites (Ferns), and the Lycepodiateceae (Club moss family).

Third. The phenogamous gymnosperms have the Cycadaceae (mostly now tropical or equatorial plants), and the Conifers, which include the great family of the Pines.
Fourth. The Monocotyledonous plants which have generally long ribbon like leaves, with parallel nerves, like the grasses. To them belong the great family of the Palms.

Fifth. The Dicotyledonous plants, whose leaves are of various forms, generally falling in winter, at least in the northern climate, and which constitute the essential part of the present vegetation.

According to their distribution, that is their great degree of prevalence at different periods of time, the plants represent in their successive development four principal epochs or reigns.

First. The reign of the Thallassophites (Thalliasso, the sea, and phuton, a plant). The marine Alge are already abundant in the Silurian. Some of them are represented Pl. 1, Figs. 1–8. But though only indistinct remains of vegetables have been recognized in the Cambrian, the presence of graphite in the rocks of that age, that also of carbonaceous substances which have blackened whole beds of slates, seem to indicate that some kind of vegetation was already then predominant and entered into the compounds of that oldest geological formation.

The reign of the Thallassophites, as referable to the times when the Alge were the only representatives of the vegetation, has been until now extended to the middle Devonian. But recently remains of land plants have been discovered in the middle and upper Silurian, and therefore the first epoch has to be much reduced in time. This, of course, will not say that the Alge have ceased to exist in the Silurian or the Devonian. They have continued their life until the present time in all the localities appropriate to it, and even they have probably greatly increased, if not in the number of their representatives, at least in diversified specific and generic forms. But until the middle of the Silurian, as far as we know, they reigned alone without land plants.

The second epoch, that of the vascular cryptogamous plants, includes the Devonian, the Carboniferous, and the lower part of the Permian. The vegetation of that epoch was composed essentially of Ferns, Lycopodiaceae and Equisetaceae, with some phenogamous gymnospermous plants, which by some paleontologists are referable to the Cycadaceae, by others to the Conifers, but which seem to represent an intermediate group partaking of some of the characters of both these families. Large fossilized trunks are found imbedded in the black shale of the Devonian, in Indiana and Ohio especially. By analysis of their internal structure the woody tissue is seen composed partly of dotted ducts or vessels, like the wood of some Conifers. It is probable, however, that these trunks are derived from Cordaites, a genus abundantly represented in the Devonian and the Carboniferous by large trees which, as it has been recently found, have in the texture of the wood the same kind of perforated ducts. Hard fruits distributed, sparingly in the Devonian already, but abundantly in the Carboniferous, are
mostly derived from these Cordaites, and by their characters also they indicate a relation to the Cycadeae as well as to the Pine family, as we shall have occasion to see in the examination of their remains.

The third epoch, known as the age of the Gymnosperms, is counted from the middle of the Permian, continuing through the Trias and the whole Jurassic period, represented as it is especially by the Cycadeae and the Conifers with ferns and already a few Monocotyledonous plants. But already in the lower Permian some Gymnospermous and traces of Monocotyledonous plants are found.

Through the immense number of ages occupied by divers formations of this vegetable epoch, the vegetation has been subjected to gradual modifications which may be recognized in examining the characters of the plants and which gives occasion to a number of more or less important subdivisions. But it suffices to say now, merely to give an idea of the length of time represented by that period, that in some parts of Europe, for example, the Jurassic formations have a thickness of not less than fourteen thousand feet of successive strata, some of which are composed mostly of remains of animals, especially shells.

The fourth epoch apparently begins with the Cretaceous. It is that of the Angiospermous or Dicotyledonous plants, which gradually increase in development through the Tertiary to the present time, when they constitute the essential part of the vegetation. They, with the Conifers, mostly compose the flora of the temperate regions of the earth. Oaks, maples, poplars, hickory, willows, etc., belong to the great branch of the Dicotyledons.

The appearance of these plants in the Cretaceous is a remarkable phenomenon. In the lower strata of the formation in Greenland a single species of Dicotyledons, a Poplar, has been found mixed with the remains of ferns, Conifers, and other vegetables of the third epoch, and already in the middle Cretaceous of North America, named the Dakota group, the Dicotyledons are found in a predominance quite as marked, if not more, as it is at the present time, and representing a number of types still remaining in the North American flora, like Poplar, Plane trees, Beech, Oak, Magnolia, Tulip trees, Sassafras, Persimmon, etc. This vegetation, so different from that of the third period, seems like a spontaneous apparition, or creation, and has greatly interested paleontologists. But it is evident that from the Jurassic to the middle of the Cretaceous, a long succession of ages have passed, all with their successive groups of vegetation of which we know nothing as yet. The gradual modification of these groups may be hereafter opened to the study of the paleontologist by new discoveries. For vegetable paleontology is still in its infancy. Its progress, formerly very slow in this country, is now rendered more active by the prodigious abundance of fossil remains discovered in the strata of most of the formations of North America,
and by the impulse given to researches by the numerous scientific institutions and associations lately founded. Thirty years ago the coal flora of this Continent was known only by about twenty species sent for determination to Brongniart, the celebrated French Paleontologist; now the North American coal flora counts more than seven hundred species. Fourteen years ago nothing was known of the Dakota group flora, of which more than two hundred species have been now described, or examined from an immense number of specimens. It is the same with the tertiary flora, of which also five to six hundred species are known. Hence, the progress is very rapid, and shows what may be expected from future explorations, which are now greatly facilitated and encouraged by the geological surveys.


First and Second Class. Fungi and Lichens.

It is scarcely worth mentioning these classes of vegetables, as very few, if any, of their remains have been found fossil in the paleozoic times, or even in the recent geological formations. Both these classes of plants, the first especially, are very numerously represented now. They inhabit the ground, the bark of trees, the vegetable in process of decomposition, even the hardest stones. Of mere cellular tissue, they have been destroyed easily by atmospheric action. Fungi of a certain order, generally very small, are now found everywhere attached to the leaves or the decaying wood, etc., resembling small spots, round points or variously curved lines. These have been sometimes observed upon plants of the cenozoic formations, and also, but very rarely, on fossil remains of the Mesozoic. The stems of the coal also are perforated by small round or oval depressions, which may be taken for fungous impressions. But they have not been as yet, distinct enough to afford positive determination. Perhaps the organism the more positively referable to a Mushroom in the carboniferous, is that which I have discovered under the bark of a Sigillaria, in Pennsylvania. Its characters recognized by competent botanists are those of Rhizomorpha, a kind of plant represented by long intertised filaments, stems or radicles, of an adventive vegetation formed under the bark of trees, and from which, certain species of Mushrooms are derived. These peculiar remains, Rhizomorpha Sigillaria, has been described and figured in the United States Coal Flora, p. 3, pl. 13, f. 2.

Of the Lichens scarcely any species has been described fossil, except from fragments imbedded in amber.
REPORT OF STATE GEOLOGIST.

Third Class. Algae.

These plants, mostly water plants, named Thalassophytes, when they live in the sea, Hydrophytes, when they inhabit fresh water, are extremely variable in their forms, and therefore, numerous in their species.

The fresh-water Algae are of a soft tissue, generally in thin filaments, easily decomposed after death, either in water or under atmospheric influence. Their remains are, therefore, rarely preserved, and it does not appear that any of them have been discovered in the paleozoic formations. These plants live in shallow ponds, canals, or any other kind of basins of stagnant water. Their part in the economy of nature, though unapparent it may be, is not without appropriate value; for, by their growth, they cleanse stagnant waters of a part of their impurities, allaying their miasmatic influence; they feed by their vegetation an immense number of small molluses and other animals, and by their detritus constitute a kind of clayey mud, rapidly deposited at the bottom of the basins and gradually forming layers, sometimes of great thickness. In some countries canals or basins of wide extent prepared by man for ornaments in parks or by nature in land depressions, are filled with half a foot of muddy deposit in one year. This mud, by compression and the introduction of some mineral elements soluble in water, becomes a siliceous compound, a kind of clay, like that which underlies most of the peat bogs, rendering the basins impermeable and appropriate to the growth of the plants which enter into the composition of the peat. As most of the coal beds are underlaid by a bottom clay of the same appearance as that under the peat bogs, it is probable that the origin of that matter is partly due to the vegetation of fresh-water Algae of the carboniferous times. As no fragment of these plants is preserved in the mud deposits of the present epoch, we can not be surprised if none of them are found in the clay of the old formations.

The marine Algae, though generally of a soft tissue, are less rapidly destroyed by maceration. Some even are hard, coriaceous, and of these many have been fossilized. These plants are extremely numerous and varied in their forms. Some were simple cells, microscopical in their size; others very long, linear and simple; others divided into an inconceivable multiplicity of branches; others still, very large with trunks of a foot or more in diameter or with stems hundreds of meters in length. Either regular or irregular in their divisions, always elegant in shape, of a most pleasant and attractive aspect, being diversely, often brilliantly, colored, they form in the bottom of the sea like floral gardens of admirable beauty, or sometimes compose at the surface of the ocean immense carpets of a vegetation, which, of great thickness, covers thousands of square miles of surface. Such is the Sargasso Sea, between the
Canary Islands and Terre Nova, where the progress of ships is often retarded and even stopped by the compact tissues of the inter-woven plants. The floating prairies between the Kurile Islands and Japan are also of this kind.

It is certain that the marine Algae have in the economy of nature a part which, though still somewhat unrecognized, can not be less important than that assigned to land vegetation. They feed an immense number of marine animals, they keep the water of the seas clear and pure, they give to man fertilizers for the land, food, coloring matters, a number of valuable compounds for domestic use, like soda, and others obtained by chemical agency. But they are useless for fuel, their texture being merely cellular, not fibrous and woody.

This fact of course eliminates the hypothesis of some naturalists who have supposed that the marine Algae had in the ancient epochs contributed to the materials of the coal beds, by the deposits of their remains. When rapidly decomposed under atmospheric influences, the marine plants pass to a fluid state, or when coriaceous, they are dissolved under the alternate action of dryness and humidity. The heaps of wrack, or of hard species of marine Algae thrown upon the beach by the waves, do not become compact or dry, and can never be used for fuel, like peat; they gradually pass at the base of the banks into a half fluid matter, which percolates through the sand. But it is very probable that the Algae of ancient formations may have, by the decomposition of their debris, contributed to the formation of mineral oil, and filled the vast reservoirs of this precious matter now so greatly used and no less important for the progress of the civilization of our age than have been the deposits of land plants, which have formed the coal. For the remains of marine Algae are sometimes found in paleozoic strata in prodigious abundance. Whole and thick beds of the Devonian are filled with these, and in some rocks where marine shells have been left in small cavities, and where marine plants appear to have been decomposed, the casts of shells are filled with mineral oil.
§ 10. DESCRIPTIVE PART.*

FIRST SERIES—ALGÆ.

The examination of the fossil Algae is forcibly restricted to short descriptions of the few genera and species more definite and more interesting in their characters.

Soft plants, like Algae, have been generally badly disfigured by compression and partial decomposition, and nothing has been left for their analysis but impressions of their outlines, which are very rarely marked by peculiar recognizable characters. For this reason Brongniart and other phytopaleontologists had admitted for the species of the marine Algae the common generic name of *Fucales*, which signifies a plant more or less like a *Fucus*. Though the genus is still preserved, for some more recent species, authors, among others Schimper, in his Vegetable Paleontology, have modified the genus to a more or less great degree, by subdivisions which, like most of those established for fossil plants, are artificial; for they depend upon characters which, observable upon fossil specimens, are supposed to be identical with some of the more striking ones observed upon living plants, like the form of stems, leaves, etc., and which are of no real importance for a classification based on nature (natural classification). Of course the paleontologist has to search carefully for points of affinity between the preserved organs of fossil plants and those of living vegetables, in order to fix a classification as closely related as possible to the order established by nature. But sometimes, no real points of correlation can be found, and this is the case with the Algae. For example, the botanists for the description of the living marine plants, now have divided the whole series into three essential families or sub-classes as follows:

1. **Melanospermæ** (*melanos*, black—*sperma*, seed). Plants olive green or olive brown in color; fructifications monoeious or dioecious.

2. **Rhodospermæ** (*rodeos*, rose color). Plants rosy red, purple, rarely brown or greenish red; fructification dioecious.

3. **Chlorospermæ** (*chloros*, light green). Plants grass green, rarely of a livid purple; fructifications disposed through all parts of the fronds, every cell being capable of having its contents converted into spores.†

As the spores or seeds of the *Algae* can be discovered only by microscopic anatomy, and as the color of the plants is never preserved in a fossil state, it is clear that a classification of this kind can not be taken into account for the study of the remains of fossil *Algae*.

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*Some of the descriptions are borrowed or modified from my work, U.S. Coal Flora, report P of the Second Geol. State Survey of Pennsylvania.*

†W. H. Harvey, *Nereis borealis—Americana.*
I shall, therefore, merely remark here upon some groups or species of *Algae*, classing them according to what is known of their distribution, first, in the Cambrian and Silurian; second, in the Devonian; third, is the Carboniferous.

1. CAMBRIAN AND SILURIAN *ALGAE*.

OLDHAMIA, *Forbes*.

Plants composed of thin filaments of equal length, with flexuous or dichotomous divisions, disposed star-like around a central point.  
*O. radiata*, Forb., pl. 1, f. 2 (3 enlarged), Cambrian rocks, Ireland.  
These remains, as yet extremely rare, are still problematical in their nature and in their relation. Some paleontologists have considered them as being those of animals, Ascidians or Bryozoans; others see in them merely tracks of some kinds of worms; others, among them Schimper, who has had for examinations the best preserved specimens of this kind, admit them as plants related to the Nullipores or Coralines, a group which is still represented in the vegetation of the seas by species of beautiful and large plants, whose tissue is generally covered with a stony crust.

SPHEROCOCCITES, *St.*

Plants flat, many times dichotomous, from the base divisions disposed star-like.

S. SHARAYANUS, *Goepp*.

*Pl. 1, f. 4.*

Plants orbicular in outline, composed of branches diverging from around a central point, branches rigid, forking from the base, flat, truncate, or somewhat obtuse at the apex.  
*Hab.* Lower Silurian of Bohemia, with *Chondrites antiquus; Buthotrephes*, flexuosa.

HARLANIA, *Goepp*.

(*Fucoides, Hall.*)  
Fronds thick, coriaceous, dichotomous-flabellate, transversely and often longitudinally furrowed, hence sub-quadrangular.

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*a This genus has been modified by Schimper, and now contains mesozoic species only.*
Abundantly found in the Medina epoch, the lowest of the Upper Silurian, where entire strata of rocks are filled with this peculiar organism. Its nature, like that of many other species of the Silurian, has been contested and forms of this kind have been considered as being tracks of some animals, worms or crustaceans. But the interlacing of the fronds which are not passed through or flattened by superposition of others, evidently contradicts the supposition. They were apparently tubulose, like other species described here below, but already of a somewhat more complex structure than the species of the lower silurian. The genus has one species only.

**SPHENOTHALLUS, Hall.**

(Sphen, wedge—thallos, shoot, frond.)

Plants consisting of a stem with diverging wedge-form leaves, or of detached leaves, having this form, leaves apparently succulent or thickened, and sometimes coriaceous.

The author describes two species. *S. angustifolius* (with narrow leaves,) *S. latifolius* (with broad leaves,) remarking that this genus is probably limited for its habitat to the silurian or lower silurian strata. The specimens were found in the Hudson River group, or the upper strata of the lower Silurian, corresponding with the Cincinnati group, where the oldest remains of land plants have as yet been found.

The figures given of this species by Hall, Pal. of New York, p. 261, pl. 68, f. 1, are so much like that of a small branch of *Cordaites*, that if the leaves were straight, the plant would be referred to this genus. The leaves of *Cordaites* though flat, are sometimes succulent and of thick texture.

**PALEOECUS, Hall.**

(Paleos, ancient—phuesos, marine plant.)

Frond simple or ramose, cylindrical, or sub-cylindrical, articulate here and there. Plate 1, f. 5, 5a.

The three species described by Hall, are *P. tubularis* *P. rugosus* and *P. simplex*. The figure quoted above gives an idea of the characters of these plants, though it represents a species with much smaller fronds much more closely and distinctly articulate. These specimens have been found in the Trenton limestone of the lower Silurian of New York. This genus has, however, representatives in the Devonian and even the Carboniferous.
PRINCIPLES OF PALEOZOIC BOTANY.

BUTHOTREPHIS, Hall.

(Greek for produced in the depth of the sea.)

Frond cylindrical or compressed, ramose; branches numerous.

Six species of this genus are described and figured by Hall in the Pal. of New York, B. antiquata, B. gracilis, B. succulenta, B. nodosa, B. flexuosa, and B. foliosa. B. gracilis, Hall, pl. 1, figs. 1, 6, and 7, is extremely variable, at least if we have to consider as referable to the same species all the specimens which have been figured as varieties and which differ as much in the size of the plants as in their mode of ramification. From fig. 5 to fig. 6, copied from the same plate, 5, vol. 2, of the Pal. of New York, there are indeed intermediate forms which present a great diversity of size and ramification. They are described as var. gracilis, intermedia, and crassa. But as the specimens are from two different epochs, the Trenton lower, the Clinton upper Silurian, some of the so called varieties may represent true species.

Though the types of the Algae are long lived, and of wide distribution, it is probable that if perfect specimens could be obtained of the fossil species they would show a much greater diversity of characters than it is possible to see from the often indistinct fragments which have been obtained.

DICTYONEMA, Hall.

(Dictyon, fish net.)

Frond divided from a common central point into numerous branches expanding fan-like, with thick branchlets or subdivisions repeatedly dichotomous nearly in right angles connecting the primary branches, and forming a kind of reticulation like the meshes of a fish net.

D. RETIFORMIS, AND D. GRACILIS, Hall.

Pal. of New York, ii, p. 174 and 175, pl. 40 F. and 40 G.

These two species have been considered by Hall as corals, but he remarks that the branches consist of a black film enveloping a semi-calcareous or carneous interior, being apparently like Graptolites in texture. Schimper remarks that the fossil is changed into anthracite in the Silurian strata of Norway, and that Goeppert has discovered a sporangium placed upon a branchlet connecting two primary divisions; that therefore the vegetable nature of this production can not well be doubted. In the Devonian there is a predominant group of plants which have great affinity of structure with Dictyonema.
2. DEVONIAN ALGÆ.

Though remains of marine plants are found in prodigious abundance in some strata of the Devonian period, few have been collected and described. This is probably due to the great difficulty of separating distinctly preserved forms from the heaps of materials, or rather impressions, which appear to have been made by these remains. The strata where the plants are mostly found, beds of hardened clay or sandstones, have their horizontal layers carved in a multitude of more or less irregular impressions, representing mere fragments of plants, of which no definite outline can be recognized. The appearance of some surfaces seems produced by heaps of vegetables, thrown, half-decomposed, upon a soft bottom of mud or sand, and compressed there until the whole vegetable matter has been embedded to be later partly destroyed by decomposition. Formations of this kind have been observed in Pennsylvania in the vicinity of oil bearing strata. They are also frequently seen in the Waverly clay beds of Ohio, and from these beds beautiful specimens have been obtained, which, however, have not yet been examined for description.

Allusion has been made above to a group of Algae of the Devonian, related to those of the Silurian by their composition of long filaments radiating from a common center and transversely crossed by branches which seem to unite them. They look like narrow pieces of ribbons placed vertically and horizontally, at a short distance, imitating in miniature the pattern of the Scotch plaid. Of this group three genera have been described, as follows:

UPHANTÈNIA, Vanux. 
(Uphantos—woven.)

Frond large, funnel shaped, regularly latticed by broad, ribbon like ribs, one series radiating from a common center, the other disposed concentrically.

U. Chemungensis, Vanux; the only species known has been found in the Chemung, Upper Devonian.

DICTYOPHYLLUM, Hall.

Frond flabellate or funnel shaped, latticed by radiate and concentrical divisions, stem obconical or sub-cylindrical, hollow, striate outside like the divisions, equal or with inflated round or nodose articulations.

Schimper remarks that the impressions of this plant are fan like, but that when living the plant was funnel shaped. He says also that the stem is inflated here and there by large knots placed the one above the
other with some likeness to the stems of *Halonia*. This remark is not exactly correct. From a number of specimens which I have had opportunity to observe, the inflation of the stems is merely the base of branches placed in horizontal rows. The branches short, enlarged at their point of attachment, narrowed or contracted in the middle where (in one specimen) they are scarcely one cm. broad are abruptly enlarged, knot-like, at the top.

*Hab.* Chemung group.

**SPIROPHYTON, Hall.**

Fronds membranaceous, cup-shaped, or attached to a short stem around which the lamina is spirally turning upward, representing in its sections and by compression the tail of a cock (*cauda galli*).

Half a dozen species of this genus have been described by Hall, the most common being *S. cauda galli*. The general appearance of these vegetable organs is represented pl. 2, f. 1, but *S. cauda galli* has much broader, more circular fronds or segments, which when flattened upon the rocks, as they generally are, have a diameter of twelve to twenty cm., often forming whole circles by their curved branches. Some rocks are locally blackened to great thickness by the impressions of this plant.

### 3. CARBONIFEROUS ALGÆ.

For a long time it was supposed that no kind of Algae could be found in the coal measures. These plants, as it has been seen above, have not entered into the composition of the coal, and therefore their remains have not been mixed with the species of land plants abundantly preserved in the roof shale of coal beds, though these sometimes have brackish shells mixed with ferns, etc. The coal formations covered very extensive inland flats, which the sea did not penetrate, or which came into it by narrow shallow inlets, inhabited by shells, but not deep enough to support the vegetable marine life. The Algae of the coal have been found in connection with beds of limestone, or of clay iron ore, more rarely in sandstone.

As yet few species are known. Some of them are referable to the two types already present, one in the Silurian *Paleophycus*, the other in the Devonian, *Taonurus* or *Fucoides cauda galli*, others to a far different group, which seems peculiar to the formation and has indeed remarkable characters. Most of the species have been found in Indiana, and though partly described and figured in one of the annual reports, they should be here briefly recorded in order to have a general view of the paleozoic Marine Algae.

Of the genus *Paleophycus*, Hall, described above, we have seen from Indiana:
Frond large, erect or spreading around a central axis, branches forking in an acute angle of divergence or anastomosing between them, cylindrical or slightly flattened, generally thick toward the obtuse apex, sometimes umbonate, transversely cut or strangled by deep fissures at right angles to the axis; surface smooth or punctulate.

_Hab._ Concretions of carbonate of iron, over coal L. Vigo County, Indiana. E. T. Cox, J. F. Miller.

**P. gracilis, Lesq., plate 1, fig. 5, 5a.**

_Frond small, enlarging upward or outside by repeated dichotomy; branches cylindrical, forking in a more or less open angle of divergence, slender, slightly decreasing in thickness from the base up to an obtuse point, easily split transversely, generally smooth, sometimes punctate._

_Hab._ With the preceding, of which it may be a variety.

**P. divaricatus, Lesq.**

_Frond flattened into creeping branches, diverging around from a central axis; branches cylindrical or more or less flattened by compression, irregularly forking and anastomosing by cross divisions nearly equal in size their whole length, obtuse; surface smooth._

_Hab._ With the preceding. J. F. Miller.

**ASTEROPHYCUS, Lesq.**

_Stems cylindrical, expanded and divided starlike from the central axis; segments flattened or inflated._

**A. simplex, Lesq.**

_Plate B, fig. 78._

_U. S. Coal Flora, p. 13, plate 1, figs. 7 and 8._

_Frond composed of cylindrical spindle shaped branches placed starlike around a small central axis and free to the base._

_Hab._ Ferruginous clay, above the millstone grit near Beaver, Pennsylvania.
Divisions of the frond flattened, large, oblong, obtuse or obcordate; surface deeply and irregularly wrinkled lengthwise.


This species has great affinity with those of the following group, being, like them, supported by a stem or axis around which the divisions of the fronds were successively placed upon another. Its relation to Algae of our epoch is unknown.

**Cnostychus, Lesq.**

Stipe cylindrical, continuous; frond enlarging from the base upward in the shape of a cup, or growing up and enlarging by successive superposed concentrical layers; top, cup shaped, concave.

The plants of this group are distantly related to a tribe of Marine Algae of the present time, the *Acetabulariae*, which bear upon a continuous stipe successive umbrella-shaped fronds, the lower rendered solid by incrustation of calcareous matter.

**C. Broadheadi, Lesq.**

Stipe short, cylindrical, transversely ribbed; frond semi-globular, cup shaped, concave inside, distinctly three-costate and deeply wrinkled lengthwise on the outside; substance thick.

A most beautiful organism resembling a cup, more than eight cm. across at its top, five cm. upward from the apex of the stipe to the borders, with an average thickness of one cm. The outside has three equal strong ribs with enlarged wrinkles, disposed lengthwise between them, and regular undulate rugose branchlets which seem as sculptured by hand for the outside ornamentation of the cup. This remarkable organism has been figured in the U. S. coal flora (pl. B, f. 1) with the two following species.

Hab. Shale near the base of the coal measures, Vernon county, Missouri.

**C. Prolifer, Lesq.**

Fronds thick, disciform, concave, disposed in a successive series, upon a continuous narrow cylindrical stipe.
The discs are like small plates, concave above, abruptly curving on the outside of the axis, with a nearly flat base. They are grown superposed upon each other, attached to a central axis or stipe, whose remnant is seen in the center of the discs. This peculiar species is not very rare.

_Hab._ Same as the preceding, also found in Kentucky, with *Asterophycus Coxi._

**C. ornatus, Lesq.**

*Plate 2, f. 5.*

Frond obconical, composed of superposed layers or plates generally increasing in width from the base upward, and regularly lobate on the borders by deep lines diverging star-like from the axis and passing up to the top.

The mode of development of this plant agrees with that of the two preceding species and proceeds from a cylindrical basilar axis, by the superposition of successive layers formed around it.

_Hab._ Sandstone of the Coal Measures above the millstone grit of Illinois.

**Taonurus, Fish.—Ost.**

*Spirophyton, Hall. Fucoides, Vanux. Chondrites, Lesq.*

We have seen above *Fucoides, or Spirophyton Cauda galli,* as a plant extremely common in the Devonian. It passes up to the lower Carboniferous, but has not yet been found above the Millstone grit. The following species procured from the upper coal of Illinois, appear really different.

**Taonurus Colletti, Lesq.**

*Plate 2, f. 1.*

Frond large narrowed to a basilar support, obovate in outline, lamina cut into narrow linear segments, joined in their length, or separated, curved up in half circles, converging to the borders. This species appears, like the following, derived from a cylindrical axis to which it is attached by its narrowed base.

**Taonurus marginatus, Lesq.**

*Plate 2, f. 1, 2.*


Frond derived from a fucoidal cylindrical axis, branching in its lower part, enlarged upward to a small utricale, which gradually expands into
a lyrate lamina folded transversely in irregular striae curving scythe shaped and converging on both sides to the flattened smooth borders.

This species merely differs from the preceding and from Fucoides Cauda galli, by the persistence of its fucoidal smooth border around the striate, or plicate lamina. This character has not been observed in F. Cauda galli. But the first mode of growth of this last plant has not been sufficiently observed, and probably we have here a demonstration of its peculiar development by the gradual enlarging of the hollow cylinder into a vesicular appendage, as in f. 2, considerably enlarged, for the composition of large fronds, like those figured in the Mem. of the Phil. Soc., where the border is persistent, while it is mostly destroyed in T. Colletti, and entirely so in F. Cauda galli.

Hab. Ferruginous very hard, compact shale at the horizon of the midstone grit, on Slippery Rock Creek, Pennsylvania.

II SERIES—VASCULAR ACOTYLEDONOUS PLANTS OR ACROGENS.

FIRST CLASS: EQUISETACEAE OR HORSETAIL FAMILY.

Plants herbaceous or tree-like, coming out of subterranean articulate rooting rhizomas often tuberculate at the articulations (pl. 4, f. 3); stems generally striate or furrowed lengthwise, fistulose and articulate, traversed at the articulations by a diaphragm (partition of thin cellular tissue); branches coming out at the base of the leaves, verticillate like the leaves, which are generally united at the base, forming sheaths; flowers of both series born upon a fugacious prothallium (a primitive tissue composed of thin intersected filaments, covering the ground at the base of the plants); fructification composed of verticillate receptacles, attached in rows around a central axis by short pedicels, (pl. 4, f. 5), and superposed in the form of a cone, (pl. 4, f. 4 and top of f. 1).

This class is separated into two sub-classes, the first comprising the true Equisetaceae, to which is applicable the above definition, and to which belongs the genus Equisetum (Horsetail); the second the Calamariae.

The Equisetaceae are at the present epoch herbaceous plants of comparatively small size, the stems in the northern hemisphere being scarcely one cm. in diameter and half to one cm. in altitude. In the tropical regions, some plants of this family are four to five cm. high and two cm. thick. The Equisetaceae have had their largest point of development in the Trias and the Jurassic, but have been sparingly represented in the Carboniferous, there only by a few separate sheaths of Equisetites.

For the present I have to consider merely the second group or subclass; that of the Calamariae or Calamites, which essentially differs from the
Equisetaceae by the leaves free to the base, generally lineal-lanceolate or obconical; by the branches coming out from the axils of the stem-leaves, verticillate in the upper part of the stems, and especially by the great size of the plants.

The origin of the plants of this section goes up to the middle, even the lower Silurian, where fragments represented (pl. 3, f. 3-6) and referred to two genera of the Calamariae have been found. In the Devonian, remains of Calamites, the more important genus of the Calamariae, are already abundant. But the group takes its essential development in the Carboniferous, where trunks and branches of many of its species are found in connection with nearly every coal bed or appears to have composed layers of coal by their remains only. From the upper Carboniferous to the middle Permian the Calamariae rapidly decline and altogether disappear.

CALAMARIAE.

CALAMITES, Suckow.

Pl. 5, f. 1-6.

Plants arborescent; stems cylindrical, narrowed at base to the point of attachment to a subterranean rhizoma, (pl. 5, f. 1, reduced size), hollow, more or less distantly articulate, constricted and traversed at the articulations by an horizontal membrane (diaphragm, f. 5), regularly striate or costate lengthwise by equal parallel more or less broad furrows (f. 2-5), gradually narrowed or rounded at top, divided at the articulations in opposite or verticillate branches. The leaves upon the primary stems fall off very soon, at least they are never found attached to the stems, but only the scars of the point of attachment are marked by small round or oval tubercles, just above or below the articulations. These scars are distinctly seen upon f. 4 and 5; but they are often obsolete or totally destroyed, as in f. 2 and 3. The branch-leaves, however, are generally preserved fossil. They are all equal, linear,narrowed up to a short point, free to the base, very entire and costate to the middle, placed in whorls at the articulations. The fructifications of Calamites are described with the genus Asterophyllites, or what Schimper calls Calamocladus, branches of Calamites, as they are considered to be by some authors.

For a long time the derivation of the stems of Calamites from a rhizoma and their mode of attachment to it, have been unknown, and the ancient authors, Brongniart, Lindley & Hutton and Sternberg, have sometimes considered the conical part of the stems as their top and have figured them accordingly, or upside down. Recently some authors, especially Grand 'Eury, a celebrated paleontologist of France, have discovered the rhizomas and have seen the mode of attachment of the stems, as seen in
pl. 5, f. 1, a figure copied from the Coal Flora of this last author. It appears, however, that the stems of the Calamites have been very soon separated at their base from the rhizomes, or that rootlets and rhizomas being of a soft cellular tissue, have been rapidly destroyed by maceration, and for this reason are rarely found in connection with stems. There is near Carbondale, Pennsylvania, a forest of Calamites, whose stems are still standing, embedded into a bank of sandstone, twenty to thirty feet high, through which an inclined tunnel has been cut. An immense amount of fragments of these stems have been thrown out of the mine and neither in connection with the fragments, nor at the base of the stems seen erect along the walls of the tunnel, could any remains of rootlets or of rhizomas be discovered. The stems are there in their natural state and position, as they were when living, erect, covered with a thin hard polished and ribbed epidermis, the whole internal cylinder transformed into sandstone, but the original hollowness of the trees is seen in transversal bends, depressions, irregular folds, caused evidently by compression, or by semi-prostration; for when they were imbedded in the sand by some cataclysm, they were already dry and in an incipient state of decay. The stems of these Calamites at Carbondale vary from eight to sixteen cm. in diameter, and as far as can be seen from the thickness of the sandstone bank through which they pass, as some of them are seen piercing the upper surface of the bank, their length was six to eight meters. Some larger trunks of Calamites have been observed in Carboniferous strata, but they are generally found flattened after decomposition, and it is then difficult to measure exactly their diameter.

The Calamites, as said already, have contributed a large part of the materials which enter into the composition of the coal beds. Their range of distribution is from the middle Devonian to the Permian. They lived in local groups, under circumstances favorable to their growth; for if some beds of coal appear nearly entirely formed of their remains, no trace can be seen of them, neither in the coal nor upon the roof shale of some others. They were probably annual or of short existence, and thus, though their stems were hollow, they could contribute to the matter of the coal an immense amount of woody materials by the repeated prostration and heaping of their stems and branches.

The possibility of such a fact has been disputed by some authors as being against the laws of nature, which, at the present epoch, they say, can not, even in humid tropical regions, produce such an amount of vegetable matter by the growth of any tree in one year. Without considering the great difference in the atmospheric conditions at the coal period, as compared with those existing now, it may be remarked that we have in the present flora of North America a kind of vegetable which, in its nature and mode of life, may elucidate in some way the mode of vegetation of the Calamites. The Cane (Arundinaria) is a kind of grass, which, in the
swamps of the South or on the borders of some rivers, grow at one shoot twenty feet in length—even more, branch the second year and a few times afterward, until it flowers, and then dies and decays. The undergrowth of forests of Magnolias and other large trees in the Dismal Swamp of Virginia, is essentially composed of Canes, growing so close that they form a kind of impassable wall which can be penetrated only with the ax. In some years this whole compact mass of vegetation is locally prostrated, giving by its decomposition a thick layer of woody matter or peat.

The bark of the Calamites, sometimes thick, is easily destroyed by maceration, and therefore most of the specimens of stems, obtained in sandstone and other kind of strata, are merely impressions of the mold or of the inner surface under the bark. This bark is sometimes a hard, polished crust of no more than one mm. thick, while some species (pl. 5, f. 6), have a thick compact woody bark, often as persistent against decomposition as the inner wall of the cylinder. A specimen of the same species as the one figured as quoted above has the inner cylinder six and one-half cm. broad, flattened, and the bark one and one-half cm. thick. From this peculiar character and from that of some Asterophyllites, Brongniart and other authors have supposed that these vegetables are not all mere acrogen plants, but that some of them are referable to dicotyledonous gymnosperms of a peculiar genus allied to the conifers, and named Bornia or Calamodendron.

The specific characters of the Calamites can be derived only from the outside appearance of their bark or from the surface of the stems, the ribs, their width and relative position in crossing the articulations where their ends are either continuous in the same plan of direction, or alternate; from the distance of the articulations, the size and position of the tubercles or scars of leaves, etc., and as all these so-called characters are variable sometimes upon the same stem, it is very difficult to satisfactorily define the species. Some authors have, for this reason, multiplied them in great number; others, like d’Ettingshausen, have come to the conclusion that there is only one. There are, however, between their stems, some differences which appear to be constant and sufficiently distinct to be considered as specific. And what shall be seen here below of the fructifications of Asterophyllites, evidently shows that if the Calamites are their trunks, they ought to represent a certain number of species. Those which are more generally admitted are the following:

**Calamites Suckowii, Brgt.**

*Pl. 5, f. 5.*

Stems of medium size, always larger than the space between the articulations; ribs half round, separated by narrow furrows; tubercles oval, more or less distinct; bark thin. The most common species of the genus.
PRINCIPLES OF PALEOZOIC BOTANY.

C. major, Weiss.

Stem large, twenty cm. or more; articulations close; ribs large, three mm.; bark thicker than in the preceding.

C. ramosus, Artis.

Stem branching at the distant articulations (merely in the upper part); ribs flat, furrows narrow; tubercles oval or undefined at both ends of the ribs; scars of branches large, round.

C. cannaeformis, Schloth.

Pl. 5, f. 2.

Stems large, articulations at variable distances; furrows broad, obtuse, sometimes marked in the middle by a sharp line; ribs convex, wedge form, alternately jointed at the articulations; scar leaves distinct or obsolete.

C. approximatus, Schloth.

Pl. 5, f. 6.

Stems very variable in size; bark thick; articulations somewhat contracted, close, especially toward the base where they are sometimes only one-half cm. distant; ribs indistinct upon the bark; surface clearly marked upon the impressions of the under side, convex, with deep furrows, two or three, sometimes, converging at the base to one point of the articulations.

C. cistii, Bryt.

Pl. 5, f. 4.

Articulations distant, ribs narrow, half round; furrows obtuse, striate, tubercles small, round, oval or absent.

C. dubius, Artis.

Merely differs from the last by the furrows more distinctly striate, the ribs narrower, the articulations very distant, the tubercles mostly obsolete.

BORNIA, Rœm.

Differs from Calamites by the articulations scarcely constricted, the ribs being cut square or obtuse at the articulations and continuous (not alternating); cortical cylinder thick; leaves verticillate.
Genus as yet unsatisfactorily defined like Calamites and Calamodendron, and of which one species only is described, Bornia radiata, Schpt., (Calamites, Brgr.), represented by a stem bearing a row of canalicate leaves at the articulations. The leaves of the only specimen I have seen as referable to it are less than one mill. broad and six and a half cm. long, apparently joined by two at the base.

ASTEROPHYLLITES, Brgr.

Pl. 6.

Calamocladus, Schp. Bechera, Bruckmannia, Volkmannia, etc. St.

Stems articulate; branches opposite, simple, open or oblique; central axis, hollow or solid; leaves verticillate, free to the base, linear and acuminate, simple-nerved; fructifications either in elongated ears or cones, bearing double sporanges attached to the axis by a short pedicel (pl. 4, f. 9, 10), or in tubercles (macrospores), attached to the axils of the leaves.

There is still a great deal of uncertainty concerning the true nature of the plants which have been named Asterophyllites by Brongniart and most of the authors after him, and which considered as branches of Calamites by Schimper, and described under the name of Calamocladus or Calamophyllites, appear to have a more marked degree of analogy to the Lycopodiaceae than it has been supposed until now. Pl. 4, f. 6, 9, 10 show, by the cross section of a cone, exactly the same kind of fructification as is observed on a cone of living Equisetum, f. 1, 4, 5. Now I have figured pl. 6, f. 4–6, branches of Asterophyllites gracilis, bearing (f. 5) small tubercles, or rather, macrospores, in the axils of the leaves, and fig. 6 a conical ear of the same nature, by its outside characters, as that of pl. 4, f. 6, and still in f. 3 of pl. 6, an ear also of the same kind as those which are generally considered as fructifications of the Asterophyllites. F. 5 and 6 belong to the same species; the character of the leaves is too distinct from those of any other species to permit any doubt about the identity of the specimens, which, moreover, are all from the same locality and mostly upon the same pieces of shale. As far as I have been able to see it by breaking some of the sporanges of f. 3, they contain only microspores, so small, indeed, that with a high power of the microscope they appear like glomerules of pulverulent matter; while branches of Asterophyllites have the tubercles of the axils of the leaves very close, as f. 2, and some of them, distinctly exposed by falling off of the leaves, show the tetrahedral structure of macrospores. This, indeed, indicates a fructification very much like that of the Lycopodiaceae of the coal, as seen in pl. 16, f. 5, 6. This peculiar mode of fructification is still elucidated by the characters of other specimens. But until this question may be decided by the anatomy
of silicified cones, cut in thin lamellæ for microscopical examination, I
shall follow the general classification of the European authors and describe,
the cones like those of pl. 4, f. 5, under the name of *Calamostachys* (stachys,
an ear), and those like f. 3, 6, as *Volkmannia*.

The range of distribution of the genus *Asterophyllites* is from the Middle
Devonian to the Permian, like that of *Calamites*. Its more commonly
found and more distinctly characterized species are the following:

**A. equisetiformis, Schloth.**

*Pl. 6, f. 1-2.*

Primary branches long, striate; costa thick; branches more or less
oblique; leaves linear acuminate, open, straight or curved inwards, thick-
ly costate; fruiting plants with thick branches, close articulations and
small round tubercles in the axils of the leaves. *Pl. vi, f. 3* may repre-
sent the *Volkmannia* of this species, which is common in all the thickness
of the coal measures.

**A. anthracinus, Heer.**

Is much like the preceding, differing merely by the leaves, longer
than the internodes, curved upward, the medial nerve obsolete. Not as
common as the preceding. Middle coal measures.

**A. longifolius, Brgt.**

Branches generally small; articulations distant; leaves numerous, very
long, six cm. or more, and narrow, scarcely one mill. in diameter, flat, flex-
uous, apparently soft, subulate pointed. Lower coal measures, rare.

I have seen a specimen which seems to be the *Volkmannia* of the spe-
cies. It is the upper part of a branch one cm. broad, irregularly striate,
with lateral branchlets or ears two and one half and three and one half
cm. long, covered with appressed linear, narrow scales eight mill. long,
connate to near the apex, twice as long as the articulations. The leaves of
the stems are two to four cm. long, narrow, broadly flat-nerved, lineate
lengthwise by the erosion of the surface exposing the fibrous texture.

**A. regidus, Brgt.**

Differs from the preceding by thick branches, the short articulations,
the leaves rigid, shorter, concave or carinate, incurved, half cylindrical,
the thick nerve. It is more generally found than the last.
A. sublevis, Lesq.

Branches thick; articulations close, equidistant; internodes smooth, not ribbed, merely slightly undulate under the inflated articulations; leaves short, linear-lanceolate, gradually acuminate; branchlets at right angles, short, narrow, with two or three whorls of short leaves. Very rare except in the anthracite of Rhode Island.

A. foliosus, Il. and Hutt.

Branches slender, narrowly striate; leaves shorter than the articulations, generally open and flat, in whorls of eight to ten; distinct at base, linear lanceolate, obscurely nerved.

Species described under many specific and generic names from the different appearances presented by its fragments; the trunk and branches are sometimes covered with rootlets divided in multiple very thin filaments which have been described as Pinnularia or Myriophyllum, etc., while the tops of the branches, forming buds with close appressed leaves, have been taken for Annularia. It is not rare, but often in unrecognizable fragments.

A. grandis, St.

Stems distinctly striate, contracted at the articulations; leaves open, narrowly linear-lanceolate, short, thin, with the nerve indistinctly marked. This has been described as Beechera by Il. and Hutt. Rarely found.

A. fasciculatus, Lesq.

Plate 6, f. 7.

Stem comparatively thick; branches dichotomous; fasciculate or opposite and distichous; distinctly striate under the articulations; internodes short; leaves short, three to four mm., lanceolate; fructifications in axillary tubercles of narrow linear spikes. A fine species especially found in the coal of Clinton, Missouri.

A. gracilis, Lesq.

Plate 6, f. 4–6: pl. 5, f. 3.

Ultimate branches very slender, obscurely striate; leaves two mm. long, longer than the internodes, narrowly lanceolate, pointed, curved inward in whorls of eight to ten; fructifications of two kinds; in lanceolate cones (Volkmannaia), sessile on the articulations, narrowed at the point of attachment, three cm. long, one-half cm. broad toward the base, covered
with appressed imbricate, short lanceolate scales, connate to the middle, pointed (f. 6), and in small tubercles attached in rows in the axils of the leaves (Calamostachys, f. 5 and 5a). The fragment of Calamites (pl. 5, f. 3), represents the stems of this species. Found as yet in the sub-conglomerate coal measures.

**ANNULARIA, Br.**

*Plate 3, f. 3—3b; pl. 7, f. 1—5.*

Stems articulate, traversed at the articulations by a strong diaphragm; branches opposite, diverging nearly at right angles from the articulations; leaves verticillate, joined at base by a narrow ring (*Annulus*), hence their name, lanceolate, spathulate or lingulate, abruptly or gradually acuminate, sometimes obtuse, fleshy, even emarginate at the apex; fructifications in long cylindrical spikes with close articulations and narrowly lanceolate bracts, bearing round sporanges in the axils of the leaves, or oval ones pedicellate, attached in the middle of the internodes.

The fructifications as described and figured by the authors are much like those of *Asterophyllites*. But their characters are not yet sufficiently known; for these fructifications are very rare, at least as found attached to their support.

**A. LONGIFOLIA, Br.**

*Plate 7, f. 1, 2.*

Stem narrowly striate; leaves in whorls of eighteen to twenty-four, lanceolate spathulate, more or less abruptly acuminate, medial nerve broad, deep. A very common species, and very variable in the size of its leaves.

**A. INFLATA, Lesq.**

Leaves inflated, semi-cylindrical, club-shaped and obtuse, apparently fleshy; medial nerve none, or indistinctly seen upon leaves flattened by compression.

May be a variety of the preceding species deformed by immersion; the number of the leaves is generally greater, twenty-six to thirty-two in the large whorls. Rarely found except in the nodules of Mazon Creek.

**A. CALAMITOIDES, Schp.**

Stems thick, branches closely articulate; stem leaves long, erect, numerous; branch leaves shorter, linear-lanceolate gradually acuminate. The leaves are flat, shorter, not as thick as in *A. longifolia*. A rare species.
A. spheno phy lloides, Bryt.

*Plate 7, f. 3, 4, 5.*

Stems slender; branches and branchlets at right angles; verticils flat, of twelve to twenty leaves which are often longer on the outside, spatulate, slightly emarginate or obtuse at the apex, (f. 3, 4,) or abruptly apiculate, (f. 5,) more or less re-curved on the border. The species is common and very variable; mostly found in the middle coal measures.

A. Emersoni, Lesq.

Plants of small size; stems comparatively strong, distinctly striate, with divisions as in the last species; verticils of leaves smaller; leaflets thick, oblanceolate, taper pointed; costa none or immersed and obsolete.

A fine, small species, found at the horizon of the Pittsburg coal.

A. Remingeri, Lesq.

*Plate 3, f. 3-3b.*

Stems long and slender, articulate, smooth; articulations at short, regular distances, inflated, bearing oblique branches and small linguately apparent flat leaves, either truncate or rounded at the top; nerve obsolete.

The remains of this plant, which is not very clearly defined on account of too fragmentary specimens, merit to be considered, as they evidently represent a species of this genus and therefore prove the existence of the Calamaricæ already in the lower Helderberg Sandstone or upper Silurian. These specimens were found by Dr. Reminger in Michigan.

SPHENOPHYLLUM, Bryt.

*(Sphen, wedge.)*

*Plate 3, f. 4-6; plate 7, f. 6-11.*

Plants herbaceous, stems articulate, somewhat inflated at the articulations, pinnately, bipinnately divided; leaves verticillate, sessile, in whorls of wedge-form leaflets, entire at the lateral borders, round or truncate at the lacinate dentate or lobate upper margin; medial nerve none; veins diverging from the base, straight, dichotomous; fructifications in cylindrical spikes of globular sporanges placed in the axils of bracts or scales curved upward in a sharp flexure from near their base (f. 7).

The plants of this genus, like those of Annularia, were water plants whose upper or emerged branches were spreading upon the surface of stagnant water. Some species have the leaflets more or less divided, often more expanded on the upper side of the whorls, according, it seems, to their growth upon the surface of the water.
Verticils of five to nine broadly cuneate leaflets, rounded and crenulate at the upper border; veins free at the base, dichotomous, distinct.

A most common and beautiful species, easily known by the rounded upper borders of the leaves. It ranges through the whole thickness of the coal measures from the conglomerate upward.

S. emarginatum, Brtgt.

Differs from the preceding by the leaflets truncate, not rounded, obtusely dentate at the top, in verticils of six to nine; the veins are less numerous. Found especially in the upper coal measures, but not common.

S. longifolium, Germ.

Stems robust; leaflets large, one and one-half to three cm. long or more, either bifid at the apex with lobes merely crenate or deeply dentate or split in long acuminate divisions (f. 11); veinlets numerous, not confluent at base; verticils of six to nine leaflets. A very fine species apparently rare. I have seen specimens from the low coal of Clinton, Mo., and from the Pittsburg coal, an upper vein.

S. cornutum, Lesq.

Stem thick, obscurely striate; branches nearly at right angles; verticils of six leaflets, connate to above the base, broadly cuneiform, divided from the middle into seven to nine linear obtuse nearly equal lobes; veins distinct, flat, four to five at the base of each leaflet, forking once only, each division ascending to the top of one of the lobes. A very remarkable species, the leaflets being divided like the fingers of a hand. Found only as yet at Colchester, Ill.

S. filiculme, Lesq.

Branches slender, very long, filiform; verticils of six narrow leaflets, the lateral twice as long as the two inferior ones, all narrowly cuneiform, truncate and dentate at the upper borders; primary nerves two to three, distinct at base, forking twice. Not uncommon, and found in the whole extent of the coal measures, even at the base of the Permian of Virginia.

On account of the difference in the length of the leaflets, a difference which may be caused by habitat in the water or upon its surface, this form has been considered as a variety of the following species. It is, however, found locally always with the same characters.
S. oblongifolium, Germ.

Plate 7, f. 9.

Leaves obovate-oblong, bifid to the middle, one to three acutely dentate, in verticils of six. A rare species, found only at Cannelton.

It is well to observe that the species of this genus are all subject to great variety by the size and subdivisions of the top of the leaflets. That is shown by the multiple synonymy of the species published by European authors.

S. primævum, Lesq.

Plate 3, f. 4-6.

The species is made from specimens too fragmentary to afford a satisfactory specific diagnosis. It is, however, evident that the fragments represent, either by stems or by separate leaflets, a species of this genus very closely allied to S. Schlotheimii.—All these fragments have been found in the Cincinnati group of the Hudson River epoch, lower Silurian.

MACROSTACHYA, Schimper.

Plate 5, f. 7.

Plants arborescent, articulate; articulations close, smooth or the internodes thinly striate; outer surface distinctly striate or plano-costate, with very narrow furrows alternating at the articulations; leaves appressed, linear, carinate and simply nerved in the middle, acuminate and finally truncate; leaf-scars marked upon the articulations by transversely oval rings; scars of branches verticillate, large, round, umbonate with a stigmarioid central mammillæ; spikes very large, cylindrical; bracts lanceolate, costate in the middle, imbricate, scarcely longer than the internodes.

The above definition is taken from Schimper's "Vegetable Paleontology," for I know, of the plants of this genus, only fragments of stems like the one figured and the large spikes which I have figured (pl. 4, f. 7 and 8), and which the author refers to Macrosachya. Some of them are very large, oblong, larger in the middle, narrowed upward or downward or cylindrical and sometimes curved, varying in length from four to eighteen cm. and from one to four cm. in diameter. Sometimes their base is marked upon the shale by circular impressions nearly as large as the broad scars at the base of pl. 5, f. 7, but often also they are narrowed into a pedicel, as in pl. 4, f. 7, and therefore do not seem to have any reference to the large stems, being apparently attached to small branches like the spikes of Calamites; hence the relations of these peculiar organs is still uncertain. The large spikes, though not very common, are found in the whole thickness of the coal measures. The stems are per contra very rare. The two fragments which I have seen come from the coal of Cannelton, where the large spikes are abundant enough.
Everybody knows the ferns. They grow everywhere, in every kind of climate, in the cold regions of the North, where they are rare, becoming more and more abundantly distributed toward the equatorial countries, especially in the islands, wherever atmospheric humidity predominates.

The Ferns belong to the Acrogens, plants with a distinct axis, gradually unfolding from the apex only, composed of woody fibers and vessels. They have that in common with the Equisetaceae, but they differ from them by the apical uncinate development of their stems and branches and by their leaves, flat and thin laminae, either entire or divided in multiple sections, according to the characters of their nervation.

Fossil remains of this class of plants have been found in the lower Silurian of France, in a specimen representing a branch with leaves of large size, already denoting an advanced stage of development. This fragment discovered at the base of the middle Silurian, near Angers, and described by Saporta as Eopteris Marieri, is figured (pl. 3, f. 9). No remains of ferns have been found as yet in this country lower than the Devonian. But in this formation, the ferns are already so numerous and represented by species of so large development, that their first appearance or their origin on the North American continent may be rationally supposed to be much older, at least as old as it is in France or in the upper part of the lower Silurian.

Ferns show the greatest degree of predominance in the carboniferous age, where the number of their species, extremely diversified, is considerably larger, at least locally compared, than it has been at the preceding geological periods and even than it is at the present time; for the number of species already described from the carboniferous is nearly one thousand. At the present epoch more than three thousand species of ferns are known. But we must consider that the coal flora, though widely distributed, was governed by permanent and uniform atmospheric and geological circumstances, while now the ferns are distributed over all the part of the world inhabited by man, and therefore, their life is modified by the greatest differences in the temperature and habitat, according to the localities where they are found. Taking for comparison some countries where the circumstances of climate are not much varied, the superiority of the vegetation of the ferns at the coal epoch appears very great in favor of the carboniferous. For example, the Philippine Islands have only three hundred species of ferns; Java and Southeastern Africa, four hundred; the islands of the Gulf and the eastern intertropical shores of America, six to seven hundred.

Atmospheric moisture and a high uniform degree of temperature essentially favor the vegetation of the ferns. These elements were, it seems, at the highest degree during the Carboniferous period, hence the luxuriance
of the vegetation of ferns which at that epoch, covering all the low grounds, either as thick bushy species of the undergrowth, or as trees, have contributed by their remains at least one-half of the materials which compose the coal. The fern-trees now inhabit intertropical regions, especially the islands of the Pacific Ocean, or the slopes of high mountains near the equator. There, in foggy regions, they sometimes reach an altitude of one hundred feet. Their shape is most graceful (pl. 8, f. 1); their trunks, simple or without branches and cylindrical, are generally covered by the scars of the base of decayed leaves (f. 5, 6, 7), very varied in forms, and their fronds (whole leaves) are cut into multiple, always graceful, subdivisions. At the present time the trunks of tree-ferns rarely measure thirty cm. in diameter; in the coal measures silicified trunks of ferns are found twice as large.

The bushy ferns of the coal were also generally of very large size. Though most of them are known only by small fragments of stems and leaves, parts of fronds are seen on the roof-shale of the coal beds, measuring three or four meters in length and proportionately large, with flattened stalks fifteen to twenty cm. broad.

The ferns are perennial, herbaceous, climbing or arborescent plants. Their branches and branchlets are, before expansion, convolute in spiral, like a watch spring (circinate vernation), and gradually unfold in their march of development. The stems grow up from inflated or more or less elongated creeping organs, rhizomas (root-stalks). The rhizomas are generally, for the bushy herbaceous ferns at least, of soft cellular tissue, and therefore easily decomposed and destroyed by maceration. Their remains are very rarely found preserved in the coal measures.

The fronds, that is leaves of ferns including the stalks, are simple, without division of the axis (petiole or rachis), or more generally branching; the branches (pinnae) are primary when attached to the main axis (rachis), secondary as divisions of primary pinnae, tertiary, quaternary, and so on for the subdivisions.

The branches of the fronds are either pinnate by opposite or alternate branches on both sides of the rachis, or dichotomous by the forking of the stems and branches as seen pl. 8, f. 2. Very often the primary and secondary divisions are dichotomous while the branches are pinnate.

As it is very rare to find fronds of ferns preserved entire in a fossil state, and as the paleontologist has generally mere fragments for its description, the preserved part of a fern is often described as leaf or pinna and the divisions accordingly as primary, secondary pinnae, etc. The foliate divisions are pinnules or leaflets, which are entire or lobed, or cut in various forms and described with the same terms as for the dicotyledonous plants.

The more important characters to be considered in the determination of the ferns are their nerves or veins, and the fructifications. The
fruited organs, being generally absent or destroyed by maceration, the
nervation has therefore to be studied with the greatest care. The first
nerve traversing the pinnules, sometimes lengthwise, is simple and then it is
generally strong, often looking like a division of the rachis. It is more
essentially divided and subdivided in the same way as are the fronds, in
primary, secondary, tertiary nerves or veins, the ultimate divisions reach-
ing the borders of the leaflets, being the nervules or veinlets; the veins
are then pinnate, bipinnate, etc. Often, also, no medial nerve being
formed, the veins may be all of about equal thickness, either parallel at
base along the rachis, pl. 11, f. 1, 2, or diverging fan-like from the base
or from a point of the leaflets (pl. 10, f. 1, 2, 6), and filling them,
either straight or curving back, alternately forking in ascending. This
kind of venation is flabellate and dichotomous.

Sometimes the veins in passing up towards the borders from their base
are curved in numerous flexures, which become joined in the middle, as
in pl. 11, f. 3–4, forming a reticulate nervation.

The fructifications (fruit dots) of ferns are generally placed upon the
lower surface of the leaflets in small receptacles supporting or containing
the capsules (sporangia) which bear the sori (glomerules of seeds). Not
only, as said above, the fructifications of the ferns of the coal measures are
rarely found, but when present, the sporanges are generally obscure and
the disposition of the sori is rarely distinct enough to allow the determina-
tion of their characters. Hence it has not been possible to fix, as is
done for the living ferns, a classification based upon fructifications. It is
therefore upon the characters which may be clearly seen, those taken
from the arrangement and ramification of fronds or leaves, the forms
and subdivisions of the pinnules and especially the nervation, that the
distribution of the ferns in groups, genera and species has been estab-
lished.

Brongniart's Classification, which is still generally followed, is based
upon these different characters. It is abridged by Schimper in his
"Paleontologie Vegetale", as follows:

1. Frond simple or with compound pinnules, free or adhering, with-
owout medial nerve or with a mere basilar nerve vanishing upward; veins
dichotomous or flabellate (Neuropteridaceae), pl. 10.

2. Frond bi, tri or many times pinnate, with pinna or pinnules nar-
rowed to the base, flabelliform, entire or scarcely lobed; veins diverging
from the base without a distinct midrib. (Adiantidaceae.) Pl. 9, f. 3, 4.

3. Fronds divided as in the last group, diversely lobed; veins pinnate
or bipinnate from the base. (Sphenopteridaceae.) Pl. 15.

4. Fronds simple, pinnate, bipinnate or tripinnate, with pinnules
generally adhering by their base to the rachis, often confluent by the
borders, forming more or less deep lobes, entire or serrulate, not lobed,
secondary veins pinnate or dichotomous. (Pecopteridaceae.) Pl. 14.
A number of other classifications, among them that of \( \text{a Ettingshausen} \), have been more recently proposed, but they are more complex and cannot be well understood without a long series of figures. I have, therefore, followed here that of \( \text{Brongniart} \), merely changing the order of the groups in accordance with the relation of the plants to be described.

1. **NEUROPTERIDEÆ.**

*(Neuron, nerve; pteron, wing.)*

This order of fossil ferns contains the genera *Neopteris*, *Leskea*, *Dictyopteris* and *Olontopteris*, which constitute a distinctly characterized and most interesting group of ferns, all bushy, generally of large size, with long dichotomous pinnae and pinnules of beautiful forms. These ferns have no analogy to any species living at the present time. They appear already in the Silurian, as far at least as can be seen by the form of the leaflets and the nervation of *Eopteris Morieri*, Sap., mentioned above as the oldest known species of fern. In the Devonian, they are represented by fragments of pinna bearing large nearly round or cuneiform leaflets; in the sub-carboniferous they are already found in a large number of species, but still more abundantly in the middle coal measures, preserving always the same typical characters, up to the Lower Permian, where they disappear entirely.

**NEUROPTERIS, Brgt.**

*(Neuron, a nerve.)*

Fronds dichotomous in the lower part, tripinnate in the upper, pinnules varying from round to ovate, obtuse or rarely acuminate, mostly entire, round, cordate or auricled at the base, attached to the rachis by the middle, sessile, rarely short pedicellate; veins either coming out all from the base of the pinnules (pl. 10, f. 2, 6, 7), or from a medial nerve (costa), (pl. 10, f. 3, 5), diverging fan-like, arched backward in passing toward the borders, many times dichotomous, the costa generally dissolved at or below the middle.

Two genera of \( \text{Brongniart} \), *Cyclopteris* (κυκλος, circle) and *Nephropteris*, are now forcibly united to this one. To *Cyclopteris*, were referred round, separate leaflets, like pl. 10, f. 7, which were supposed to belong to peculiar species, but which are now known to be merely lower leaflets attached to large stems, mostly in the forks or the base of pinnae of *Neopteris*. The lower leaflet (pl. 10, f. 4) shows already a deviation of the common form, which is still more marked in f. 7 of the same plate. To the genus *Nephropteris* were referred separate oval or ovate leaflets, with all the veins
diverging from the base, as in pl. 10, f. 1, where the small basilar leaflets have this character, and therefore should be placed in the genus *Nephropteris*, while the large leaflets of the same species, as seen in the figure, have a distinct medial nerve from which the veins are derived. Until recently these small leaflets have been found always separated, and their true characters in the composition of the pinnae had not been recognized.

The fruitification of *Neuropteris*, and indeed that of all the *Neuropteridae*, is not positively known. Small oval tubercles are sometimes seen in the forks of the veins near their base, on the surface of some species of *Neuropteris*, but they are much like those small parasitic excrescences (*fungi*), seen upon the leaves of ferns and other living plants. What seems to confirm the opinion that those small tubercles represent the fruitifications of *Neuropteris* is the discovery in France of true sporanges having about the same forms as those of *Neuropteris* and attached upon the point of the veins at the borders of the leaflets of *Odontopteris*. I have already figured this kind of organism upon leaflets of *Neuropteris gibbosa* in the first Geological Report of Pennsylvania, 1858, (pl. 5, f. 3).

The more common and more remarkable species of *Neuropteris* are those with trifoliate leaves, one of the leaflets being very large, ovate, obtuse, terminal, the other two small, round or oval, basilar. Of these are *N. hirsuta*, *N. decipiens*, *N. cordata* and *N. angustifolia*, (the last pl. 10, f. 1), all very similar in all their characters, differing merely by the surface smooth or covered with hairs, the veins more or less close, the size of the leaflets, which in *N. decipiens* attain a length of twelve to fifteen cm. long and four to six broad. Though the nervation appears exactly the same in these species, the difference in the closeness of the veins is readily seen in counting their number as marked on one cm. of space at the borders of the leaves. Then those of *N. fimбриata* (pl. 10, f. 2) with leaflets variable in size, sometimes as small as f. 4 and oval, sometimes twice as large as in f. 2 and round, always beautifully and distinctly fringed on the borders. *N. Elrodi* (pl. 10, f. 3) represents a species not rare in the sub-carboniferous sandstone or on the shale of the whetstone beds of Indiana, where it was found by Dr. Elrod. It is represented in the coal fields of Alabama, also, with *N. Smithii*, which has the same kind of nervation, but the leaflets broadly oval or nearly round. One of the most common species and the more widely distributed, found as it is from the sub-conglomerate measures to the Permian, is *N. Loschii* (pl. 10, f. 4). I have represented only an ultimate pinna, the primary pinnae being very large, alternately and pinnately branching and the leaflets generally of the same size as figured; the lower pinnules become round or cyclopterids towards the base of the fronds; f. 7 is one of these. It has been described as *Cyclopteris elegans*, before its relation to *Neuropteris Loschii* was recognized. F. 5 and 6 are two leaflets of a peculiar form, *N. callosa*, which shows the great diversity of the pinnules of the same species; the leaflets (f. 5) are
attached pinnately like those of f. 4, while those like f. 6 are basilar. Their identity is perfectly ascertained by the characters of the nervation. This shows how difficult it is sometimes to specify fragments of ferns, and how many species could be made from a single plant, if one would consider only as characters the peculiar forms of the leaflets. The number of American species of *Neuropteris* described until now amounts to more than forty.

**ODONTOPTERIS, Bryst.**

*Plate 11, f. 1, 2.*

*Odous, a tooth."

Fronds large, bipinnate; pinnae opposite or subalternate; pinnules of various forms, generally oblong-obtuse, joined to the rachis by their whole base (not by the middle only), sometimes decurrent, either disjunct and separated to the base, or connate to the middle, becoming confluent toward the top of the pinna and gradually effaced in passing to a terminal leaflet; lower pinnules sometimes attached to the main rachis and disjunct; veins derived from the rachis, more rarely from a midrib, thin, dichotomous, diverging straight or in slight curves in passing out to the borders.

This genus is so intimately allied to *Neuropteris* that some of its species, like *Odontopteris Alpina, O. Worthenii*, are indifferent to one or the other of the two genera.

The species of *Odontopteris* were bushy ferns with immense fronds. Some have been seen five to six meters long with petioles more than thirty cm. broad. Their distribution in the geological measures is about the same as that of the species of *Neuropteris*. No species, however, are known in America from the Devonian; they appear somewhat later, that is, at the base of the millstone grit, being more predominant in the first coal above these measures, at Mazon Creek, etc., where the largest number of species have been observed. Some of peculiar types are found in the upper coal beds of Pittsburgh, and above it in the permo-carboniferous measures. In Europe many species have been described from the Permian.

The more notable species are:

**ODONTOPTERIS ALPINA, Geinit.**

Fronds dichotomous or irregular in their divisions, pinnules, either large, obtuse, attached to the rachis by the middle of their base, like the leaflets of *Neuropteris*, or smaller, half round, attached by their whole enlarged base, and therefore with the true characters of the genus. The veins are rarely straight, but generally curved back as in *Neuropteris*. 
O. CORYNGA, Lesq.

Known merely by a few leaflets lanceolate in outline, entire towards the base, divided from the middle upward in linear lanceolate acuminate lobes irregularly placed, the terminal one being generally longer, linear-lanceolate.

O. HETEROPHYLLA, Lesq.

Has some likeness to the preceding by the great variety of forms and sizes of the pinnules or of the lobes, which are short, half round, reniform, or long, linear lanceolate.

O. SUBCUNEATA, Burtb.

Pinnæ linear, with distant oblique ovate or cuneate pinnules, obtusely acuminate or obtuse, auricled at base, enlarging or decurring to a broad point of attachment. A new species, *O. affinis*, (pl. 11, f. 1) closely allied to this, has the leaflets oblong, very obtuse, attached by the whole decurring base, which is never auricled.

O. SCHLOTEOHEU, Brutt.

*Pl. 11, f. 2.*

Fronds bipinnate, with primary divisions oblong-lanceolate, enlarged in the middle, the secondary pinnæ at right angles or somewhat oblique, pinnately divided in oval obtuse pinnules, the lower nearly free, the others generally smaller, more and more confluent toward the apex where they pass into small deltoid or lanceolate obtuse terminal pinnules; veins parallel from the base, distinct and distant, forked above the middle.

Of the eighteen species described in this genus from the United States coal measures, four only are European.

LESLEYA, Lesq.

Pinna or leaf simple, very entire or deeply lacerate on the borders, broadly lanceolate, gradually narrowing towards the base, obtuse, traversed by a thick costa effaced under the apex, veins oblique, curved, equal, repeatedly dichotomous.

This genus is known by one species only, *L. grandis*, represented by some beautiful leaves or simple pinnæ found under the Chester limestone of Illinois, by Prof. A. H. Worthen. It is intermediate for its characters between *Neuropteris* and *Glossopteris* of Brongniart, this last genus containing only jurassic species and distinct by the veins reticulate at base,
nearly as in *Dictyopteris*. The leaves of *Lesleya*, one of which is preserved entire, are twenty-two cm. long, eight cm. broad in the middle.

**DICTYOPTERIS, Guth.**

*Plate 11, f. 3, 4.*

Fronds bipinnate, pinnules cordate, truncate or rounded at base, sessile by the middle or short pedicellate, oblong, obtuse or lanceolate, entire; veins flexuous, connected by flexures or intersections, forming a more or less distinct and close reticulation of polygonal meshes.

Though the genus is widely distributed from the sub-carboniferous to the upper coal strata, its species are few and generally found in small fragments. Two of them, which have been described from American specimens, are proper to this continent: *Dictyopteris rubella*, pl. 11, f. 4, with a bi or tripinnate frond and leaflets either smaller oblong obtuse or broadly lanceolate, or larger nearly round (cyclopterid) cordate auriculate at base narrowed to an obtuse apex all entire: *D. obliqua*, pl. 11, f. 3, whose leaflets, at right angles to the rachis and very close, are all of the same size and form, oblong, somewhat narrowed to an obtuse apex and falcate or slightly curved inward, the meshes of the areolation being close and round polygonal.

**GENERAE OF INDEFINITE RELATION.**

In "United States Coal Flora" the following genera have been considered separately as being without distinct relation to any of the groups established by the authors: *Megalopteris*, Daws; *Tenuipoteris*, Brgt.; *Neriopteris*, Newby.; *Orthogoniopteris*, Andrews; *Protoblechnum* and *Idiophyllum*, Lesq. Of these, the two first only have been described from good specimens with reliable characters.

**MEGALOPTERIS, Daws.**

*(Megas, grand.)*

*Plate 9, f. 2.*

Fronds very large, simply pinnate; pinnæ or leaflets oblique, lanceolate, entire, recurring by the prolonged lower side upon the main rachis which is thus alate, the prolonged part of the pinnules joining at base the upper basilar border of the ones underneath; medial nerve thick; veins all emerging from the thick rachis, obliquely diverging toward the borders, dichotomous and curved upward in reaching them.

The name of this genus implies for the fronds of its species a very large
size. Indeed some fragments of leaves have been found measuring eleven and one-half cm. in width, indicating a length of sixty cm. Eleven species of Megalopteris have been described. But as the nervation is scarcely different in any of them, and the form of the leaflets is much the same, this number will probably be reduced when good specimens have been obtained. All the species are sub-carboniferous or upper devonian.

TÆNIOPTERIS, Brgt.

Plate 11, f. 5.

(Tanion, ribbon or band.)

Fronds or pinnae simple, large, linear; medial nerve or rachis broad, canaliculate; veins at right angles to the costa, either simple or forking a little above the base, very thin and close.

The species of this genus are considered as Permian or Permo-Carboniferous by the European authors. T. Smithii, Lesq., figured as above, has been obtained in the sub-conglomerate coal measures of Alabama.

Of the other genera, Neriopteris and Orthogonipteris are more or less uncertainly defined, as they have been established each for a simple species and from fragmentary specimens. Danuviis, a genus of Geppert, has its essential characters taken from the position and the form of the sporangies. The two species which I have referred to it have the nervation of Alethopteris, and should perhaps be placed in this genus. The last, Idiophyllum, is established for a very peculiar, nearly round coriaceous leaf, with a thick medial nerve, gradually effaced upward, thick lateral veins, sub-opposite, oblique and curving in passing toward the borders, crossed nearly at right angles by continuous equidistant venules, which appear as folded up in contrary directions, forming by intersections regular quadrate meshes. The characters of this leaf, figured in "United States coal flora" (pl. 23, f. 11), totally at variance with those of any species of ferns of the carboniferous, are somewhat like those of a dicotyledonous leaf; the nervation, however, recalls the type of some Jurassic species of ferns. This leaf has been found in the concretions of Mazon Creek. A few species of this genus have been lately described by Prof. Schenk, from the Carboniferous of China; none as yet from that of Europe.

PSEUDO-PECOPTERIDÆ.

To this group pertain the genera Leucophyllum, Callipteridium, Alethopteris, Protoblechnum, Pseudopecopteris, Pteris and Oligocarpia. The three first of these genera are intermediate between Neuropteris and Pecopteris.
Lescurypteris, Schp.

Pl. 11 f. 6.

(Personal name.)

Fronds large, tripinnate; rachis broad, foliaceous; pinnae close, pinnatifid, oblique; lobes ovate, obtuse or acute, inclined outside, connate to the middle, decurrent; primary nerves thin, dichotomous; lower pairs of lateral veins emerging from the rachis, the other alternately from the midrib, forking twice, the upper once only.

The two species described, L. moorii, Lesq., and L. adiantites, Lesq., pl. 11, f. 6, are from the upper coal of Pennsylvania.

Callipteridium, Weiss.

Plate 12, f. 1.

(Kallós, fine.)

Fronds large, polypinnate; pinnules attached to the rachis by the whole base, often decurrent, the lower descending to the main rachis, all connate or disjointed at base, primary nerves distinct, often strong, dissolved below the apex; lateral veins oblique, curved backward in passing to the borders, dichotomous, the lower generally attached to the main rachis.

By the dichotomous divisions of the arched veins, this genus is related to Neuropteris; by the mode of attachment of the pinnules and by their form to Alethopteris or even to Odontopteris. Its more important species are:

C. Sullivanii, Lesq.

Plate 12, f. 1.

Pinnae long, linear-lanceolate; leaflets large, decurring, lingulate, rounded at the enlarged apex, narrowed, connate and decurring toward the base; costa very thick, flat; veins thin, close, dichotomous, the lateral nervation being that of Neuropteris.

This beautiful species is not rare in the coal above the conglomerate, especially in the nodules of Mazon Creek.

Callipteridium Mansfieldi, Lesq., C. neuropteroides, Lesq., are two species of the same type and closely allied to the preceding, while C. Owenii, C. inaequale, C. Praroei, are more distinctly related to Alethopteris. The other species, C. Aldrichi, C. membranaceum and C. Massilloneum are like true Alethopteris, and should have been referred to this genus except for the curving back of the veins. C. rugosum, Lesq., pl. 13, f. 1, is more distinctly related to Pseudopepecopteris.
The distribution of the genus appears limited to the upper strata of the sub-conglomerate coal measures, and to the lowest of the middle, especially.

**ALETHOPTERIS, St.**

*Plate 12, f. 2.*

Fronds polypinnate, pinnules coriaceous, mostly entire, enlarged at base, connate or free, with borders generally reflexed; medial nerve thick, immersed into the epidermis, marked by a groove on the upper face of the leaflets, prominent on the lower; lateral veins open, often at right angles to the rachis, simple or forking once, continuous, derived from the main rachis between the primary nerves.

The separation of this genus from *Pecopteris* is not marked by a very definite line. The only characters which I consider as distinctive of the two genera are the presence of the rachial veins in *Alethopteris*, the larger size of the pinnules and the direction of the veins more at right angles from the medial nerve. The fructifications of this genus, also, appear to be marginal, the sori being placed under the reflexed margin as in the living *Pteris* or *Pellea*, while those of *Pecopteris* are round, separate and generally placed in two rows upon the lower surface of the pinnules.

The distribution of the genus is the same as that of *Callipteridium*. Most of its species have been found either in the upper part of the sub-conglomerate coal strata or immediately above the millstone grit. Of the eleven species described in the coal flora the most common and distinctly characterized are:

A. **SERLII, Bryt.**

*Plate 12, f. 2.*

Generally found in large pinnae whose pinnules are all linear-lanceolate, sub-obtuse, like those of the upper part of f. 2, with the secondary veins at right angles, very close, either simple or forking once from near the middle.

A. **LOCHITICA, Schloth.**

Much like the last; but the pinnules are generally smaller, disjointed to the base and extremely variable, sometimes broad and obtuse, sometimes narrow linear and acute; the terminal pinnules are long, linear-lanceolate; the lateral veins also nearly at right angles, are more distant, simple and more rarely forking from near the base.

A. **AQUILINA, Schloth.**

Resembles the preceding; it has the pinnules shorter and comparatively broader, the veins slightly oblique, forking twice, while *A. ambigu*, Lesq.
smaller in all its parts, has the veins mostly obsolete, covered as they are by a thick epidermis, distant, simple or forking once. The medial nerve is comparatively very thick, abruptly dissolved under the apex of the leaflets.

PROTOBLECHNUM, Lesq.

Fronds large, simply pinnate; rachis very thick, scaly towards the base; pinnae long, narrow, linear-lanceolate, acuminate, entire, enlarged at base on the lower side into a decurring auricle, generally free; medial nerve strong, reaching the apex; veins at a broad angle of divergence, curving in passing to the borders, forking twice.

The only species P. Holdenii, Andr., is represented by two opposite extremities of a frond which was apparently fifty to sixty cm. long. The simple pinnae are much shorter toward the base of the frond, only two cm. long, while those of the middle are six to seven cm. long; the rachis is one cm. broad at base, where it is covered with a thick coating of long scales; the nervation is oblique and arched, nearly as in species of Callipteridium, a genus from which it differs essentially by its simply pinnate frond. The specimens were found in the Waverly formation of Ohio at the base of the lower coal measures.

PSEUDOPECLOPTERIS, Lesq.

(Pseudos, false.)

Plate 12, f. 3; pl. 13, f. 2.

Primary rachis forking near the base in diverging branches of equal size or divaricate and dichotomous; branches polypinnate; ultimate divisions sometimes forked; pinnules connate or separated to the base, of various shape, oblong, obtuse or ovate, lanceolate, oblique, or at right angles, simple or diversely lobate, generally decurring to the rachis and bordering it by a narrow wing; lateral veins oblique, generally forking once, the lowest pair twice; sometimes dichotomous.

This genus includes a large number of species whose essential and common character is the dichotomous division of the fronds, especially in the lower part of the stems. The character of the leaflets, their relative position, their shape and nervation are variable, sometimes like those of Pecopteris, sometimes also like those of Sphenopteris, and for that reason, the plants which are now embodied in a single genus, were indifferently referred by the authors either to Pecopteris or to Sphenopteris. Though differing in their specific characters, they all have, besides the dichotomous division of the stems, a peculiar and common facies, the leaflets often being more or less regularly lobate as in pl. 12, f. 3, or the primary nerves
by decurring to the rachis and joined by all the secondary ones, leaving a distinct smooth-border along the base of the pinnae, as in pl. 13, f. 2.

The fructifications of *Pseudopecopteris* are not positively known. In the first section of the genus containing species whose relation is marked to *Pecopteris* by the form of the leaflets and their relative position, fruiting pinnae of one species, *P. Mazoniana*, have been observed with large round sori, placed in simple rows along the border of the pinnales, near the end of the upper branches of the veins containing three to four oblong sporanges placed star-like around a central point, therefore, very much like the fructifications of *Pecopteris*, as seen (pl. 13, f. 3a and 3b). This first section should then seem more appropriately placed with *Pecopteris*, though the ramifications of the branches is evidently dichotomous. But fructifications of an analogous character are also seen in *Gleichenia*, a genus of ferns which, still represented in the flora of this epoch by a number of species, was already present in the jurassic flora and became predominant in that of the Cretaceous. Therefore the species composing the first section of *Pseudopecopteris* have their proper place in this new genus as related to the *Gleichenieae*. From recent observations made in Europe, the fructifications of species of the 2d section are analogous to those of *Dicksonia*.

Of the three species composing the first section, *P. Mazoniana*, Lesq., is the more remarkable. Its size is larger than that of any species of *Pecopteris*, the primary pinnae are pinnately divided in the lower part and forked near the top; the pinnales are large, oblong, half round at the apex; the veins are pinnate distinct and forking once in the middle from a thick medial nerve. Fine figures are given of this species in the U. S. Coal Flora, pl. 32.

The distribution of the twenty-five species which compose the second section, is in accordance with the relation of their characters. Ten species are sub-conglomerate, one of them found even at the base of the carboniferous in its point of union to the Devonian. They are all composed of lobate, or more generally of trilobate leaflets, like *P. muricata*, Brgt., pl. 12, f. 3, a species most common in the Whetstone beds of Indiana, to which *P. glandulosa*, Lesq., *P. latifolia*, Brgt., *P. acuta*, Brgt., *P. speciosa*, Lesq., *P. virginiana*, Meek, *P. trifoliata*, Brgt., *P. polyphylia* and *P. macilentia*, Ll. and Hutt., are closely related. Ten species of the same section are found at the horizon of the first coal above the Millstone grit. The more remarkable are *P. Newberryi*, pl. 13, f. 1, allied to *P. nervosa*, Brgt., *P. Plukeneti*, Brgt., *P. dimorpha*, Lesq., *P. anceps*, Lesq.—*P. irregularis*, St., though found above the conglomerate is analogous to *P. trifoliata*, Brgt., which is sub-conglomerate, but has also been found in small fragments above the Millstone grit.

In order to give a better insight into the characters of these ferns, I describe the more important species of the second section.
PSEUDOPECOPTERIS NERVOSA, Brgt.

Fronds tripinnate or compound, dichotomous and multifid; primary pinnae large, broadly lanceolate; secondary divisions open, linear-lanceolate toward the apex; pinnules oblique, connate from the base or above, ovate, obtuse or lanceolate obtusely acuminate, the inferior ones on the lower side generally bilobate; medial nerve effaced above by divisions; lateral veins all derived from the midrib, at an acute angle of divergence, forking once. A large beautiful fern, not rare in the sub-conglomerate measures and in the first coal above the conglomerate.

P. PLUCKNETI, Schloth.

Somewhat like the preceding, but smaller in all its parts, the pinnules entire, undulate and crenulate on the borders, the lower not lobate, the lower veins forking twice, the upper only once, all distinct but not inflated. Species common above the Millstone grit, not observed under it.

P. NEWBERRYI, Lesq.

Plate 13, f. 2.

Pinnae divided at the top in two diverging branches; secondary pinnae short, distant, nearly at right angles to the rachis; pinnules about as in the preceding species, the veins being all forking once only, the upper simple. The frond appears small and simply forking at the top of the stipe, but never pinnate. I have seen small plants not higher than four cm. and in an apparently incipient state of development, with exactly the same characters as those of the one figured.

P. MURICATA, Brgt.

Plate 12, f. 3.

Fronds very large, decompound and dichotomous or polypinnate; secondary pinnae long, linear-lanceolate; tertiary divisions open, sometimes at right angles, distant; pinnules distant, variable in shape, lanceolate-acuminate, sometimes distinctly lobate, the lower lobes half round, the terminal pinnules acute, or the upper lanceolate, entire or undulate; primary nerve thick, dissolved under the apex; lateral veins thick, more or less inflated toward the borders, the upper forked once, the lower twice. Mostly sub-conglomerate. The figured specimen is from the Whetstone beds of Indiana.
PRINCIPLES OF PALEOZOIC BOTANY.

P. ANCEPS, Leq.

Frond divided as in the preceding species; pinnae of the third order oblique, distant, rigid; ultimate pinnae short, inclined upward, lanceolate or oblong; pinnules short, round, ovate or subquadrate, the lowest generally free, the upper ones gradually more and more connate, the ultimate becoming simple and undulate by the cohesion of the pinnules; veins forking twice, either derived from a thin middle nerve, or dichotomous and flabellate from the base. Species locally very common above the conglomerate.

P. LATIFOLIA, Brgt.

Frond tripinnate, bipinnate above; secondary pinnae long, with a thin alate rachis; pinnules distant, inclined outside, ovate-lanceolate in outline, deeply lobed; lobes half round, entire, the lower sometimes irregularly dentate; middle nerve flexuous; lateral veins dichotomous, curved, forking once or twice; substance of the pinnules very thick, coriaceous—rarely found. The only good specimens I have seen are from the sub-conglomerate of Alabama.

P. acuta, Brgt., has the same characters as the last, but the terminal pinnules are acute.

P. speciosa, Leq., and P. Virginiana, Meek, are two splendid species whose divisions of stems and leaves have great analogy to those of P. maricata, but are all much larger, with pinnae and pinnules flat, the rachis winged. The nervation is of the same character. Both these species are sub-conglomerate and sub-carboniferous, P. Virginiana being found at the very base of the carboniferous measures.

PECOPTERIDEÆ.

PECOPTERIS, Brgt.

Plate 13, f. 3; pl. 14, f. 1, 3 b.

Fronds bi, tri or poly-pinnate; ultimate pinnae long, pinnatifid; pinnules adhering to the rachis by their whole base, free or more or less deeply connate at base, open or inclined but not occurring, borders generally contiguous or nearly so; secondary veins derived from the medial nerve of the pinnules, simple, or bi-trifurcate; fructifications often preserved as round sori, in simple or double rows along the borders, and composed of sporanges generally placed star-like around a central point. (Pl. 13, f. 3, 3 b.)

The species of this genus are very numerous and variable, especially in the form and relative position of the pinnules. Schimper, in "Paleontologische Vegetale," has grouped them in separate sections according to their
apparent relations to genera of ferns of the present epoch. This mode of division being difficult to understand for those who are not well acquainted with the living ferns, I have admitted the following sections, established from characters which, observable upon fossil species of the coal, are generally persistent and more easily recognized:

1. Pecopteris goniapterida (gounos, fructified). Lateral veins simple or forking, incurved.

2. Pecopteris proper or Cyatheoides (kuathos, cup), answering to the characters described for the genus. The leaflets are generally coriaceous, of coarse substance, convex on the upper face. The species of the group are sub-divided according to their nervation either in simple or in once or twice forked veins. (Pl. 14, f. 1, 2.)

3. Pecopteris villous, whose leaflets have the surface hairy or villous.

4. Pecopteris cestate, whose pinnules are short, lobate or cut at the apex in two or three small teeth.

Of the group of the Goniapterida, the more important and common species is P. unita, Brgt., (pl. 13, f. 3). I have figured merely an ultimate pinna with the pinnules contiguous in their whole length, the veins simple, incurved; the fructifications seen upon separate leaflets. But the fern was very large, its secondary pinnae broad and short with the tertiary ones like that figured, close, all of the same length and character. Another species, P. emarginata, has the tertiary pinnae much longer and broader, some of them fourteen em. long, two and one-half em. broad, but all the characters, nervation, fructifications, form of the pinnae, are so exactly like those of P. unita, that these large leaflets, always found separate from the stems, have been considered by some authors as representing a large form of the same species. P. longifolia, Brgt., P. lanceolata, Lesq., are, however, positively distinct species, the pinnae being entire, not lobate nor undulate on the borders. P. arguta, Goep., has the veins thick, oblique, parallel, straight to the borders, not incurved. These last named species and two others composing the group are rarely found in the American Carboniferous; the two first are common enough. All pertain to the supra-conglomerate measures.

PECOPTERIS (Cyatheoides.)

The species of this group were mostly tree-ferns, hence their remains are locally very abundant. I have seen a whole cabinet of carboniferous fossil plants composed merely of fragments of fronds and pinnae of the same species. Of course these fragments are mostly different, representing pinnae of first, second, third degree of divisions, all of peculiar and sometimes so varied characters that it is at first difficult to recall them to one species only. None of the species of this group have been as yet found below the Millstone grit, at least in the North American
PRINCIPLES OF PALEOZOIC BOTANY.

Carboniferous. Among the more noticeable are *P. arborescens*, Brgt., which takes its name from the elegant shape of its pinnae, comparable to that of a miniature tree. Its pinnales are small, the lateral veins simple. In the lower part of the branches, the ultimate pinnae become much longer, the pinnales narrow, close, of unequal length and the veins forking once. With *P. platyrachis* and *P. nodosa*, which have the nervation of the same character, the species is distributed in the upper part of the carboniferous from the Pittsburg coal to the Permian. Per contra, *P. quadratifolia*, which has also large and multifid fronds, but which is easily recognized by its very small, nearly round leaflets, truncate or angular at the top, is, for its distribution, limited to the lower strata above the conglomerate.

P. Stronghi, Lessq.

*Plate 14, f. 2.*

Remarkable for the great length of its pinnae and the peculiar position of its leaflets which, deflexed near the base and all more or less distant, give to the pinna the appearance of a simple frond. The species has, however, been found in fragments of pinnae like that of f. 1, which, represents another species of fern. Its habitat is in the coal just above the conglomerate.

P. oreopteridis, Schloth.

Pinnules broader and shorter; veins forking once at or near the base and curving, so that their ends reach the borders at right angles.

P. Candolleana, Brgt., and P. elliptica, Bamb.

Especially distinct by the pinnules distant from each other and not contiguous on the borders. The first has long linear narrow pinnules; the second has them short smaller ovate. The nervation is about the same in both, the lateral veins forking once or twice.

The largest species of the group, *P. Miltoni*, is extremely diversified in the form of its pinnae and the size of the pinnules, which, though generally large, become very small in some of the lateral divisions of the fronds. In this species, the veins are generally twice forked, first near the base and then in the upper part of each veinlet. This and the two preceding are found generally distributed through the middle carboniferous measures.

The villous *Pecopterids* are not very numerous in species. As their surface is covered with a more or less thick coating of short hairs the nervation is indistinct or seen only with difficulty. It happens, however, that by maceration the upper surface of the leaflets is sometimes destroyed and
the veins are exposed in relief; at other times the coating of hairs has been rubbed off and the veins become distinct. This is the case in *P. vestita*, pl. 14, fig. 1, which has the same kind of division of its fronds as the species of the preceding section, but which, besides its generally villous surface, is distinct by the very oblique veins forking once at base, the upper branch forking again. As seen in fig. 1 a., the sori are placed between the veins near their point of division.

*P. villosa* is the more common species of this group, even perhaps of the genus, sometimes covering by its remains the roofs of long tunnels of some veins of coal. It is by the characters of its divisions and also of its nervation much like *P. Miltoni*, differing by its smaller leaflets, contiguous on the borders, and the villous surface.

The crestate *Pecopterids* are especially represented by *P. erosa*, Guth., whose ultimate pinnae are linear, narrow at right angles to the rachis, thick-nerved in the middle and cut on the borders by simple or double very small teeth, giving to them the appearance of small saws. The veins are simple to above the middle and there branch in two or three divisions reaching the point of the teeth. The fructifications are on comparatively large round sori placed on the borders of the pinnae, covering the teeth in the dentate species, or placed as in the following:

**P. solida**, Lesq.

*Plate 14, fig. 3, 3 b.*

Pinnae simple, with a very thick rachis and divisions at right angles attached by the enlarged base of the thick medial nerve; pinnules linear or slightly narrowed to an obtuse apex, rounded and enlarged at the base, very entire, coriaceous, without trace of veins; fructifications in round distant sori placed in rows along the borders, with sporanges placed starlike around a central point.

Some species of *Pecopteris* are of uncertain relation to the groups established. In the U. S. coal flora, forty-five species of this genus are described.

**OLIGOCARP, Goeppl.**

Fronds bi or tripinmate; primary pinnae oblong-lanceolate; secondary open, linear; pinnules divided in oblong or half round leaflets, connate at base, crenulate on the borders; primary and secondary veins nearly of the same size, thin, distinct, the lateral curved to the borders, simple or forked.

This genus is intermediate between the *Pecopterideae* and the *Sphenopterideae*, the divisions and shape of the pinnae being like those of *Pecopteris*, while the nervation and the crenulate borders indicate affinity to *Sphenopteris*.
Three species have been described; one *O. Gumbieri*, common to Europe and America, has been found as yet only in the lower coal beds above the conglomerate; another, smaller in all its parts and more delicate, *O. Alabamensis*, pertaining to the sub-carboniferous, is known from a mere fragment. *O. flagellarii*, Lesq., is upper carboniferous.

**SPHENOPTERIDEÆ.**

Fronds bi, tri, poly-pinnate; divisions open or at right angles; pinnules narrowed at base, often decurring, cuneiform, entire or pinnately lobed; lobes rarely entire, crenulate, dentate or laciniate; primary nerve (medial nerve of the pinnules) slender, alternately dichotomous, the simple branches entering the base of each lobe to pass by branchlets into the sub-divisions of the lamina. In the genus *Eremopteris*, the lateral veins enter the lobes at an acute angle of divergence from the midrib and passing up to the borders are flabellate, dichotomous, parallel and close, as in species of *Neuropteris*. In the genus *Archaeopteris*, the veins are flabellate and dichotomous, as in *Odontopteris*, but diverging and flabellate from the wedge-form base. (U. S. Coal Fl.)

Until now little has been published by European authors on the fructification of the *Sphenopteridea*, which are variable for each group. A number of fructified species have been found in the North American Carboniferous, and it may soon be possible to fix a classification of the species upon the characters of their sori. Until this can be done and in order to facilitate their determination I have separated them in the following sections:

1. *Sphenopteris* (*Pecopteris*). Fronds with ultimate pinnae deeply lobed; lobes connate to the middle or higher; veins pinnate as in *Pecopteris*. Some species of this group have been described as *Pecopteris* by Brongniart.

2. *Sphenopteris* (*proper*). Pinnae more deeply divided in lobes or pinnules, narrowed and decurring at base, generally dentate or crenate at the apex.

3. *Sphenopteris* (*Hymenophyllites*). Fronds poly-pinnate, rachis of the ultimate and penultimate divisions composed of narrow linear fascicles of veins, mostly united into a simple, rarely double nerve, bordered by a narrow lamina and repeatedly dichotomous in the pinnules, whose lobes or segments of lobes are entire, linear, obtuse or narrowly lanceolate, acuminate, rarely cuneiform.

*Eremopteris*, separated from *Sphenopteris*, by Schimper, is a transitional division passing to the genus *Triphyllopteris*, of the same author or to the following group.
4. **Adiantites.** The characters of this group are mentioned above for its more important genus, *Archaeopteris*. On account of the peculiar nervation, its species have been sometimes united to *Cyclopteris*, though, as it will be seen, the characters are far different.

**SPHENOPTERIS, (Pecopterid.)**

Of the species of this group, *S. chorophylloides*, Brgt., is one of the finest, and more generally found in good specimens in the coal measures. The leaf is bipinnate, the pinnae long, linear or lanceolate in the upper part, composed of oblique close deeply pinnately lobed pinnaules, the lobes obscurely dentate and distinct to below the middle; lateral veins forked. The fructifications are in small round sori, placed upon the lower branches of the veins abruptly ending in the middle of the lamina. This species has been described by Brongniart from European specimens.

Two other European species, *S. Murrayana*, Brgt., and *S. alata*, Brgt., are represented in the "U. S. coal flora," by plants whose characters are somewhat at a variance with those described by the author. As of these two species the first is in Europe, of jurassic age, the other from the carboniferous of New Holland, the two analogous North American forms, though previously supposed identical, have been described as *S. pseudo-Murrayana* and *S. subalata*. Both are fine and distinct. The divisions of the pinnae and pinnaules are of the same type as in *S. chorophylloides*. Six species have been described of this group, all from the first coal above the conglomerate.

**SPHENOPTERIS, (proper).**

In the plants of this group the rachis is generally flat, the ultimate pinnae long, curved and flexuous, the pinnaules oblique, pinnately lobed or dentate, the veins pinnately derived from the medial nerve, the lower forking, the upper simple.

Of the seven species of this division, six have the same range of habitat as those of the last; one is sub-conglomerate.

*S. mixta*, Lesq.

*Plate 15, f. 1, 2.*

Most variable and diversely represented in fragments of its pinnae, the pinnaules being either pinnately lobed, as in fig. 1, with lobes half round entire or diversely cut, or merely pinnate, as fig. 2, with lobes inclined oblong obtuse entire.
PRINCIPLES OF PALEozoIC BOTANY.

S. BRITTSH.

Plate 15, f. 3.

Pinnæ regularly pinnately divided in alternate oblique oblong more or less deeply crenate lobes. It was first known from small fragments found in Missouri but has been recently obtained in very large and beautiful specimens from the coal measures of Southern Ohio, the locality and horizon, however, being still unknown. The fructifications are marked in one or two deeply set round sori, placed inside of the undulations or teeth of the lobes. The surface of the leaves is verrucose.

SPHENOPTERIS, (Hymenophyllites).

Plate 15, f. 4.

These plants, by the divisions of the pinnules and the nervation, have a relation to species of Hymenophyllum of the present epoch. The divisions are more or less numerous, obtuse or acute, always entered, each by one veinlet which ascends to the borders.

The ten species described from this group have been mostly found below the conglomerate, even in the sub-carboniferous measures below the Chester limestone; two only ascend to the base of the middle coal. Indeed, most all of the species of Sphenopteris have been found in the lowest coal strata, either below the conglomerate or immediately above it. A peculiar group of the genus, however, is represented in the Permo-Carboniferous measures of Virginia.

S. SPINOSA, Goepp.

A peculiar and very rare species. The frond is divaricate, poly-pinnate; primary pinnæ reflexed, large; secondary divisions ovate or broadly lanceolate in outline, pinnately lobed; lobes palmately cut in linear or wedge form obtuse generally bifid laciniae, the terminal prolonged into a long sub-cylindrical acuminate or obtuse point.

The whole plant is thick; the branches thick, round; the pinnules squamous on the surface; the veins, very thin, buried into the epidermis, are in fascicles, dividing at the base of the lobes and entering them.

The species is very rare in the American coal measures; some fragments have been found at the Colchester coal, of Illinois, above the conglomerate. A very fine specimen is in the National Museum at Washington, coming from Paxton, Sullivan County, Indiana. Fragments of the species have also been obtained at Clinton, Missouri.
S. tridactylites, Brgt.

Plate 15, f. 4.

This species represents a type of ferns most common in the sub-carboniferous measures. The fronds are tripinnately divided; the secondary pinnae open, lanceolate; the pinnules ovate-lanceolate in outline, gradually shorter toward the apex, sessile, slightly inclined or at right angles to the round rachis, pinnately lobed; lobes wedge form, the lower trifid, the middle narrower, bifid, the upper simple, the segments short, linear-obtuse. The fruitifications are in groups of small round sori placed on the under face of the lobes and covering them nearly entirely. They have been figured in the "U. S. Coal Flora," pl. 55, f. 9, 9 b.

As closely allied to this species, the following may be quoted: S. furcata, with longer pinnules, palmately deeply lobed, subdivided in three linear long segments, oblique or diverging. S. Hildrethii differing from the last by the rachis narrower, not geniculate, the pinnules pinnately lobed, the segments shorter. S. flexiculitis, which has the division of the rachis very flexuous and winged, the pinnules small, palmately lobed into short entire obtuse segments. To these may be added S. trichomanoides, S. elegans and S. Heninghauwii, differing by the position and form of the lobes all small and palmately divided.

Three species of Sphenopteris are still separately described as of uncertain relation, S. Ballantini, Andr.; S. linearis, Brgt., both sub-conglomerate, and S. flaccida, Crepin, found in the Vespertine sub-carboniferous of Pennsylvania.

EREMOPTERIS, Schimper.

Plate 15, fig. 5 (eremos solitary).

Upper part of the fronds dichotomous; pinnae open or oblique, irregularly pinnatifid; segments long, narrowly obovate or wedge form, obtuse, entire or crenulate, the lower deeply lobate.

Of the eight species described of this genus, six are sub-carboniferous, mostly found in the low coal of Alabama; the two others ascend to the first coal above the conglomerate. Two of them are European.

E. artemisfolia, Brgt.

Plate 15, fig. 5.

Answers to the above description of the genus. The other species differ especially by the position of the pinnae at right angles, the rachis flexuous, and the length and mode of division of the pinnules.
E. marginata, Andr.

Plate 9, fig. 5.

Is of uncertain affinity, related by its nervation to Adiantites. The species of this genus are generally rare.

ADIANITITES, Brgt.

Fronds large, bipinnate or tripinnatifid; pinnules oblique, simple or bi, trilobate, gradually or abruptly narrowed to the point of attachment; veins dichotomous from the base, dividing fan-like, straight, thin, distinctly marked.

To the Adiantites, I refer Triphylopteris, Schp., and Archaeopteris, Daws.

TRIPHYLOPTERIS, Schp.

Lower pinnules sub-opposite, tripartite or trifoliate, sometimes pinnatifid, the upper gradually more simple, all narrowed or contracted to a flat slightly decurring short pedicel; veins equal, simple or dichotomous.

Of this genus, two American species only have been described, one from the sub-conglomerate measures, the other from the sub-carboniferous.

T. Cheathamii, Sp. nov.

Pl. 15, f. 6.

Pinnæ apparently large; secondary divisions at right angles to a flexuous narrowly keeled rachis; pinnules or ultimate pinnæ oblique, broadly lanceolate in outline, pinnately three to five lobed; lobes trifid, cuneiform, the upper simple or bifid, the terminal cuneiform, crenate or split at the apex; veins dichotomous, flabellate.

T. Lescuriana, Meek.

Pinnules broadly wedge form, narrowed to a short oblique flat pedicel, decurring to the rachis, deeply three, rarely four lobate; lobes disjointed to the middle or below it, the middle distinct, longer, all oblanceolate blunt at the apex, rarely acute; nervation that of the genus.

A beautiful species discovered by Prof. B. F. Meek at the base of the sub-carboniferous measures of Virginia.
ARCHAEOPTERIS, Daws.

(Artchos, ancient.)

Plate 9, f. 3, 4.

This fine genus has the characters described above for Adiantites. All its species belong to the upper Devonian or the lowest strata of the sub-carboniferous; none have been found in the productive carboniferous measures. The fronds were very large, some of them at least, with long straight or flexuous branches and wedge form leaflets, rounded at the upper borders or truncate, entire or crenulate, variable in length from less than 1 to 5 cm. and $\frac{1}{2}$ to 4 cm. broad. The fructifications, or decomposed fertile pinnules, are placed along the rachis of the pinnae in rows of fascicles of club-shaped spore-cases attached to an excurring medial nerve, pl. 9, f. 3.

Seven species have been described, two of which are figured. One, *Archaeopteris minor*, Lesq., pl. 9, f. 3, represents the species with fructifications, the other, *A. obtusa*, Lesq., pl. 9, f. 4, is a fragment of a very large pinna. Both are Devonian or of the lowest sub-carboniferous measures of Pennsylvania, the Pocono. Fragments of one species only, *A. Bockschiana*, Goepp., represent the plant as tri-pinnately divided, the ultimate pinnae bearing reniform or broadly obovate pinnules, either alternately placed along the rachis or trifoliate, indicating the relation of the group to the *Sphenopteris*. These fragments were obtained in the (Pocono) sub-carboniferous measures of Pennsylvania.

FERNS OF UNCERTAIN RELATION.

RHACOPHYLLUM, Schimper.

Plate 15, f. 7–9.

Fronds either flabelliform nearly entire, or irregular many times divided; rachis flat, generally much enlarged, leaf-like or scarcely thicker than the foliaceous lamina which is always very variable in the size and mode of its divisions; veins generally indistinct, following the rachis in parallel bundles passing by dichotomy in the foliaceous divisions.

Though the morphology of the plants described in this genus may be quite as clear as that of the other ferns of the Carboniferous, their nature and their role in the vegetation is as yet uncertain. If some species appear related to *Sphenopteris* (*Hymenophyllites*) by the divisions of their pinnae and the distribution of the veins, first in flat bundles in the primary rachis, then diversely forking in passing to the pinnae, the lobes, etc., others are without any affinity whatever to any known characters of the
ferns. They appear to have been either a protophyllous vegetation, appearing before the stems of ferns and preceding their development, as are now the tissues of filaments preceding the vegetation of mosses or mushrooms, even of some ferns of the present epoch, where parts of the organs of the inflorescence are developed before the production of the fruiting plants. Others were evidently parasites, as they are often found attached to the stems of different species of ferns. Extremely variable in their characters, especially in the forms of their divisions even upon the same species or the same branches, as can be seen (pl. 15, f. 7), they are still more so in the size of the plants. Some are still smaller than that figured, pl. 15, f. 8; others have pinnae twenty to thirty cm. long, either dividing all around from a central point, or erect and pinnately branching, the main axis being two to four cm. broad. Their texture sometimes thick and coriaceous, was apparently generally soft and easily decomposed, as they have been rarely found in the stratified shale of the coal, but often in the concretions or nodules of Illinois and Indiana, where the soft cellular remains of plants have been more generally preserved.

More than twenty species referable to this genus, or rather group, have been described. What is said above, of the great disposition of the plants to vary, renders the circumscription of the so-called species as difficult as it is uncertain. Some of the more marked are the following:

**R. flabellatum, St.**

Leaves large, fifteen to twenty cm. long, coriaceous, rounded, wedge form, entire at base, enlarged, flabellate and lacinate at the apex; fascicles of nerves distinct, parallel.

A very rare, beautiful species, found in the sub-carboniferous of Indiana, Illinois, rarely in the coal above the conglomerate.

**R. membranaceum, Lesq.**

Frond large, pinnately divided, rachis or medial axis flat, broad; divisions alternate, broad, turned upward, cut at the apex in acute short segments; veins distant, distinct and dichotomous.

The frond was at least twenty cm. long; the main rachis forty cm. broad, the primary divisions two cm. The specimen which only shows a fragment of the frond is from the Clinton coal, Missouri.

**R. lactuca, St.**

Medial axis either long and pinnately divided or sessile, enlarged from the base all around, diversely lacinate; primary divisions large, curving outward, the ultimate short, linear, lanceolate, or long, linear, flexuous,
obtuse or acute. The specific name is derived from the subdivisions of
the fronds of this fern, spreading around like the leaves of a bunch of
lettuce. The species is commonly found in the middle coal measures.

R. corrallinum, Lesq.

Plate 15, f. 7.

Plants of small size; basilar pinnae diverging in a circle from a central
axis; broadly lanceolate, pinnately dichotomous; divisions oblique, the
ultimate either short, truncate, obtuse, or narrow, slender, filiform, forked
once or twice, surface dotted with hairs.

This species obtained in the nodules of Mazon Creek exposes the vari-
bility of the ramification and the diversity of characters of fragments of
the same plant.

R. adnascens, Il. and Hutt.

Plate 15, f. 8.

Still smaller than the preceding and not less variable; fronds many
times dichotomous; divisions radiate or divaricate from the base, narrow,
linear, obtuse or truncate; veins parallel or simple in each division.
Common and often found attached to the rachis of other ferns.

R. inflatum, Lesq.

Plate 15, f. 9.

Ramification subpinnate; lower lobes divided in obtuse half round
pinnules, most of the others being linear and entire.

Some species of this genus, composing a peculiar group, have analogy to
Fucoids or marine plants, or to some kinds of fungi.

TRUNKS OF FERN-TREES.

As seen pl. 8, where a tree-fern has been reproduced in its general
appearances, the trunks of these trees are distinctly marked from their
base upward by the scars of the points of attachment of their leaves or
of the base of the petioles upon the bark. In living tree-ferns the traces
of the vessels which pass from the trunk to the rachis are more or less
distinctly preserved, pl. 8, fs. 5, 6, 7. On the fossil specimens, the traces
or points of vascular bundles are generally effaced and the outlines only
of the inner structure of the base of the petioles remain as in pl. 8,
fs. 8–10. These scars are not rare in the American coal measures, but rarely found, still attached to stems, and mostly isolated upon detached fragments of the bark.

These scars are so distinct and so widely different in their characters that they serve for the determination of species of tree-ferns, of which, of course, the fronds and leaves are unknown; for until now no trunk of a fossil tree-fern has been found with the fronds attached to it, and therefore the specific relation of the scars to fern-leaves is unknown.

Tree-ferns are often found silicified in the coal measures. In petrifications of that kind, as it has been remarked already, the internal structure is generally distinctly preserved and can be studied anatomically by thin slides prepared by the lapidary for microscopical examination. But for these trunks, also, a peculiar or separate study has to be made, independent from that of the remains of fern-leaves preserved in the shale; for the silicified trunks have not even the bark preserved, and therefore not, or very rarely, the scars of the petiole. Hence the inner structure can no more give an idea of the foliaceous vegetation of the tree, than do the scars of the petioles.

According to the characters of the scars and of the inner structure, which are peculiar, very varied, and apparently reliable for the constitution of specific or generic groups, the fragments of fern-trees have been more generally considered under the following four divisions: *Stemmatopteris*, *Caulopteris*, *Megaphyllum* and *Psaronius*.

**STEMMATOPTERIS, Corda.**

*Plate 8, f. 9–10.*

Trunks erect, cylindrical; scars large, disciform, oval, round or ovate, disposed in quincunxial or spiral order, and composed of an outer flat border or ring, and of an internal disk, formed by impressions of fascicles of vascular tissue generally horse-shoe shaped, the horns curved inward in the upper part of the scars, either short and hooked, or descending to below the middle of the scars and there united.

Fourteen species of *Stemmatopteris* are known now from the American specimens obtained from the middle coal measures, the range of these trees being especially from above the conglomerate to the Pittsburg coal, and still higher to the Permo-Carboniferous. Some of these disks are remarkable for their large size, which, in *S. insignis*, is twelve cm. in length, eight and a half cm. broad; others by the scales bordering the scars; others still by their peculiar shape, as *S. mimica*, pl. 8, f. 10, which represents the outlines of the face of a man. *S. polita*, f. 8, is a simple inside scar, with inner surface quite smooth. *S. angustata*, f. 9, is remarkable for its narrow shape compared to its length. These are figured to show the great difference between the characters of the scars.
CAULOPTERIS, Ll. & H.

This name, like the preceding, merely signifies trunk of fern. The species of the genus differs from those of the last in being marked by linear bands or stric, remains of vessels passing from the trunk to the rachis, or by impressions of rootlets obliterating their original shape. Generally the scars appear ovate or elliptical, without mark of the horseshoe shaped vascular lines. The unreliability of the so-called generic divisions of this kind is seen in the fact, that sometimes, when the linear bands are casually effaced by erosion or maceration, and the horseshoe shaped lines are seen underneath. Generally, however, the species of this group have the scars continuous, elongated at base in such a way that the upper scar is joined to the lower by that linear often flexuous prolongation. The species of this genus, of which eight are known, follow the same distribution as those of the preceding.

MEGAPHYTUM, Artis.

Plate 8, f. 11.

(Megas, large; phuton, plant.)

Scars large, round-quadrate in outline, contiguous or very close, placed in opposite bi-serial rows; internal disks convex, with central or vascular impressions, horseshoe shaped, or a medial band, dividing vertically the disks into two lobes, joined in the middle or at the base.

The disposition of fronds of ferns in two opposite rows and close to each other is peculiar, and has not been remarked upon any fern-trees of the present epoch. The appearance of these trees was probably, upon a very large scale, however, about like that of the leaves of certain species of palms, divided in the middle by the prolongation of the petiole with the rays or leaves on both sides of it.

Of the four species described, M. protuberans, Lesq., is represented by a small fragment and in reduced size (pl. 8, f. 11). M. McLayi, Lesq., has scars of about the same form, broader, however, measuring nine cm. at the cordate base and twelve cm. long. The distribution of the species is like that of Stemmatopteris.

PSARONIUS, Cotta.

(Psaros, speckled.)

As a generic division, this name is admitted by authors for the description of trunks of ferns found silicified, generally covered in the lower part by a coating of adventive roots, and whose woody cylinder is subdivided into branches composed of fascicles of vessels of various shapes immersed into the cellular medular tissues. When the transverse section of
these trunks is polished the fascicles of vessels represent multiple varied and beautiful designs, like those of marble, variegated in color and often figured like stars. Trunks of *Psaronius* are common enough in divers parts of our coal measures, especially in Southern Ohio, Virginia and Northeast Kentucky.

Some silicified rachises of ferns, whose internal structure has been examined by transverse sections, have been described by authors under the name of *Rachiopteris*.

**LYCOPODIACEÆ, or club moss family.**

*Plate 16.*

The *Lycopods*, living at the present epoch, are herbaceous, rarely shrubby plants, with a dichotomous ramification (pl. xvi, f. 1, 2), or branches, alternately or pinnately divided. The leaves are small, disposed in spiral or in verticils, uniform of biform, ovate-lanceolate or linear, simply nerved in the middle. The disposition of the leaves is very variable, even upon the same stem or branches. In the genus *Selaginella*, the leaves are four ranked and biform, one series being placed in the upper part of the stems, composed of smaller leaves appressed to the stems, the other on the lower face, of much longer leaves, horizontally spreading. The organs of reproduction are in sporanges, placed in the inside part of the leaves, generally axillary (pl. 16, f. 4, 4a), containing spores, either large, macrospores (f. 5), or, in some genera, spores of two kinds in separate sporanges; macrospores, organs of germination and fructification; microspores (small spores), apparently contributing like the pollen of the dicotyledons to the fertilization of the macrospores. The *Lycopodiaceæ* have, therefore, a higher degree of organization than the ferns.

The *Lycopodiaceæ* of the Paleozoic formations had nearly the same organization as described above for species of the family living at the present epoch. As seen, pl. 16, f. 6, 7, which represents a strobile, the sporanges (f. 6) are placed in the axils of leaves (blades), curved at base into a support (sporangiophore) joining the axis in right angle (f. 6a), and these sporanges merely contained macrospores (f. 5, 6). Sometimes sporanges, placed in the upper part of the cones, contain only microspores, while those underneath have macrospores, a fact which, however, has been rarely observed. The cones of the *Lycopodiaceæ* of the coal are sometimes very large, four to five times as large as those figured; pl. 16, f. 6, 7. They are rarely found in a complete state of preservation; some fragmentary, like f. 6, expose, by disintegration, the axis and the sporanges attached to it; some others, cut transversely, as f. 8, and flattened, show the disposition of the sporanges around the axis, and the form and mode of attachments of the blades. Generally the sporanges or
the sporangiophores with the blades, are found detached and separately mixed with other fragments of plants upon the shales of the coal, as f. 9, 10, 11. They show great variety in the characters of the fructification and, of course, of the plants wherefrom they are derived.

The *Lycopods* of the coal, generally of small size and herbaceous, are rare and compose a group of little importance, the *Lycopodites*. A second group, that of the *Lepidodendraceae*, is mostly composed of large trees of elegant forms, bearing long branches, early deprived of their leaves and fruiting strobiles pending from their extremities. One of the trees representing the genus *Lepidodendron* is reproduced, pl. 17, f. 1. The leaves were linear, or linear-lanceolate, very variable in length, from one to twenty cm., according to the different species, generally flat or concave or canalicate, marked in the middle by a strong nerve. Their points of attachment are distinctly seen even upon the small branches deprived of their leaves, by cicatrices, which were generally, at first broadly rhomboidal or square, and very small, one to two mm., and they generally increased, especially in length, with the growth of the trunks and of the branches. The scars, therefore, vary in size according to their age or their place upon the trees, either upon the branches or the trunks. These scars, generally distinctly preserved, (pl. 17, f. 3–7), and now found upon fragments of trunk or of bark, serve by their characters to the determination of the species. Of course they are somewhat subject to variations, either by casual modifications in the growth of the trees, or by some unknown local deformations, and, therefore, it has been supposed by some paleontologists that the determination of species, from the scars of the bark, is fallacious and that, without reason, a too high valuation has been made of the number of species of *Lepidodendron* described from the carboniferous. In contradiction to this opinion it may be said that impressions of trees of *Lepidodendron* have been found in Europe, upon sandstone strata, measuring a hundred feet in length and ten feet in diameter, whose surface was distinctly marked with their scars. Of this size I have not seen any. But I have visited in Pennsylvania, at the falls of Little Beaver River, a sandstone formation containing the remains of a forest of *Lepidodendron, Stigmaria, Sigillaria*, etc., where impressions of trunks are distinctly exposed, sixty feet long (sixteen to eighteen metres), fifty cm. in diameter, with the scars of the bark distinctly preserved in their minutest details, and all exposing the same characters in the whole length of the stems. What is known also of the great diversity of forms and sizes of the leaves, of Lepidodendron, of their cones, and of their blades, seems on the contrary to show that the number of species described as yet from the characters of the scars of the bark is rather put too low than too high.

The genus *Lepidodendron* is as remarkable for its peculiar distribution as it is for the great number and the great size of its representatives. In the Paleozoic times, immense forests of these trees composed part of the
vegetation, covering as wide surfaces as are occupied by the great forest of conifers at the present epoch. Their remains have entered for a great part into the components of the coal.

The presence of the *Lycopodiaceae* has been recognized in the old geological formations as far down as the lower Silurian. Two species of *Psilophytic*, Dawes (*psilos*, naked; *phyton*, stem*), a genus related to *Lepidodendron*, have been found, the first, *P. gracilimum*, Lesq., (pl. 3, f. 1), in the Cincinnati group, lower Silurian, the second, *P. cornutum*, Lesq., (f. 2), in the lower Helderberg sandstone of Michigan. Fragments of the species of the same genus have been discovered also in the upper Silurian of Canada. The fragments of branches (pl. 3, f. 7, 8,) representing, by the scars of their surface, plants related to *Lepidodendron* or *Sigillaria* have been found also in the lower Silurian of Ohio. Hence the family appears, by the same kind of evidence, as old as the ferns and the *Equisetaceae*.

Fossil remains of the *Lycopodiaceae* found in the American coal measures, represent with some species of *Lycopodites*, or true Lycopods, the following genera of the *Lepidodendraceae*: *Lepidodendron* with their organs of fructification *Lepidostrobus* and *Lepidophyllum*; *Ulodendron*, *Knoria*, *Halonia*, *Lepidophloios*, *Cyclostigma* and fructifying fragments, *Lepidoceystis* and *Sporeceu**stis*, not sufficiently known in their relation to the plants which they represent.

**LYCOPODITES, Br.**

Plants herbaceous or subarborescent; leaves all of the same form in spiral order, or biform four ranked; fructifications in small axillary tubercles (macropores), either spread along the stem or agglomerated in spikes at the top of the branches.

Of the eight species of the *Lycopodites* known from the North American coal measures, one, *L. Ortoni*, distinctly represents the group of the *Selaginellae* of the present epoch. Another, not yet published, *L. simplex*, has a long, simple stem, linear, somewhat flexuous, five mill. broad, covered with short lanceolate sharply pointed leaves, bearing in the axils small round tubercles. It is closely related to *L. leptostachys*, a species described from European specimens by Goldenberg. Another, *L. arboroseens*, has a primary stem three cm. in diameter, which divides nearly at right angles into a round branch only seven mm. broad with numerous dichotomous pending branchlets, and short, ovate, concave, lanceolate, sub-imbricate leaves. Branches of this kind are not very rare in the coal, but when found separate from the primary stem, as they generally are, they have been considered as fragments of branches of *Lepidodendron*. They greatly differ by the concave leaves, whose nerve is obsolete and the stems without leaf scars.

*Lycopodites* appear to follow in the distribution of their species the same march as *Lepidodendron*. The best known are from the sub-con-
glomerate measures of Pennsylvania and from the lowest coal above the conglomerate of Illinois. One species only, *L. strictus*, Lesq., is from an upper coal bed near New Harmony, Ind.

**LEPIDODENDREÆ.**

**LEPODOENDRON, St.**

*Plate 17. (Lepidos, gen. of lepis, scales; dendron, tree.)*

The genus has the characters of the *Lepidodendreae*, above described. The species are recognized merely by the leaf-scars marked upon the bark or surface of the branches and trunks. These scars, which are the remains of the base of the leaves, are rhomboidal-oblong or rhomboidal-square upon the small branches, and very variable in size. Generally called bolsters, when taken in their whole, they bear in the inside, cicatrices or leaf-scars, which, rhomboidal, enlarged on the sides, are dotted in the middle by three points (vascular scars), and generally have under the lower border two small oval tubercles, cicatrices of bundles of vessels, named appendages, and placed on each side of a medial line (*cauda*, tail), which, like the appendages, is more or less distinct, sometimes deep and wrinkled across, sometimes obsolete. Pl. 17, f. 6, represents distinctly these different organs.

Little is known of the internal structure of *Lepidodendron*. One silicified species, *L. Harcouri*, has been described by Bronniiart from microscopical analysis of its internal tissue. Its characters have been found analogous to those of some *Lycopsids* of the present epoch, *Psilotum* and *Timesiapteris*. Another species, *L. vasculare*, has shown the structure of *Sigillaria*.

The roots of these trees are not positively known. Some authors consider *Stigmaria* as roots of *Lepidodendron* and *Sigillaria*.

A subdivision of *Lepidodendron* into different genera has been proposed by some European authors, based upon the relative position of the bolsters and the mode of attachment of the leaves, either toward the top, or the middle of the cicatrices. As these characters are unreliable, this classification especially followed by Sternberg and Goldenberg has been abandoned.

Of more than forty species of Lepidodendron known from American specimens, I merely describe a few of the more remarkable ones, in order to show on what kind of characters are based the specific determinations. The essential groups are represented upon plate 17.
1. Bolsters ovate or obovate, angular on the sides or not.

*L. distans*, Lesq.

*Plate 17, fig. 7.*

Bolsters or cicatrices distant, ovate, narrowed upward and downward about in the same degree, rounded on the sides; leaf-scars rhomboidal, with equal sides; vascular points, appendages and cauda very distinct; space between the scars narrowly wrinkled lengthwise.

To this group belong a number of species. *L. obovatum*, which has the same characters, but the lobes contiguous, as are those of fig. 6. *L. modulatum*, whose cicatrices are bordered by a deep undulate groove which appears upon the impressions like a half round regularly deeply wrinkled margin. In these species the leaf scars are placed low, nearer to the middle. *L. dichotomum*, St. pl. 17, f. 1b., represented by a large number of varieties, among them *L. obovatum*, *L. gracile*, etc. It is the most common of the genus.

2. Bolsters narrow, acute or acuminate at both ends, angular on the sides. leaf-scars enlarged sideward, but not reaching to the borders; vascular points, appendages and cauda distinct.

*L. aculeatum*, St.

*Plate 17, f. 6.*

Characters as above.

The difference in the place of the leaf-scars, either in the middle of the cicatrices or in the upper part and in their forms also, serve as characters for the determination of the species of this group.

3. Bolsters still longer and narrower, either contiguous or separated by a narrow space; leaf-scars in the middle generally prominent, appendages and cauda none.

*L. rimosum*, St.

*Plate 17, f. 3.*

Leaf scars unequally rhomboidal, more rounded on the lower side, comparatively very small. The group has few species or perhaps only the one figured.

4. Bolsters broadly ovate; leaf-scars in the upper part, as broad as the space between the borders, transversely oval; vascular scars very distinct; appendages none; cauda marked by transverse wrinkles filling the base of the bolsters.

To this group belong *L. Britsii*, Lesq., pl. 17, f. 4 a, 4 b, *L. Worthenii* and the European *L. Volkmannianum*, which is considered there as one of the species limited in its distribution to the Culm or sub-carboniferous.
Of the two species named above, the first has been found at Clinton, Mo., in the lower coal above the conglomerate, the second is sub-carboniferous, or of the horizon of the Chester limestone. This species should be present in the Whetstone of Indiana.

5. Bolsters ovate, rhomboidal; leaf-scars broad, rounded above, subtruncated at base; vascular scars and cauda distinct; appendages none; cicatrices of the decorticated surface rhomboidal quadrangular.

L. diplote gioides, Lesq.

Plate 17, f. 5.

A peculiar species of the sub-conglomerate of Arkansas.

With L. dichotomum, the most common species of the genus is L. Volt¬heimianum, St., which, more generally present in the sub-conglomerate, has however, been found in the upper strata of the coal measures, even according to Geepert in the lower Permian. The species is difficult to determine and very variable. Its more marked character is the position of the broad leaf scars in the middle of the bolsters, whose borders are continued in the form of an S, with more or less deep undulations. The appendages, vascular points and cauda are more or less distinct; the bolsters are short or long, either contiguous or separated by a narrow space or flat border; the leaf-scars are transversely spindle-shaped, the upper part convex, the lower obconical.

A form which has been considered by some authors as a variety of this last species is L. elypeatum, Lesq. Its cicatrices are irregularly rhomboidal, nearly as broad as long with the sides obtuse, unequilateral, and the leaf-scars transversely rhomboidal, large. This species, though extremely variable, is distinct, not only by the unequilateral twisted shape of the bolsters, but also by its distribution, which is mostly with the first coal above the conglomerate, though some specimens have been found in the sub-conglomerate coal measures.

LEPIDOSTROBUS, Brgt.

Plate 16, f. 6, 7, 8; plate 17, f. 2.

The strobiles or fruit-bearing cones of Lepidodendron have been considered above in their mode of organization. Their form is generally cylindrical, conical, acute or rounded at the top. They greatly differ in their length and size, from two to three cm. long and less than one cm. broad, to forty to fifty cm. long and four to five cm. broad. The characters serving to determine them specifically are far more diversified, reliable and persistent than those of Lepidoden¬dron. They are taken not merely from the size and shape of the strobiles,
but especially from the form of the blades or bracts of the sporangio-
phores, the form and mode of attachment of the sporanges, their direc-
tion, either oblique or in right angles, etc. However, there is often some
difficulty in ascertaining the characters of the blades and the sporanges
when the cones preserved in their integrity are flattened by compression.
And when they are broken in parts, either showing the sporanges and the
blades in circular rows as in pl. 16, f. 8, or disseminated and separated
from their supports as in pl. 16, f. 9–11, the shape and size of the cones
often remain uncertain. It has, therefore, been advisable to separate the
organs according to their degree of preservation. The genus *Lepidostrobus*
represents the entirely preserved cones of *Lepidodendron*, or such part of
the strobiles well preserved enough to show their shape and size, while in
the genus *Lepidophyllum* (*phyllon, leaf*) are described merely the leaves of
*Lepidodendron*, and especially the blades of their cones, pl. 16, f. 9, 10, 11.

The more interesting or more common species of *Lepidostrobus* found in
the coal measures of North America are:

**L. Goldenberghi**, Schp.

Strobiles very large, cylindrical, thirty-three cm. long, four and one-
half cm. broad; blades or bracts broadly lanceolate, acuminate, two and
one-half cm. long, four to five mill. broad, half open, curved inward.

**L. praelongus**, Lesq.

Spikes narrow, cylindrical, very long, seventy cm. or more; sporanges
inclined upward, blades narrow, linear or lanceolate-acuminate.

**L. hastatus**, Lesq.

*Plate 17, f. 2.*

Strobile conical, short; blades lanceolate-acuminate, enlarged, hastate
at base, as in pl. 16, f. 9, which is *Lepidophyllum hastatum*, or the detached
blade of this strobile.

**L. spectabilis**, Lesq.

Cone linear-oblong, rounded at base, obtuse at the top, sporanges long,
at right angles to the axis; blades short, narrowly lanceolate-acuminate,
appressed and closely imbricate. A beautiful cone forty cm. long, five
broad in the middle. The European *L. variabilis* is of the same type, but
much smaller.
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**L. oblongifolius, Lesq.**

*Plate 16, f. 8.*

Strobiles with a broad axis; sporanges short, cuneiform, acuminate at base; blades large, oblong-lanceolate to the acute or obtuse apex.

**L. ornatus, Park.**

*Plate 16, f. 6, 7.*

Strobiles small; blades short, broadly lanceolate-acuminate, closely imbricate, appressed, coriaceous, convex and carinate on the back by the thick medial nerve. The point of attachment to the sporanges is large rhomboidal and equilateral. The cones of this character discovered in the N. American coal measures, are larger than those figured from European specimens.

A group of cones of *Lepidostrobus* type which I have separated under the name of *Macrocladis*, have long strobiles, large sporanges joined to the axis by their base without either sporangiophores or bracts; pedicels none, or very short; sporanges filled with macrospores attached around a central axis.

These strobiles were extremely long, their sporanges oblong, obtuse at the outside or bladder-like, of various size and shape. A number of species are described with figures in the U. S. coal flora. When detached, these sporanges have been sometimes taken for and described as fruits (*Carpopoities*).

**LEPIDOPHYLLUM, Brgt.**

As representing blades or bracts of strobiles of *Lepidodendron*, the descriptions of species of *Lepidophyllum* relate to their form and size. But of course the species are hypothetical, for the blades found separate from the cones may belong to strobiles already described as *Lepidostrobus*. Specimens of *Lepidophyllum* are much oftener found than those of entire well preserved cones, and generally they are found spread together in numbers upon the shales. From this, the persistence of their characters may be surmised, as generally the shales or specimens obtained at the same place bear only blades and sporanges of one distinct form identical in shape and size. Some of the species of *Lepidophyllum* have been described or mentioned above in considering the genus *Lepidostrobus*. They are figured pl. 16, f. 9, 10, 11. But there is another group of species of this kind, all of much larger size, with blades seven to ten cm. long, twelve to sixteen mill. broad, which pertain to cones of *Lepidophloios*, and will be examined with the genus.
ULODENDRON, Il. and Hutt.

(Ulos, wood—forest.)

Plate 18, f. 2, 3.

Stem arborescent, rarely branching, bearing in alternate or opposite rows, large round or oval cicatrices, impressions of the base of sessile cones, marked with concentrical impressions of scales around a central axis and short, lanceolate leaves, which, early falling off, have left, as scars of their points of attachment, rhomboidal oblong or oval small bolsters, disposed in spiral like those of Lepidodendron; fructifications in long, cylindrical strobiles.

The affinity of Ulodendron with Lepidodendron is so well marked that some authors have not separated the genera, though legitimate the separation may appear. The trunks of Ulodendron seem to have been simple or rarely ramified, like those of Sigillaria; the leaf-scars are scarcely variable in size or not much larger upon trunks of great size, for the bark is not expansible as in Lepidodendron, but splits lengthwise by the enlarging of the trunks, and the intervals between the borders of the scars are filled by woody excrescences which, sometimes, widen laterally and cover part of the bark and its scars. To these differences may be added the fact that the leaves of Ulodendron are very rarely seen. I have not yet been able to find any one attached to the stem.

The large disks placed in vertical series and supposed to be scars of cones, are variable in size, increasing in width with the growth of the trees. No kind of organism has been found attached to trunks of Ulodendron which might explain the origin of these scars. Some paleontologists consider them as supports or cicatrices of a strobiliform inflorescence, or of cones of fructification produced upon young stems and easily detached. Others, among them Brongniart, regard them as cicatrices of conical tubercles covered with leaf-scars as are those of Halonia. The first opinion appears more probable, and is more generally admitted, but some American specimens have been found which give the same degree of authority to both assertions, showing that if, in some cases, those large impressions are the scars of small fruiting organs like strobiles, they represent in some others the abortive buds of branches. The question is discussed in the "United States Coal Flora," pp. 399 and 400.

Six species of Ulodendron have been described from American specimens. Their range of distribution is the same as that of species of Lepidodendron. The more distinctly characterized are the following:

U. MAJUS, Il. & Hutt.

Stem large, bolsters rhomboidal, peltate or angular at the apex, the lower half round; inside scars transversely oval, marked in the middle
by three vascular points; disks of strobiles large, round, generally umbo-
nate in the middle, about one cm. distant, transversely, six to seven mill.
vertically. The scars of the base of the strobiles are slightly excentrical.

U. minus, Il. & Hutt.

Plate 18, f. 3.

Stems of small size; disks circular, close; leaf-scars small, convex,
rhomboidal, marked at the basilar angle by a short vertical line. This
species is generally found in the subconglomerate measures.

U. elongatum, Lesq.

Plate 18, f. 2.

Leaf scars distinctly rhomboidal, twice as long as broad, acute at both
ends, bordered with a flat, smooth margin; inside scars exactly central,
small, rhomboidal, elongated and narrowed sideward; disks oval, large,
distant, pitted or rugose inside; axis central and umbonate. This species
with U. ellipticum, Lesq., a closely allied one, is not rare in the first coal
above the conglomerate.

U. punctatum, Il. & Hutt.

Leaf scars punctiform in corticated specimens and disposed in quin-
cunxial order; disks very large and distant, oval, marked with deep lines
or striae, radiating toward the borders from an excentrical protuberance.
The disks of this species are very large, sometimes as long as fourteen
cm., and ten cm. broad; the excentrical axis is a protuberance having
rather the appearance of the base of a broken branch than that of the cic-
atrice of the base of a strobile. But all the scars have the same kind
of excentrical protuberances and it is not well possible to explain how all
these cicatrices, if they were those of broken branches, could have exactly
the same form and size. The species is mostly found in the conglomerate
sandstone.

New discoveries concerning these large disks of Ulodendron rather tend
to increase the uncertainty concerning their true natures than to clear it.
A large trunk, examined upon the roof of a tunnel in a mine of Pennsyl-
vania, shows two rows of alternate disks, one of them composed of disks
twice as large as those of the other, but of the same form, the large ones
fifteen cm. long, ten broad; the small only five cm. long and two broad.
Of course such differences can not be caused by maceration and compres-
sion.
KNORRIA, St.

Plate 19, f. 7, 8.

Trunks covered with elongated, semi-conical or truncate tubercles placed in spiral order, more or less closely imbricated, leaving, after falling off, round, convex marks, with a single vascular scar or point in the middle; leaves long, linear, more or less inflated at the base, medial nerve flat.

Until now the only specimens I have seen referable to this genus are decorticated or obscure fragments covered with the persistent base of the leaves, as in f. 8, or with short, either broad, obtuse, or narrow, circular leaves or impressions. Some authors do not consider as reliable or persistent the characters which separate Knorria from Lepidodendron and have identified some so-called species of Knorria as a decorticated state of Lepidodendron Veltheimianum. Impressions of that kind are also sometimes remarked upon the decorticated surface of trunks of Sigillaria monostigma. But these deformations are casual, while the characters of Knorria are traceable through the successive layers of the bark. Of this kind one species only is described here from American specimens:

KNORRIA IMBRICATA, St.

Plate 19, f. 7, 8.

Tubercles of the trunks semi-cylindrical, conical, truncate or obtuse, those of the branches small, papilliform, closely imbricate.

A number of European species are all, more or less, distinctly referable to this. Among others, K. acicularis, Goepp., whose scars are cylindrical, about one cm. long, only two mm. thick. Upon the same flattened specimen I have seen, on the upper part, the scars exactly of the above description, while on the lower face of the branch, they were more enlarged, convex like those of K. Schrammiana, a species also of Goeppert, and on one side they were effaced into round scars like those of a small kind of Stigmaria described by the same author under the generic name of Ancistrophyllum. Specimens of Knorria have been found mostly in the sub-conglomerate coal measures and immediately above the conglomerate.

HALONIA, Ll. & Hutt.

Plate 18, f. 1, 4.

Stems of medium size, dichotomous; surface of the bark tuberculate; space intermediate to the tubercles marked with rhomboidal bolster; decorticated surface covered with punctiform round or oval papillae, obtuse or perforated in the center, placed in spiral order.

There is, upon the nature of the different kinds of cicatrices marked upon
these trunks, the same uncertainty as for those of *Ulodendron*. The large tubercles, pl. 18, f. 4, placed in quincunxial order, either flattened or hollow at the top, or entirely covered with scars of scales or of leaves and obtuse at top without traces of perforation, have been considered by some authors as the inflated base of leaves, and the intermediate surface scars as marking the point of attachment of scales. But it is not possible to admit that leaves were placed at the top of tubercles sometimes very large, while intermediate rhomboidal scars, like those of *Ulodendron*, are seen, f. 4, covering the large tubercles even to the top. Discussing the matter and the opinions of authors in "United States Coal Flora," pp. 409–418, and having, for examination of this genus, American specimens better preserved than any found in Europe, I have considered the large tubercles of *Halonia* as mere adventive or undeveloped buds of branches, and the intermediate surface cicatrices as leaf-scars.

All the American specimens referable to this genus have been procured in the low coal measures, either below, or within, or just above the conglomerate.

**H. tuberculata,** Brgt.

*Plate 18, f. 4.*

Tubercles large in quincunxial order, button like, conical-obtuse, open, irregularly deeply hollowed at the top, or more acute, entire or closed; leaf scars transversely rhomboidal, marked in the center by a punctiform vascular scar; decorticated surface punctate.

**H. tortuosa,** Schp.

Stems small; tubercles in quincunxial order or alternate in vertical rows, variable in distance, small, half globular, marked in the middle by a large vascular point; intermediate scars transversely rhomboidal; decorticated surface marked by small round papillae.

The specimen is flattened; the tubercles of the upper face are close, in two rows nearly in the middle, while on the lower more flattened face, there are also two rows of the same kind of tubercles, but distant, placed along and close to the borders, as if the stems had been creeping and the scars forced outside. This specimen seems to represent a creeping rhizoma.

**H. flexuosa,** Gold.

*Plate 18, f. 1.*

Tubercles distant, inflated, lateral and alternate; leaf-scars of the corticated surface vertically rhomboidal (as figured by the author); those under the cortex are ovate, acute, small papillae, marked with a distinct vascular point.
As seen on the figures, the large tubercles placed on the sides give to the branches a flexuous form. They are covered with leaf scars to the apex. Found in the middle coal measures.

H. pulchella, Lesq.

Branches small, cylindrical; scars small, hemispherical, close, in spiral order.

A very small branch, a little more than one cm. in diameter; found in the sub-conglomerate coal of Arkansas.

H. secreta, Lesq.

Stem of medium size; tubercles in regular spiral order, equidistant, transversely oval, covered with a thin hard convex smooth cortex; sub-cortical scars rhomboidal-oval, inflated at the borders, marked in the central narrow depressions by three round vascular points placed in horizontal series as in Lepidodendron; surface of the stem smooth.

A very peculiar species, described from a remarkably well preserved specimen four and one half cm. broad, which, originally cylindrical, has been flattened by compression. All the scars marked upon the surface are somewhat convex and transversely oval, the convex part being a thin but very hard, smooth crust, covering deep cavities at the bottom of which are seen the true leaf scars distinctly marked by the three vascular points described above. This specimen shows better than any other of this genus that these tubercles represent undeveloped or adventive organs, either leaves or branches. In this case the distribution of the vascular scars indicates them as leaves.

LEPIDOPHLOIOS, St.

Plate 18, f. 5-8.

Stems arborescent, erect, with four-ranked branches disposed in spiral order; leaves coriaceous, linear, long and narrow, with a thick medial nerve attached at base to thick sub-erect or recurved bolsters inflated in the upper part, dotted under the leaf-scars by a small mammilla. Areoles transversely rhomboidal, marked horizontally by three vascular scars minutely papillose under the cortex.

The figures made from American specimens do not give a just representation of the surface characters of the plants. The leaves were apparently produced upon long inflated bladder-like supports, which, by compression, have been curved back and flattened. At least this is surmised from the large beautiful specimens which have been found in Europe and have been described and figured by Golderberg. In these specimens, the
branches are horizontal, the scales or base of the leaves on the branches on both sides are flattened, so that the leaf-scars are turned toward the stem, and those upon the stem toward the base, and therefore, to be right to nature, the fragment of bark represented (pl. 18, f. 5), should be overturned. The leaves were like those of *Lepidodendron*. I have seen only short fragments upon a broken stem of one species. They are rarely found still attached to the branches; even the stems with these scars are very rare. The fructifications are like those of *Lepidodendron*, in sporanges fixed to large strobiles by the base, with sporangiophores enlarged outside into large oblong lanceolate blades, as in *Lepidophyllum acuminatum*, Lesq., (pl. 18, f. 6). These large species of *Lepidophyllum*, of which there are many, have not yet been seen in connection with strobiles. But fragments of very large cones, twenty cm. in diameter or more, have been found at Cannelton, covered with scaly-form leaves like those of pl. 18, f. 7, under which are large appressed glomerules of macrospores, at least twice as long and as thick, like those of f. 8. These agglomerations do not seem to be enclosed in sporanges; they appear merely covered by the bracts. There is still a great deal of uncertainty about the true nature of these plants, which, however, are evidently referable to the *Lyceopodiaceae* by the characters of the fructifications and the cicatrices of their bark.

The more interesting species described of this genus from American specimens, and mostly known by the scars of the surface, are the following.

**L. crassicaulis**, Corda.

Bolsters elongated, persistent, imbricated (a character common to most of the species); leaves linear-acute, carinate on both sides, and by transverse section, rhomboidal or inflated in the middle and alate on the borders; leaf-scars rhomboidal, narrowed and elongated to the base. The pith or medullar cylinder of this species, and perhaps of other species of *Lepidophloios* is woody and transversely ribbed like that of species of *Cordaites*. It is generally known under the name of *Artisia*. Its habitat is in the first coal above the conglomerate.

**L. auriculatus**, Lesq.

Bolsters very large, thick, broadly rhomboidal, rounded both in the upper and lower part, imbricated on the borders, polished; leaf scars transversely narrowly rhomboidal and acuminate on the sides, obtuse at the top, angular at the base. The bolsters are as large as three cm. laterally and two and a half cm. vertically. I found this beautiful species at St. John, Illinois, with numerous specimens of *Lepidophyllum acuminatum*, Lesq., pl. 18, f. 6.
L. macrolepidotus, Gold.

Plate 18, f. 5.

Bolsters imbricating at base, somewhat tumescent, obtusely curved on the sides, mammillate in the middle; leaf-scars transversely rhomboidal, rounded on the upper side, nearly truncate on the lower; vascular scars three, the middle larger and placed a little lower. This species, which has been found at Grape Creek, on the limits of Indiana and Illinois, greatly resembles L. loricinus, which has bolsters and leaf scars much smaller, and which has been found at divers localities at the horizon of the conglomerate or below, as far down as the Chester limestone.

Cyclostigma, Haught.

Stems arborescent; surface of the bark covered with small sub-globose or conical acute tubercles placed at a short distance, about one cm., topped by a vascular prominent point or flattened at the apex into small round areoles with a medial vascular point; decorticated surface smooth or obscurely striate lengthwise by the series of tubercles, which, under the bark, are oval, elevated at the upper part and gradually effaced in decuring downward, like the base of leaves of Knorria, and preserving the impressions of the vascular scars.

The only specimens of this kind found in the American coal measures are referable to C. Kiltockense, Haught., which answers by its characters to the description of the genus. These specimens were found at the base of the middle coal measures near Peoria, Illinois. Plants of this kind are common in the old red sandstone of England, and also in the coal measures of Bear Island, where, associated with Bornia radiata, Lepidodendron Veltheimianum, species of Knorria and of Archaeopteris, they indicate the age of the formation as sub-carboniferous.

Sigillarieae.

Trees of large size; trunks simple or forking near the apex, either smooth or longitudinally ribbed or furrowed, marked by leaf-scars (areoles) of various forms, disposed in spiral or quincunxial order; leaves linear, grass-like, triplicate, simple nerved; radicular divisions (Stigmaria) thick, dichotomous, horizontally expanded, bearing long linear simple cylindrical fistulose leaves or rootlets, flattened by compression, more or less regularly disposed in spiral order, leaving as scars of their points of attachment, exactly circular areoles with a central vascular round point.

The internal structure of the plants of this family is as yet little known. The phytopaleontologists who have in France and in England studied the
texture of the wood by slides prepared of silicified specimens, do not agree in their definition of the essential characters, the first considering the structure as analogous to that of the *Dicotyledonous gymnosperms*, the second to that of the *Lycopodiaceae*. It is not advisable to discuss the question now, especially for the reason that we have not as yet discovered in the American coal measures any silicified remains of these plants, and are unable to study their structure. Considering what is known from outside characters, leaves, the scars of their points of attachment, it is evident that the relation of the *Sigillaria* is with the *Lepidodendron*. Their external conformation is the same, and by their large size and the great number of their species, they fill in the formation of the coal, the same part as the other kinds of Lycopodiaceous trees.

Species of *Sigillaria* are distributed through the whole thickness of the Carboniferous. Rarely found in the lower strata they become more abundant in the middle and upper part of the coal measures. Of this family we have only the two genera, *Sigillaria*, and the appendages considered as their roots, *Stigmaria*.

**SIGILLARIA, Brgt.**

*Plate 20.*

The essential characters of the genus are the same as those of the family described above. The areoles are extremely variable in size and form, round, oval, truncate, emarginate, hexagonal, transversely rhomboidal, either in vertical series upon trunks costate lengthwise, or upon smooth or variously rugose surfaces not costate, where they are spirally placed in juxtaposition or at more or less distance. They are always marked, either in the center, or more generally in the upper part, with three small vascular cicatrices, one simple medial punctiform, the two others lateral and vertical, semilunar or linear. The species of this genus are very numerous, more than fifty are described from the American coal measures.

In order to facilitate their determination, they have been distributed in groups from their affinity in the disposition, shape and place of the leaf-scars or areoles as follows:

1. Trunks not costate; areoles more or less distant, not contiguous. Pl. 20, f. 6.

2. Trunks not costate; areoles close; contiguous. Pl. 20, f. 7.

3. Trunks costate; ribs not large, simple; areoles close, nearly contiguous at base, or more distant, discoid or ovate. Pl. 20, f. 3–5.

4. Ribs large, generally divided in three zones. Pl. 20, f. 1, 2.

In the first section the more common species is *S. obliqua*, Brgt., with surface smooth, areoles one to two cm. distant, oblique rhomboidal, prolonged and obtuse downward, emarginate at top, angular on the sides. To this species, *S. fissa*, Lesq., and *S. monostigma*, Lesq., are closely
allied. This last is remarkable on account of its simple vascular scars, without lateral ones, placed near the top of the areoles. Its bark is composed of different layers, which, taken separately, have each scars of different shape and size. It is well to remark now, that, as is seen pl. 20, f. 1, 6, the surface scars are always very different from those of the decorticated layers, and that the decorticated specimens are rarely, if ever, appropriate for specific determination.

**S. dilatata, Lesq.**

Areoles flat or slightly umbonate, enlarged and acuminated on the sides, emarginated at the upper border, arched at the lower, cortex distinctly undulate-striate lengthwise; subcorticated scars two, small, oval, horizontally close to each other; intermediate surface undulate-striate lengthwise.

**S. reticulata, Lesq.**

*Plate 20, f. 6.*

Much resembles the last species by the form of the areoles, which are, however, much larger. The intermediate surface is deeply irregularly transversely striate, and the scars surrounded by a smooth flat border.

**S. stellata, Lesq.**

Is a beautiful species with large distant hexagonal areoles, whose upper borders are emarginated, the lower rounded, the lateral slightly curving outside in the middle, surrounded by deep flexuous lines, diverging all around star-like. Very rare.

Of section 2, *Sigillaria Brardii*, Brgt., pl. 20, f. 7-7 c, is the more common and the more remarkable species. The areoles are transversely rhomboidal-oval, enlarged and acuminated on the sides, with the lower borders obtuse, the upper emarginated. The decorticated surface is extremely variable. Sometimes, as in f. 7 a, the inside areoles are obsolete, the vascular scars two, large, oval, only marked in the middle; or as in f. 7 b, the lower outside lines are erased, the upper only preserved, covering the inside areoles, whose vascular scars are erased. In f. 7 c, nothing is left but the vascular scars. Fig. 8 represents a fragment of the root or *Stigmaria* of the species. The species is more abundant in the subcarboniferous.

In section 3, with costate surface and areoles vertically close, contiguous at base or distant, *S. tesselata*, Brgt., with transversely ovate, small, very close areoles, and *S. mammillaris*, Brgt., with large oblong-ovate obtuse ones, a little more distant, are the most common. Few species of this group are known, but those of the following, with areoles vertically more distant, are numerous.
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S. PITTSTONIANA, Lesq.

Plate 20, f. 3.

Ribs flat, convex on the borders only, surface irregularly rugose; areoles comparatively small, oval, obtusely truncate at top; vascular scars in the middle of the areoles; upper bark thick, transformed into coal, marked with a single small oval scar.

S. SILLIMANNI, Brgrt.

Plate 20, f. 5.

Ribs narrow, plano convex, slightly undulate, punctate or rugose above the scars, areoles ovate, truncate at the top, enlarged toward the rounded base; vascular scars placed a little above the middle, decorticated surface distinctly lineate; vascular scars double, small, oval, close.

S. OVALIS, Lesq.

Plate 20, f. 4.

Resembles the preceding. Areoles are strictly ovate, obtuse at both ends; furrows between the ribs marked by mere lines and flat; decorticated surface more coarsely striate; scars simple, small; narrowly oval.

The species of the fourth section are remarkable not merely for their large ribs divided in three zones, but for the peculiar property of the subcortical scars of increasing to a great degree by the growth of the trees, and of becoming so much deformed, that their original shape is totally obliterated. The supra-cortical areoles do not increase in the same degree; they are, on the contrary, generally small, and thus one may see, upon good, partly decorticated specimens, the small areoles of the upper layers, while on the sub-cortical surface the scars are sometimes more than twice as large. This can be explained only in supposing that the upper cortical layers may become separated from the lower cortex, which, remaining attached to the trees, continue to grow and enlarge while the surface layers remain unchanged.

Two of the more important species are the following:

S. SIGNILLARIA MARGINATA, Lesq.

Plate 20, f. 1.

Ribs very large, bordered on both sides by a broad narrowly striate zone; medial furrows flat; areoles large, distant, ovate in outline, truncate at the top, rounded at the base; space between the areoles punctate; decorticated surface thinly striate, its scars double, oval, long, contiguous in the middle. Found near Pittston, Pennsylvania, in the middle coal measures.
Ribs very large; lateral zone convex, the medial canaliculate; areoles very distant and comparatively very small, oval or ovate-oblong, deeply emarginate at the top, rounded at base or, when deformed by lateral compression, enlarged in the middle and narrowed, obtuse at both ends; sub-cortical scars single, large, lanceolate or more enlarged and inflated at base. Found in the middle coal measures near Pittston.

A group of species of *Sigillaria* has been considered by Brongniart as a separate genus under the name of *Syringodendron* ["suirygos", reed-like]. It includes deeply costate species whose vascular scars are united in one very small and diversely shaped, either round with a central punctiform vascular scar, or cuneiform emarginate at top, or oval, more enlarged on one side, and mucronate. The species, according to Schimper, represent merely decorticated forms of *Sigillaria*, of which the relation of the scars to the areoles of the surface is unknown, and which, therefore, can not be satisfactorily determined.

**STIGMARIA, Brgr.**

*Plate 19, f. 1–4.*

In the definition of the genus *Sigillaria*, *Stigmaria* is described as representing its radicular sub-divisions. Indeed trunks or stems of *Sigillaria* have been found in Europe, in Canada and in this country, with roots still attached to their base, these roots bearing the characters of *Stigmaria*. For reasons mentioned below, I consider the *Stigmaria* as a vegetable of a peculiar nature, capable, like some water plants of the present epoch, of maintaining its life a long time independently of aerial stems, but able in peculiar circumstances to produce by vertical growth, trunks of *Sigillaria* as its fruiting stems. According to this the genus *Stigmaria* is defined as follows:

Floating stems or roots, generally growing horizontally, distantly forking; branches long, scarcely variable in size in their whole length, sub-cylindrical or more or less flattened on the lower side; medullar cylinder (pith) woody, often eccentrically, composed of fascicles of vessels disposed star-like; leaves long, tubulose, linear when flattened, leaving, after disruption, on the surface of the stems, round scars composed of two concentrical rings with a central umbonate mammilla pitted in the middle by a punctiform vascular scar.

In their original floating state, the plants of *Stigmaria*, like those of some conifers, mosses, even phanogamous species have continued for long periods their vegetation at the surface or on the bottom of shallow water basins, and have gradually filled them with their debris. Most of the
under clay beds of the coal contain remains of *Stigmaria* only, without even a fragment of trunk of *Sigillaria*. Beds of this under clay from twenty to forty feet thick, seen along rivers of the coal fields of this country, in Kentucky especially, are filled with fragments of *Stigmaria*, without any other kind of vegetable remains. This proves that, as for the under clay beds of the peat deposits of the present epoch, which have the same characters as those of the coal and are formed of detritus of floating water plants, the *Stigmaria* plants have lived for long periods of time by themselves or in their floating nature, and that, as it is the case also for the formation of the peat beds, it is only when the mass had become compact by the heaping of the debris, and strong enough for supporting trees, that *Sigillaria* have grown upon *Stigmaria*, as trees producing flowers and fructifications. Some plants of the present epoch have the same property. They live as floating stems, dividing in numerous filaments, some of them bearing bladdery or vesicular appendages by which they are sustained in water, never producing flowering stems until they have a compact solid ground, when budding knots are formed by the connection of some branches, from which aerial fruiting plants are derived.

*Stigmaria* stems and leaves are also found in the coal, where they are always flattened and recognized only by the scars of their leaves. In the clay, the stems generally preserve their cylindrical or sub-cylindrical shape, for often, the pith is not central, but placed at the under surface, which is then somewhat flat and without leaves.

The scars of the leaves of *Stigmaria* being always of the same form or round, variable only, either in their relative disposition, sometimes in regular spiral or quincunxial order, sometimes irregularly placed, or in the size of the scars, it is very difficult to find distinct characters for the determination of the species. For this reason some authors have described one form only as species, with a great number of varieties.

**S. ficoides**, Brgt.

*Plate 19, f. 1, 2. (Fig. 1 is in a very reduced state.)*

A most common form. Its characters are the same as given for the genus. The stems are extremely long. On the flat surface of a bed of metamorphic clay, as hard as limestone, in Pennsylvania, I have followed these stems prolonged to sixty meters or more without diminution in their thickness, except at their point of dichotomy, which is very rarely seen. The leaves also are very long, thirty, sometimes sixty cm. or more. Some authors represent them as forking near their extremities. I have never seen any one divided in that way, but always simple and of the same thickness, only enlarged above the point of attachment, which is more or less contracted. They sometimes, but rarely bear at their ends a kind of large oval tubercle, which has been considered by some authors as the
fructifications, but which is merely a bladder-like appendage to support them in water. The leaves and also their scars are of different thickness according to species or varieties.

Of the varieties described by authors the more marked are:—**Var. undulata** (pl. 19, f. 3). Cortex marked by longitudinal, narrow ribs, undulating by contraction between the scars.—**Var. stellata**. Cortex marked by short, broad lines diverging star-like from the scars as in pl. 19, f. 4.—**Var. inaequalis**. Areoles unequal in size, indistinct, surface obscurely striate.—**Var. reticulata**. Surface distinctly reticulate—striate around the scars.

Under the generic name of *Stigmarioides*, I have described fragments of roots bearing rootlets and marked with much smaller tubercles than those of *Stigmaria*, without central vascular points, as pl. 19, f. 5, and under that of *Sigillarioides*, fragments apparently of the same nature or roots, bearing appendages like leaves of *Sigillaria*, flat with a medial nerve and leaving, for their impression of the point of attachment, transversely rhomboidal areoles, similar to those on the stems of *Sigillaria* (pl. 19, f. 6). These generic divisions are not yet definite. The organs representing roots, of soft cellular texture, are very rarely preserved in the coal shale; the few of them known as yet have been found in concretions of Mazon Creek.

As seen from the description of the genera of the Lycopodiaceous plants, where so many facts and appearances are still unexplained, or merely hypothetical, it is not surprising that vegetable paleontology is not yet able to ascertain the nature and characters of fragments of their roots.

But, admiring the multiplicity, the regularity, the harmony of the forms observed in the stems, the scars of leaves or of branches, the cones and their sporanges, their blades, the appendages considered as roots or floating divisions, etc., we are forcibly led to the conclusion that the family of the *Lycopodiaceae* was, at the coal epoch, represented by an immense number of plants of divers characters, many still unknown to us, and of which the genera and the species established and described as yet, only represent a mere fraction.

**NOEGGERATHIEÆ.**

The relation of this order of vegetables is not positively determined. The plant from which it was established, *Noeggerathia foliosa*, St., was considered by Goeppert as related to *Cyclopteris* or to the ferns, while Brongniart comparing it to species of *Zamia* placed it between the *Cycadaceæ* and the Conifers or in the dicotyledonous gymnosperms. A number of species referable to *Noeggerathia* have been described by authors, all of uncertain affinity, and I have myself, in the Report of the First Geological Survey of Pennsylvania, 1858, placed in the genus *Noeggerathia* four spe-
cies later recognized as ferns of the genus *Archeopteris*; for the pinnules or leaflets of *Noeggerathia foliosa* have about the same shape and the same nervation. As far as known until now the only leaves obtained in the American coal measures, and related to this genus or with characters appearing intermediate between the ferns and gymnosperms, have been abundantly found on the roof of a coal mine of Ohio. From these leaves the following genus has been established.

**WHITTLESEYA, Newby.**

*Plate 9, f. 1.*

Frond simple or pinnate; nerves fasciculate, confluent at the base, simple, not dichotomous, ascending parallel to the upper border, which is dentate or undulate; fructifications unknown. Of the three species described, the following only has been found in a large number of specimens.

**W. elegans, Newby.**

*Plate 9, f. 1.*

Leaves, or pinnae simple, thick, narrowly fan-like, rounded in narrowing to the petiole, truncate and acutely dentate at the upper border; veins in bundles of slender parallel filaments, converging at the base toward the top of the petiole and at the apex in entering the teeth, becoming connivent at their sharp points.

Though the leaves have been found in profusion in the locality indicated above, none has been seen attached to stems; the pedicels, generally cut short, are not longer than one cm.

The relation of this species is apparently with *Cyclopteris digitata*, Brgt., now referable to *Baiera*, a genus of the Cycadeae. The relation seems the more probable since a species of *Baiera* and other vegetable fragments related to the Ginkgo, a Conifer, have been discovered in the Permo-Carboniferous measures of Virginia, as published by Profs. White and Fountain in Report P. P. Geological Survey of Pennsylvania.

**III SERIES. GYMNOSPERMOUS PLANTS.**

**Cordaitae.**

From recent researches especially pursued by Grand’Eury and B. Renault, two celebrated French authors, who have made anatomical analyses of the woody tissue and of divers organs of the *Cordaitae*, the plants of this order are now recognized as pertaining to the *Phenogamous gymnosperms*, and to compose a separate group intermediate to the Conifers and the Cycadeae. A number of genera have been described as referable to the *Cordaitae*. Of these, the best known and more commonly distributed, are the following ones.
PRINCIPLES OF PALEOZOIC BOTANY.

CORDAITES, Ung.

*Plate 21, f. 1, 3.*

(Dedicated to Corda.)

Plants sometimes of great size, irregularly divided; trunks composed of a large medullar cylinder or pith, marked on the outer surface by transverse narrow parallel ribs, rarely joined by divisions, covered by double or triple layers of wood and bark; leaves placed in spiral order, more or less distant, of various length and width, linear, more generally enlarged upward, obtuse, entire or obliquely truncate, undulate and vertically cleft at the apex, semi-embracing at base or gradually narrowed to the somewhat inflated point of attachment, marked lengthwise by primary and secondary close simple parallel nerves generally more distant in the middle of the leaves and slightly thicker toward the base; flowers in simple racemes from the axils of the leaves; fruits generally ovate, sessile of various size.

These plants, known until now merely by fragments of leaves, are not rare in the coal measures and are generally distributed from the upper Devonian to the upper coal strata, passing above to the Permian. The flowers were known formerly as Antholithes, the fruits as Carpolithes, but their reference to species of coal plants, represented by leaves or fronds, was unknown. Now Grand’Eury has found in France a prostrated and silicified forest of Cordaites, and has been able to give by restoration, the figure of their trunks (thirty m. high, more than thirty cm. in diameter) with branches, leaves and flowers. These flowers are now separately described as Cordaianthus, the fruits as Cordaicarpus.

As said above, the leaves or Cordaites being generally large were known merely by fragments. Their reference to the genus was easily made, on account of the peculiar nervation which has no analogy to that of the ferns; but the American specimens could rarely be specified until a few years ago when a number of well preserved large ones, bearing not only leaves preserved in their integrity, but branches with leaves attached to them and flowers, pl. 21, f. 1., were obtained at Cannelton, Pennsylvania. From these specimens it has been possible to describe a number of well defined species of which the following are the more important.

C. grandifolius, Lenz.

Leaves large, of a strong texture, widening upward and fan-like from a narrow truncate base, round truncate or rounded undulately lobed and cleft at the apex; nervation double; primary nerves obtuse, distantly dichotomous or splitting, inflated and more distinct toward the base, with one often indistinct secondary nerve. The stems of this species are unknown. The leaves are very large and much enlarged upward. One of
these, thirty-one cm. long, with a base of one cm.; is sixteen cm. wide at the upper border, where it is cleft in short laciniae; another six mill. broad at base, thirty-two cm. long, is fifteen cm. broad at the apex. The species is found at Pittston, in the sub-conglomerate measures.

C. borassifolius, *Ung.*

Leaves five to eight cm. broad in the middle, where they are widest, gradually narrower both ways, upward to the obtuse or truncate apex more or less deeply cleft downward to the slightly contracted semi-lunar point of attachment; primary nerves indistinct to the naked eyes, close, five to seven in one mm., with generally one intermediate secondary vein; surface thinly rugulose crosswise. The leaves of this species are sometimes very long and rounded at the apex, and there nearly as broad as in the middle; and sometimes forty-five cm. long. They are commonly found over the whole thickness of the middle coal measures.

C. Laccoei, *Lesq.*

*Plate 21, fig. 2.*

Leaves elliptical, obtuse or rounded and narrowed to a point, small and comparatively broad at base; nerves distinct, the primary about one mill. distant, with four to six intermediate ones. A rare species found at Pittston.

C. Mansfieldi, *Lesq.*

Stems with a thin polished bark indistinctly marked by the scars of the convex base of the leaves; leaves long, open, narrow, nearly exactly linear, gradually narrowed at the apex to an obtuse point, averaging fifteen mm. broad and fifteen cm. long, but much shorter and narrow upon the young branches; nerves distinct, the primary separated by two to four intermediate veinlets; flowers in simple racemes, composed of four sepaloid involucre attached by short peduncles to the common flexuous pedicel; fruits oval, sessile. The species is abundant at Cannelton. The fruits are larger than those of the following species.

C. costatus, *Lesq.*

*Plate 21, f. 1–1b, 4.*

Stem irregularly costate by the decurring prolongation of the tumescent leaf scars; leaves erect, narrow, nearly linear or slightly enlarged upward; primary nerves unequal in distance, three to five in a space of
two mm.; intermediate veins three to four; surface transversely rugose; male flowers sessile, on simple sub-cylindrical axillary racemes; fruits large, oval, slightly contracted to the tumescent point of attachment upon a narrow branch. The species is as common at Cannelton as the last and sometimes in very large specimens, one of which has been found with a branch bearing a fruit like f. 4.

C. serpens, Lesq.

Stems slender, narrow, flexuous or serpentine, abruptly truncate at the top by the flattening of the medullary cylinder and continued by a broad terminal long flat leaf-like prolongation; lateral leaves in right angle to the stems, sub-linear, narrowed to the point of attachment; nervation distinct; primary nerves separated by three to four intermediate ones.

A very remarkable species, which seem to have lived in water and floating. The terminal leaves at the end of the stems are large, two to two and one-half cm. broad; those along the stems are at right angles, one-half to one cm. broad; the stems narrow, one and one-half to two cm. broad. The conformation of the stem is very peculiar. Always flexuous, serpentine, unequal in thickness or inflated here and there, its woody cylinder transversely ribbed, pl. 21, f. 3, is abruptly flattened or truncate at the end of the branches, where its place is taken by large leaves, following the direction of the stem, while the lateral are much narrower, sometimes flexuous, divided in narrow laciniae and placed at right angles as floating. These characters have been observed upon a large number of specimens. Found with the last.

Cordaianthus, Grd.'E.

(Anthos, flower.)

This genus includes, as implied by its name, flowers of Cordaites. The characters of the species are rarely distinct, as the flowers are generally flattened, obscured or half destroyed by maceration and compressed. C. gemmifer represents the group of species of male flowers, buds or gemmules, composed of imbricated scales, often attached to the axil of a linear bract. C. baccifer is appropriated for fertile flowers in racemes, bearing at the axils of foliaceous bracts small rudimental or immature ovules, either obtuse or pointed.

Cordaicarpus, Grd.'E.

(Carpos, fruit.)

This genus is established for the description of the fruits of Cordaites, of which the number is considerable, but whose relation to the plants to which they belong is generally unknown, as they are mostly found loose or remaining attached to the racemes only when very young and still immature.
C. Gutbieri, Gein.

Plate 21, f. 4, 5.

Fruit oval or ovate, sub-cordiform, rounded or truncate at one end, obtusely pointed at the other; surface smooth; pericarp (outer envelope) transformed into a thin coating of coaly matter.

These fruits, extremely common at Cannelton, with remains of Cordaites, are all about of the same shape, but very variable in size. Those of f. 6, 6a, described as C. apiculatus, are analogous in their form, but represent a distinct species.

A few other genera, described by Grand'Eury and myself in this section, are not as yet clearly enough related to the Cordaites. Among them are the following:

DICRANOPHYLLUM, Grd.'E.

Stems slender; leaves narrow, grass-like, linear, sub-coriaceous, of various lengths, forking or dividing at the top in filaments, nerved like Cordaites. A few American fragments are apparently referable to the genus, but they are not sufficient for specific determination.

DESMIOPHYLLUM, Lesq.

Stems slender; leaves narrow, sub-linear, gradually enlarged from the base, either simple or sparse or fasciculate at base, joined three or four together, surface of the stems and leaves irregularly striate lengthwise by prominent large bundles of nerves buried under the epidermis, which is thick, irregularly granulose.

There is of this genus a single species, D. gracilis, Lesq., represented by one specimen only.

TENIOPHYLLUM, Lesq.

Plate 21, f. 8, 8a.

Stems large; leaves crowded, fistulose, flat by compression, thick, exactly linear, recurring at base; surface smooth, opaque or shining.

The characters of this genus, of which three species are described, are not in concordance with those of Cordaites. The leaves, exactly-linear, were apparently tubulose when living; their surface is not marked by parallel nerves, but by very short lines directed lengthwise, crossed in right angles by thinner ones, forming a kind of areolation like the meshes of a very fine tissue. I have also found some of these long leaves containing within their channels or under the coaly layer of their surface groups of macrospermes, which could be seen for the whole length, either marked indistinctly through the compressed surface, or distinctly wherever
the epidermis was destroyed. If this appearance, observed upon many specimens, is not deceptive the relation of these plants is with the Lyco-
podiaceae.

FRUITS OR SEEDS.

A number of fruits or seeds of very different characters are found already in the upper Devonian and become more and more abundantly distributed in the carboniferous measures. Plate 22 represents by a few specimens of those fruits, some of their more remarkable forms and their great variety of size and shape. I have already described under the name of Cordaicarpus a few of the species positively referable to Cordaites. The relation of the others in regard to the plants from which they are derived is mostly unknown. Considering merely the outside characters of the seeds of the coal measures, those which can be recognized without anatomical analysis, most of the paleontologists have classed them in four generic divisions, Cardiocarpus, Rhabdocarpus, Trigonocarpus and Carpol-
ithes. Some French authors, Brongniart especially, have been able to examine the inner structure of a number of silicified fruits of the carbon-
iferous and have applied to them a different nomenclature. A record of these determinations would now be useless in this country, where no fruits have been found silicified or preserved in such a way that their inner structure can be microscopically studied. I have, therefore, preserved the old and general classification.

CARDIOCARPUS, Brgt.

( Cardia, heart.)

Seeds of various shapes, composed of a compressed, generally cordiform or oval nucleus, surrounded by a flattened fibrous border, or a membran-
ous wing, representing the pericarp or testa.

As it is difficult to understand the characters of the seeds from mere description, I mention only the figured species of this or of the other gen-
era of fossil fruits.

C. Harveyi, Sp. nov.

Plate 22, f. 1.

Nucleus large, oval in outline, with concentrical borders nearly one cm. broad, deeply emarginate at top, forming two erect sharply pointed horns separated by an obtuse sinus. The tube by which the pollenic substance enters the ovary (tubular micropyle) is distinct.

Found in the sub-conglomerate coal of Arkansas.
Nucleus cordiform, narrowed at the apex into a micropyle passing up to the sinus of the margin; wing broad, following the outline of the ovule, becoming a little larger toward the apex, where it is deeply cut into a narrow sinus. Same geological station as the last, but found at a different locality.

C. ovalis Lesq.

Same geological station as the last, but found at a different locality.

C. simpllex, Lesq.

Seeds of medium size; nucleus cordiform ovate; border narrow, concentrical, slightly larger above, emarginate at the apex. I consider f. 4 as representing the nucleus loosened from its testa. The species is common in the sub-conglomerate beds of Arkansas.

C. bicornutus, Lesq.

Seeds small, broadly winged; nucleus oblong-ovate, acute, bordered by a broad margin prolonged downward and narrowed into a pedicel, enlarged, deeply emarginate to the apex of the nucleus, and diverging in two acuminated horn-shaped points. This seed is very remarkable. The nucleus is hard, compact, less flattened by compression than the testa from which it is easily separated. It evidently belongs to a different group and was first described under the name of Ptilocarpus, Lesq. Found in the upper coal of Ohio.

C. mamillatus, Lesq.

Seed small; nucleus oval, mamillate at the base, regularly and deeply striate, surrounded by a narrow border or flattened testa. The testa is destroyed in the specimen figured. I have only seen it fragmentary upon a specimen somewhat different, a little larger and round, which may represent another species. It may therefore be referable to the following group:
PRINCIPLES OF PALEOZOIC BOTANY.

RHABDOCARPUS, Goepp and Berger.

(Rabdos striated.)

Fruits often of large size, costate or striate lengthwise, acute or acuminate, surrounded by a testa sometimes destroyed or deficient.

R. insignis, Lesq.

Plate 22, fig. 6.

Seed (nucleus?) large, broadly oval, apiculate, marked at base by a large cicatrice at its point of attachment, indistinctly striate by equidistant larger leaves, and irregularly closely lineate or wrinkled lengthwise.

A beautiful fruit found at Pittston, Pennsylvania.

R. Mansfieldi, Lesq.

Plate 22, fig. 7.

Fruit very large, obovate, truncate at the point of connection to the stem; testa thin, wrinkled by fragments of a layer of rugose coaly matter; nucleus distantly obscurely striate lengthwise. Fruits of this kind, but scarcely as large as the one figured, are not rare at Cannelton. One has been found apparently attached to a branch of Cordaites Mansfieldi, and is therefore a Cordaiaecarpus. As the attachment to the stem is considered by some a mere casual superposition of the fruit to a fragment of stem, I describe the fruit here in the genus to which it is referable by its outside characters.

R. multistriatus, Presl.

Plate 22, figs. 8, 9.

Seeds oval, rounded at base; outer testa prolonged beyond the nucleus and narrowed upward into an obtuse or truncate apex, obscurely ribbed and striate lengthwise; nucleus shorter, ovate, apiculate, distinctly equally ribbed, marked at base by a large cicatrice or point of attachment. Found over the middle coal measures, especially in the shale of the first coal above the conglomerate.

R. Howardi, Lesq.

Plate 22, fig. 10.

Fruit large, oblong, curved to one side, rounded at base, abruptly narrowed at the apex to a short acumen, marked lengthwise, with distant narrow elevated ribs indistinctly minutely lineate in the intervals. Appears to be a nucleus, perhaps referable to Trigonocarpus. Found in a bed of sandstone in the coal measures of Ohio.
TRIGONOCARPUS, Br.apt.

*Plate 22, f. 11, 12.*

Fruits ovoid, compressed triangular at the point of insertion, three or six costate; ribs more distinct and prominent toward the base, sometimes disappearing above; apex pitted by a small round or triquetrous mamillate cavity.

T. Dawesh, *Ll. and Hutt.*

*Plate 22, f. 11.*

Fruit broadly ovate or oblong, abruptly pointed, marked with three strong prominent ribs.

These seeds as described by European authors are very variable in size and also of different shape, appearing to represent different species. Found in many specimens at the base of the coal measures of Indiana in conglomerate sandstone.

T. subcylindricus, *Lesq.*

*Plate 22, f. 12.*

Fruit small, tri-costate and slightly triangular, subcylindrical in outline, generally narrowed upward and pointed, smooth; basilar cicatrice large, triangular.

CARPOLITHES, *Schloth.*

*Plate 22, f. 15--18.*

Seeds of various forms and of uncertain relation, not referable by their characters to any of the preceding genera, often representing ovules deprived of their testa.

C. bicuspidxtus, *St.*

*Plate 22, f. 15.*

Nucleus small, enlarged in the middle or transversely oval, rounded at base, rapidly narrowed to a sharp point, entirely smooth. Fruits of this kind are not rare in the lower coal measures, sometimes found with a narrow pedicel.

C. orbicularis, *Newby.*

*Plate 22, f. 16.*

Nucleus exactly orbicular, inflated, smooth. Rare. Found at Cannelton.*

* Cannelton and Pittston, referred to in this paper, are in Pennsylvania.
C. REGULARIS (?), St.

Plate 22, f. 17, 17a.

Nucleus very small, oval, surrounded by a concentrical larger testa, pitted at the apex by a small round alveole. Species perhaps referable to Cardiocarpus. Shale of the middle coal strata; rare and unsatisfactorily known like all the Carpolithes.

C. ARCUATUS, Lesq.

Plate 22, f. 18.

An oblong linear fruit, five cm. long, without its slender, curved pedicel; one cm. broad in the middle where it is narrower, like strangled, slightly curved, inflated above, abruptly narrowed to a short inclined beak, and also narrowed at base into a pedicel one and one-half cm. long. The upper surface of the pericarp is a striate coating of coal, the lower surface is dotted by transversal short wrinkles. The fruit is very peculiar and does not show relation to any kind of seeds described as yet from the coal measures. Found in a thin layer of coal in Kentucky, at the horizon of the Conglomerate. It is probably referable to the genus Rhabdocarpus, and is described as R. arcuatus in the "United States Coal Flora."
THE FOSSILS OF THE INDIANA ROCKS, NO. 3.

BY CHARLES A. WHITE, M. D.

GENERAL REMARKS.

One of the most important formations in the State of Indiana is that which is known by the name of Coal Measures; a name which was applied to the corresponding formation in England in the early history of geology. Whatever of signification the name may have originally had, it is now used as a proper name of a geological formation, just as the names Niagara, Hamilton, Corniferous, etc., are used for other formations. The great Carboniferous system of rocks is known to exist over a large part of the two Americas, and large parts of Europe and Asia also. It probably exists in other divisions of the earth, but in those just named it has been more or less extensively studied.

The strata of the Carboniferous system are usually separated into three divisions, namely, the Lower Carboniferous (or, as it is sometimes called, Subcarboniferous), the Coal Measures and the Permian. The Lower Carboniferous strata are well developed in Indiana; and some of the most interesting fossils that have been found in the State come from that formation. In the States to the westward of Indiana, the Lower Carboniferous series has been divided into five distinct groups, each being characterized by fossils which are peculiar to its own strata. The greater part of these groups are recognized within the State of Indiana, and have received much attention from geologists and paleontologists, on account of their interesting geological features and the richness of their fossil remains.

The Coal Measures are, in like manner, divided into three groups or subdivisions, under the respective names of Lower, Middle, and Upper Coal Measures, the latter being sometimes called Permo-Carboniferous. The lines or planes of demarkation between these three subdivisions of the Coal Measures are not so distinct as they are between the subdivisions of the Lower Carboniferous series; neither are they so distinctly separated from each other by the character of their respectively contained fossils.
In consequence of this similarity of the fossils contained in the Coal Measure series, some geologists are not disposed to recognize the subdivisions that have been named as anything more than a convenience of arrangement for study and description. Many geologists also seriously question the existence of the Permian formation in any of the States which lie to the eastward of the Mississippi River; and, so far as any information is concerned which may be furnished by invertebrate fossils, the question is still an open one. Professor Cope, however, has described some important vertebrate remains from Vermillion county, Illinois, which he regards as clearly indicating the Permian age of the strata from which they were obtained.

In this article, I shall treat only of the fossils of the Coal Measures, and I shall confine myself to the invertebrate forms, omitting, entirely, all vertebrate forms and plants. Before proceeding with the description of these fossils, I will, in compliance with the often expressed wish of Professor Collett, present some popular remarks of a general character which have a bearing upon the subject of this article.

To properly understand the subject of any special investigation in Paleontology, one must carefully inquire into the physical conditions which existed at the time the fossil forms he studies were living ones; and this may be done with more satisfactory results than many may suppose. It is not strange, that those who are not accustomed to geological investigations often think such efforts are necessarily profitless, nor that they should sometimes regard any statements which may be made with reference to the physical conditions that existed upon the earth at a time so remote as the Carboniferous age as amounting to nothing more than vagaries of a vivid imagination, or that they are, at best, mere speculations as to what conditions may possibly have then existed. It is true that we can not now know what the physical conditions were which prevailed during any former period of the earth's history with the same minuteness that we know the conditions now existing, but nothing is more certain than that we may know what some of those conditions were with approximate accuracy. Taking the present conditions which prevail upon the earth as a key to the past, we are able to reach conclusions which, for extent, variety, and evident accuracy, would have startled us at the outset. Let us consider, briefly, a few examples of the methods by which geologists reach their conclusions with reference to physical conditions which prevailed during past geological ages.

The most northerly point in American seas at which true reef-building corals now exist is in the vicinity of the Bermuda Islands. The waters of the sea to the northward of this are, except perhaps in the deepest waters, too cold to allow the existence of coral-forming polyps. But this does not materially affect the application I make of the facts mentioned.

* Since this paragraph was written, the labors of the U. S. Fish Commission have demonstrated the existence of a considerable variety of corals in the deep sea in much higher latitudes; but this does not materially affect the application I make of the facts mentioned.
more, coral-forming polyps are found only in marine waters, never in fresh waters. In all the geological periods, however, which are represented by the formations of Indiana, of whatever age, coral-forming polyps existed, and, in the strata which represent those periods, fossil corals are now found. We infer, therefore, that the waters in which all the formations of Indiana were deposited (with the exception of the beds of coal and some of their immediately associated layers) were of marine saltiness, and probably as warm as those of the Florida Keys. Furthermore, formations of the same geological age as some of those of Indiana are found within the Arctic circle, containing, in both regions, fossil corals of the same or closely related species. Similar forms of fossil corals are also found in various parts of both the eastern and western hemispheres, and on both sides of the equator. We, therefore, infer that the conditions of climate upon the earth, in those ages, were very different from those which now prevail, and certainly much more uniform. Again: We find imbedded in certain of the strata within the Arctic circle, where no trees can now grow on account of the coldness of the climate, remains, not only of a great variety of forest trees, but, also, many vegetable forms that are closely related to living tropical or subtropical species. We infer from these facts, that there has been a time when the climate within the Arctic circle was milder than the present climate of Indiana. 

By the study of the aqueous life now existing upon the earth, naturalists find that certain genera, families, orders, and even classes, of animal forms are restricted to marine waters; that is, to those which have a saltiness equal to that of the ocean. Other forms, again, are found only in brackish waters; and still others only in waters that are wholly fresh. When, therefore, we find any fossil remains that come under either of these three categories, we feel confident that we know, approximately at least, whether the waters in which those animal forms lived were salt, brackish or fresh, although long geological periods have elapsed since the last of those forms was living and since those waters gave place to dry land.

Again, certain forms of mollusks are now found living only upon the land, and others mainly or only in marshy places. In case, therefore, of the discovery of fossil shells like those of the first-named kind, we infer that the land upon which they lived was near by, and that the shells were drifted into the waters in which the deposits which now contain them were made. In the case of the other forms, it is legitimate to infer that they were entombed where they lived; and the associated conditions and contents of the strata will tell, with approximate clearness, whether their habitat was a marsh or a lake. In a few instances, discoveries of fossil land shells have been made which were mingled in the same strata with those of true marine mollusks. The inference, in those cases, was plain, and associated
circumstances confirmed it, that the strata in which these fossils were found were deposited in the sea and near the shore, that the land shells were washed into the sea by land drainage, drifted out, sunk, and were entombed with the shells of those mollusks which had lived and died in the waters there. The sediment which entombed them was hardened into rock, the sea receded by the gradual elevation of the land, and now, in the heart of a continent, the geologist’s hammer lays bare these ancient forms, and he reads a history which had lain, as in a sealed book, for ages.

By the study of marine life, naturalists also find that certain mollusks and other animal forms inhabit deep, and others shallow, waters. Others, again, are known to thrive in waters charged with sediment; while certain forms can exist only in the clearest water, and are instantly killed by the accession of sediment. Similar distinctions are recognized by paleontologists among fossil forms, and the character of the material of which the strata are composed usually agrees with such determinations; that is, the character of the rocks which enclose the forms corresponding to deep sea life indicates a finer condition of the sediment than that of the wave-washed shallow water deposits. It is no uncommon thing to find among the strata of a formation evidences of the local destruction of life by the irruption of sediment into waters which had long previously been clear.

Since all stratified rocks have been deposited under water, the various formations, when first deposited, were, of necessity, approximately level. When, therefore, we find the formations tilted so that the strata stand at any considerable angle with the horizon, we necessarily infer that they have become so tilted by a subsequent movement of the earth's crust at that place. This tilting of the strata may be so slight as not to be discernable to the eye at the limited exposures which the prevalent overlying soil allows. In such cases, it is only discoverable by traversing the region in which the strata in question occur, and, finding them to gradually disappear beneath another formation, or, finding still another formation, to come gradually to the surface from beneath the one upon which our observations began. In other cases, the strata are found tilted at a high angle, or flexed up against a mountain side, and often entering largely into the structure of mountains. In all such cases, it is needless to say that these movements of the earth's crust took place after the strata so disturbed were deposited, but the use geologists make of this obvious fact is important. For example: It is well known that strata of the Carboniferous age enter largely into the structure of the Allegheny Mountains, and, as the greater part of these strata were formed beneath the level of the sea, it is clear that the entire elevation of those mountains took place after the close of the Carboniferous age. Indeed, certain other facts are now understood to point to a very much later date for the origin of the elevation of those mountains than the close of the Carboniferous age. Again, Cretaceous and Tertiary strata are strongly flexed up against the
ranges of the Rocky Mountain system, and in some places they enter largely into the structure of those mountains. It is, therefore, plain that the Rocky Mountain system had no existence prior to the close of the Cretaceous period or the beginning of the Tertiary. Mountains are by no means the stable objects they seem to be in comparison with the shortness of human life and human history, and it is probable that many mountains and mountain ranges have risen upon, and disappeared by erosion from, the face of the earth in former geological times, but it is practically certain that all the present mountains of the earth were formed since the animals lived whose remains are described upon the following pages.

These remarks will serve to indicate the methods by which geologists reach the conclusions they put forward. While many of these conclusions are full and satisfactory, it is not to be denied that many important problems still await solution; and that, in many cases, the order of past events is obscure or the geological record of them is abruptly broken. Considering the circumstances, however, the minuteness and accuracy of the geological history which has been read in the rocky strata of the earth are truly surprising. While the student of the physical geography of the present day defines the features of the earth as they now are, the geologist catches here and there, through the ages that have passed, a multitude of glimpses of the features that our old earth has put on and worn for a time, and then laid aside; of broad seas whose boundaries were far from those which are known to modern geography, and whose waters teemed with strange forms of life; of the rise of continents, where once were only islands or a shoreless sea; of mountain ranges that rose in grandeur, and then slowly wasted away to their very bases by the corroding action of the elements; of broad regions covered with verdure and peopled with a wonderful wealth of animal life. With these hints concerning the method of reasoning adopted by geologists, I may now present some remarks concerning the physical conditions which are thus understood to have prevailed during the Carboniferous age and while the animals were living whose fossil remains are described on following pages.

When the name "Carboniferous" was first chosen for the great system of stratified rocks that succeeds those of the Devonian age, it was supposed that all the mineral coal of the earth was contained within it, and the name was chosen in consequence of that opinion. A coal-like substance, called lignite, was then known to exist in comparatively small quantities in different formations of much later geological age than the Carboniferous; but these deposits were regarded as unimportant and the coal was believed to be inconsiderable in amount. The idea then prevailed that during the Carboniferous age, peculiar conditions existed for the abundant growth of vegetable life such as the earth never
knew before and has never known since. As our knowledge of the geology of the earth has increased, however, so much coal has been found in strata other than those of the Carboniferous age, that it has become a question whether more than half of the known coal of the earth is referable to that age. All the coal of the numerous and important mines that have been opened in western North America, west of the 100th meridian, is obtained from strata none of which are older than the Cretaceous period; and its origin is, therefore, of much later date than the close of the Carboniferous age. It is now, also, known that immense quantities of coal of much later origin than the Carboniferous age exist in other parts of the world, notably in China. The following extract from a chapter by the eminent geologist, Dr. Newberry, in Pumpelly's Geological Researches in China, Mongolia, and Japan, presents this fact in a clear light: "We have, of course, no right to assume that no Carboniferous coal exists in China, for it may very well happen that, as in our own country, coal seams of economic value, but of different ages, will be found there at points not greatly removed from each other. But geologists will not fail to be deeply interested in the fact that so large portions of the coal basins of China, including beds of both anthracite and bituminous coal—worked for hundreds of years, probably the oldest coal mines in the world—are wholly excluded from the Carboniferous formation. So large is this coal-bearing area, indeed, that, when joined to the Triassic, Cretaceous, and Tertiary coals of North America, they quite overshadow the Carboniferous coals of Europe and the Mississippi Valley, and suggest the question, whether the name given to the formation which includes the most important European strata has not been somewhat hastily chosen."

Moreover, there are large regions in different parts of the earth where the strata of the true Carboniferous age, known to be such by the character of the fossils they contain, are found to contain no coal. Still the name "Carboniferous"—coal-bearing—remains as a proper name for this system of rocks, wherever it may be found, although its strata may contain no coal; and even though strata of another geological age in the same region may contain an abundance of coal. These facts make it clearly apparent that the mere presence of coal in any strata, is, of itself, no indication of their geological age, and it will, therefore, be readily understood that the only true indication of the geological age of any formation is furnished by the fossil which it may contain. Hence, the importance of paleontology in the study of the geology of any region.

As regards the coal of Indiana, it all belongs to the true Carboniferous age, and no strata of the geological age of those which contain the coal of western North America exist in this State. In the further discussion of this subject, therefore, I shall have reference to strata of the Carboniferous age alone.

Those who have studied the fossils of the Mesozoic and Tertiary periods
that is, the geological periods which succeeded those of the Carboniferous age—are familiar with the fact that there is great diversity of the species of those fossils in the various regions of the earth; that is, the number of species belonging to any given one of those periods which are found in more than one of the grand divisions of the earth, is very small, and a large proportion of the species are apparently confined to a small area. In the case, however, of the fossils which characterize the Carboniferous age, we find many of them to have an almost world-wide distribution. For example, several of the species which occur in the Coal Measure rocks of Indiana are not only found in other and widely separated parts of our own country, but they occur, also, in the Carboniferous strata of South America, Europe, and Asia. This fact indicates that a far greater uniformity of conditions then existed all over the earth, than existed in the subsequent periods, or than exists at the present time; that is, the conditions were sufficiently alike in different parts of the earth to allow of a great uniformity of animal life. But since coal is found in only a part of the whole series of strata which make up the Carboniferous system, and in certain regions coal does not exist at all among its strata, although the characteristic fossils are there, it is plain that the precise conditions which resulted in coal making were not everywhere uniform. Indeed, it is certain that in large portions of those regions of the earth within which deposits of stratified rocks were produced during the Carboniferous age, no coal whatever was produced. It is, also, true that within those areas where coal-forming material was accumulated, the conditions favorable for its production alternated with unfavorable conditions, so that beds of coal alternate with beds of limestone or sandy and clayey layers.

Coal is unquestionably of vegetable origin; and, although traces of vegetable structure are not always distinguishable in it, fragments of plants like those which contributed to its production are found scattered in the layers which are associated with the coal beds. Alternating with the coal beds are strata composed of sandy and clayey shales, together with limestones and sandstones, which strata make up the great bulk of the Coal Measures. These strata contain the fossil remains which characterize the formation. In some of the layers, as before stated, remains of plants are found; but, in others, fossil shells, corals, etc., prevail, sometimes abundantly. It is plain that the plants must have grown upon the land, and that the animals which formed the shells and corals lived in the waters in which the strata were deposited, and their characters show plainly that those waters were marine. The abundance of vegetable matter that it must have required to produce such extensive beds of coal, the character of the coal beds, and their freedom from extraneous substances, and the character, also, of some of the associated strata, show that the vegetation in question grew upon the very surfaces upon which we now find their remains in the form of coal. The character of the
vegetation whose remains we find, that of the material composing the
layers which enclose them, and that of some of the animal remains which
those layers also enclose, show that the coal-producing vegetation grew in
immense marshes, only slightly raised above the level of the sea. It is
hardly to be questioned that coal was in the condition of peat in the first
stage of its production, and that this peat was produced, as peat always is,
by the partial decomposition of vegetable matter under water, or in a
state of constant moisture.

Now, these conditions being understood, the following conclusions nec­
essarily follow: In every region that is now a coal field there were, dur­
ing the period in which the material was produced of which the coal was
formed, oscillations of the earth's crust; that is, there were gentle and
wide spread risings and sinkings of the crust, in consequence of which
the land surface remained for a long time just above the level of the sea;
then, sinking, it remained for a long time beneath its level. These ris­
ings and sinkings were repeated as often as there are separate beds of coal,
however thin or economically unimportant they may be. While the land
surface was just above the level of the sea in the Carboniferous age, veg­
etation grew most luxuriantly, and, from its debris, peat beds of enorm­
ous thickness and extent were formed. When the land gradually sank
again beneath the sea level, these peat beds were covered with sediment­
ary material, which afterward, as the ages passed, became changed to
the condition of shales, sandstones, and limestones that we now find them
to be, and the peat became changed to coal. We find those shales, sand­
stones, and limestones charged with fossil remains of such a character as
to show that both they and the strata which enclose them are of marine
origin.

Such is a statement of the leading features of the conditions which pre­
vailed during the coal-forming period of the Carboniferous age. Such
conditions prevailed over a large area which is now included in the North
American continent, and of which a large portion of Indiana now forms a
part. As before stated, the coal-making conditions did not prevail every­
where during the Coal Measure period; but they occurred in circumscribed,
yet very extensive, areas. It is believed by geologists, that the great area
in which the coal of Indiana was deposited once extended from eastern
Pennsylvania to beyond the Missouri River, and from Michigan to the
northern portion of the Gulf States. Coal has been found among Car­oniferous strata as far west as eastern Nebraska and Kansas, but with
insignificant exceptions, it has never been found in any strata of the
Carboniferous age to the westward of that region, although the ag­
gregate thickness of the strata of the Carboniferous system is very
much greater in that far western region than it is anywhere east of
the Missouri River. In that western region, the strata are almost
wholly of marine origin; and as they consist almost entirely of sand-
stones and limestones, without coal or carbonaceous shales, it is plain that conditions favorable to the abundant growth of vegetation did not exist there in any portion of the Carboniferous age. That is, while the coal-plant forests of the eastern portion of the continent were growing luxuriantly, the unbroken sea prevailed over what is now the western portion, or at least over that part of it which is found to be occupied by Carboniferous strata. In those western marine Carboniferous strata very many of the fossil species are identical with those which are found in Indiana, in strata which alternate with beds of coal. We, therefore, infer that while those portions of Indiana which are now occupied by the Coal Measures were beneath the level of the sea, the waters which submerged them were continuous to that far-off western region. Indeed, as I have before shown, it was doubtless then continuous, also, over a large part of the earth.

Now, let us inquire as to the character of the life that existed during the time within which the Coal Measures of Indiana were formed, and within the area which now constitutes the great coal field of eastern North America. If, during that period, there were mountains upon any part of what is now the North American continent, they were far to the northward and northeastward; at least, it is certain that none of the mountains that now make up either of the great mountain systems of North America then existed. During that portion of the long Carboniferous age, when and where the land was above the level of the sea it was clothed with a luxuriance of vegetation, such, perhaps, as the earth has never witnessed at any other period of its history. Trees of strange form sent up their towering trunks above the dense undergrowth, but no birds perched in their branches, nor waded the marshes or swam in the pools among them. A few reptiles and batrachians lived there, but reptilian life seems not yet to have gained much of a foothold upon the earth, especially compared with it as it afterward became. None of the mammalia, the chief forms of the animal life of the present day, had yet come into being so far as we yet know. Insects and Myriapods lived then, and, probably, in great abundance, for their means of subsistence abounded in the bountiful vegetation, and their natural enemies were remarkably few. The earth was then a great solitude, and the reigning stillness was perhaps broken, in the intervals of storms, only by the hum of insects and the bellowing of frog-like batrachians. Where the sea prevailed during all this long period, its waters teemed with life. Fishes were there; some of them large and powerful, but all were unlike the scaly fishes of to-day. Mollusks in great abundance, and corals of delicate beauty existed; and a diversity of crustaceans nestled and sported among the seaweeds or crept along the oozy bottom.

Coal-making conditions did not apparently begin with the beginning of the Carboniferous period. The earliest known coal beds were not
formed until near the close of the Lower Carboniferous period, and at a time when fully one-third of the great Carboniferous age had passed; and the coal-making condition was not fully established until the middle, or Coal Measure, period of that age. Marine conditions, apparently, alone prevailed during the Lower Carboniferous period. Its fauna was similar to the marine fauna of the Coal Measure period—a portion of the fossil remains of which are figured on plates accompanying this report.

The foregoing remarks are intended to convey to the general reader an idea of the character and significance of the fossil remains I shall describe on following pages. It would require a series of volumes to illustrate all the forms that are now known to have existed during the Coal Measure period alone. In this article I shall necessarily confine myself to a consideration of the fossil shells, corals, and crustacean remains that have been found in the Coal Measure strata of Indiana and those of the adjacent States. I have aimed to select those only which may be reasonably looked for in Indiana, but far the greater part of them have actually been found in its strata. Many of the figures have been borrowed from works previously published, but they are nevertheless correct representations of forms that exist in the strata of Indiana and representatives of the ancient life of a region of which this State now forms only a small part.

**FAUNA OF THE COAL MEASURES.**

**DESCRIPTION OF SPECIES.**

**PROTOZOA.**

The Protozoa are not very numerous in the Coal Measures of the United States, or, at least, they are not conspicuous objects to the general collector. Protozoan life doubtless abounded during the Coal Measure period, but the calcareous shells of the Foraminifera appear to be the only forms that have been preserved. The only conspicuous species (or the only one which is likely to attract the attention of the general collector) is the one which is described in the following paragraphs.

**FORAMINIFERA.**

*Genus Fusulina, Fischer.*

**Fusulina cylindrica, Fischer.**

*Plate 23, figs. 1, 2 and 3.*

**Fusulina cylindrica.** Various European and American authors.

Shell small, varying in shape from elongate-fusiform to subglobose, and, also, varying greatly in size; the extremities usually somewhat prominent,
formed until near the close of the Lower Carboniferous period, and at a time when fully one-third of the great Carboniferous age had passed; and the coal-making condition was not fully established until the middle, or Coal Measure, period of that age. Marine conditions, apparently, alone prevailed during the Lower Carboniferous period. Its fauna was similar to the marine fauna of the Coal Measure period—a portion of the fossil remains of which are figured on plates accompanying this report.

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Fusulina cylindrica. Various European and American authors.

Shell small, varying in shape from elongate-fusiform to subglobose, and, also, varying greatly in size; the extremities usually somewhat prominent,
even in the subglobose forms, and have the appearance of being somewhat twisted; surface marked by five longitudinal furrows, which mark the position of the septa, and which are straight, except that they are a little flexed at the ends; aperture very small, and usually obscured by the imbedding rock; volutions six to ten in number, closely coiled, the interspaces narrow; septa from twenty to thirty or more in the outer volution, undulating along their inner edge; the foramina of the septa, or foramen apertures, moderately distinct in specimens that are well preserved.

The common size and shape of specimens of this species is closely like that of a grain of a wheat, but they are often found very much smaller,* and sometimes larger and longer, and both more slender and more globose.

This interesting form is not only common in the Carboniferous rocks of various parts of Europe, but it is found in the Coal Measure strata of the United States, from Ohio to California. It may be sought for at Lodi, Fountain county, Indiana, in the limestone roof of coal K.

**CELENTERATA.**

**POLYPI.**

As a large proportion of living Polyps form no coral skeletons, it may be inferred that many kinds of Polyps existed in the Coal Measure and in other geological periods, which have left no trace of their existence in the rocks which represent those periods. In strata of some of the periods fossil corals are abundant, but, although a considerable number of widely differentiated forms are found in Coal Measure strata, they are seldom found to constitute a conspicuous feature of the fossil fauna of that formation. I herewith present descriptions of five species of fossil corals, all of which are more nearly related to forms which existed in the previous geological formations than they are to any that are now found living.

**Genus Zaphrentis, Rafinesque.**

*Zaphrentis Gibsoni* (sp. nov.)

*Plate 23, figs. 4 and 5.*

Corallum curved, conical in form; its outer surface marked by concentric lines and numerous strong wrinkles of growth, and also by numerous distinct longitudinal raised lines; calyx subcircular, deep, and its edges thin; septal fosset well developed, and situated at the concave side of the corallum; septa thirty-six to forty in number, prominent, and thin within the calyx.

Length, along the longest side, 32 mm.; diameter of the calyx, 25 mm.

This is plainly a typical species of *Zaphrentis*, and, so far as I am aware, it is the only species of that genus which has been found in the true Coal

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*In Indiana, it is rarely larger than half the size of a grain of wheat.*

C.
Measures of the United States, although the genus is well represented in the Lower Carboniferous. It resembles in shape Z. spinulijera, Hall, from the Lower Carboniferous limestone, but it is without spines, its proportions are somewhat different, and the calyx is deeper.

**Locality.** The specimen herein described and figured was obtained from the Coal Measure strata of Vermillion county, Indiana, by Mr. William Gibson, in whose honor the specific name is given.

**Genus Lophophyllum, Edwards and Haime.**

**Lophophyllum proliferum, McChesney.**

*Plate 23, figs. 6 and 7.*

Corallum subconical-elongate, more or less curved; more or less irregular in form; base slender, usually pointed; epitheca thin; concentric lines and wrinkles of growth distinct, especially the latter; longitudinal strie distinct; a few spinules sometimes observable near the slender base; calyx subcircular, moderately deep; columella strong, prominent, compressed so that its longer axis is in the plane of the curve of the corallum; septa varying in number with the size of the corallum, from about thirty to nearly or quite fifty, each alternate one much less prominent than the others, the latter extend to the columella, near which they are usually a little flexed.

Different specimens are variable in proportions; a common size is 18 or 20 mm. long and 10 mm. across the calyx.*

This species is a very common one in the Coal Measures of Indiana, Illinois, and Iowa. A more slender form than the one here described occurs in Illinois and Indiana, to which Professor Worthen has given the name *Cymathaxonia distorta.* To a larger and more robust form I have given the name *Lophophyllum sauridens.*

**Locality.** Common throughout the Coal Measures.

**Genus Axophyllum, Edwards and Haime.**

**Axophyllum rudis, White and St. John.**

*Plate 23, figs. 8 and 9.*


Corallum irregularly turbinate, more or less contorted; attached at the apex or along the greater part of its length, usually expanding rapidly from the apex to the calyx; surface marked by irregular concentric undulations of growth, by faint longitudinal lines which indicate the position of the septa, and often by more or less numerous irregular rootlets; outer portion of the calyx shallow, central portion moderately deep; columella small, somewhat prominent, flattened.

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*Indiana species are three or four times as long as wide.*
The size of the specimens is somewhat variable. An example of ordinary size measures 20 mm. in length and 12 mm. across the rim of the calyx.

This species is not uncommonly met with in the Upper Coal Measures of Indiana, Illinois, and Iowa. It is sometimes found as a single simple corallum, but it not unfrequently occurs in clusters, which have originated from a parent corallum by lateral gemmation; and the new corallums are often more or less bound together by their rootlets.

**Locality.** The specimens figured are from Newport, Indiana. These are rather smaller than the average size.

**Genus Campophyllum, Edwards and Haine.**

*Campophyllum torquium, Owen.*

*Kyathophyllum torquium, Owen, 1852. Geol. Sur. Wis., Iowa and Minn., plate IV, fig. 2.*  

Corallum simple, moderately large, having one or more abrupt flexures in the first five or six centimeters of its length; but, beyond that, it is subcylindrical and approximately straight when full-grown; epitheca thin; surface marked by concentric lines and numerous wrinkles; calyx subcircular, shallow at the outer portion, but deepening abruptly at the middle; margins of the calyx thin; a moderately distinct septal fosset is observable at the side of the calyx, near the convex curve of the corallum; primary septa from thirty to fifty in number, extending a little more than half the distance from the margin of the calyx to its center, moderately strong; secondary septa short, thin, and inconspicuous; tabulae very wide, occupying about two-thirds the full diameter of the corallum, somewhat irregular, but all arching a little upward; dissepiments forming a multitude of small oblique vesicles between the radiating septae.

Large examples reach 150 mm. or more in length, and have a diameter of 35 or 40 mm.; but the ordinary size is less.

This coral has hitherto been found only in the Upper Coal Measures or Permo-Carboniferous strata. It is common in Iowa, Missouri and Nebraska, is known in Illinois, and is likely to be found in Indiana in Sullivan and Vigo counties, on and west of the Wabash.

**Genus Michelinia, de Koninck.**

*Michelinia Eugenii (sp. nov.)*

*Plate 23, figs. 14, 15 and 16.*

Corallum usually in the form of a small globular or irregularly ovoid mass, higher than broad, with the corallites usually opening upon all sides, except its very small base, which is often concave and irregular;
corallites small, but very irregular in size and shape; calyces moderately deep, their walls rather thin and margins narrow or even sharp.

Height of one of the larger masses in the collection 26 mm.; transverse diameter of the same, 17 mm. Diameter of the larger calyces, 3 mm.; of the smaller ones, 1 mm.

Usually the calyces cover the whole outer surface of the corallum except the small base, which was evidently attached to some foreign body; but occasionally a considerable surface above the base is free from calyces and is covered with a wrinkled epitheca. This is the only species of *Michelinia*, so far as I am aware, that has ever been found in the Coal Measure strata of North America, although two or three species are known to exist in the Lower Carboniferous rocks. It is likely that the *Favosites Whitfieldi*, White, from the Kinderhook group at Burlington, Iowa, will prove to be a species of *Michelinia*. If so, it somewhat resembles the form here described in the smallness of the corallites, but not in the shape of the corallum.

**Locality.** Edwardsport, Knox county, and Eugene, Vermillion county, Indiana, and one or two localities in Illinois.

**BRACHIPODA.**

The *Brachiopoda* are among the most abundant and characteristic fossils of the Carboniferous rocks. At the close of this age, a large proportion of the genera, and also some of the families that flourished in this and the preceding age, ceased suddenly to exist. In all the rocks of Mesozoic and Cenozoic age, and also in existing seas, Brachiopods are among the least abundant of shell-bearing animals.

**Genus Lingula, Bruguiere.**

**Lingula umbonata, Cox.**

*Plate 25, fig. 14.*


Shell subelliptical in outline, a little narrower behind the mid-length than in front of it; the sides broadly convex; anterior and posterior ends both rounded; the body of the shell gently and somewhat regularly convex, but the umbo narrow and more prominent; beak narrow, minute.

This shell is evidently identical with the *Lingula umbonata* of Cox, although the flattening along the middle is not so distinct as it is represented to be by his figure.

**Locality.** Cox's specimens were obtained in Kentucky. Those here described and figured are from Vermillion county, Indiana.
Genus *Discina*, Lamarck.

**Discina nitida**, Phillips.


*Discina nitida* (Phillips), Meek and Worthen, Illinois Geol. Reports, V, p. 572, pl. 25, fig. 1.

Shell small, subcircular, depressed-conical; the sides sloping nearly straight from the apex to the margins; apex prominent, situated at about one-third the diameter of the shell from the posterior border; lower valve flat, with the usual depression around the foramen; surface of both valves marked by concentric lines and fine lamellations.

Diameter of an average sized example about 8 mm.

**Locality.** This small *Discina* is common in the Coal Measures of Indiana, Illinois, Iowa and Missouri; abundant at Cannelton and Horse Shoe, of Little Vermillion.

**Discina convexa**, Shumard.


Upper valve broadly but somewhat prominently convex; sub-circular in marginal outline; the height nearly equal to one-half the diameter; apex somewhat obtuse, but moderately prominent, situated at about one-third the diameter of the shell from its posterior margin; surface marked by the usual distinct concentric lines of growth. A smaller under valve was found at the same locality with the upper valve above described, and probably belongs to this species. It shows a similar surface, which is nearly flat, but it is depressed about the foramen, which is of the usual character; the foramen is situated just beneath the position of the beak of the upper valve.

Diameter of the upper valve, just described, 27 mm.; height, 12 mm.

**Locality.** Dr. Shumard's specimens were from the Upper Coal Measures of Kansas. Those here described are from Vermillion county, Indiana.

Genus *Crania*, Retzius.

**Crania modesta**, White and St. John.


The type specimen of this species was free, and both valves were together in place, but the specimens of this collection all appear to have been attached to some foreign object by the lower valve; the upper valve is moderately convex, and the lower flat; both marked by concentric lines of growth. The only examples in this collection are under valves
attached to other fossils, and, of course, show only the inner surface. Figure 5, plate 36, shows such valves adhering to a fragment of *Orthoceras Rushensis*, and figure 9, plate 35, shows similar valves adhering to a specimen of *Athyris subtilita*.

**Locality.** Eugene and Newport, Vermillion county, and at Merom, Sullivan county, Indiana.

**Genus Productus, Sowerby.**

**Productus Nebrascensis, Owen.**

*Plate 24, figs. 7, 8 and 9.*

*Productus Nebrascensis, Owen, 1852.* Geol. Report Wis., Iowa and Minn., p. 584, pl. V, fig. 3.

Shell of about average size for a species of this genus; outline in front of the cardinal border rudely semi-elliptical; length usually less than the breadth; cardinal border generally a little less in length than the greatest breadth of the shell, and never exceeding it; antero-lateral margins strongly, and front margins broadly, rounded, in the latter sometimes a little emarginate at the middle; postero-lateral margins somewhat straightened upon, and in front of the ears, meeting the cardinal border at a somewhat obtuse angle; ears small, seldom prominent; ventral valve somewhat regularly convex from front to rear, greatest convexity behind the middle; umbo prominent, projecting behind the hinge line; beak prominent, incurved a little over the cardinal margin; a mesial flattening, amounting sometimes, but rarely, to a distinct sinus, extending from the umbo to the front margin; dorsal valve flattened in the visceral region, the antero-lateral and front portions curving abruptly upward; beak and auricular regions depressed so as to produce a slightly raised, rounded, diverging fold between them respectively, at each side; mesial fold seldom distinct and perceptible only at the front; surface of both valves covered with numerous spines of different sizes, but all very small, those of the ventral valve are borne upon more or less distinctly defined concentric folds, and may be divided into two sets or kinds, one consisting of the stronger and more erect spines, and the other of small, short ones, the latter being closely appressed against the surface; both kinds are more or less connected by means of numerous raised radiating lines, which are more apparent upon the concentric folds than upon the surface of the interspaces.

Length, 33 mm.; breadth, 35 mm.

This species is a common one in the Coal Measure strata in the States of the great Mississippi valley, from Indiana westward; and it is frequently found in the Carboniferous strata of the Rocky Mountain region. As it is usually obtained from a limestone matrix, the spines and outer layer of the shell are removed. Such specimens present an appearance so different from that of those which have been perfectly preserved in a soft matrix
that they have been referred to different species, by different authors. See further remarks in connection with the description of the next species.

**Locality.** Fountain, Vermillion, Parke and Vigo counties, Indiana.

**Productus symmetricus, McChesney.**

*Plate 25, figs. 1 and 2.*

**Productus symmetricus, McChesney, 1866.** Trans. Chicago Acad. Sci., I, p. 25, pl. I, fig. 9.

Shell suborbicular in marginal outline, the breadth being a little greater than the length; the cardinal border a little less in length than the greatest breadth of the shell; the lateral margins rounding regularly to the front margin, the latter being broadly rounded; ventral valve moderately convex, without a mesial sinus; ears not distinctly defined from the body of the shell, obtusely angular or rounded at their extremities; beak somewhat prominent, incurved but not projecting much over the cardinal border; dorsal valve moderately and somewhat uniformly concave; cardinal process slender, trifid at the end, the middle division being a little more prominent than the other two; surface of both valves marked by small concentric wrinkles or ridges, which are covered by numerous short minute spines, which are directed obliquely forward, and which are somewhat larger upon the ventral than upon the dorsal valve.

Length, 50 mm.; breadth, 52 mm.; convexity, 21 mm. But these dimensions vary somewhat in different specimens.

This form seems to be worthy of a separate specific designation; but it is not to be denied that it is closely related, on one hand, with *P. Nebrascensis*, and on the other with *P. punctatus*, both of which species are also frequently met with in the Coal Measure rocks of the United States. It is also clearly related to *P. scabriculus* of the European Carboniferous. Being associated in the same formation with the two first named species, and possessing so many points of resemblance in common with each other, the genetic relationship of these three forms would seem to be unquestionable; and yet they possess differences which, for both zoological and geological reasons, it is desirable to recognize. The differences between these forms have been discussed at length by Mr. Meek in Hayden’s Report on the Geology of Eastern Nebraska, and in Vol. IV of King’s Reports on the Geology of the 40th parallel. In the latter work, he has proposed the new specific name *P. Nevadensis*, for a form that is so closely like *P. punctatus* that it has usually been regarded as identical.

**Locality.** McChesney’s type specimens of *P. symmetricus*, and also the one which is figured on plate 25, are from Coal Measure strata in Illinois; but it may be sought for in Vermillion, Vigo, Sullivan, Vanderburg, Dubois, Warrick and Pike counties, Indiana.
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**Productus punctatus, Martin.**

*Plate 27, figs. 1, 2 and 3.*

This species is described and figured in this series of reports for 1881, page 373, plate 42, figs. 1, 2 and 3. For the purpose of grouping the Coal Measure fossils together in this report, that description is repeated here.

This is one of the best known species of characteristic Coal Measure fossils, and one the specific identity of which with the European form of that name has never been seriously questioned. The following description applies to the species as it exists in widely separated localities in the United States.

Shell large, test thin; marginal outline varying from imperfectly four sided, the narrowest side being the posterior one, to subovate, sometimes being wider than long, but sometimes longer than wide; cardinal margin almost invariably shorter than the width of the shell at any part in front of it; anterior border broadly rounded, but usually a little emarginate at the middle; sides flattened, by which means the lateral margins are somewhat straightened; ears small; ventral valve broadly arcuate from front to rear, in which direction there is also a broad mesial flattening of the valve, with usually a shallow but somewhat distinct mesial sinus along its middle; umbo prominent, narrow; beak small, incurved, and projecting slightly over the cardinal border; dorsal valve moderately concave; beak, as such, wanting, its place being concave; mesial fold ill defined, there being only a slight mesial elevation of the valve extending along the visceral and anterior portions; surface of both valves marked by rather numerous and regular concentric folds, which are smaller at the beak and borders than elsewhere, upon adult shells, and smaller and more distinct upon the dorsal than upon the ventral valve; interspaces between the concentric folds plain; folds supporting numerous spines of varying size, but all minute and more or less appressed against the shell.

Length of the example figured, which is of adult size, 67 mm.; breadth of the same at the broadest part, about the same as the length.

**Locality.** Same counties as foregoing.

**Productus costatus, Sowerby.**

*Plate 24, figs. 4, 5 and 6; and plate 25, figs. 3, 4 and 5.*

The form here described is the one which has usually been referred to the European shell to which Sowerby originally gave the above name. There is, however, much reason to doubt its real specific identity with the European shell, but I am not now prepared to discuss that question satisfactorily.

The shell is of medium size; width greater than the length, measured in a straight line from the hinge to the front border, strongly and deeply
arcuate from rear to front; hinge line nearly or quite equal in length to the greatest width of the shell; ears thin, well defined, and bent slightly downward; free margin broadly rounded, the front being slightly emarginate; ventral valve gibbous and strongly curved, having a broad shallow sinus extending from the umbonal region to the front, producing there the before-mentioned emargination of the front border; beak prominent, incurved, but only slightly projecting over the cardinal margin; dorsal valve flattened or only slightly concave in the visceral region, abruptly curved upward at the lateral and front margins; front showing a very slight mesial fold, corresponding with the broad, shallow mesial sinus of the other valve; surface of both valves, except that of the ears, marked by distinct, more or less unequal, rounded, radiating costae, with interspaces of somewhat less than their own width between them; costae generally continuous through the greater part of the length of the shell, but sometimes bifurcating, and occasionally two or more of them may be seen to coalesce and form a single costa of more than ordinary size; crossing the costae, especially on the posterior half of the shell, and forming distinct reticulations with them, are more or less numerous concentric wrinkles; upon the ventral valve, especially toward the margins and upon the ears, there are usually scattered strong, more or less perpendicular, spines. Some of the shells are apparently nearly free from spines, or have only a few upon and near the ears.

Length, 28 mm.; breadth, 34 mm.; convexity, 18 mm.

This is one of the most common and characteristic species of the Coal Measure fossils of Indiana, Illinois, Iowa, and Missouri, and it is also frequently met with in the Carboniferous rocks of the Rocky Mountain region.

It ranges in the Mississippi valley from the Lower Carboniferous to the Upper Coal Measures. It is closely related to \( P. \textit{semireticulatus}, \) Martin (the next species described), but it is a smaller shell, and more coarsely and distinctly costate.

\textit{Locality}. It has been found throughout the Coal Measures of Indiana.

\textit{Productus semireticulatus}, Martin.

\textit{Plate 24, figs 1, 2 and 3}.

This shell is widely known in the Coal Measures of the United States, and has been generally regarded by authors as identical with the European species to which the name was first applied.

It is a large shell, strongly arcuate; width greater than the length; the length of the hinge line sometimes greater and sometimes less than the greatest width of the shell; cardinal area of both valves very narrow, but distinct; ears thin, more or less prominent, lateral and front borders continuously rounded, the front being slightly emarginate; ventral valve
strongly curved; beak depressed and projecting very little, if any, over the cardinal border; a broad, shallow, obscurely defined mesial sinus in most of the examples, extends from near the umbonal region to the front, giving the shell an indistinctly bilobed appearance; dorsal valve flattened in the visceral region, bent abruptly upward at the sides and front; beak flattened or slightly concave; surface of both valves marked by numerous coarse rounded striæ or small costæ, which are crossed in the visceral region by somewhat regular concentric wrinkles of nearly uniform size, giving that part of the shell a semi-reticulated appearance, which is more distinct in some examples than in others; more or less numerous strong, erect spines are scattered upon the ventral valve, generally arising from the costæ upon the body of the shell and from the strong wrinkles upon the ears, upon which latter part they are usually most numerous.

Length of an ordinary sized example, measured in a straight line from the hinge to the front margin, 45 mm.; width, 60 mm.

The differences between this species and *P. costatus* have already been mentioned. Like that species, this one has not only a wide geographical range, but it is also found, in the Upper Mississippi River region, to range from the Lower Carboniferous to the Upper Coal Measures.

**Locality.** Common throughout the Coal Measures and often in the Lower Carboniferous.

**Productus Cora, d'Orbigny.**

Plate 26, figs. 1, 2 and 3.

This species was, by Dr. Owen and Prof. Marcou, referred to the South American form described by d'Orbigny, in "Voyage dans l'Ame­rique Meridionale," under the name *Productus Cora*. Other American authors have, however, given it various names, and of late years it has generally gone by the name given it by Norwood, *P. Prattenianus*. I have, however, lately, had an opportunity to examine some examples which were brought by Dr. O. A. Derby from the South American local­ities from which d'Orbigny obtained his type specimen. A careful ex­amination of these has left no doubt in my own mind that Owen and Marcou were right in referring our North American form to *P. Cora*, d'Orbigny. Some of the new specific names proposed by American authors were based upon varietal differences, such as the presence or absence of spines and small tubercles scattered over the surface, or the difference in the size of the radiating striæ; but, while I admit the existence of these variations, I do not regard them as being of specific value. The follow­ing description is regarded as fairly representing the species:

Shell sometimes reaching a large size; the breadth generally greater than the length; hinge line sometimes longer and sometimes shorter than the greatest width of the body of the shell; lateral and front margins regularly and continuously rounded; ears prominent, thin, and, therefore,
they are generally broken off in the imbedding rock; mesial fold and sinus wanting, but, sometimes, there is an indistinct mesial flattening of the ventral valve; ventral valve somewhat uniform convexly convex; umbonal region gibbous; beak scarcely projecting over the cardinal border; ears marked by strong wrinkles, which pass inward upon the sides of the valves and become obsolete there, but ending abruptly at the cardinal margin; surface of the valves marked by fine, rounded, radiating striae, some of which may be traced continuously from the umbonal region to the front, increasing by implantation and occasionally coalescing. A few strong, erect spines are often scattered over the surface of the ventral valve, and the cardinal border always bears a greater or less number of small spines. Although the striae which mark the surface are always small and slender, their relative size differs very much in different individuals, in some cases being minute and hair-like; in the latter cases, the spines are usually absent from the general surface. One of the examples figured on plate 26, bears the finer striae, and those of the other two bear the coarser striae with the spines.

Locality. This species has a wide geographical and vertical range in the Carboniferous rocks of North America. It may be sought for at the following Indiana localities: Fountain, Vermillion, Parke, Montgomery, Clay, Owen, Pike, Dubois and Warrick counties; also in the Lower Carboniferous.

Productus longispinus, Sowerby.

Plate 24, figs. 10 and 11.

This is another species from the Coal Measure rocks of North America, which has been identified with a European form. It is an exceedingly variable shell, as is evidenced by the large number of synonyms which have been given to it, both in this country and Europe. The form that I here describe and figure is a characteristic one of the Coal Measures of North America, and it is yet a question whether it is correctly identified with the European *P. longispinus*. It is one of the smallest species of *Productus* among the somewhat numerous forms that the Carboniferous rocks afford.

It is much wider than long; the hinge line longer than the full width of the body of the shell; ears prominent, thin, and sometimes a little reflexed, the lateral and front margins forming a rude semi-ellipse, but the front margin is more or less emarginate at the middle; ventral valve gibbous, the more abrupt portion of the antero-posterior convexity being behind the middle; umbo of the ventral valve moderately prominent, the beak projecting slightly over the cardinal margin; mesial sinus broad, and distinct only near the front; surface marked by obscure radiating ribs.

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*The Owen Cabinet contained specimens from Indiana, identified by d'Orbigny, and labelled in his own handwriting *P. Cors*. C.*
usually obsolete upon the umbo, which are crossed by the usual lines of growth; moderately strong, erect spines are scattered over the surface of the valve (these were originally long, but they are almost always broken off); dorsal valve concave; the median portion slightly raised near the front, corresponding with the shallow sinus of the other valve; surface marked like that of the other valve, except that it is without spines.

Length, 11 mm.; breadth of body portion, 17 mm.; length of hinge line, 21 mm.

LocalitY. The following Indiana localities have furnished the species here described: Fountain, Parke, Vermillion, Vigo, Sullivan, Knox, Pike, Warrick, Spencer, Posey, Gibson and Vanderburg counties.

Genus Chonetes, Fischer.

Chonetes Verneuiliana, Norwood and Pratten.

Plate 25, figs. 7 and 8.


Shell small, much wider than long; the cardinal portion extended beyond the sides of the body of the shell, sometimes mucronate; ventral valve convex, bearing a moderately deep rounded mesial sinus which extends from near the beak to the anterior margin, toward which it rapidly deepens and widens; the sinus is usually so distinct as to produce the appearance of two prominent lobes upon this valve; ears somewhat angular and a little reflexed, sometimes obtuse, and in other examples acute and produced; beak moderately prominent; area distinct but narrow, a little wider, however, than that of the dorsal valve; foramen wide; cardinal margin bearing four oblique spines on each side of the beak; dorsal valve concave, and bearing an obtuse mesial fold corresponding with the sinus of the other valve; surface of both valves marked with numerous fine radiating striae which, with the growth of the shell, increase by bifurcation. These are crossed by a few lines of growth.

Length, 8 mm.; breadth, 12 mm.

Two or three other species of Chonetes are more or less common in the Coal Measure rocks, but this one may be readily distinguished by its mesial sinus and the bilobed appearance of the ventral valve.

LocalitY. Every county in the Coal Measures of Indiana has furnished this species.
Genus Orthis, Dalman.

Orthis Pecosi, Marcou.

Plate 32, figs. 20, 21 and 22.


Shell small, sublenticular; outline subcircular or subovate; length and breadth nearly equal, but sometimes the length is a little the greater; front margin regularly rounded or slightly emarginate; hinge line very short, less than half the breadth of the shell; ventral valve having its greatest convexity at the umbo, often flattened a little at the front, but it is always without a definite mesial sinus; beak small, pointed, somewhat prominent, and arched over the small, well-defined area, which is also arched; dorsal valve more convex than the ventral, in old shells, its greatest convexity being behind the middle, generally showing a mesial flattening which extends from the umbo to the front margin; area distinct, but smaller than that of the other valve; beak small, not prominent; surface of both valves marked by fine, close-set, radiating striae, which increase mainly by implantation, but occasionally by bifurcation; these striae are crossed by fine concentric lines of growth, and near the front by imbricating lines. The striae often show small pores upon their backs, apparently marking the position of minute tubular spines which have been removed.

Length and breadth of a large example, each 13 mm.; but the average size is considerably less.

Locality. This little Orthis is widely distributed in the Coal Measures from Indiana to Nebraska, and also in the Carboniferous rocks of the Rocky Mountain region. It has been found at the following Indiana localities: Horse Shoe of Little Vermillion and Garrett's Mill, Vermillion counties of Indiana and Illinois.

Genus Hemipronites, Pander.

Genus Streptorrhynchus, King.

Hemipronites crassus, Meek and Hayden.

Plate 26, figs. 4, 5, 6, 7, 8, 9, 10 and 11.


Shell subquadrat or transversely suboblong in marginal outline, compressed; hinge line usually a little shorter than the greatest transverse diameter of the shell, but it is sometimes equal to it; front margin broadly rounded; lateral margins rounded to the front, but straightened posteriorly, forming a more or less distinct angle with the cardinal border;
surface marked by numerous raised radiating striae, which increase by implantation; the radiating striae are crossed by numerous concentric lines and several stronger marks of growth; ventral valve nearly flat; cardinal border sloping a little to the lateral margins; beak more or less prominent, usually a little distorted; area flat, moderately broad, and inclined a little backward; pseudo-deltidium thick and moderately prominent; cardinal teeth small; scars of the adductor muscle large and separated by a thin mesial ridge, their outline well defined in old shells; dorsal valve gently convex in the middle and flattened at the postero-lateral portions; both valves marked by crenulations at the inner surface of the borders, but this feature is often obscured.

Length of an average sized example, as they are usually found in the Coal Measures, 25 mm.; breadth, 27 mm.

I have here given the name that this species has come to be generally known by, but it is now generally understood among paleontologists that it does not differ specifically from the *H. crenistria* of Phillips. It is also probable that King's generic name *Streptorhynchus* ought to be used for this group of shells, so that the species here described would then properly bear the name *Streptorhynchus crenistria*.

There is also a much larger form than the one here described, which occurs in the Coal Measure strata of Iowa and Missouri, but which seems to be in all other respects identical with this, although it becomes rough and ventricose with age. Professor Hall has described this form, in his Geology of Iowa, under the name of *Orthis robusta*. A form closely similar, and perhaps identical with the smaller form here described, has been found in the Lower Carboniferous rocks of Iowa.

**Locality.** This species may be sought for at the following Indiana localities: Lodi, Eugene, Perrysville, Merom, Big Creek, and New Harmony.

**Genus Meekella, White and St. John.**

*Meekealla striatocostata, Coz.*


Shell variable in size and shape, indistinctly trihedral in outline, both valves becoming gibbous at full adult age; hinge line usually much shorter than the greatest breadth of the shell; ventral valve usually more capacious than the other, but sometimes the difference in this respect is slight, deepest near the umbo; beak more or less distorted by being flattened, bent backward or to one side or the other, usually toward the dextral side; area triangular, more or less irregular in consequence of the distortion of the beak; height of the area seldom so great as its width at
the base, and often much less, its lateral borders well defined, its surface finely striated, both vertically and transversely; fissure varying in proportional width in different individuals, but usually quite narrow, and completely closed by a pseudo-deltidium, which is more or less flattened along each side, prominent along the middle, along which prominence there is a slightly raised mesial line; dorsal valve capacious, more regularly convex than the other; the convexity in some cases is so great behind the middle as to carry a portion of the valve a little behind the cardinal border; flattened along the middle toward the front, but never possessing a true mesial sinus; beak broadly convex, strongly incurved, not projecting over the hinge line; area obsolete, postero-lateral portions compressed so that small, thin ears are formed at the hinge extremities; surface of each valve marked by from ten to fourteen more or less angular radiating plications, having deep, angular interspaces between them; the plications not extending to the beak, increasing in size toward the front, mostly simple, but sometimes bifurcating; plications and interspaces both marked by numerous fine, radiating striae which, toward the front margin of adult shells, usually converge to the crests of the plications, upon which they meet at acute angles; crossing these converging lines there are also usually zigzag lines of growth to be seen. The convergence of the radiating striae does not take place until the shell has reached nearly mature size, and occasionally not then.

This shell is quite variable in size and shape, but it is thought that the foregoing description, together with the figures in plate 26, will enable any one to identify the species without difficulty. It is widely distributed in the Coal Measure strata of the States which border upon the Mississippi and Missouri Rivers, and it is also frequently found in the Rocky Mountain region.

**Locality.** The following Indiana localities have furnished examples of this species: Western part of Vigo county, and adjoining parts of Illinois.

**Genus Syntrielasma, Meek and Worthen.**

**Syntrielasma hemipligata, Hall.**

*Plate 26, figs. 15, 16, 17 and 18.*

*Spirifer hemipligatus, Hall, 1852.* Stansbury’s Salt Lake Report, p. 409, pl. IV, fig. 3.  

Shell subglobose when fully adult, but only moderately convex when young; hinge line very short, not more than one-third the greatest transverse diameter of the shell; dorsal valve more convex than the ventral, strongly arched, especially in old shells; umbonal region gibbous, projecting backward a little beyond the cardinal border; area narrow, concave; ventral valve convex; beak slightly prominent and slightly incurved; area triangular, small, moderately well defined, higher than wide; surface
of both valves marked by fine, regular, crowded, radiating striae, and a few large subangular radiating plications, which are most distinct at the front margin, but never reach the umbones; a few concentric lines of growth near the front, impart a zigzag appearance as they cross the plications and interspaces.

Genus Rhynchonella, Fischer.

Rhynchonella Uta, Marcou.

Plate 25, fig. 6.

Rhynchonella Uta, Marcou, 1858. Geol. of N. America, p. 51.

Shell rather small, varying considerably in form, usually subtriangular in marginal outline, and somewhat wider than long; postero-lateral margins converging at an angle which varies in different shells from eighty to one hundred and ten degrees; front broadly rounded, emarginate at the middle; dorsal valve more capacious than the ventral, abruptly convex at the front; beak strongly incurved; mesial fold not prominent, and perceptible only at the front; plications somewhat angular, varying in number from seven to nine and rarely more, distinct at the front, but becoming obsolete at the middle and sides of the valve; from two to four of these plications are borne upon the mesial fold, which becomes obsolete backward with the plications; ventral valve rather shallow, similar to the other valve in the number, distribution, and character of the plications; beak narrow, prominent, and gently incurved; mesial sinus broad and shallow, having from one to three plications which are smaller than those at the sides, and, with the sinus, become obsolete about the middle of the valve; the posterior half of the shell plain, or marked only by occasional lines of growth.

The length of an adult example is about 10 mm.; breadth, 11 mm.

This shell has a very wide geographical range, it having been found from Indiana to Utah and New Mexico. It is closely related to a form that occurs in the Lower Carboniferous of Iowa, to which I gave the name of R. Ottumwa, and it is probable that the latter should be regarded only as a variety of the former.

Locality. This species has been found throughout Upper Coal Measures.

Genus Spirifer, Sowerby.

Spirifer cameratus, Morton.

Plate 35, figs. 3, 4 and 5.

Spirifer cameratus, White, 1881. Indiana Geol. Rep. for 1880, p. 149, pl. VIII. fig. 3.

This species was described in a former report (loc. cit.), but it is repeated
here with better illustrations, and for the purpose of bringing together all
the Coal Measure species hitherto described for the Indiana Reports.

Shell usually of medium size, but sometimes quite large, subsemi-circu-
lar or subtriangular in outline, almost always broadest at the hinge line;
the hinge extremities often pointed and sometimes mucronate; dorsal valve
not quite so capacious as the other; mesial fold distinct, broad at the front,
sometimes sharply elevated, but more commonly rounded, clearly defined
from front to beak and rapidly increasing in width to the front by the
greater or less curving outward of the sides; sides of the valve sloping
almost directly from the mesial fold to the lateral borders; antero-posterior
convexity of the mesial fold very slight from front to middle, but increas-
ing from the middle to the beak; beak small, projecting slightly over the
cardinal border; ventral valve strongly arched from beak to front, the
beak being prominent, pointed and curved over the area; area concave,
of moderate width, and not narrowing to a sharp angle at the hinge ex-
tremities; foramen almost equilaterally triangular, partially closed by a
pseudo-deltidium, which is often removed by weathering; mesial sinus well
defined from front to beak and in all respects answering to the mesial fold
of the other valve; surface marked by numerous distinct, rounded striae
of unequal size, which increase gradually in size toward the front; striae
increasing in number by the division near the beak of the few which are
continuous to its point; they are thus generally gathered into more or less
distinct fascicles of three or more striae in each fascicle, the middle striae
of each fascicle being more prominent than the others, and these are the
only striae which reach the point of the beak; the mesial fold and sinus
usually have striae of the same character and arrangement as those upon
other parts of the shell, but in some cases they are obsolete upon the sides
of the fold and sinus respectively; besides the radiating striae, the surface
is marked by the usual lines and laminations of growth. This is one of
the most common species in the Coal Measure strata of North America,
of which it is also one of the most characteristic fossils.

Locality. Throughout the Coal Measures of Indiana.

SPIRIFER (MARTINIA) LINEATUS, Martin.

Plate 27, figs. 4, 5 and 6.

This species was described and figured in the Indiana Geological Report
for 1881, page 372, and plate 42, figures 4, 5 and 6. These are repeated
in this report for the purpose of bringing the Coal Measure fossils together.

The shell which is here figured is one which has usually been referred
to SPIRIFER LINEATUS, Martin, but which McCheesney described under the
name of S. perplexa. Although it very closely resembles S. lineatus, one
can hardly be satisfied that it is really specifically identical, and it is
probable that we shall be justified in adopting McCheesney's name. Not
having the means for direct comparison with the European form at hand, however, I prefer to leave our shell for the present with *S. lineatus*, where it has been placed by the majority of paleontologists who have noticed it, making the following brief description:

Shell moderately gibbous, transversely subelliptical in marginal outline, the front and sides regularly rounded; hinge much shorter than the width of the shell; cardinal extremities rounded; cardinal area distinct, arched and moderately high; ventral valve convex; umbonal portion prominent; beak prominent, incurved; area small; without median sinus, but there is a slight flattening of the valve at the front, which gives the front margin a very slight sinuosity; dorsal valve regularly convex, both transversely and longitudinally; umbonal portion prominent, but not so much so as that of the other valve; beak moderately prominent and projecting a little beyond the hinge line; surface marked by numerous very faint radiating lines and somewhat stronger concentric lines, the latter being impressed and finely crenulate, the minute crenulations apparently marking the bases of hair-like spines when the surface of the shell was perfect.

Length from ventral beak to front, 17 mm.; breadth, 18 mm.; greatest thickness, both valves together, 13 mm.

**Locality.** Fountain, Parke, Vermillion, Vigo, Sullivan, Gibson, Pike, Knox, Posey, Vanderburg and Warrick counties, Indiana.

*Spirifer* (Martinia) *planoconvexa*, Shumard.

*Plate 32, figs. 23 and 24.*


Shell very small; breadth varying from a little more to a little less than the length; hinge line moderately long, but always shorter than the full breadth of the shell in front of it; lateral and front margins regularly and continuously rounded; the dorsal valve nearly flat, and it would be almost circular in marginal outline but for its truncation by the straight hinge line; beak minute, not prominent; cardinal area very narrow; ventral valve capacious, especially its posterior portion, which extends much behind the hinge line and ends in a prominent, strongly incurving, pointed beak; area very narrow, high, concave; mesial sinus absent, but in its place there is usually a slight flattening at the front, and sometimes an indistinct impressed line is seen to extend from the beak to the front margin; surface apparently smooth, but under a lens it is seen to be finely granular, the apparent granules being the bases of minute setae; a few concentric lines of growth are usually observable upon both valves.

Length, 13 mm.; breadth, 13 mm.; convexity, 8 mm.

This common American shell agrees so closely in many respects with *S. Urii*, Fleming, from the British Carboniferous strata, that the propriety of placing it under any other specific name may well be questioned. In
view, however, of the fact that the characteristics of the subgenus Martinia admit of the development of very few salient specific features, I am at present disposed to regard these minor differences as affording sufficient reason for continuing the use of Shumard's name.

**Locality.** This little shell is one of the most widely distributed of the Coal Measure species. It has been found from Virginia to Utah and New Mexico, and in some of the strata of the States bordering upon the Mississippi and Missouri Rivers it occurs in great numbers. It has been found throughout the Coal Measures of Indiana.

**Genus Spiriferina, d'Orbigny.**

*Spiriferina Kentuckensis, Shumard.*

*Plate 35, figs. 13 and 14.*


Shell small, variable in outline, sometimes subsemicircular and occasionally almost globose, and sometimes the extremities are produced and mucronate; ventral valve more capacious than the dorsal; beak prominent, arching backward; area moderately high, well defined, concave; foramen higher than wide; mesial sinus distinctly defined, rather narrow, often moderately deep, without plications except occasionally a small obscure one at the bottom; dorsal valve somewhat regularly convex; beak scarcely prominent, projecting slightly over the cardinal margin; mesial fold narrow, distinctly defined, a faint linear depression sometimes observable along its middle, which corresponds with the small linear plication which is sometimes seen at the bottom of the sinus of the ventral valve; surface of each valve marked by from ten to eighteen simple prominent plications, rounded or almost angular at top and separated by interspaces of similar width; the plications which bound the sinus are a little larger and more prominent than the others, which thus serve to more clearly define the sinus from the remainder of the shell; the entire surface is also marked by fine, distinct, prominent and closely crowded lines of growth.

The length of a specimen of about average size and proportions is 9 mm.; breadth, between the hinge extremities, 13 mm.

**Locality.** This is one of the more common of the Coal Measure shells, but it is never found abundantly. It has been discovered at the following Indiana localities: In the Middle and Upper Coal Measures of Vermillion, Vigo, Knox, Gibson, Posey, Vanderburg, Dubois, and Spencer counties.
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Genus Athyris, McCoy.

Athyris subtilla, Hall.

Plate 35, figs. 6, 7, 8 and 9.

Among the fossil shells of North America, perhaps no species has come to be so well and widely known as this. It is also one of the most common and characteristic of the Coal Measure species.

It is variable in size, and somewhat also in outline, but it is seldom large; subovate in marginal outline, not often as wide as it is long, moderately gibbous, and old shells are sometimes inflated; ventral valve generally a little more capacious than the dorsal; beak prominent, strongly incurved; mesial sinus not very deep, even at the front, and becoming obsolete about the middle of the shell; a more or less distinctly impressed line usually exists along the bottom of the sinuses, and extends from the beak to the front margin; dorsal valve somewhat uniformly convex, but more convex near the umbo than elsewhere; beak small, slightly prominent; mesial fold not distinctly defined; surface marked by concentric striae and by occasional imbricating lines of growth; faint traces of radiating lines, such as are common on shells of this genus, are also occasionally seen.

Length of a specimen of ordinary size, 24 mm.; breadth, 20 mm.; height, 9 mm.

In all the variations which this shell is subject to, it is easily recognizable after an acquaintance with the species has once been formed. One of the most noticeable of its constant characteristics is the impressed mesial line at the bottom of the sinus of the ventral valve. This feature is sometimes obscure, but it is usually sufficiently distinct to be readily recognized. This species ranges through the whole Coal Measure series, and, according to Mr. Meek, into the Permian, also. In geographical distribution it is known from Virginia to the Rocky Mountain region.

Locality. It has been found common throughout the middle and Upper Coal Measures, rarer in Lower.

Genus Retzia, King.

Retzia Mormonii, Marcou.

Plate 35, figs. 10, 11 and 12.


Shell small, ovate in outline; both valves more or less gibbous; hinge line short; ears minute and observable only in well preserved examples; ventral valve a little more capacious than the dorsal, posterior portion narrowed to the umbo, which is prominent and considerably arched; beak
small, truncated by a foramen of moderate size; area small but well defined; dorsal valve almost as prominently convex as the ventral; umbo prominent; beak incurved and extending a trifle over the cardinal border; surface of each valve marked by from fourteen to seventeen simple, narrow, radiating costae, having interspaces of similar width; costae sharply elevated, their backs, as well as the bottom of the interspaces, narrowly flattened; mesial fold and sinus wanting or obsolete.

Length of the largest examples, 12 mm.; breadth, 9 mm.; thickness, 8 mm.; but the average size is less.

This is another widely distributed Coal Measure species, and one that may be readily identified.

Genus Terebratula, Lhwyd.

Terebratula bovidens, Morton.

Plate 32, figs. 17, 18 and 19.


Shell ovate or elongate-ovate in marginal outline; sides, behind the middle, laterally compressed, where also the shell is narrower and its vertical diameter greater than it is forward of the middle; ventral valve strongly arcuate from beak to front, the curvature being greatest behind the middle, rather more capacious than the other valve; beak prominent, incurved, but not coming quite in contact with that of the dorsal valve; foramen moderately large, not squarely truncating the beak, but opening obliquely backward; mesial sinus broad, more or less distinct at the anterior part of the valve, but becoming obsolete at or a little behind the middle; dental plates extending but little, if any, in front of the teeth, placed so near the sides of the beak that the space between them and the sides of the shell is very narrow; dorsal valve generally almost straight along the median line from the front margin to a little behind the middle, from which part it gently curves to the beak; gently and somewhat uniformly convex from side to side, without a mesial fold, except that sometimes the front margin is slightly raised to conform to the shallow sinus of the other valve; character of the loop not fully known, but it reaches farther forward than the middle of the shell; surface nearly smooth; shell structure finely punctate.

This shell varies considerably in size and shape. One example in the collection of the U. S. National Museum measures 30 mm. in length. An average size is about 17 mm. long and 12 or 13 mm. broad. This species is more or less common in Coal Measure strata, and it is known to range from Ohio to Nevada.

Locality. It has been found at the following localities in Indiana: Perrysville, Eugene, Newport, Lodi, Terre Haute (west of), Posey, Warrick, Perry and Crawford counties.
FAUNA OF THE COAL MEASURES.

POLYZOA.

Genus Synocladia, King.

Synocladia biserialis, Swallow.

Plate 25, figs. 11, 12 and 13.


Polyzoary probably infundibuliform, but the specimens usually found consist only of spreading frond-like fragments; primary branches a little larger than the others, the latter increasing by divergence at various angles from the primary branches, also occasionally from each other, and rarely by starting upward from the middle of a dissepiment; dissepiments celluliferous, a little narrower than the branches, arching upward a little as they extend from branch to branch; fenestrules irregularly four-sided; upper side usually convex and the lower side sometimes concave; about nine of them may be measured in the length of a centimeter; measured upward, they are generally wider than the branches, but occasionally narrower, especially near the base of the polyzoary. Upon the poriferous side of the polyzoary the branches and dissepiments, especially the former, are each provided with an irregular mesial carina, consisting of small, elongate, confluent nodes, which are sometimes sharp and prominent. Cell-apertures moderately large, rounded, borders prominent; cells arranged in single, quite distinct lines, one on each side of the mesial carina of the branches, and generally each dissepiment bears a double row of similar cells. Upon some of the dissepiments the cells form only a single row at the middle, while upon others they are not only double, but another cell is added near the junction with the branch, giving three cells abreast at those points.

This form is one of the most common of the Fenestelloid Polyzoa that occur in Coal Measure strata.

Locality. It may be sought for in Indiana above the roof of coal K., and thence throughout Upper Coal Measures.

CONCHIFERA.

Genus Lima, Bruguiere.

Lima retifera, Shumard.

Plate 28, fig. 4.


Shell obliquely subovate; posterior side short; anterior side obliquely extended; the valves gently convex; cardinal border comparatively short; the basal border forming a nearly regular semi-circular curve; posterior margin regularly rounded; anterior margin somewhat narrowly
rounded below and sloping obliquely upward and backward to the cardinal border; ears small, distinct, nearly equal in size, the anterior one forming an obtuse angle and the posterior one a nearly right angle; beaks moderately prominent and projecting slightly beyond the cardinal margin, and situated near the mid-length of that margin; surface of each valve marked by about twenty-five angular radiating costae, with interspaces of similar width with the costae, all of which are crossed by numerous concentric, fine lamellations of growth.

Height, 15 mm.; length, 18 mm.

This is a somewhat rare shell, but it has a rather wide geographical range.

Locality. It may be sought for in the following Indiana localities: Knox, Gibson and Posey counties.

Genus Monopteria, Meek and Worthen.

Monopteria gibbosa, Meek and Worthen.

Plate 30, figs. 11 and 12.


Shell, exclusive of the wing and posterior prominence, irregularly suborbicular in marginal outline; the valves moderately convex or a little gibbous; the anterior and basal margins forming an almost regular semicircular curve; posterior portion of the shell produced, narrow and narrowly rounded, or subangular, at the extremity; wing slender, compressed and extending backward as far as the narrow posterior extremity, between which the posterior margin forms a deep, broad notch, that is narrowly rounded at the bottom; umbonal ridge moderately distinct; beaks equal, not placed so far forward as the front margin of the shell; anterior lunule deep; cardinal border not as long as the full diameter of the shell; surface marked only by the ordinary lines of growth.

Length, from posterior extremity to front, 27 mm.; height, from base to beaks, 23 mm.

Locality. This shell was originally described from Gallatin county, Illinois. It may be sought for in the following Indiana localities: Vermilion, Sullivan and Posey counties.
Genus Myalina, de Koninek.

Myalina subquadrata, Shumard.

Plate 29, figs. 1 and 2; and plate 30, figs. 1 and 2.


Shell large, oblong in marginal outline, the height being much greater than the antero-posterior diameter; right valve nearly flat or only slightly convex; the left valve more convex than the right; hinge line nearly straight, usually equal to the greatest width of the valves, at right angles with the vertical axis of the shell; basal margin regularly, and sometimes, but not usually, somewhat narrowly rounded; posterior margin nearly vertical or moderately convex, rounding to the base below and usually meeting the hinge line at nearly right angles, but sometimes at an obtuse angle; anterior margin rounded to the basal margin, vertical along the middle, then reaching the projecting beaks by a moderately broad, concave curve; cardinal area moderately broad, the narrow cardinal furrows well defined; beaks terminal and projecting prominently forward; surface marked only by concentric lines and a few laminations of growth, which are more distinct upon the left valve than upon the right.

Height, from base to cardinal margin of a full grown example, 94 mm.; transverse width of the same, 58 mm.

Locality. This large Myalina has quite a large distribution in the Coal Measures. It has been found at the following Indiana localities: Upper Coal Measures of Knox, Gibson and Posey counties.

Myalina recurvostris, Meek and Worthen.

Plate 29, figs. 3 and 4.


Shell moderately large, except as compared with M. subquadrata; obliquely subtrigonal in marginal outline; posterior side compressed; transversely flattened a little beneath the beaks; both valves moderately convex, the left valve being more so than the other; umbo of each valve gibbous and narrowly rounded along the axis; cardinal border straight or slightly convex; its length about equal to the height of the shell in young examples, but it is proportionally shorter in adult examples; posterior margin gently convex in outline, its general range being at nearly right angles with the cardinal border, rounding gradually to the narrowly rounded basal margin; anterior margin rounding to the base below, a little concave above, where it ranges at an angle of about 55° with the cardinal border; beaks terminal, pointed; that of the left valve twisted so as to have a partially backward direction, but the other is merely directed forward; surface of both valves marked by numerous concentric
lamellae of growth, which are most distinct upon the left valve, and more prominent upon the anterior part of the shell than elsewhere; ligament area narrow and traversed by a few longitudinal coarse striae; just beneath the beaks the anterior margin is thickened so as to present a kind of false area, a little broader than the cardinal area; between these two areas, in the left valve, there is an oblique groove and a corresponding prominence in the right valve; posterior muscular impression large and elongate-subovate, the narrower end being uppermost and located near the middle of the posterior side.

Height, on a vertical line, at right angles with the hinge, 45 mm.; greatest breadth, 40 mm.; convexity, 24 mm.

**Locality.** The original examples of this species were obtained from the Upper Coal Measures, near La Salle, Illinois, but they may be sought for anywhere in the Indiana Upper Coal Measures.

**MYALINA (? SWALLOVI, McChesney.**

*Plate 30, figs. 6, 7 and 8.*


Shell small, oblique, equivelar or nearly so; valves gibbous along their upper median portion, the general aspect of the shell being like that of a *Mediola;* anterior margin sinuous, so that an indistinct small lobe is formed in front of the beaks and the somewhat prominent umbonal ridge; hinge line equal to about one-half the entire length of the valves, straight, meeting the posterior margin without a perceptible angle; postero-basal margin narrowly rounded; cardinal area very narrow and marked by two or three indistinct longitudinal striae; surface marked by the ordinary concentric lines and a few imbrications of growth.

Extreme length of an average sized example, 28 mm.; greatest transverse breadth, 14 mm.; convexity, 10 mm.

This is a shell concerning which the real generic relations have been regarded as obscure by every author who has written of it. It seems to be worthy of at least a separate subgeneric designation, but none has hitherto been proposed for it.

**Locality.** It has a very wide distribution in the North American Carboniferous rocks, and in the States bordering the Mississippi it is regarded as characteristic of the Upper Coal Measures. It has been found at the following Indiana localities: Parke, Vermillion and Vigo counties, at the horizon of coal M.
Genus Entolium, Meek.

**Entolium aviculatum, Swallow.**

*Plate 28, figs. 7 and 8.*


*Entolium aviculatum,* Meek, 1872. *U. S. Geol. Surv. Nebraska,* p. 188, pl. IX, fig. 11.

Shell compressed lenticular, thin, equivalve, suborbicular in marginal outline, exclusive of the ears; height usually a trifle greater than the transverse width of the shell; the lateral margins, from the mid-height of the shell, regularly and continuously rounded with the basal margin; lateral margins above the mid-height, straight and converging toward the beaks; cardinal margin short, its length less than one-third the transverse diameter of the shell; ears small, flat and nearly equal, obtusely angular at the extremities, defined from the body of the valves by a distinct depression, but not by any auricular grooves; beaks small, compressed, equal, not projecting beyond the cardinal margin; each valve has two shallow, undefined impressions diverging from the beak nearly to the anterior and posterior margins respectively, that on the posterior side being the longer; surface apparently plain, but under a magnifier it is seen to be marked by very fine, close-set, concentric striae, and occasionally traces of fine radiating striæ.

Height, 24 mm.; breadth, 22 mm.

**Locality.** This species is found in both the Upper and Lower Coal Measures. Its known geographical range is from Indiana to Nebraska. It has been found at the following Indiana localities: Horizons of coals K., L. and M., in Fountain, Vermillion, Vigo, Pike, Dubois, Perry, and Spencer counties.

Genus Eumicrotis, Meek.

**Eumicrotis Hawni, Meek and Hayden.**

*Plate 30, fig. 10.*


Shell subovoid in marginal outline; obliquity, little or none; upper posterior margin nearly straight, sloping abruptly downward from the cardinal margin; anterior margin more or less regularly rounded below the ear; basal margin somewhat regularly rounded; cardinal not so long as the median transverse diameter of the shell; hinge area moderately broad; cartilage pit distinct, placed immediately below the beak in each valve; left valve moderately ventricose; umbo a little incurved and projecting a little above the cardinal margin; posterior ear narrow, obliquely truncated; anterior ear larger, its outer margin narrowly rounded; the
notch below it deep and subangular; surface marked by somewhat irregular undulating costae of unequal size; these are crossed by more or less distinct lamellae of growth, which are sometimes vaulted on the costae; right valve nearly flat; byssal sinus deep and narrow; surface more obscurely marked than that of the left valve.

Height, 34 mm.; breadth, 28 mm.

**Locality.** The original specimens were obtained in Kansas. It is also known in Illinois, and may be sought for in the Upper Coal Measures of Indiana.

*Genus Aviculopecten, McCoy.*

**Aviculopecten occidentalis, Shumard.**


Shell inequivalve; both ears well defined; cardinal border at nearly right angles with the axis of the shell and almost as long as its full antero-posterior diameter; marginal outline, exclusive of the ears, subovate; left valve more convex than the right; anterior ear about as long as the posterior one, more convex and a little more sharply defined, by the auricular furrow, from the body of the valve than the other ear, its extremity obtuse, and inferior border concave; its surface marked by distinct radiating costae, which are a little coarser than those upon the body of the valve at the same distance from the beak; posterior ear clearly defined from the body of the valve by a shallow auricular furrow, sharply angular at the outer extremity; outer margin concave, its surface marked by concentric lines, all radiate markings being obsolete; surface of the body of the valve marked by depressed, flattened, or very slightly convex, radiating costae, which gradually increase in size toward the free margins, and increase in number by implantation at different distances from the beak, only about a dozen of them reaching it; the implanted costae, beginning as mere strie between the others, are of unequal size on all parts of the valve; the costae are crossed by numerous distinct concentric strie; right valve flat or slightly convex; beak flattened, and not distinct, as such, at the cardinal border; costae similar in character to those of the other valve, but they are not nearly so distinct; outline corresponding with that of the left valve, except that the anterior ear is narrower, and defined by a deeper and sharply angular sinus.

Height, from base to cardinal border, 42 mm.; breadth, 37 mm.

This is one of the most common Conchifers of the Carboniferous rocks of the United States, from Indiana westward, and it has been found in Utah and Arizona. It ranges, also, from the Lower Coal Measures to the Upper, and, according to Meek, it passes up into the Permian strata in Kansas.

**Locality.** It has been found in Pike and Gibson counties, Indiana.
Shell rather less than medium size; its axis a little oblique with the cardinal border; moderately convex; the height and breadth nearly equal; cardinal border nearly or quite straight; its length not quite equal to the transverse diameter of the shell, bearing a marginal ridge in each valve; full margin, regularly and continuously rounded from a little below the mid-height of the shell on the posterior side to a little above it on the anterior side; above this rounded portion the sides of the body of the shell, exclusive of the ears, slope directly to the beak; left valve more convex than the other; the posterior ear well defined, somewhat extended and acutely pointed at the extremity, its outer and lower margin broadly concave; anterior ear about two-thirds as long as the other, more obtuse at the extremity but still angular, distinctly defined from the body of the valve by an auricular furrow, and divided below by a subangular sinus; right valve nearly flat or very gently convex, its anterior ear narrow, and beneath it there is a deep abrupt sinus; posterior ear similar in size and shape with that of the left valve; the left valve bears fifteen or sixteen angular radiating ribs which are separated by furrows of similar size with the ribs, each one terminating at the free border in a sharp, recurved spine; the surface is also marked by lines of growth, which are more distinctly observable upon the ears, which are not marked by distinct radiating features; besides the lines of growth, there are, at somewhat regular intervals, distinct concentric imbrications, which, having been once free borders, show digitations similar to those of the margin; the surface markings of the right valve are similar to those of the left, but much less distinct.

Height, from base to cardinal margin, 19 mm.; breadth about the same.

This is probably the same species that was described, but not figured, by Professor Swallow, from the Upper Coal Measures of Missouri, under the name of Pecten Broadheadi; and it is no doubt identical with the Pecten Havni of Geinitz, from Nebraska. Specimens of the same have also been found in New Mexico, by parties connected with the United States explorations and surveys west of the 100th meridian.

Locality. This species has been found at the following localities in Indiana: At Lick Branch, near Silverwood, Fountain county, and in Vermillion county.
AVICULOPECTEN (?) INTERLINEATUS, Meek and Worthen.

Plate 30, fig. 9.


Shell rather small, broadly subovate in outline exclusive of the ears; breadth nearly equal to the height, slightly oblique, or the axis almost at right angles with the cardinal border; hinge line about equal in length to the full breadth of the shell; ears prominent, posterior one more prominent than the other; anterior, basal, and posterior margins regularly and continuously rounded; beak depressed; umbonal slopes moderately distinct; left valve slightly convex or nearly flat; posterior ear a little larger, or nearly of the same size as the other, produced to a sharp angle at the cardinal extremity, its outer border sometimes straight and sometimes curved, and forming an obtuse retreating angle with the posterior margin of the shell; anterior ear triangular, flattened, its outer border slightly convex or nearly straight, and its extremity bluntly angular; surface marked by ten or twelve sharply raised, slender, concentric ridges, each one being of nearly uniform width throughout, but each successively a trifle stronger than the preceding one, separated, along the axis of the valve, by interspaces each of which are four or five times as wide as the adjacent concentric ridges; but the interspaces diminish in width toward the umbonal region, upon which the ridges are very near together; the latter then diverge, crossing the ears, and all end abruptly upon the cardinal margin; surface between the ridges marked by numerous fine, uniform, concentric striae, and also by faint indications of radiating costae.

Breadth, 17 mm.; height, from base to cardinal margin, 16 mm.

This interesting shell is somewhat rare, but it is known in the widely distant regions of Central Illinois and Northern Arizona.

Locality. It may be reasonably sought for in the Upper Coal Measures of Indiana.

Genus PINNA, Linnaeus.

PINNA PERACUTA, Shumard.

Plate 28, figs. 1 and 2.


Shell long and slender, tapering regularly from the larger to the smaller extremity; the valves so convex that the shell is subcylindrical, except toward the larger end where it is more flattened; hinge margin straight; the dorsal edges of the valves suddenly erected so as to give the hinge margin a carinated appearance; ventral margin straight like the dorsal, with which it forms an angle of about 12°; posterior margin rounded broadly and obliquely upward and backward to the dorsal margin; surface plain, marked only by obscure concentric lines of growth.
This species is remarkable for its long and slender form. The full length of the largest examples could not have been less than 250 mm.

**Locality.** It is known in both the Upper and Lower Coal Measures, from Indiana to Nebraska. It has been found in the Upper, Middle and Lower Coal Measures of Indiana.

**Genus Nuculana, Link.**

*Nuculana bellistriata, Stevens.*

*Plate 31, figs. 8 and 9.*


Shell transversely elongate-subovate, gibbous anteriorly and attenuate behind; basal margin broadly convex, straightened in the middle; anterior margin narrowly rounded; posterior margin very narrow; postero-dorsal margin nearly straight, sloping backward and a little downward from behind the beaks; umbonal ridges well defined, situated near to the postero-dorsal margin, their outline, as seen from above, forming an elongate ellipse which has a concave surface on each side of the median ridge, which is formed by the up-flexed margins of the valves there; umbones prominent; beaks incurved, situated about two-fifths of the full length of the shell from its front; surface marked by fine, regular, concentric, raised striae, which are obsolete upon the umbonal ridges and the space which they enclose.

Length of a large example, 27 mm.; height, 12 mm.; convexity, 9 mm. A large majority of the examples are considerably smaller than this.

**Locality.** This species has been found at the following localities: Horizon of coal M., in Vermillion, Sullivan, Vanderburg, and Warrick counties.

**Genus Nucula, Lamarck.**

*Nucula ventricosa, Hall.*

*Plate 27, figs. 9 and 10.*

*Nucula ventricosa, Hall, 1858. Geol. of Iowa, Part II, p. 716, pl. 29, fig. 5.*


Shell small, subovate in marginal outline; valves ventricose, the greatest convexity being a little forward of the middle; posterior end short, obliquely truncated from the beaks to the narrowly rounded posterior margin; basal margin broadly rounded; front margin narrowly rounded; dorsal margin sloping downward with a gentle convex curve to the front margin; beaks well defined, incurved; a more or less distinct dorsal con-
cavity behind them; the general surface having a smooth appearance, but concentric strie are generally observable toward the basal margin.

**Locality.** Coal Measure strata, Sullivan county, Indiana, and generally at roof of coal M.

**Genus Schizodus, King.**

**Schizodus Wheeleri, Swallow.**


Shell of moderate size, irregularly subtriangular or subovate in marginal outline; posterior portion laterally compressed; anterior portion inflated; umbones elevated; beaks incurved, situated at about one-quarter of the full length of the shell from the anterior extremity; margins of the front and the anterior part of the base forming a continuous and regular curve; basal margin sloping upward and meeting the downward and backward slope of the posterior margin at a prominent angle, which is abruptly rounded at the extremity; dorsal margin straight, sloping a little downward from the beaks to the obliquely truncated posterior margin; posterior umbonal slope prominent, sometimes forming a rather distinct ridge, which ends at the prominent angle of the posterior margin and considerably increases its projection; surface marked only by the ordinary lines of growth.

Length of an ordinary sized example, from the front margin to the posterior angle, 31 mm.; height, from base to umbones, 22 mm.

This is a widely distributed Coal Measure species, it being known to range from Indiana to Nebraska and New Mexico. It is usually found in the condition of casts of the interior of the shell, which give no surface features, but in such cases it is recognizable with little difficulty by its shape.

**Locality.** It may be reasonably sought for in the Upper Coal Measures of Indiana.

**Genus Clinopistha, Meek and Worthen.**

**Clinopistha radiata, Hall.**

*Edmondia radiata, Hall, 1858. Geology of Iowa, part II, p. 716, pl. XXIX, fig 3.*  
*Clinopistha Radiata, M. & W., 1873. Illinois Geol. Reports, V, p. 584, pl. XXVII, fig. 7.*

Shell irregularly oblong or suboval in marginal outline, the anterior side being somewhat deeper than the posterior; the valves moderately convex when young, but the shell becomes ventricose with age; beaks obtuse, moderately prominent, situated very near the posterior end of the
shell; anterior margin regularly rounded; posterior margin short, vertically truncated; basal margin straightened or slightly emarginate; dorsal margin nearly straight and rounded down to the front margin; ligament short, suboval, and situated immediately behind the beaks; surface having a polished aspect, but it shows fine concentric lines of growth and obscure, fine, radiating lines.

Length, 25 mm.; height, 16 mm.; convexity, 10 mm.

Locality. Upper Coal Measures of Indiana.

Genus Edmondia, de Koninck.

Edmondia Aspinwallensis, Meek.

Plate 31, figs. 4 and 5.

Edmondia Aspinwallensis, Meek, 1872. U.S. Geol. Survey Nebraska, p. 216, pl. IV, fig. 2.

Shell transversely subovate in marginal outline; valves having considerable convexity, the greatest being in front of, and a little above the middle; basal margin broadly convex; posterior margin somewhat narrowly rounded or sometimes faintly subtruncate; dorsal margin sloping a little downward with a slight convexity; anterior dorsal margin short, and declining abruptly to the narrowly rounded front margin; beaks not prominent, incurved, situated near the anterior end of the shell; surface marked by distinct lines and undulations of growth.

Length, 37 mm.; height, 27 mm.; diameter, 18 mm.

Locality. This species is known to range from West Virginia to Nebraska. It may be sought for in the Upper and Middle Coal Measures of Indiana.

Genus Allorisma, King.

Allorisma subcuneatus, Meek and Hayden.

Plate 31, figs. 1, 2 and 3.


Shell reaching a large size, transversely elongate, being two or more times as long as high, gibbous anteriorly, compressed posteriorly, where the valves are a little gaping; basal and dorsal margins sub-parallel, the latter very broadly convex; posterior margin narrowly rounded; front margin still more narrowly rounded below, but above it slopes abruptly upward and backward toward the beaks; dorsal margin slightly concave or nearly straight, and rounded to the posterior border; surface marked by concentric lines and distinct undulations of growth.
Length, 103 mm.; height, from base to cardinal margin, 41 mm. Many examples are somewhat smaller than this, but, occasionally, an example is found that is considerably larger.

This large fine shell has a very wide geographical range, it being known from Indiana to Utah and New Mexico. Throughout this wide range it retains all its essential characteristics so completely that it is readily recognizable.

**Locality.** It has been found throughout the Coal Measures of Indiana.

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**GASTEROPODA.**

**The Genera Macrobeilus and Soleniscus.**

No more confusion probably exists in relation to any group of fossil shells than is to be found among those which have been referred to the genus *Macrobeilus*, from North American Devonian and Carboniferous strata. Not only have shells of doubtful and diverse character been referred to that genus by different authors, but much uncertainty also exists as to the specific identity of the forms to which various specific names have been given. The causes of this uncertainty are various. First, several of the species which have been proposed have never been figured, the type specimens are inaccessible, and the descriptions alone are insufficient to permit a satisfactory discrimination of those species among the closely related forms. Second, the range of variation among all the recognizable species is so great that with numerous specimens in hand it is often difficult to decide upon definite specific limits. Third, dissimilar groups of species have been placed together under *Macrobeilus*.

Among the somewhat numerous North American Devonian and Carboniferous species, especially the latter, that have been referred to the genus *Macrobeilus* of Phillips, are certain forms which plainly do not answer the description of that genus as it was originally given, or as its characteristics have usually been stated by authors. The differences between these species and those which I regard as true *Macrobeilus* pertain mainly to the columella and inner lip; but they also possess a more massive test. Some of the American species which have been referred to *Macrobeilus* have a plain, more or less sinuous, inner lip, which is only slightly covered with callus and destitute of any trace of ridges or folds. These, I assume to be typical forms of that genus, and the following, among others, may be mentioned as examples: *Macrobeilus Hebe* and *M. Hamiltono*, Hall, of the Devonian; and *M. anguliferus*, White, of the Carboniferous. My present belief is that all the Devonian forms that have been referred to *Macrobeilus* will fall into this group, but that it will properly include only a very small part of those which have been referred to that genus from Carboniferous strata. With the very few
exceptions referred to, I think all the numerous North American Carboniferous forms which various authors have referred to *Macrocheilus* constitute a distinct natural group which ought to be designated by one, and a different, generic name. I, also, think the form for which Meek and Worthen proposed the generic name of *Soleniscus* ought to be included in this group.

The shells of the group in question are characterized by a more or less thickened inner lip, which also bears one more or less distinct revolving fold. This fold, when the outer lip is entire, is usually visible only as an obtuse prominence near the anterior end of the inner lip; but upon breaking away the outer lip the fold is usually found to be distinct, and often sharp and prominent. Sometimes, also, there is, upon the posterior side of the fold, a broad concave depression which ends at, and deepens, the inward flexure of the inner lip, the posterior border of which depression is sometimes so well defined as to appear like a second revolving fold. This depression is excavated out of the callus which covers the columella and inner lip quite thickly, in such cases, between the depression and the posterior angle of the aperture. Forward of the fold there is little, and sometimes no, accumulation of callus, the anterior end of the outer lip, where it joins the inner lip, being usually thin and more or less prominent when entire. There is, therefore, in unbroken shells, a rather broad, short, more or less distinct, anterior canal, too broad and short to really deserve the name of canal, strongly recalling the corresponding part of *Nassa*. The anterior border of this short canal, however, is prominent, and not emarginate as in *Nassa*.

From the fact that the columellar fold upon these Carboniferous shells is distinct only within the aperture, and that the latter is usually filled with the imbedding matrix, this distinguishing feature seems to have generally escaped the notice of authors. It has not always done so, however, both those eminent paleontologists, Professors Hall* and Geinitz,† having referred to it in published descriptions. Meek and Worthen also observed that the inner lip is “usually provided with an obtuse revolving fold,” but none of these authors appear to have regarded that feature as separating such shells generically from those which are destitute of it. Mr. Conrad, however, so early as 1842, proposed the generic name of *Plectostylus* to include shells possessing this character; but that name was previously used by Beck for an entirely different group of mollusks. Mr. S. A. Miller, also, in his Catalogue of American Paleozoic Fossils, refers the *Macrocheilus Hallii* of Geinitz to *Soleniscus*, Meek and Worthen. In 1881, I described‡ two species of this group from the Carboniferous rocks of New Mexico, and also referred them to *Soleniscus*.

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*Geology of Iowa, 1858, Part II, pages 719 and 720.
†Carbonformation und Dyas, in Nebraska, 1866, page 6.
‡Expl. and Sur. West of the 100th Merid. Supp. to vol. III, pp. 28 and 29, pl. IV, figs. 4 and 5.*
Notwithstanding the conscientious accuracy which is apparent in all the work of those authors, I suspected that the anterior portion of their type species is not so prominent as it is represented to be by the restored part of their figures. Applying to Mr. Worthen for permission to examine the type specimen, I learned that it was inaccessible, but he sent me, for examination, an authentic duplicate example. A careful examination of this specimen satisfies me that the anterior portion of the shell in this species is really only a little more prominent than it is in several of those forms which have been referred to *Macrocheilus*, and that that portion is not produced into a proper beak. Meek and Worthen's figures show that the anterior portion of their type-specimen was broken off; and if the line of the restored part had been continued with the curve of the outer lip, or the longitudinal convexity of the volution, it would agree with the lines of growth which are observable upon the specimens sent me by Mr. Worthen. Moreover, their figure shows a prominence of the fold upon the inner lip which did not appear on the one just referred to, until I had dug deeply into the stony material which had filled the aperture. Their figure also appears to represent the outer lip as entire; but to exhibit the columellar fold so prominently as it appears in that figure, the outer lip must have been largely removed. So removing the outer lip, and not its anterior part, would leave the latter having somewhat the appearance of a beak.

Understanding the real characters of the type species of *Soleniscus* to be such as I have here indicated, it is, I think, necessary to regard the form to which they applied that name as congeneric with the greater part, if not all, the forms which are figured with it on plate 34, and with most of those Carboniferous shells which have been by different authors referred to *Macrocheilus*. According to my observations, the principal differences which that species presents from the others referred to, are its more than usually elongate form, a little greater than the usual prominence of the anterior part of the aperture, and a smaller accumulation of callus upon the inner lip.

These forms, as before remarked, are regarded as constituting a natural group which, it appears to me, well deserve a generic designation distinct from *Macrocheilus*. If it were not that Conrad's name *Plectostylus* was preoccupied by Beck, that name could be appropriately retained for this group, to which it was really applied. Conrad's name not being available, the next generic name that has been used for any member of the group ought to be used for the whole group. As *Soleniscus* is regarded as a member of this group, that name ought to be used for it, because no other available name has priority over it.

The following species, which have hitherto been referred to *Macrocheilus*, have been found to possess the prominent columellar fold and other characteristics of the group here discussed, and I would, therefore, refer them
all to Soleniscus; Macrocheilus fusiformis, Hall, M. Newberryi, Hall, M. planus, White, M. ventricosus, Hall, Soleniscus brevis, White, M. Texanus, Shumard?, M. paludinaformis, Hall, and M. Halli, Geinitz. All except the last are figured on plate 34.

It is not to be denied that there are certain forms among those Carboniferous species, which have usually been referred to Macrocheilus, that possess, at best, only an obtuse fold upon the columella. They are, however, much more closely related, by all their characteristics, to the species just referred to Soleniscus, than are those Devonian and other species which I have referred to Macrocheilus proper. Among these species are the three following, which are represented, with the others, on plate 34: Macrocheilus ponderosus, Swallow?, M. medialis, Meek and Worthen, and M. primigenius, Conrad. These, I regard as, at most, no more than subgenerically different from those which I have referred to Soleniscus.

Genus Soleniscus, Meek and Worthen.

Soleniscus typicus, Meek and Worthen.

Plate 34, figs. 18 and 19.


Shell fusiform; spire produced, conical, acute at the apex; volutions, seven or more, gently convex, the last one constituting at least three-quarters of the full length of the shell, moderately ventricose about the middle and tapering a little toward the front; aperture comparatively narrow, acute posteriorly, narrowed at the front, outer lip thin and sharp; suture slightly impressed; fold of the columella nearer to the front end of the aperture than to the posterior end, inconspicuous when the outer lip is entire, but prominent within the aperture; surface plain, showing only the usual fine lines of growth.

Length, about 18 mm.; diameter of the last volution, 9 mm.; apical angle, the sides being slightly concave, about 40°.

This appears to be a rather rare species, and has hitherto been found only in the Upper Coal Measure rocks, in the vicinity of Springfield, Illinois; but it is likely to be found in the corresponding rocks in Indiana.

This species was made the type of the genus Soleniscus, by Meek and Worthen, but, as I have already shown, a large proportion of the shells that have been referred to the genus Macrocheilus possess essentially the same generic characters.
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Soleniscus (Macrocheilus) Newberryi, Stevens.

Plate 34, fies. 7 and 8.

Macrocheilus Newberryi, Hall, 1858. Geology of Iowa, Part 2, pl. 719, p. XXIX, fig. 9.

Shell fusiform; spire produced; its sides convex, apex acute; volutions seven or more, the last one moderately ventricose and constituting more than half the full length of the shell; those of the spire moderately convex; suture distinct, but not very deeply impressed; aperture comparatively narrow; outer lip thin, but the remainder of the test comparatively thick; inner lip thickened by callus; collumella appearing flexuous, and with an obtuse fold anteriorly, when the outer lip is entire, but when the latter is much broken away that fold is found to be angular and prominent, with a deep, broad, concave groove behind it; the posterior side of that groove being abruptly rounded has much the appearance of a second revolving fold; in front of the fold, and between it and the front border of the aperture, there is a narrow concave space or a short broad canal; surface marked by the ordinary fine lines of growth, but it has, in well preserved examples, an almost polished aspect.

Length, 26 mm.; breadth of the last volution, 12 mm.

Locality. Danville, Illinois; but it may be looked for at the horizons of coals M. and N., in Indiana.

Soleniscus planus, White.

Plate 34, fies. 9 and 10.

Soleniscus planus, White, 1831. Expl. and Sur. west of the 100th Merid., Sup. to Vol. III, p. XXIX, pl. IV, fig. 4.

Shell subfusiform; spire nearly one-half the full length of the shell; its side gently convex; apex acute; volutions eight or more; those of the spire gently convex; the last one large, but not much ventricose; suture distinct but not deep; test moderately thick; fold of the columella well developed and placed a little forward of the mid-length of the aperture; the spiral groove behind it broad, concave, and well defined; the callus of the inner lip thick, especially behind the groove; outer lip thin, its margin sharp; surface marked only by the usual lines of growth.

Length, 27 mm.; greatest diameter, 9 mm.

This form was described by me from the Carboniferous rocks of New Mexico (loc. cit.). I am now inclined to regard it as identical with the Macrocheilus Newberryi of Hall, but still it presents such variations that, for the present, I retain it under the name I have applied. At the time I described it, I was not aware that the M. Newberryi possessed the distinct columellar fold that I have now shown it to possess, as well as S.
Considering the evident wide specific variation of these forms, it seems not improbable that, with full collections in hand, it will be difficult to clearly define the specific boundaries between S. Newberryi, S. planus, and S. fusiformis; all three of which are here separately described.

**Locality.** The form figured on plate 34 was obtained from near Danville, Illinois; but it may be sought for in Indiana at the horizons of the roof of coals M. and N., and in the Upper Coal Measures.

*Soleniscus (Macrocheilus) fusiformis, Hall.*

*Plate 34, figs. 4, 5 and 6.*

Macrocheilus fusiformis, Hall, 1858. Geology of Iowa, part II, p. 718, pl. XXIX, fig. 7.

Shell elongate-subfusiform; spire more than half the full length of the shell; its sides nearly straight or slightly convex; volutions about ten in number, those of the spire gently convex, the last one large and moderately ventricose; suture shallow; test moderately thick, but the outer lip is thin and sharp when entire; inner lip covered with a strong callus; columellar fold distinct within the aperture, its outer portion obtuse; groove behind the fold broad and deeply concave, with its posterior margin obtuse, but distinctly defined; surface marked only by the ordinary lines of growth.

Length, about 40 mm.; diameter of the last volution, 15 mm.

The specimen here described differ somewhat from the description and figure given by Prof. Hall, but the differences are assumed to be of a varietal character only. As already remarked, however, this form is closely similar to the two forms herein just described.

**Locality.** Prof. Hall's type specimen is from the Coal Measures of Iowa. The forms here described are from Illinois. The species may be sought for in the Upper Coal Measures of Indiana.

*Soleniscus (Macrocheilus) paludineiformis, Hall.*

*Plate 34, fig. 17.*

Macrocheilus paludineiformis, Hall, 1858. Geol. Iowa, part II, p. 719, pl. XXIX, fig. 10.

Shell short subfusiform; spire prominent, but it constitutes somewhat less than half the full length of the shell; its sides gently concave; its apex small, acute; volutions eight or more in number, those of the spire gently convex, the last one ventricose; suture slightly impressed; test comparatively thin for a shell of this group, but there is a thick accumulation of callus upon the inner lip; columellar fold distinct; the groove behind it broad, concave and deep, as seen after a portion of the last volution is removed; surface marked by the ordinary lines of growth.

Length, about 26 mm.; diameter, 15 mm.
I have no doubt that the specimen upon which the foregoing description is based is specifically identical with the *Macrocheilus paludinosformis* of Hall. It is possible, also, as Prof. Hall remarks, that it was upon a cast of this species that Conrad proposed the genus *Plectostylus*, but his specimen being only a cast of the interior, its specific identity can not be fully known.

**Locality.** The specimen here described is from the Coal Measures of Vermillion county, Indiana. The species is also known to exist in the corresponding strata of Illinois and Iowa.

*Soleniscus (Macrocheilus) ventricosus*, *Hall*.

*Plate 34, figs. 11 and 12.*


Shell subglobose; spire very short, apex small and prominent; volutions about eight in number, those of the spire moderately convex, the last one ventricose; test moderately thick; suture distinct, but not deep; fold of the columella prominent, especially within the aperture, situated a little in advance of the mid-length of the aperture; a distinct, rather broad, deep concavity or revolving furrow at the distal side of the fold; callus of the inner lip moderately thick and broad; surface marked only by the usual lines of growth.

Length 17 mm.; diameter of the last volution, 11 mm.

This is a widely distributed species, and a somewhat variable one, especially in the prominence of the spire; but its small size and globose form render its identification an easy matter. I failed in identifying it with the New Mexican form (*loc. cit.*), because I did not then know that the authentic forms possessed the distinct columella fold that they are now known to have.

**Locality.** Specimens of this species have been found in Illinois, Iowa, and New Mexico. They may be sought for, in Indiana, at the horizon of coal M. and in the Upper Coal Measures.

*Soleniscus (Macrocheilus) Texanus*, *Shumard (?)*.

*Plate 34, figs. 13 and 14.*


The form figured on plate 34, is doubtfully identified with the *Macrocheilus Texanus* of Shumard. I am not satisfied that this is not a large variety of *S. (M.) ventricosus*, but for the present I prefer to regard it as distinct. It is somewhat more globose than *S. (M.) ventricosus*, and the spire is proportionally less prominent than it usually is in that species.
Shumard's type was found in Texas, and the specimen here figured was obtained from the Coal Measure strata at Danville, Illinois. It is likely to be found in the Upper Coal Measures of Indiana.

Soleniscus? (Macrochromeilus) medialis, Meek and Worthen.

Plate 34, figs. 15 and 16.

Macrochromeilus medialis, M. and W., 1866. Illinois Geol. Reports, II, p. 370, pl. 31, fig. 5 a and 5 b.

Shell subovate; spire depressed-conical, its sides a little convex, but the apex is small and acute when entire; volutions six or more in number, those of the spire convex, increasing rapidly in size, the last one large, moderately ventricose; suture distinct, but not deep; outer lip thin and sharp at the margin, when unbroken; inner lip covered with callus, and having a moderately deep sinus at the middle, forward of which there is a tendency to form an obtuse fold; but it is not yet known to be continuous within the aperture with a sharp fold, such as all the species possess which have just been herein described; surface plain.

Length, 22 mm.; diameter of the last volition, 17 mm.

Locality. Meek and Worthen's examples were obtained from near Springfield, Illinois. The example figured on plate 34, is from Vermillion county, Indiana.

Soleniscus? (Macrochromeilus) ponderosus, Swallow?

Plate 34, figs. 1 and 2.


The example figured on plate 34 is from the Upper Coal Measures of Iowa, and is given here for comparison, in connection with the discussion of the shells just described. It has not yet been found in Indiana, but there is no apparent reason why it may not be found in the rocks of this State.

This shell, like the last described, is not known to possess a sharply raised fold within the aperture, but it has the deeply sinuous inner lip, and a broad obtuse thickening of the columella below it; in short, it has all the general characteristics of the more globose of the forms that have been referred to Macrochromeilus, except, perhaps, a sharply raised columellar fold.
Soleniscus? (Macrocheilus) primigenius, Conrad.

Plate 34, fig. 3.


Macrocheilus primigenius, Hall, 1858. Geology of Iowa Part II, p. 720, pl. 29, fig. 11.

This shell is a somewhat common one in the Coal Measure rocks of Ohio, Indiana, Illinois, and Iowa. In form it resembles the M. ponderosus of Swallow, as it has just been identified, but it is regarded as specifically distinct. It differs still more widely from the Soleniscus type than either of the two forms that have just been noticed under the respective specific names medialis and ponderosus. There seems to be nothing upon the columella that is suggestive of a fold, although just behind the place at which such a fold should appear there is a distinct concavity which passes around the columella within the aperture. The test is thick, and there is a considerable accumulation of callus upon the inner lip, and the general characteristics of the shell are like those of the species that have already been noticed.

Genus Bellerophon, Montfort.

Bellerophon crassus, Meek and Worthen.

Plate 33, figs. 1 and 2.


Shell large, massive, subglobose; volutions gradually expanding laterally, broadly rounded upon the back, more abruptly rounded at the sides and into the umbilici, which are rather small; outline of aperture reniform, the transverse diameter being the greater; posterolateral portions of the lip thickened and spread outward and backward over the inner volutions, and also partly over the umbilici; anterolateral portions of the lip thinner than the others, their margins slightly convex on each side of the mesial notch; mesial band narrow; mesial notch distinct, but not deep; surface marked by distinct lines of growth, a part of which assume the character of somewhat irregular transverse wrinkles.

Diameter in the plane of the coil, 58 mm.; transverse diameter of the aperture, 50 mm.

Locality. This species is known to exist in both the Lower and Upper Coal Measures, and to range from Indiana to Nevada. It has been found in Sullivan and Posey counties, Indiana; but, there, only in the Upper Coal Measures.
Bellerophon percarinatus, Conrad.

Plate 33, figs. 9, 10, 11, 12, 13 and 14.

Shell subglobose; laterally expanded at the front; umbilici closed; outer lip thin at the front, thickened by callus at the sides; inner lip thickened by callus, which is sometimes in the form of a broad, prominent lobe, sometimes trilobed, and sometimes presenting only one narrow lobe, and that at the median line; the last volvation is always marked by one strong, rugose or nodose median carina, which extends from the inner lip to the front margin; in most cases there is a more or less distinct revolving ridge at each side of the median carina, and of equal extent with it; the whole surface is also marked by strong transverse wrinkles and lines of growth, but sometimes the lateral ridges are wanting.

Length, 24 mm.; breadth, the same.

This is one of the more common of the shells of the Coal Measure rocks.

Locality. It has been discovered from coal M. throughout the Upper Coal Measures.

Bellerophon carbonarius, Cox.

Plate 33, figs. 6, 7 and 8.

Shell subglobose; dorsal side broadly rounded; umbilici very small, shallow; aperture arcuate, much wider transversely than in the plane of the coil; its border not expanding more rapidly than the uniform rate of increase in the size of the volutions; inner lip not developed as such, the accumulation of callus there being often imperceptible; outer lip thin along the median portion but thickened a little and having a rounded edge toward the umbilici; median sinus not deep, rounded at bottom; median band obscure upon the costate portion of the shell, but moderately distinct upon the outer, plain portion, where it is bounded upon either side by a more or less distinct raised line; the outer third, or more, of the last volvation is plain, but the remainder is marked by from twenty to twenty-eight simple, distinct, narrow, revolving, raised ridges or costae; the two or three nearest the umbilici are, near the plain portion, sometimes broken up into small, irregular nodes.

Diameter of the coil and transverse diameter nearly equal, each being about 17 mm. in the type specimen of Cox, which is figured on plate 33.

Formerly, authors generally referred this shell to the B. Urii of Fleming, and it is even now doubtful if we are justified in separating it fully
from that species. There are, in different parts of the wide range which this species has, several noticeable varieties, the differences being as to size and character of surface markings. One of these varieties, found in the Rocky Mountain region, I have thought of sufficient importance for separate specific designation as *B. subpapillosus*. The typical forms, however, have a range from West Virginia to Nebraska.

**Locality.** This species may be sought for throughout the Coal Measures of Indiana.

**Bellerophon nodocarinatus, Hall.**

*Plate 33, figs. 3, 4 and 5.*

*Bellerophon nodocarinatus, Hall, 1858. Geology of Iowa, part II, p. 723, pl. XXIX, fig. 15, a, b, c.*

Shell subglobose; somewhat expanded at the sides; umbilici closed; the smaller part of the last volution somewhat regularly rounded transversely, but upon the outer half of it there is a broad subnodose median carina, with a narrow, shallow furrow along its middle, and upon each side of the carina there is a broad, shallow depression; the inner half of the outer volution is marked by coarse, revolving, raised lines; outer lip thin; little or no callus upon the inner lip, sides of the aperture near the umbilici having thickened and rounded edges.

Diameter in the plane of the coil, 40 mm.; greatest transverse diameter, 37 mm.

This form is referred with doubt to the *B. nodocarinatus* of Hall, but it seems to present some important differences. It is also closely related to the form which I described from New Mexico under the name of *B. inspeciosus*. The latter shell is more expanded at the outer, and narrower at the inner, part of the last volution than the form here described; the carina is also not so well defined, nor is it nodose. It is probable, however, that both *B. inspeciosus* and the form here described will prove to be only varieties of *B. nodocarinatus*.

**Locality.** The form here described is from New Harmony, Indiana.

**Genus Platyceras, Conrad.**

**Platyceras Nebrascense, Meek.**

*Plate 32, figs. 15 and 16.*

*Platyceras Nebrascensis, Meek, 1872. U. S. Geol. Sur. Nebraska, p. 227, pl. IV, fig. 15, a, b.*

Shell small, elongate-conical, more or less curved, or sometimes sub-spiral; apex free, bluntly pointed, more or less curved towards the body of the shell and turned toward its dextral side; aperture irregularly oval; its margin thin, broadly sinuous behind and to the left of the apex.
the remainder of the border usually having several other more or less distinct sinuosities; surface marked by more or less distinct lines of growth, which are parallel with the sinuosities of the border.

Length, 20 mm.; breadth of aperture, 12 mm.

This species was originally described from the Upper Coal Measures of Nebraska, but it has been found to range from Indiana to New Mexico.

Locality. It has been found at the following Indiana localities: Eugene, Edwardsport, and New Harmony.

Genus Pleurotomaria, Defrance.

Pleurotomaria Turbiniformis, Meek and Worthen.

Plate 32, figs. 7 and 8.

Pleurotomaria Turbiniformis, Meek and Worthen, 1866. Illinois Geol. Reports, II, p. 359, pl. XXVIII, fig. 8, a, b, c.

Shell subpyramidal; spire moderately elevated; volutions five or more in number, flattened at the outer side, so as to produce nearly, straight sides to the spire, the last volution prominently angular at the periphery, and broadly convex below; umbilicus small and bordered by an obscure ridge; spiral band situated at the peripheral angle of the volutions, very narrow, and bordered by slender elevated lines; surface of each volution marked by about twenty obscure, close-set, revolving striae, which are crossed by stronger and more regular obliquely transverse lines; these lines curve backward near the spiral band.

Length and breadth, each, about 25 mm.


Pleurotomaria Tabulata, Hall.

Plate 32, figs. 4 and 5.

Pleurotomaria Tabulata, Hall. Geology of Iowa, Part II, p. 721, pl. XXIX, figs. 12, a, b.

Shell unusually elongate for a species of this genus; volutions eight or more in number, prominently angular, the angle situated at about the middle of the volution, and bearing a finely nodulated carina; umbilicus closed; columellar lip a little thickened; suture distinct; surface marked by numerous revolving raised lines which are a little coarser upon the anterior side of the last volution than elsewhere; these are crossed by lines of growth, which give the revolving stria a more or less crenulated appearance; the striae of growth bend abruptly backward to meet the peripheral angle, showing that the outer lip was notched at that point.

Length, 52 mm.; breadth of the last volution, 44 mm.
This species is known to exist in the Coal Measure strata from Indiana to Iowa. It was described and figured in the Indiana report for 1880, but it is reproduced here to bring all the Coal Measure shells together.

**Locality.** Upper Coal Measure strata, Rush Creek, Posey county; Wagon-defeat Creek, Sullivan county, and Warrick county, Indiana.

**Pleurotomaria sphærilulata, Conrad.**

*Plate 32, figs. 1, 2 and 3.*


Shell depressed, subturbinate; spire moderately extended, its sides straight or gently convex; apical portion truncated; volutions five or six in number, their outer surface flat, and bearing a tuberculated ridge at the distal border, adjacent to the suture; the last volution large, narrowly rounded or subangular at the periphery; its anterior side broadly convex; umbilicus closed; spiral band situated at the periphery, narrow and indistinct; surface marked by lines of growth which, on both sides of the spiral band, bend back to meet it, showing that the outer lip had there a broad and deep notch.

Length of a large example, 22 mm.; breadth of the last volution, 29 mm.

This is a somewhat variable shell, and also a widely distributed one. It has been found at various localities in the Carboniferous rocks, from Pennsylvania to Utah.

**Locality.** Horizon of coal K., and throughout Upper Coal Measures.

**Genus Euomphalus, Sowerby.**

**Euomphalus rugosus, Hall.**

*Plate 32, figs. 11 and 12.*

*Euomphalus rugosus, Hall, 1858. Geology of Iowa, Part II, p. 722, pl. XXIX, fig. 14.*

Shell small, discoid; upper side concave; lower side flat or gently concave; volutions four or more in number, in contact but not embracing, the whole breadth of each being exposed both at the upper and under sides of the shell; obliquely flattened at the periphery, and bearing a narrow prominent ridge at the angle formed by the outer and upper sides; and another similar ridge at the junction of the outer and under sides, the latter being directed outward, and the former upward; aperture subcircular, and not conforming in outline to the two angles mentioned; surface marked by strong lines and wrinkles of growth, which give a

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rough appearance to the shell, and especially to the two ridges as they cross them.

Diameter of the coil from 12 to 20 mm.

This, a very widely distributed and characteristic species of the Coal Measure strata, may be found from the lowest to the highest coals, culminating in the Upper Coal Measures.

Genus **Naticopsis**, McCoy.

**Naticopsis nana**, Meek and Worthen.

*Plate 36, figs. 6 and 7.*


Shell small, subglobose, wider than high; spire much depressed; volutions about three in number, the last one large, and somewhat ventricose; suture well defined; aperture broadly subovate, somewhat straightened at the inner side, its length nearly equal to seven-eighths of the full axial length of the shell; outer lip thin; inner lip moderately thickened; surface marked by fine lines of growth, which are a little stronger and more uniform on the distal side of the volutions, near the suture, than elsewhere.

Length, 5 mm.; breadth, 4 3/4 mm.

This little species is known in the Carboniferous strata from Indiana to Nevada.

*Locality.* In Upper and Middle Coal Measures.

**Naticopsis Wheeleri**, Swallow.

*Plate 32, figs. 13 and 14.*


Shell rather small, obliquely subrhomboidal in outline when laterally viewed; volutions four or more, the last one moderately gibbous and composing more than two-thirds the entire length of the shell; aperture subovate; test moderately thick; surface covered thickly with small, prominent tubercles, which, on the small volutions of the spire, are minute, but they increase in size with the growth of the shell; outer lip moderately thin; inner lip somewhat thickened with callus.

Length of a large example, 16 mm.; breadth of the last volution, 14 mm.

This species is a well marked one; and it has also a wide geographical distribution. It is known in the Coal Measure strata from Indiana to New Mexico.

*Locality.* Swallow's type specimens were obtained from the Coal
Measure strata of Missouri, and Meek and Worthen described and figured it from Illinois. It may be found in Upper Coal Measures of the western part of Vigo county.

**Genus Polyphelemopsis, Portlock.**

**Polyphelemopsis peracuta, Meek and Worthen.**

*Plate 32, figs. 9 and 10.*

*Polyphelemopsis peracuta, M. and W. Illinois Geol. Reports, II, p. 375, pl. XXXI, fig. 7, a, b.*

Shell slender; spire long, attenuated, its sides gently concave; apex small and acute; volutions, twelve or more in number, flattened or very slightly convex at the outer side, the last one large and constituting about one-half the entire length of the shell, extended and somewhat contracted anteriorly; suture slightly impressed, but distinct; aperture narrowly subovate in outline; sharply angular behind, and somewhat effuse anteriorly; outer lip thin; inner lip flexed and a little thickened; surface plain, but, under a lens, fine lines of growth are seen.

Length, 45 mm.; breadth of the last volition, 13 mm.

This species is not a very common one. It is regarded as characteristic of the Upper Coal Measures.

**Locality.** The species was originally published from the Upper Coal Measures of Illinois. It may be reasonably sought for at the following Indiana localities: Horizons of coals M. and N. of the Upper Coal Measures.

**Polyphelemopsis nitidula, Meek and Worthen.**

*Plate 27, figs. 7 and 8.*

*Polyphelemopsis nitidula, M. and W., 1866. Ill. Geol. Repts. II, p. 374, pl. XXXI, figs. 9, a, b.*

*Polyphelemopsis nitidula, White, 1882. Eleventh Indiana Geol. Report, p. 370, pl. 42, figs. 7 and 8.*

This shell was published in the Eleventh Annual Report, and referred, with some doubt, to the *P. nitidula* of Meek and Worthen. Our example is larger than the type specimen of Meek and Worthen, but it seems to be specifically identical. It is subsusiform; spire extended, its sides nearly straight; volutions eight or more in number, moderately convex, the last one rather large, constituting a little more than half the full length of the shell; suture impressed and distinct; aperture subovate in outline, angular behind; surface plain.

Length, 27 mm.; diameter of the last volition, 11 mm.

**Locality.** The type specimens of Meek and Worthen came from the Upper Coal Measures of Springfield, Illinois. The specimen here described and figured is from the Coal Measure strata at Eugene, Vermillion county, Indiana.
In the Indiana Geological Report for 1880, I figured and described this form as *Polyphemopsis fusiformis*, identifying it with the *Macrocheilus fusiformis* of Hall, at that time believing that species to be properly referable to *Polyphemopsis*. In the last particular, I was wrong; and I have, on a preceding page, included Professor Hall's species among those shells which have hitherto been referred to *Macrocheilus*, referring them all, provisionally, to *Soleniscus*.

The form here in question, I do not regard as certainly identical with the *Macrocheilus fusiformis* of Hall, nor am I confident that it properly belongs to the genus *Polyphemopsis*. I refer it here, provisionally, to the last named genus, but it is quite likely that it will hereafter be found to be congeneric with those shells which in this article I have referred to *Soleniscus*.

This shell comes from the Coal Measure strata at Newport, Indiana.

**CEPHALOPODA.**

**Genus Orthoceras, Breynius.**

**Orthoceras Rushensis, McChesney.**

*Plate 36, fig. 5.*

Shell small, slender, cylindrical or terete; septa moderately concave; siphuncle subcentral; test finely and distinctly striate when the epidermis is not removed.

This is probably the species that was described by McChesney in his pamphlet entitled New Paleozoic Fossils. There are probably three or four small species of *Orthoceras* in the Carboniferous strata of the United States which are so near alike that it is difficult, and apparently unprofitable, to attempt to separate them. The species of this genus, at best, present few prominent specific characteristics. The figure on plate 36 will give a better idea of the character of the fossil in question than a description of it could do.

**Locality.** Eugene, Newport, Lodi, Merom, Graysville, New Harmony, Rush Creek, Newberg, Indiana, from coal A. to top of the Measures.
Genus Nautilus, Breynius.

Nautilus Winslowi, Meek and Worthen.

Plate 36, figs. 1 and 2.


Shell moderately large, subdiscoidal; umbilici broad and moderately deep, showing nearly the full size of each volution; peripheral side broadly flattened, the middle third being more distinctly flat than the remainder, and the sides sloping slightly to the lateral margins; volutions four or more, their transverse diameter about one-third greater than that of the opposite direction, the lateral margins of the volutions bearing each a row of prominent rounded nodes, which project outwards laterally; from the rows of nodes the sides slope inward with gentle convexity; surface marked by distinct lines of growth, which curve gently backward in crossing the sides of the volutions from the inner margin, and also curve strongly backward in crossing the periphery, indicating a broad mesial sinus in the outer lip.

Diameter of the coil, 125 mm.; transverse breadth near the aperture, including the nodes, 88 mm.

Locality. The type specimen of this species was obtained from the Coal Measure strata at Danville, Illinois. It may be sought for at the following Indiana localities: At horizons of coals M. and N.

Nautilus Forbesianus, McChesney.

Plate 36, figs. 3 and 4.


Shell somewhat massive; volutions in contact but not embracing; broadly convex on the peripheral side; abruptly rounded at each lateral portion, from which the sides slope abruptly into the umbilici; these are large, broad and deep, showing almost the whole width of each volution; transverse section of the volutions subelliptical, about half as wide in the plane of the coil as it is in the opposite direction; septa plain and moderately concave; siphuncle subcentral; a row of prominent rounded nodes occupies each side of the volutions, and where the shell substance is preserved, it shows close-set, coarse, revolving, raised lines which apparently covered the whole surface.

The full diameter of an adult shell is not known, but it probably reached as much as, or more than, 100 mm.

Locality. Prof. McChesney's type specimen was from Mercer county, Illinois. The one figured on plate 36, is from Newport, Indiana.*

* N. decoratus, Cox.
**Nautilus Missouriensis, Swallow?**

*Plate 35, figs. 1 and 2.*


Professor Swallow's description is incomplete, having been evidently based upon either a very small example or the inner volutions of one of larger size. Our example, although incomplete, is much larger than Swallow's specimen, but the characters which he mentions in his description induce me to refer it to *N. Missouriensis* rather than to propose a new name for it, or refer it to any other described species. It is certainly very closely related to *N. spectabilis* of Meek and Worthen (Illinois Geol. Survey, II, p. 308, pl. 25) of the Chester Limestone. Its proportions are similar, and its septa have a like gentle sinuosity, but it is apparently without the row of gently raised obtuse nodes at each side, which characterize *N. spectabilis*. This specimen being only a cast, and somewhat eroded, may really have possessed that feature. The principal objection to regarding our example as specifically identical with *N. spectabilis* seems to lie in the fact that it comes from another formation; but in view of the known intimate faunal relationship between the Chester Limestone and the Coal Measures, their specific identity does not seem improbable.

The full diameter of the coil of our example, when perfect, was not less than 80 or 100 mm.

**Locality.** Silverwood, Fountain county, Indiana.

**CRUSTACEA.**

The crustacean remains that have been discovered in all the strata of that great coal-field which includes a large part of the State of Indiana, are few, but they are interesting and important. If we were to regard the smallness of the number of species that have been recognized among these fossil remains as an indication of the prevalence of crustacean life during the Coal Measure period, our estimate would be a very low one. But the small number of species referred to embrace forms which differ widely from each other, and include representatives of four or five orders of the class *Crustacea*. Because of the great diversity of form and structure among these fossil remains of the Coal Measure period, we necessarily infer that crustacean life was not only abundant during that ancient period, but that it had then reached almost as wide a range of differentiation as it has at the present day.

The crustacean life of the Carboniferous age possesses peculiar interest for several reasons. In its strata are found the latest known examples of the Trilobites, that remarkable order of Crustaceans which under a multitude of forms prevailed so abundantly in all the previous geological
periods. In strata of later date than those of the Carboniferous age, these
crustacean forms have never been discovered, and it is believed that the
last of that order became extinct with the close of that age.

The earliest known representatives of the order to which the living
horse-foot crab belongs are also found in Coal Measure strata; and with
them are also found the earliest known representatives of the shrimps and
cray-fishes of the present day. A few other forms are, also, occasionally
found in these strata which, like the Trilobites, have ceased to exist, but
they are few, and the last of their kind.

We thus find in the strata of the Carboniferous age, and especially in
those of the Coal Measure period, a commingling of ancient and modern
types of crustacean life. Old things were then passing away, and the
new were introduced to supply their places. The same is true, also, with
regard to certain other classes and orders of animal life, but not with ref-
rence to all, for the changes were gradual, and many important ones did
not take place until much later periods.

The following descriptions, with their accompanying illustrations (the
former considerably condensed), are copied, mainly, from the work of
Messrs. Meek and Worthen upon the Coal Measure fauna of the adjoining
State of Illinois, but it will not be unreasonable to expect to find any and
all of them in the Coal Measure strata of Indiana.

GNATHOSTOMATA.

Genus LEALIA, Jones.

LEALIA TRICARINATA, Meek and Worthen.

Plate 39, figs. 10, 11, 12 and 13.


The carapace valves of this species are transversely oblong, the length
being somewhat more than one-quarter greater than the height, but these
proportions vary in different specimens; the anterior border rounded;
basal margin broadly convex; posterior margin truncated, nearly straight
and usually nearly perpendicular, but, sometimes, oblique, and meeting
the dorsal margin at a slightly acute angle; dorsal margin straight, and
the dorsal border of each valve is bent abruptly in at right angles with
the plane of the valves, thus forming a well defined lanceolate corselet,
which is margined at each side by a slender carina; the lateral radiating
ridges, slender, sharply defined, and diverge from each other at an acute
angle; the posterior one is the longer of the two, straight, and extends
to the postero-basal margin; the anterior one is a little curved, and passes
from the beak to the antero-basal border; the surface is marked by from
twelve to sixteen minute, slender, raised striæ, which run parallel to the
posterior and anterior margins respectively.
Length of one of the larger examples, about four-tenths of an inch; height, a little less than three-tenths; and the thickness, both valves together, nearly one-fifth of an inch.

Examples of this interesting bivalve crustacean have been found at various localities in the Coal Measure strata. It is usually so compressed in shale or other rock as to flatten the valves almost completely and obscure the portion which is flexed inward at the dorsal border to form the dorsal corselet. Meek and Worthen, however, obtained some specimens which were uncompressed. The test was very thin, and is usually not preserved upon the specimens. Upon casts of the inner surface of the valve an impressed line shows the position of each radiating ridge, and a similar and much more slender one shows the position on the outer side of each of the delicate, concentric, raised lines.

This form resembles the *Leaia leidyi*, Lea, from Pennsylvania, but Meek and Worthen regard them as quite distinct. These differ from *L. leidyi* in being about twice as large, in having the posterior margin more oblique, the basal margin more convex, and the radiating ridges more sharply defined. The shell is also shorter in comparison with its width.

*Locality.* Patty's Ford of Little Vermillion River, west of Eugene, Brouillet's Creek, Vermillion county, Indiana.

**MEROSTOMATA.**

**Genus Eurypterus, DeKay.**

**Eurypterus (Anthraconectes) Mazonensis, Meek and Worthen.**

*Plate 37, figs. 1, 2 and 3.*


Only one specimen of this interesting fossil has yet been found, and it is the only known representative in this country, found in the Carboniferous strata, of an interesting order of *Crustacea* that seems to have reached its culmination in the Upper Silurian age. Some of those whose remains have been found in the Waterlime Group of New York were monsters—one of them seems to have been not much short of three feet in length, according to the statements of those authors who have described them.

This carboniferous specimen consists of an impression upon the split surface of an iron-stone nodule. It shows the under surface of all the thoracic segments, and a part of one or two of those of the abdominal series; also the operculum or thoracic flap, the post-oral plate, and the maxillary or basal joints of the swimming feet, all in place. All these parts are in a more or less unbroken condition, but they have been flat-
tended by pressure. There are, also, imprints of some of the succeeding joints of one of the swimming feet, and its ear-like expansion; some obscure impressions of three of the smaller legs on one side, and some of the basal joints of their fellows upon the other side. All these organs converge toward the mouth, the position of which is immediately in front of the post-oral plate. The legs are slender, terminate in a long sharply pointed dactylus like that of the legs of Pterygotus, and appear to be without any lateral spines. The carapace, dorsal portions of the thorax, the posterior portions of the abdomen and the telson are unknown.

The post-oral plate is about three-quarters of an inch in length, and eleven-twentieths of an inch in breadth, at the widest part, which is a little behind the middle. It is subovate in outline, broadly rounded at the sides, more narrowly rounded at the ends, the anterior end being distinctly emarginate at the middle. The maxillary joints or plates of the swimming feet expose a subtrigonal outline, their length being a little more than three-fifths of an inch, and their breadth, at the posterior margin, seventeenths of an inch. Their lateral slopes are slightly sinuous along the middle, while their anterior ends are narrow, pointed, incurved, and hardly project beyond the anterior end of the post-oral plate. The succeeding joints are distinguishable upon the specimen, but they are not sufficiently well preserved to allow of satisfactory description.

The breadth of the thorax, near the middle, is nearly two and a half inches, and a little more than two inches in length. On the ventral side the middle segments are a little more than seven-tenths of an inch in length or antero-posterior diameter; but both the anterior and posterior ones, especially the latter, are shorter; and they are all rounded at their postero-lateral angles. Some impressions upon the surface of the specimen, however, show that the lateral terminations of the dorsal portion of the posterior thoracic segments extended out beyond the rounded ends of those below, into acutely pointed extremities, directed obliquely outward and backward. These projecting points of one of the posterior thoracic segments are seen to extend out obliquely nearly half an inch beyond the rounded extremities of those below, and to terminate in sharp points. A portion of one of the anterior abdominal segments which remains, appears to show that the abdomen is comparatively narrow, and that the postero-lateral extremities of its segments terminate in strong angular processes, directed nearly straight behind, but having oblique anterior margins.

The thoracic flap has lateral wings similar to those of the typical forms of Eurypterus, and they have the appearance of being composed of two of the body segments anchylosed together, the anterior one being not more than half as broad as the other, which is of the same size as the body segments. Its mesial appendage has the remarkable length of one and six-tenths inches, and can be traced on the specimen as far back as the posterior margin of the fifth thoracic segment, and it is evidently not
bipartite at the extremity. On each side of the anterior end of the mesial appendage there is a small spatulate piece which does not correspond to any known parts of the operculum of the *Eurypterus*. These pieces are a little more than four-tenths of an inch in length and three-twentieths of an inch in breadth. Their sides are nearly parallel, anterior extremities pointed, and their posterior ends transversely truncated with their lateral angles rounded. Their anterior pointed ends terminate nearly in contact with the two small pieces called intercalated pieces, by Prof. Hall.

In consequence of the differences which this species presents from the typical forms of *Eurypterus*, Meek and Worthen suggested that it might be found to be generically, or at least subgenerically, distinct. The differences they designated are the great length and non-bipartite extremity of the mesial appendage of the operculum, and the presence of an additional spatulate appendage at each side of the long mesial one.

**Locality.** This specimen was obtained from the Coal Measure strata at Mazon Creek, Grundy county, Illinois. It may reasonably be sought for at the following localities in Indiana: Patty's Ford of Little Vermillion River, Brouillett's Creek, Vermillion county, and Durkee's Ferry, Vigo county.

**Genus Euproops, Meek and Worthen.**

**Euproops Danae, Meek and Worthen.**

Plate 39, fig. 1.


This interesting ancient representative of the living horse-foot crabs was first described under the generic name of *Belinurus*, and by that name it became somewhat widely known. Upon the discovery, however, of better examples than were at first known, Meek and Worthen found that it possessed certain characteristics which are not shown by *Belinurus*. They, therefore, proposed the genus *Euproops* to receive it.

The cephalo-thoracic shield is transversely crescentic in outline, more than twice as wide as long, moderately convex, its height nearly equal to half its length at the median axis; the front margin, including the spine-bearing sides, continuously and regularly rounded; the lateral angles directed obliquely outward and backward with a slight curve, the convexity of which is outward; these angles end in slender acute spines, their points being nearly opposite the middle of the abdomen, and at some distance from its sides; the posterior margin of the cephalo-thoracic shield nearly straight along the middle portion, and gently concave at each lateral portion; mesial lobe small, a little less in height than the adjacent ocular ridges, rounded and well defined at its posterior end, where it bears
a central tubercle, which is probably sometimes spine-like; at about one-third the length of the shield from the posterior margin, a less distinct tubercle sometimes appears; the sides of the lobe converge gently forward, then they suddenly converge into a linear carina, which extends forward to the anterior transverse division of the ocular ridge; the area which is included by the ocular ridge is subquadrangular in outline or crown-shaped, and constitutes the middle third of the cephalo-thoracic shield; at its anterior end it is a little wider than its full length, which is equal to about five-sixths the length of the shield; its lateral margins concave; anterior side convex, with a central emargination; its surface is divided into four irregular areas by the mesial lobe with its anterior linear prolongation, and the two less distinct linear transverse ridges; ocular ridge narrow, but distinct, its lateral portions arching inward behind the eyes, and terminating posteriorly at the margin of the shield, nearly opposite the middle of each lateral lobe of the abdomen, in a spine-like process which appears to have been triangular, the process being directed backward, outward and a little upward; the anterior transverse division of the ridge arching forward at each side, and curving backward at the middle. Compound eyes small, distant from each other, and located one at each antero-lateral angle of the crown-shaped central area of the shield, about one-third its length from its anterior margin. Simple eyes are not known to have existed. The abdomen is transversely suboval in outline, wider than long; the lateral margins rounded in abruptly at the front, but, posteriorly, they blend into a regular curve with the posterior margin; the surface of the abdomen a little more depressed than that of the cephalo-thorax, especially in front; the flattened lateral borders are rather narrow, and scalloped between the marginal spines; the breadth of the mesial lobe about equal to that of the cephalo-thoracic lobe, a little more elevated than the lateral abdominal lobes, and half as broad; segments distinct, the first and third, each, bearing a small tubercle, the sixth as long as any of the others, narrowed and depressed behind and bearing a large tubercle, which is apparently sometimes spine-like; lateral abdominal lobes, depressed along the inner side, rounding abruptly down to the flattened free borders at the outer sides and behind; segments defined by linear ridges, which are separated by flattened spaces four or five times as wide as the ridges; the latter extend obliquely outward, and a little backward, across the lateral lobes and their flattened borders, and are produced into the slender lateral spines, which have a gentle backward curve.

The telson is apparently nearly two-thirds as long as the abdomen, gradually tapering, subtrigonal, flat below, angular at each side, and obtusely angular above.

The appendages of the under side unknown, except one leg. This is seen, in one specimen, projecting out from under the cephalo-thoracic
shield, between its posterior margin and the abdomen. The leg is slen­
der; about one-eighth of an inch in length of the first segment appearing
from beneath the shield; the next segment about one-quarter of an inch
long and scarcely more than one twenty-fifth of an inch in breadth. The
succeeding segments are traceable upon the specimen nearly one-third of
an inch, curving toward the extremity, and apparently ending in a point.
The position of this leg in the series has not been ascertained.

The entire length of the animal, from the extremity of the caudal seg­
ment to the anterior border of the cephalo-thoracic shield, is nearly two
inches. Length of the cephalo-thorax, nearly six-tenths of an inch; 
breadth of the same, to the extremities of the lateral spines, one and
seven-tenths inches; length of the area included by the ocular ridge, half
an inch; greatest breadth of the same (the distance between the eyes),
six-tenths of an inch. Length of the abdomen, nearly five-sixths of an
inch; breadth of the same, excluding the flattened free margins, a little
more than nine-tenths of an inch; breadth of the mesial lobe, nearly a
quarter of an inch; length of caudal segment, six-tenths of an inch.

Locality. The type specimens of this species were found at Mazon
Creek, Grundy county, Illinois, but they may be sought for in the follow­
ing localities in Indiana: Brouillett's Creek and Durkee's Ferry, Vigo
county.

Euproops Colletti (n. s.)

Plate 39, fig. 2.

On the face of a split iron-stone nodule found in Coal Measure strata at
Durkee's Ferry, Vigo county, Indiana, there is an imperfect impression
of an Euproops, which seems to be specifically different from E. Danae.
The specimen is too imperfect for detailed description, and it is, therefore,
not attempted. It seems to differ from E. Danae in the following par­
ticulars:

The cephalo-thoracic shield is proportionately a little larger, and,
although its postero-lateral extremities are sharply angular, they appear
not to have been produced into slender spines. The median lobe is wider
in front, and it narrows more rapidly posteriorly, and with straighter
sides. The caudal spine appears to have been smaller. The lateral spines
appear to have been less slender, and the two last ones seem to have been
very small and very close to the caudal spine.

Assuming this form to be distinct from E. Danae, the proposed new
specific name is given it in honor of Mr. Josephus Collett, who dis­
covered it.
TRILOBITA.

Genus Phillipsia, Portlock.

Phillipsia (Griffithides?) scitula, Meek and Worthen.

Plate 39, figs. 6, 7, 8 and 9.

Phillipsia (Griffithides?) scitula, M. and W., 1873. Illinois Geol. Reports, V, p. 615, pl. XXXI, fig. 3.

As has already been stated, the great order of Trilobites became extinct with the close of the Carboniferous age. With the close of the Devonian age, the order became reduced to two or three genera, at most; and in the Coal Measure period, only a few examples of one or two genera are found. Only the two small species which are here described are likely to be found in the Coal Measures of Indiana, yet it is possible that others may yet be discovered.

This species is small, and, when distended, its outline is nearly elliptic. The cephalic shield is semi-elliptic, prominently convex, its breadth about one-third greater than its length; its anterior margin rounded; its posterior margin nearly straight; its posterior angles projecting backward, and forming somewhat strong carinated, sharp spines, their points reaching as far back as the fifth thoracic segment. The glabella is broadly rounded, sloping in front, without an anterior projecting marginal rim; contracted toward its posterior end, which is the most elevated part; its prominent convexity defines it from the cheeks at either side, and it is also bordered, laterally, by a shallow furrow, which becomes obsolete around its front margin; posterolateral lobes, comparatively large, sub-trigonal, very oblique, depressed, and distinctly defined by the lateral furrows in front; second and third lateral lobes small, transverse, indistinctly defined by short, nearly obsolete, linear furrows; anterior lobe larger than all the remaining portions of the glabella between it and the neck furrow. The neck segment is a little more prominent at the middle than the glabella, strongly arched upward but not forward, its antero-posterior breadth more than twice as great as that of one of the thoracic segments; a minute tubercle is usually observable upon its median line; neck furrow deep, broad, and corresponding to the arching of the neck segment. Eyes comparatively large, half as long as any part of the glabella, prominent behind, the position of their posterior margins opposite the neck furrow, and reaching forward less than half their own length beyond the posterior margins of the cheeks; the visual surface prominent, subhemispherical, smooth, and even appearing to be polished, under a pocket lens. When examined by a high magnifying power, however, it shows numerous regularly disposed minute lenses beneath the smooth, transparent outer layer; palpebral lobes semicircular, convex, and having the appearance of eye-
lids. Cheeks small in comparison with the eyes and glabella, and slope abruptly from the eyes into the deep, broad marginal furrow; the furrow suddenly becoming obsolete at the anterior lateral margin of the glabella, but extends backward to the subspiniform appendages; posterior margins having an elevated rim, strongly defined by the deep continuation of the neck-furrow; lateral margins, when viewed from above, showing a narrow rim, which, by side view, is seen to be deep, vertically flattened, and marked by fine parallel longitudinal striae; anteriorly, the rim continues around to the front of the glabella, but it is not sufficiently prominent to be visible from above, and its upper margin is continued in the form of a carina, along the middle of the spinous processes, to their points. Facial sutures, cutting the anterior border in front of the eyes and the posterior margins of the cheeks behind the outer margins of the eyes.

Thorax almost as long as the head, but it is a little narrower, and distinctly trilobate; its mesial lobe prominent, convex, and a little wider than the lateral lobes; its nine segments narrow and subangular. The lateral lobes are depressed, convex, and flattened along their inner sides, sloping abruptly at their outer sides, producing, thus, an obtuse longitudinal angle along each lateral lobe; segments of the lateral lobes, six in number, simple, bent abruptly downward at the middle, where each has a minute pustule, but terminating abruptly at the rather wide border. Surface of the glabella and all the segments more or less granular, the granules being coarser on the posterior part of the glabella and neck segments than elsewhere.

Entire length of a medium sized example, nearly seven-tenths of an inch; length of the pygidium, two-tenths of an inch; breadth of the same, three-tenths; length of thorax, a little less than two-tenths; breadth of the same, a little less than three-tenths; length of the cephalic shield, two and a half tenths; breadth of the same, a little over three-tenths.

Locality. This species is widely distributed in those States which embrace portions of the Coal Measures. It may be found in the following places in Indiana, among others: Perrysville, Eugene, Lodi, Silverwood, and Newport.

**Phillipsia (Griffithides?) Sangamonensis, Meek and Worthen.**

*Plate 39, figs. 4 and 5.*

**Phillipsia (Griffithides?), Sangamonensis, M. and W., 1873.** Illinois Geol. Reports V, p. 615, pl. XXXII, fig. 4.

This species resembles the foregoing in general aspect, but it is larger. It is subovate in entire outline, as indicated by the detached parts that have been discovered. The cephalic shield is convex, its outer border forming more than a semi-circle, about one-third wider than long, regularly rounded in front and straight behind, but its postero-lateral angles
are produced into strong carinated subspinous processes, which are equal in length to the distance from the posterior side of the cheeks to the anterior end of the eyes; glabella prominent, sub-inflated, defined from the cheeks, at each side, by a moderately distinct furrow, which is continuous around the front; its greatest convexity behind the middle, from which it declines to the rounded front; its length is about one-fourth greater than its width, which is slightly greater between the eyes than it is further forward; the sides are nearly parallel, but a little sinuous along the middle; posterior lateral lobes, comparatively large, prominent, and isolated by the distinct lateral furrow which passes obliquely across, with a lateral curve, from opposite the middle of each eye, so as to intersect the neck furrow; second lateral lobes obscure and much smaller than those behind, defined by a faintly impressed curved oblique line; forward of these lobes there are also obscure traces of two other short obsolete lateral furrows which are hardly visible to the naked eye. Occipital segment well defined but shorter than the glabella, strongly arched upward but not forward, and projecting backward a little behind the range of the posterior border of the cheeks; neck furrow distinct and arched upward with the occipital, or neck segment; its prolongation along the posterior sides of the cheeks very deep and nearly straight for about two-thirds of the way across, towards the lateral margins, where it intersects another furrow, which passes around the sides of the cheeks.

Eyes lunate, rather large, or nearly half as long as the glabella, exclusive of the neck segments; they are prominent, being about as much elevated as the glabella, and their position is about half their own length in front of the posterior margins of the cheeks. The visual surface is smooth, and has a polished appearance under a pocket lens, but no traces of lenses have yet been detected in the eyes by a higher magnifying power. The palpebral lobes are convex, and rest upon the eye like a lid. The cheeks are subtrigonal, sloping abruptly away from the eyes; lateral margins turned downward, and forming a sharp edge below, which is continued backward along the postero-lateral spines. Above this there is a vertically flattened, or sometimes slightly concave, zone, which extends from near the front of the glabella, around the outer side of each cheek, and, passing backward, it becomes a shallow furrow upon the spines, traceable nearly to their extremities. Between this zone and the eyes there is another somewhat similar zone, which extends posteriorly around each cheek, from near the front, and unites with the lateral connections of the neck furrow behind; they then continue, as a single furrow, along the upper margin of the spines, and leave a more or less defined mesial ridge between these two furrows along the entire length of the spines, as well as around the cheeks, to near the front of the glabella; posterior margins of the cheeks behind the neck furrow prominent.

Facial sutures extending obliquely forward and outward from the ante-
rior side of the eyes, then curving inward, so as to cut the anterior margin nearly on a line with the anterior inner extremity of the eyes; from the posterior end of the eyes the sutures are directed outward and backward, intersecting the posterior margin about midway between the neck segment and the spine-like postero-lateral projections.

Thorax not fully known, only a few of the posterior segments having been discovered. These show the mesial lobe to be wider and more prominent than the lateral lobes; the latter lobes are flattened near the mesial lobe, and along the median line of each they are abruptly bent downward; segments divided by a furrow, which extends from the knee inward, along the anterior side.

The pygidium is semi-elliptic in outline, somewhat convex, and a little wider than long, narrower and a little longer than the cephalic shield, narrowing posteriorly, and abruptly rounded at the posterior extremity. Mesial lobe prominent, a little flattened at each side, narrower than the lateral lobes, separated from them at each side by a broad, strong furrow; the lobe tapers gradually backward, and terminates abruptly at a distance equal to about one-third its own length from the posterior margin; a broad, nearly flat, or gently sloping smooth border extends continuously along the whole free margin of the pygidium, which is a little broader at the posterior extremity than it is nearer to the abdominal portion; segments of the mesial lobe seventeen or eighteen in number, straight, rounded, and well defined.

Lateral lobes less prominent than the mesial, and one-third or one-fourth wider, abruptly convex at their outer side; segments nine or ten, simple, separated by distinct furrows, all terminating abruptly at the inner edge of the broad, smooth, marginal zone. The whole surface of the test nearly smooth.

Length of cephalic shield along the median line nearly half an inch; breadth of the same, six and a half tenths of an inch. Length of the glabella, three and a half tenths of an inch; breadth of the same, three-tenths of an inch at the widest part.

Locality. This species is not so commonly found as the preceding one, but it may be sought for at the same Indiana localities as the foregoing.

ISOPODA.

Genus Acanthotelson, Meek and Worthen.

Acanthotelson Stimpsoni, Meek and Worthen.

Plate 37, figs. 4 and 5.


Our present knowledge of this interesting species has been gained from
several successive discoveries of more or less imperfect examples, and the successive publications of it by the authors above cited have varied somewhat as additional knowledge was gained. The following is a summary of its characteristics:

Elongate or sublinear in shape; the upper antennae fully as long as, if not longer than, the head and first five thoracic segments together; peduncle rather stout, a little longer than the head; first joint a little longer and wider than the two others, the latter being nearly of equal length; flagellum slender and minutely jointed; accessory appendage about as long as the flagellum and, like it, minutely jointed; inferior antenna as long as the head and seven thoracic segments together; peduncle a little longer and larger, but, in other respects, it is like that of the upper antenna; flagellum similar to the upper pair, but a little larger. Head apparently subquadrangular, its upper side longer than the lower, the anterior side being oblique. Eyes small, round, situated just below the bases of the upper antennae. The thoracic and abdominal segments, together, fourteen in number, all distinctly observed, except the last one; a few of those nearest the head are a little shorter than the others, but, except this, they are all of nearly equal length; their antero-basal margins rounded; posterior margins subrectangular.

The thoracic legs of the first pair are about one-fourth longer and a little larger than those of the five succeeding pairs, and seem to end in a sharp dactylus. The five succeeding pairs of legs are of nearly equal size and form, and their upper segments are short and not enlarged. The seventh pair are nearly as long as the first, and more slender than any of the others. Abdominal natatory appendages long and slender, the styliform pair having the first segment short and quadrangular; second and only other joint as long as the telson, which they closely resemble in shape, their upper and lower margins each with a row of short oblique rather distant setae, between which a good lens reveals numerous close-set minute setae. Length of the telson equal to the length of the last four abdominal segments; its vertical width at the base equal to one-half the width of the penultimate abdominal segment, but it tapers to a mucronate point; upper and lower margins setigerous like those of the stylets.

Locality. All the specimens yet found are from Grundy county, Illinois, but it may be sought for at the following localities in Indiana: In concretions on Little Vermillion river and Brouillet's Creek of Vermillion county, and Durkee's Ferry in Vigo county.

**Acanthotelson, Eveni, Meek and Worthen.**

*Plate 38, figs. 4, 5, 6, and 7.*


All the specimens of this species that have yet been discovered are...
fragmentary, but Meek and Worthen were satisfied that it is a distinct species from *A. Stimpsoni*. The differences which they pointed out are: That it is larger and more robust, while its body is proportionally longer and more slender. The joints of all the legs, and also of the antennæ, are proportionally longer and more slender. At first, these authors supposed that the stylets were not connected with penultimate, but with the antepenult segments. In their latest publication (loc. cit.) they express the opinion that the appearance just mentioned was deceptive, and produced by a displacement of the parts in their specimen during the process of its fossilization.

**Locality.** This form was discovered in Grundy county, Illinois, associated with the preceding and other crustacean species, and is likely to be found in any of the Indiana Coal Measure strata that contain similar crustacean forms.

**Genus Dithyrocaris, Scouler.**

*Dithyrocaris Carbonarius, Meek and Worthen.*

Plate 39, fig. 3.

*Dithyrocaris Carbonarius, M. and W., 1873. Illinois Geol. Reports, V, p. 618, pl. XXXII, fig. 1.*

This species is yet known only by the caudal appendage; but this is so characteristic as to render its identification an easy matter by any collector. It is especially interesting as being the only representative of the genus which American strata have afforded.

The telson and stylets are lanceolate in shape and flattened. All three are closely similar in shape and size, but the telson is a trifle shorter than the stylets, and tapers to the extremity a little more rapidly. The telson is flattened upon its under side, and bears a faint mesial longitudinal ridge, with a faint longitudinal sulcus at each side of it; the lateral margins sharp. Its upper side bears a distinct mesial carina, from which the surface at each side slopes with gentle concavity to the sharp edges. The stylets are flattened upon their under side, where six or seven longitudinal ridges are seen. On the upper side, there is a distinct mesial longitudinal carina, with a concave furrow at each side of it. Along each lateral margin, there are two closely approximate carinae, one above and the other below, with a narrow sulcus between.

Length of the telson, three-quarters of an inch; greatest breadth nearly one-eighth of an inch. The stylets are a trifle longer, and of the same breadth.

**Locality.** The original specimen of this species were found in Coal Measure strata at Danville, Illinois. It is a rare species, but it may be reasonably sought for in almost any of the Coal Measure localities in Indiana.
Upon the original discovery of the first example of this form, Meek and Worthen believed it to belong to the genus *Acanthotelson*, and accordingly placed under the *Isopoda*; but upon the subsequent discovery of other and more perfect specimens, they established the new genus *Paleocarid*, and placed it with the *Macoura*ns.

The body, in general shape, is linear, the thorax being slightly wider near its middle than the abdomen, the length of the segments nearly equal in both thorax and abdomen, the length of the inner antennæ about equal to that of the head and thorax together, the peduncles stout, the first joint of it being a little longer and wider than either of the other two; the latter joints are of nearly equal length and their inner borders are margined with fine, close-set setæ; the flagellum very slender and minutely jointed; accessory appendage about as long as the flagellum, which it closely resembles in all respects.

The outer antennæ appear to be a little longer than the others, and the peduncles slightly longer than those of the other pair, and they are also minutely setigerous in front; basal scales (?) oblong, squarely truncated, and about equal in length to the first joint of the peduncles.

The thoracic legs are long and slender, the anterior ones apparently not differing in this respect from the others; none appear to be chelate; the first two or three joints short, the fourth (?) joint tapering and extended horizontally, its length being about equal to four body segments; the succeeding joints slender, and bent abruptly downward and backward. Swimming appendages of the abdomen acutely lance-linear, the length of some of them being equal to four abdominal segments; base of the telson nearly as broad as the penultimate segment; the telson tapering at the sides, which are minutely setigerous, its length equal to two and a half abdominal segments; first joint of the stylets minute; the second lance-linear, each division being as long as the telson; extremities pointed; margins parallel and setigerous.

The ridge and proportions of the parts are given by the figures on plate 38.

**Locality.** This form, like most of the known crustaceans of the American Coal Measures, was obtained from the strata in Grundy county,
Illinois. It may be sought for at the following localities in Indiana: Patty’s Ford of Little Vermillion River and Brouillett’s Creek in Vermillion county, and Durkee’s Ferry, Vigo county, in iron stone concretions, above coal L.

Genus Anthrapalémon, Salter.

**Anthrapalémon gracilis, Meek and Worthen.**

*Plate 38, figs. 8 and 9.*


**Anthrapalémon gracilis, M. and W., 1866.** Ill. Geol. Rep., II, p. 467, pl. XXXII. fig. 4.


Successive discoveries caused Meek and Worthen to modify somewhat their first published descriptions of this species. The following is a summary of its structure, as now understood:

Carapace oblong in form, as seen by upper view, but the lateral margins are gently convex, the two extremities truncated, and its breadth about equal to three-fourths its length. Its lateral margins, forward of the middle, each bear six small, sharp serrations, like those on the type of the genus, but they are sharper, and are directed more obliquely forward. At each antero-lateral angle, there is, also, as in the type species, a larger, projecting, short spine, but this is turned more directly forward. The outer pair of antennæ moderately stout; each peduncle with three joints, which diminish gradually in size, the first longer than wide, and the other two of nearly equal length and breadth, and obliquely articulated. The flagellum is narrower at its base than the last joint of the peduncle, composed of very short segments, about one-third as long as wide. The antennæ were long and slender, but their full length is not known. Inner antennæ unknown.

The figures on plate 38 give the shape and proportions of all the other known parts.

**Locality.** The only known examples are from Grundy county, Illinois, but the species may be sought for in the same localities as the foregoing.
INDIANA GEOLOGICAL REPORT, 1883.

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<td>U. elongatum, St</td>
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<td>119</td>
<td>&quot;Voyage dans l' Amerique Meridionale&quot;</td>
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73
ERRATA—PART II—PALEONTOLOGY.

On page 28, line 20, from top, for dichotomous, from the base, read dichotomous from the base.

On page 31, line 7, from base, for Dictyophyllum, read Dictyophyton.

On page 33, line 5, from base, for plate I, read plate B.

On page 36, line 6, from base, for plate B, fig. 78, read plate 1, fig. 8.

On page 36, line 6, from base, for five cm. read five m.

On page 36, line 7, from base, for one cm. read one m.

On page 51, line 1, from top, for a Ettinghausen, read d’Ettingshausen.

On page 55, line 3, from base, for rachis, read costa.

On page 57, line 5, from base, for Prardeci, read Pardeci.

On page 58, line 12, from base, for all linear, read oblong or.

On page 75, line 9, from top, strike out, and.

On page 77, line 16, from top, for they, read then.

On page 101, line 15, from base, for gracilis, read gracile.

On page 78, line 12, from top, for Lepidodron, read Lepidodendron.

On page 100, line 1, from base, for ature, read mature.