Art. III.—*On some questions concerning the Coal Formations of North America;* by L. Lesquereux.

It may perhaps be said that as everybody is now acquainted with the coal, with its essential constituents and the general laws of its formation, an attempt to offer to science something new or even interesting on the subject, must prove a fruitless task. This assertion has a semblance of truth only, for it is certain that some of the various and most important phenomena connected with the formation of coal are not satisfactorily, nor even at all explained. And as they are continually brought forward for discussion, either by lecturers or systematic geologists, the subject of the formation of coal, considered as a whole, has been obscured in such a manner that it is doubtful if the most essential facts on the subject, some of which may be considered as demonstrable, are not still looked upon by many as hypothetical and individual opinions. It is with these peculiar phenomena of the coal formations, and consequently with the exposition and the discussion of geological facts connected with them, that we have to deal in the first part of this paper.

As we cannot expect to come to a right understanding of the formation of coal without some acquaintance with the vegetation of whose remains it is made, our attention must necessarily to some extent be directed to the flora of the coal period. But it is not enough to know the peculiar nature, the anatomical and chemical constitution, of the coal plants. It is necessary to study them also in their geographical distribution, in the different coal basins of America and of other countries, and also in the successive strata of the coal at different geological horizons. And it would be desirable also to examine the vegetation of the coal in connection with other external influences, in order to become acquainted if possible with the climatic conditions that prevailed at the time of the coal formation.

The plan that we propose to follow may accidentally direct the discussion to some points which do not appear to have a close relation to the formation of the coal. But we must bear in mind that geological eras are not very distinctly limited; or at least that to have a true understanding of one of them it is necessary sometimes to examine the causes that have prepared it, or that may have brought it to a close.

The supposition that coal is a true mineral, formed in certain strata of our globe only by some chemical agency and without an accumulation of wood grown on the surface and buried afterwards, has been recently revived among us, though it had long since been put aside, and apparently forever, as contradicted by all the appearances of the coal deposits and by the nature of the

coal itself. It would be useless, again to show the groundlessness of an hypothesis to which nature does not give the slightest apparent support.

The supposition that the matter of the coal (the wood) was heaped in some hollows or basins by the agency of water, as by currents of the sea or of some river, or by some other external cause, hurricanes, partial or general floods, sinking of the ground covered with thick forests, &c., has been also generally abandoned as contradicted by general evidence. The reasons against it may be briefly enumerated. They are found: 1. In the stratification of the coal measures; and also of the coal itself, which upon close examination appears to have been formed by successive layers of matter. 2. In the presence of plants in the coal and in the shales above it, plants preserved in the integrity of their most minute and fragile parts, and in a position which shows that they have been buried at the place where they have fallen from the trees or the bushes and where they grew. 3. In the absence in the coal of any matter foreign to it, of sand, of mud, &c., the ashes of the coal being generally in exactly the same proportion as in the wood. 4. In the thickness of some beds of coal containing a quantity of matter far greater than could be furnished by a buried forest.

The theory of the formation of the coal by the heaping of consecutive layers of plants and trees grown in place, preserved in water and buried afterwards; or the peat-bog theory as it is called by some, is then the only one admitted now as satisfactorily explaining the process of formation of the coal. The analogy of formation between the peat-bogs of our time and the beds of coal of the old measures cannot be called a theory; it is a demonstrable fact. We can now see the coal growing up by the heaping of woody matter in the bogs. After a while we see it transformed into a dark combustible compound that we name peat or lignite according to its age. We then see it hardening either by compression, or by this slow burning in water that has been so well explained by the experiments of Liebig. Most of the peat bogs of Europe, at least the oldest, have at or near their bottom some plates or thin layers of hard, black matter, that ocular examination or chemical analysis fail to distinguish from true coal. We find besides in Holland, Denmark and Sweden, thick deposits of peat separated into distinct beds by strata of mud and sand, giving the best possible elucidation of the process of stratification of the coal measures.

It is not only in their general features that both formations are so much alike. But in the minutest accidents and even local peculiarities, their agreement is clear and unquestionable to one who has studied the formations of the peat bogs of our time. We quote a few examples.

An author, speaking lately of the formation of the coal, mentions the presence in the coal of *wedge-shaped masses of vascular tissues found imbedded in the midst of the more structureless bituminous matter of the coal.* He accounts for this fact by supposing that these tissues are the remains of floated logs, which have finally become imbedded in the carbonaceous matter below. This supposition is rather an extraordinary one. If the coal has been formed like the peat bogs, there can not be any *floated* logs in the compound. If there were floated logs in the coal, this would take us back to the formation of the coal by transportation. In every peat bog, the process of burying trees is in constant operation. The preservation of the logs which cannot be covered with water when they fall on the ground, is due to the agency of a moss, the *sphagnum* which extends its compact tufts always saturated with water like a sponge, over every fragment of wood, from the smallest to the largest. The *Sphagna* work like the ants to bury their treasures; and as their growth is continuous and stopped only by the frost, the heaping of their own woody matter which forms the *structureless* peat added to the wood which they have to preserve and the other plants of the marshes gives an appreciable thickness for each year. In the peat bogs of Switzerland, peat grows at the rate of two inches per year, a thickness reduced to one half by compression. In the same peat bogs, the *Sphagna* do not require more than three years to cover the stem of a tree of moderate thickness.

The bogs then, even the largest, enter naturally and without transportation into the composition of the coal as they become part of the matter of the peat bogs. In the deep bogs of New Jersey, there is a class of woodmen whom I would call log-fishers, who sound the marshes with long poles, to find the sound logs which they dig out of the black and already combustible mould or peat, from a depth of from six to ten feet. Some old swamps of Northern Europe contain as many as four or five generations of trees of different kinds imbedded from twenty to fifty feet deep and separated by thick beds of compact, entirely decomposed woody matter or peat. Some of those bogs are so abundantly filled with sound and large logs of oaks, pines and birches, that their removal has gone on for more than half a century before there was any material diminution of the supply, and for a long time it was supposed and even maintained that the trees of those marshes were growing under ground.

The flattening of all the stems found in the coal and in its shales, and also the layers of bark observed in the same formations, without any trace of internal woody structure, have also attracted a great deal of attention and useless theoretical discussion. In the oldest peat bogs of Germany, especially in the large swamps or lignite-deposits of the Pliocene of Saxony, the

trees are found all softened and already flattened to a greater or less extent. Some of the buried forests of England show the same appearance. From some clay banks exposed by a slide in the Jura mountains, large trees of recent species, still living in the country around, have been exhumed, and though the wood still preserves its natural appearance and its tissues, it has lost its hardness of texture and has become as soft as the clay itself. Hence, as Liebig has proved by direct experiments, in the process of slow decomposition or rather slow combustion in water, the woody matter is generally softened before its hardening and entire transformation in coal.

In Denmark, there are immense meadows, extending for miles along the shores and covering old deposits of peat or combustible matter to a depth of from six to eight feet. The entire mass consists of a half fluid paste with layers of the bark of alder and white birch, rolled, flattened or pressed like the leaves of a book. Farther back in the interior of the country, especially in the royal park of Copenhagen, the formation of this kind of peat can be followed in all its details. First a thicket of alders and birches sprout out, covering an overflowed surface of ground. The thicket is impenetrable, and soon presents a confusedness of stems and interlaced branches. Then, as the trees become older, the whole mass begins to decay, especially at the level of the water, and by and by it falls down by its own weight, becomes submerged in a few years, and from its own seeds upon the mould of its half floating, half decomposed remains, a new generation of trees appears again and the process of formation is continued in the same way. The internal woody matter of the trees, the lignine, is decomposed at first and reduced to a paste, while the bark, impregnated with resins, is preserved for an indefinite period. In the coal basin of Trevorton, Pa., there is a perpendicular wall presenting to the eye a beautiful picture of prints of Lepidodendra and Sigillariæ, crossing each other in every possible direction, all thin layers of bark superposed without any woody or carbonized matter between. It is nothing but the surface of an old coal-swamp, formed like the peat bogs described above. The peat which it covered has formed the coal, and the woody matter floating in water above it has been mixed with mud and formed the shales.

If it is true, as we said before, that all the peculiar accidents of the coal formations can be thus exemplified and explained by phenomena now observable in the growth of the peat, is it not surprising that the peat-bog theory of the formation of the coal should be still exposed to so many contradictions, and especially be subjected to continual and hypothetical modifications, which, destroying its simplicity, render it then truly unsustainable. The following reasons have been repeated time and again. The

repeated succession of various strata in the coal measures, viz., the constant alternation of fire clay containing roots of trees, with coal and shales, both containing remains of land plants or of marine shells; with limestone containing madrepores and shells of the deeper seas; with sandstone mostly without any fossil remains: this alternation evidently shows that at the time when the formation was progressing, the sea was continually brought in contact with the coal and covered it most of the time. Hence it follows; that if the coal has been formed in marshes like our peat bogs, we ought necessarily to admit of a submergence and therefore of a subsidence of the land after each deposit of woody matter, and of an upheaval of the same land to bring it up again above the level of the sea for each successive growth of a new peat bog. This appears to some geologists an unaccountable and unnecessary use of nature's internal forces; a kind of *lusus naturæ*, resembling a miracle. To meet this objection, they have supposed that the peat bogs of the coal measures grew on the deltas of some large river, and therefore exposed to periodical inundations: that as fast as the peat grew, the river brought upon it mud and sand, the materials from which the shales and the strata of sandstone were formed: that, nevertheless, the deltas being by some *internal force* constantly sinking, they were consequently sometimes invaded by the sea which covered their whole extent and in the course of time, built upon them the strata of limestone: that as soon as these strata reached the surface of the sea (a fact which probably supposes that the movement of subsidence had stopped for a while) the land plants began to appear again, the peat to grow, and the matter to be heaped up till another large periodical inundation of the river brought new deposits of mud and sand; and thus by continuous subsidence and repeated inundations, the coal, shales, sandstone and limestone strata were alternately formed.

Before giving any reasons in support of the alternation of upheaval and subsidence as supposed by the peat bog theory, we will take the liberty to examine this new theory which we regard only as a poor modification of part of the former which it assumes to put aside forever. It is generally asserted that in the coal measures, the alternation of strata is the same in the whole extent of a basin, or in other words, "*that each stratum is generally horizontally extended over the whole coal-field in a continuous sheet, so that each seam is accompanied by the same strata above and below.*" This is only partly true. In the coal-fields of the United States, it is true only of some beds of coal and of one or two strata above the conglomerates. Every practical geologist knows well that it is impossible to identify the position of a bed of coal by means of its adjoining strata. If the same strata

had been expanded without alteration through the whole extent of a coal basin, nothing would be easier than to fix at once the geological horizon of each bed of coal after the close study of a single section. The shales above the coal give by their fossils the only reliable data; but in many places they (the shales) are entirely wanting and are replaced by sandstone or limestone. In the western coal-fields of Kentucky, the first coal below the Mahoning sandstone, or the fourth coal above the conglomerates (the same as the Pomeroy coal of Ohio or the upper Freeport coal of Pennsylvania) whose shales sometimes reach in the East a thickness of 10 feet, is immediately covered by the sandstone. There is scarcely a vein of coal worked to any great extent, that does not show a great diversity in the thickness, density and color of its roof shales. Hence the necessity of roofing differently the tunnel of a mine in different places according to the nature of the shales. The bottom clay is almost always present; but its thickness, color and density are also variable. The limestone of the coal is the most irregular of all the formations. It is mostly local, sometimes only in boulders, and its numerous variations in thickness, composition and even fossils, cannot be accounted for by any satisfactory general rule. There is not in the United States a single bed of coal that is unvariably covered with limestone. The sandstone is generally extended with more regularity; but it has also its diversities of thickness and local disappearance. The only bed of sandstone which appears to be continuous in the whole extent of the coal-fields above the conglomerates, is the Mahoning sandstone. Though its thickness is also somewhat variable, it is found topping the 4th coal (coal E of Lesley's Manual) from the anthracite basin of Eastern Pennsylvania to the western extremity of the coal-fields of Illinois and Western Kentucky. The Anvil-rock sandstone, topping the 12th coal of Western Kentucky, though generally of great thickness, has not as yet been identified in the East. For the coal itself, the assertion of its continuity could be admitted as nearly true.

Though a coal bed cannot be called a continuous sheet in its horizontality, since all the strata of coal are subjected to thinning or even entirely disappearing in some places and some others are circumscribed in narrow limits, generally speaking, most of our large beds of coal can be traced through the whole extent of the coal-fields. The great mammoth vein divides itself into three or four different beds in some places, but is found continually, thinning from Carbondale to the western limits of the Illinois coal-fields. The first coal below the Mahoning sandstone (the Pomeroy coal) is seen to have the same extent with scarcely any change in its thickness. The Pittsburg coal which from its high position in the coal measures has been washed away over

large surfaces, shows itself, along with the characteristic fossils of its shales, in every part of the measures where the thickness is sufficient to reach to its level. Thus we have some beds of coal generally accompanied, at least locally, by their peculiar shales, and one great bed of sandstone covering a surface as wide as the whole extent of the Appalachian and the Illinois coal-fields, an area of nearly one hundred thousand square miles.

In a short report on the stratigraphical palæontology of the Geological Survey of Kentucky, or rather in an introduction to a future palæontological report of the Survey of that State, I expressed the opinion that the Appalachian and the Illinois coal-fields were once continuous fields, and that the great axis of the Devonian and Silurian measures which separate them now, had been elevated at an epoch posterior to the formation of the coal. This opinion was not and could not be discussed in a short local report. I could there only give in support of it the fact of the identical distribution of the coal beds and of the coal flora in both basins. As it has been very courteously controverted in this Journal,* and especially as the discussion of this geological point enters into our subject and may help to satisfy the mind upon the value of the so-called new theory mentioned above, it is proper that I should briefly present the reasons in favor of my opinion.

It would be absurd to assert that the veins of coal or rather that the peat bogs of the coal formations were formed on a perfectly horizontal surface, and that the woody matter was deposited in the same thickness over the entire area. The most even plains have undulations on their surface; and the cross-section given in my report of a part of the Dismal Swamp of Virginia, should have explained my meaning. The peat bogs of our time are more or less broken or crossed by small elevations of sand or hills of some other deposit, which here and there break their horizontality and also their uniformity of features. For, although these irregularities may be scarcely elevated above the surface of the bogs, they are without exception, covered with a vegetation of entirely a different character from that of the peat bogs, and therefore their outline is perfectly definite. Sometimes groups of islands are thus seen rising in the middle of the bogs. Sometimes, also, as in the granitic country of the Hartz mountains, or in the basaltic region of the Rhoen mountains of Germany, peaks of granite or columns of basalt protrude like towers from some parts of the swamp. No one will contend that these irregularities break the continuity of a formation; or that the peat bogs on both sides of a hill of sand or around a block of granite are not a *continuous formation*. In a geological point of view, accidents like these cannot be taken into consideration.

* This Journal, vol. xxvi, p. 78, July, 1858.

But it is clear, at least to my mind, that the great ridge of Devonian and Silurian by which the Appalachian and the Illinois coal-fields are separated to a distance of from one to two hundred miles, cannot be regarded simply as one of those hills which separates two parts of a peat bog. We can discuss only these two alternatives: either the Silurian axis was not upraised at the epoch of the formation of the coal, and this formation, being in active progress upon the whole surface occupied now by the coal-fields and the Silurian and Devonian, was *continuous*, and consequently presented the same general features; or, the coal was formed on both sides of the ridge, and therefore in two separate basins, and then both formations, though of the same age, would have been subjected to some peculiar influences, and each of them would be characterized by some differences, either in the relative position of their coal beds, or in the composition of the strata, and especially in the distribution of their flora. The report of the Kentucky Survey shows on the contrary: that in both coal-fields, the coal beds are exactly in the same relative position; that at the same geological level, their shales contain the same species of plants; that from Eastern Pennsylvania to Western Illinois, the thinning of some strata preserves a perfectly regular progression, and does not show any change on one or the other side of the great ridge.

But there are some other reasons which may appear more conclusive.

1. The conglomerates, as also some beds of sandstone, especially the great Mahoning sandstone, are developed near the eastern limits of the coal-fields to a prodigious thickness. This heaping of loose materials, sand or gravel, evidently shows the prolonged action of the sea against its shores. Supposing that the Silurian ridge had been elevated before the formation of the coal, it would have necessarily served as a shore, and we should find somewhere a marked difference in the thickness of the transported materials abutting against it. No geologist has ever seen anything of the kind, and the conglomerates like some beds of coal and of sandstone, go thinning to the west with a constant and uniform decrease.

2. All the peat bogs are formed in basins, as also all the deposits of coal, and the outlines of these basins are of course generally broken and irregular. This fact is observable in the eastern and southern borders of the coal-fields. But on the sides of the coal-fields lying opposite each other along the great axis that separates them, the outline is well defined and unbroken.

3. In a basin where many beds of coal have been successively formed and separated by different strata, some of the upper coal beds must necessarily abut against the walls of the basin, when they are found in their horizontal position. In other words,

by the outward direction of the wall of a basin an upper bed ought to be extended somewhat beyond the lower and cover its margin. It is the case in the western borders of the Kentucky coal-fields, viz. in Christian county and other places, where the 4th coal above the conglomerate or the next bed below it, abuts against the older formation, when the lowest coal has to be looked for farther back towards the centre of the basin. On both the opposite sides of the Appalachian and the Illinois coal-fields, the appearances are different. It is the lowest coal, then the conglomerate, then the sub-carboniferous strata that appear one after the other upon the surface, following a dip corresponding to that of the sides. This undoubtedly shows that they participated in the movement which elevated the ridge that divides them, and that they were formed before its upheaval.

4. The undulations of the surface of the coal-fields, so distinctly marked in the vicinity of the Alleghany mountains that by lateral compression the veins of coal have been upraised in a perpendicular and even in a reversed position, are constantly repeated, though constantly less frequent and abrupt elevations westward. The upheaval of the Silurian ridge appears like one of those undulations, being generally in a direction parallel to the others.

5. The upheaval of the Alleghany mountains and the undulating movement caused by it upon an immense surface of country was very slow, and continued for a long period. The bends or flexures of the eastern coal, especially of the anthracite coal-fields are not jagged and angular, nor are they often broken by faults. The shales are polished by sliding, and rolled as if they had been folded in a soft state. The coal itself presents the same appearance, and at the bottom of the flexures, it is generally, as the miners well know, somewhat thicker than on the raised sides, as if the matter had slipped by its own weight when there was room for a displacement. Hence, it follows that if the undulating movement was slow, and if the strata of the coal measures were still in a soft state and easily removable, the top of the great ridge was necessarily and easily washed away as fast as it was being raised near and above the surface of the sea. No wonder therefore that the remains of the coal strata have not been preserved, and that we scarcely find any trace of them. The total disappearance of the coal washed away by erosion, is, I think, the only objection of any weight that has been or may be made against the opinion advanced in these remarks. But there are in Pennsylvania, in Ohio, and everywhere in the coal basins of the United States, evident traces of vast denudation that may be compared with the washing away of the Silurian ridge, and of which no trace has been left in the subsequent strata of this country.

It would be easy to multiply these considerations and to sustain the position by a number of geological facts. But so much is sufficient for our purpose, and we come back to the question of the formation of the coal. Upon the supposition then that at the time of the coal formations, the Appalachian and the Illinois coal-fields were united in one area, their surface would fairly be estimated at 300,000 square miles. Now, in the new theory presented above, we find it asserted: that the shales and the sandstone of the coal have been deposited upon the surface of the peat bogs of the coal formations by the inundations of some large river! Would it be possible for a sound mind to admit that a river can cover at once or even by repeated inundations, a surface of three hundred thousand square miles with a deposit of sand from six to one hundred feet thick, which is the thickness of the Mahoning sandstone.

Giving to the hypothesis the widest range of probability and considering as a peculiar Delta the area (sixty thousand miles) of the Appalachian coal-fields, still we find no geological phenomena of our time to justify it. Let us compare a few data. The whole plain of the Mississippi, comprising the Delta, from Cape Girardeau, 50 miles above the junction of the Ohio to the sea, covers an area of about 30,000 square miles. Would it be possible to suppose that an inundation would ever cover this whole surface with only a few feet of sand or of mud? According to the observations mentioned by Forshey, the mud transported in one year by the Mississippi river would cover a surface of twelve square miles with one foot of alluvium. At this rate it would take five thousand years for a river as mighty as the Mississippi to cover a single bed of the Appalachian coal-fields with one foot of shales.

Moreover, it is well known that a river cannot spread any of its transported material in a uniform manner, especially not in the deltas which are exposed to continual changes. For a delta is never composed of compact materials. It is mostly cut by variable and sometimes under currents covered only by a crust of vegetation, sustained by drift wood or floating upon the deep and muddy waters. These currents cause constant alterations: extensive marshes sink and are buried to a great depth below the general level of the country; lakes appear in some places and dry up in others; some bayous are filled and others opened. There are few square miles around New Orleans and on the Mississippi delta, that have not been thus subjected to violent disturbances, whose effects will be traced for ages in the most varied and disordered position of materials or stratification, if it can be so called. On the contrary, the stratification of the coal measures is of the most regular kind. The homogeneousness of the strata superimposed on the coal, especially the shales, shows

the total absence of a current at the time of the deposition of the matter. Not only the most delicate parts of the leaves of ferns are preserved in the shales, just as they fell from their supports; but we generally find around the same spot the remains of the same species. A kind of fern of which the deciduous leaflets are generally found separated from the stems (*Dictyopteris obliqua*, Bunb.), in some places completely covers the shales over a surface of from six to ten square feet, and without this space, not a single leaflet of the same species is found. It is evident therefore that the leaves have been buried at the place where the ferns grew and as they were falling from the stems. The slightest current would have made of all the matter a disordered mass in which leaves of every kind would have been mixed, not only in every position, but without regard to the place of their growth.

It is impossible to account for the successive deposits of shales and of sandstone by a river. When an inundation is at its height, it bears with it the heavier materials and these are deposited just as the current subsides. The sand would therefore be deposited before the mud or the sandstone formed below the shales and not above it.

But the deposits of all our great rivers, the Mississippi, the Ganges, the Amazon, the Po, is mud only. Sand is occasionally transported by a river or removed from one place to another by some strong current, but then it constitutes a bank and is generally a local formation of small extent.

All the great deposits of sand in our time, which by their thickness and extent, may give an idea of those which have covered the bogs of the period of the coal, are marine formations. The drift of North America and Northern Europe, our Pine-barrens of the south along the shores of the Atlantic; the pampas of South America, the heaths of Luneburg or sand plains along the southern shores of the Baltic Sea; the sand hills of Eastern Germany and Holland along the shores of the North Sea; the downs of the Gironde and of the Camargue in France; the sandy deserts of Syria, &c. No one of these formations can be referred to the direct agency of a river.

That the sandstone of the coal generally contains no remains of marine animals, does not prove that it is not of marine origin. The sand of our drift scarcely contains any of them. The hills of sand along the shores of the Baltic and the North Sea are almost entirely destitute of shells and animal remains. Sand is not only permeable to the all decomposing oxygen of the atmosphere, but it is a grinding agent, and as it is put in constant motion, either by the waves and currents of the sea, or by the wind, it is not to be supposed that even the shells would be long preserved in the loose materials. Yet in some places, the sandstone of the coal, especially when it is fine and soft, has

preserved the casts of marine shells, though not the remains. I have found them in many places, especially near Athens, Ohio, where a bank of soft sandstone is full of large *Producti* and *Terebratulæ*. But here, as in the sandstone of the lower measures, the animal remains have disappeared, and the mould only is preserved. It is the same with the prints of fossil wood found in the sandstone, which only shows the casts of Lepidodendra, Calamites, Sigillariæ, &c.; with only a thin lamina of carbonized bark, the whole substance of the wood having disappeared, except where silicification has taken place. This shows why the fossil remains are so rare in the sandstone, since even a cast can scarcely be made on loose sand.

In the shales of some beds of coal, especially in the southwestern part of our coal-fields, the remains of marine shells abound: some of the species are supposed to have lived in brackish water; but most of them like the fishes found in connection with them, appear to be true marine species. And what at first may look like an anomaly which will be explained hereafter, these marine remains are sometimes more or less mixed with leaves of ferns or land plants, and scarcely if ever with true marine plants or Fucoids. Thus, also, from palæontological evidence, the shales cannot be considered as deposits of a river any more than the sandstone.

The fact that the limestone of the coal measures cannot be thus disposed of, is fatal to this new theory. Its marine origin is evident and must be accounted for. And as the ocean cannot be swollen, like a river, it is necessasy to admit of a subsidence of the land for its submersion in the sea. But the supposition of a continual subsidence of a vast country is truly as violent an hypothesis as the supposition of an alternation of upheavals and subsidences of the same country, and the difficulty to account for the first proposition is far greater. Geological forces are not acting forever in the same way. It is now generally acknowledged that mountains have not been upraised in a single movement, but by a succession of gradual efforts, or by epochs of upheaval succeeded by epochs of rest, and consequently of subsidence; since a diminution in the activity of the internal forces cannot but cause a depression by the natural resistance or the weight of the upraised masses. We find proofs of such alternate changes of level at the present time; the movements of the ground about the temple of Serapis, so clearly explained by Lyell; the appearance and disappearance of some islands, &c., and especially in the stratification of our recent formations. The coal of the Miocene epoch was also formed by peat bogs upon an upraised land. The shales contain leaves of different species of trees of which the congeners are found in tropical regions. These shales are covered by successive strata of conglomerate, sand-

stone, and limestone. The coal and the lignite of the Pliocene epoch have been formed in the same way. Their shales contain remains of land plants, and sometimes also they are alternately covered by sandstone and limestone. The drift which is extended over the whole is as evident a marine formation as the limestone itself, and now it is in some places more than seven hundred feet above the level of the ocean. Is not this succession of land, freshwater and marine formations, in perfect accordance with the alternations of the strata of the coal measures, and can it be explained in any other manner than by the oscillation, the upheaval and subsidence of the land which supports these formations?

Even if the theory of continual subsidence could find in recent phenomena anything favorable to its support, it would be impossible to understand how a long protracted downward movement, especially of a Delta, would effect the repeated formation of coal beds; how the land being completely covered by the sea for the formation of the limestone, could be dried up again, so that the formation of the peat could begin anew, upon its whole surface. The river, says the theory, was still filling up again the whole space, while the madrepores were building the limestone. But this is pure speculation which is equally contrary to reason and to geological facts. For, if it is true that from causes which have not yet been clearly explained, the delta of the Mississippi is slowly subsiding, it is probable that if the subsidence was once active enough to permit the invasion of the sea over its whole surface, the soft matter, sand, mud and peat, of which it is composed, would be washed away by the marine currents, the tides, the waves, &c.

In the Report of the Geological Survey of Kentucky, I expressed an opinion which does not now perfectly satisfy my mind. I supposed that after the formation of extensive peat bogs, the subsidence of the land being at first very slow, the first result of the downward movement was a general inundation either of marine or of freshwater or of both mixed together. A depression of only a few feet of the great swamps of Southern Virginia would bring upon them by-and-by the waters of the surrounding rivers and also some water from the sea, either percolating through the sand or finding its way by some friths between the hills of sand extended along the shores. This supposition fully explains the formation of shales covered in some places with marine shells and remains of fishes mixed with land plants of the peat bogs. For, these plants, especially the ferns, mostly growing upon the thick and high rootstocks could still live in the swamps invaded by marine water. It explains also the local formation of the limestone in some depression of the marshes or marine lakes. But I supposed that after this period

of slow subsidence, the downward movement becoming more rapid, the sea broke through its sandy barriers and swept at once upon the whole plain, bringing with it the sand of its shores for the formation of the sandstone. I do not find this last supposition necessary. For, even with a slow movement of subsidence, continuous for a while, the sea ought to penetrate to the interior of the land, and with its continuous encroachments, bring forward with it the sand of its shores. This would better explain why some strata of coal and sandstone are thicker westward, where the bogs grew for a longer time and where the action of the sea was afterwards prolonged. It explains, also, why to the westward some veins of coal are double and generally more numerous than to the southeastern part of our coal-fields, this multiplication being caused by partial retrocession and advance of the marine element, which was felt only near the inside of the coal-fields and did not reach the deeper outside borders of the original basin. But there is no material difference between these explanations. In either case the repeated upheaval of the sea-covered land is supposed as a necessary condition of the formation of the peat; for this matter can grow only upon land where the water of the sea cannot reach.

To this last assertion which has not been contradicted, we can add the following: that peat never grows on swamps that are annually or periodically flooded by river water. Examining the swamps of the Mississippi, the theory says, that though covered annually by inundations, they are entirely untouched by river mud: that those favored spots are surrounded, particularly on the side next the river, by dense vegetation, which acting as a sieve, completely strains the mud from the water before it reaches the peat swamps. The water of these swamps is therefore pure, and pure peat has been deposited there for ages. Contrary to this authority, I must be permitted to say that during about thirty years of explorations in the peat bogs of Europe and of the United States, I have never seen the peat growing in places exposed to the inundations of a river. On this subject, there is better authority than my own. De Luc, in the beginning of this century, was the first to remark that along the banks of some rivers, the Elbe, for example, there were formed extensive beds of peat, which appeared to be lower than the water level of the river at the time of its inundations, and that nevertheless they were not covered by water, but by a peculiar vegetation which by its decomposition furnished the essential constituent of peat. In the prosecution of his researches, he observed that along these bogs the bed of the river was bordered by a natural embankment, which even in the highest rise of water prevented it from reaching the peat bogs. This damming up was fully explained by his remark: that at the time of the inundations and

when the water was most loaded with sediment, the heaviest particles of muddy matter were deposited all along on both sides of the river, just where the current began to lose its force; and that by this process, continued for a long period of years, a natural dam being built along some rivers, the marshes on both sides of it, and formerly inundated, were eventually put out of reach of the inundations. I have myself ascertained that the thin particles of sediment which were at first deposited upon the marshes, formed an essential preparation for the growth of the peat, viz. an impermeable basin, and that it was only when this basin was entirely isolated and protected against inundation that the plants of the peat bogs began to appear and the peat to grow. This process explains the formation of the fire-clay which underlies every bed of coal.

The true peat bogs of the Mississippi delta are mostly located on or near the old shores of some crooked bayou and surrounded on all sides by a kind of embankment. Thus they are free from the influence of river water which, though clear, would stop the growth of the peat, by destroying the peculiar vegetation of the bogs.

The action of the water in building its own banks along the principal bed of a river is beautifully exemplified in the United States, especially along the Mississippi and some of its tributaries. Both sides of the Minnesota river are thus bordered by extensive marshes which cover the bottom land to the base of the ridge of the prairies. In spring they are filled with water, while the banks of both sides of the narrow channel are mostly dry still high above water. It is then very difficult to cross those marshes from the river to the prairies or to land from a steamboat. Seen from the top of some hill near by, the Minnesota then appears like three different rivers running parallel and separated only by two narrow strips of land overgrown with trees. In the summer time, the marshes are mostly dry, overgrown with sedge and some willows; but no peat bogs have till now appeared in any part of their whole extent, because the separation from the river is not yet complete and because they are still exposed to annual inundations. In Minnesota, the peat bogs are found upon the prairies, near or around lakes without outlets, and on the banks of the upper Mississippi under the same circumstances as on the lower, viz. in such places as are beyond the reach of inundations. We may have occasion to extend these remarks farther when we come to consider the nature of the vegetation of the peat bogs.

In spring, at the time of our periodical inundations, the plants growing on the marshes of the Mississippi and along its shores are mostly lying flat upon the ground in a state of partial decomposition. The high canes only (Arundinaria) rise above water. And as they mostly bear their branches and leaves near

the top of the stems, or above water, these stems can not help much in the process of purifying the muddy water. Yet it is true that it becomes clear towards the interior of the marshes, but only as fast as the current becomes insensible or the water still.

Mr. Lyell has been quoted as authority for many assertions for which he can scarcely be held accountable, or at least for the conclusions which are drawn from them. Thus the *new* theory of the formation of the coal tries to find support in a geological assertion of the celebrated English author, an assertion that I do not recollect to have read in any of Lyell's works and which would truly show too much of ignorance of the palæontology and even of the strata of the coal measures. It is this: "In the sandstone of the coal formations, it is customary to find trunks of trees, but only trees, no small branches, leaves or tender parts. And these trunks are observed to be mostly pines, highland trees, while the trunks of the coal seams proper are Sigillariæ, Lepidodendra, Calamites, swamp trees, &c." From this, the new theory concludes: that the trunks are the remains of drift timber brought by the river from the high lands.—As if the sea could not and did not float timber as well as a river!

But it is not with the conclusion that we have to deal now, but with the assertion, erroneous in every point.

1. The trunks of trees are by far more rarely found in the sandstone of the coal than the small fragments of leaves, branches, &c. Some strata of sandstone, the Mahoning sandstone and others of the low coal measures, are sometimes entirely blackened by those small fragments of plants so bruised that it is scarcely possible to identify any species. This is not a local appearance; but it is observable in the whole extent of the coal-fields generally on the same stratum of sandstone. This shows a rapid movement of the sea, which sweeping with impetuosity upon the peat bogs of the coal, washed away part of the decomposed plants and peat bogs and mixed them with the sand.

2. Representative species of the Pine family have scarcely been found in the true coal measures. In the family of the *Cupressineæ* which has more than sixty species of fossil plants distributed in twenty genera, there is not a single species belonging to the coal epoch. In the family of the *Pines* which has at least one hundred and fifty fossil species known, distributed in twelve genera, there are only thirteen species which have been referred to the true coal measures. Two of these, *Peuce Hugeliana* Ung. and *Peuce australis* Ung., belong to uncertain formations of coal of Van Diemen and Vanguroë Islands. Of two other species, one, *Dadoxylum Beinertianum* (Endl.) belongs to the limestone (not to the sandstone of the transition epoch), the other *Dadoxylum Sternbergii* Endl. was wrongly ascribed to the coal and be-

longs to the Miocene of Haering in Tyrol. A fifth species, *Pinus anthracina* Ll. and Hutt., is a cone which was found in the *shales* of England. There are then only eight species of the pine family which have been found in England, in a bed of sandstone referred to the upper coal measures and described by Witham.

Admitting the position of this sandstone as true, though it is most remarkable that the remains of the Pine family should have been found in the coal measures of England only, there has been found in the sandstone of the coal measures 4 species of *Stigmaria*, 15 species of *Sigillaria*, 10 species of *Lepidodendron*, 3 of *Knorria*, 4 of *Halonia*, 6 of *Calamites*, 10 to 20 species of *Psaronius* and other stems. This would make at least 60 species outside of the Pine family for 8 in it. The same proportion would be true according to the number of specimens. In the state of Ohio, near Athens, there is perhaps the most extensive deposit of transported silicified trunks that it is possible to find anywhere. Of some thousand specimens that I have examined, all belong to the genera *Sigillaria* and *Psaronius*. A single specimen which is not yet determined has concentric circles, and may belong to the genus *Araucaria*.

From recent observations, it appears that the genus *Sigillaria* is related to the *Isoetes* of our time, a water plant. All the *Psaronii* are trunks of ferns and like the other genera quoted above, they all belong to the flora of the true coal formations, and are found in the shales also. Nevertheless, this does not put aside that part of the assertion: that some trees of the sandstone might have been transported from a dry land. It is a complicated question which may be examined at another time.

(To be continued.)

ART. IV.—*Some Remarks upon the use of the Microscope, as recently improved, in the investigation of the minute organization of Living Bodies;* by H. JAMES CLARK, of Cambridge, Mass.

[From the Proceedings of the American Academy of Arts and Sciences, Boston, Mass., January 26, 1859.]

I WAS incited to bring together my thoughts and experiences upon this subject, by discovering, three or four months ago, a novel feature in the so-called glandular dots of the wood of our common White Pine (*Pinus Strobus*, Linn.).

A dot of this kind is usually represented by a circle (fig. 1, C, *d*), in the centre of which is a single or double ring (*a*, *b*), which has about one third the diameter of the first (*d*). The outer circle (*d*) is described as the boundary of a lenticular space (A, *e*) between two *contiguous cells*, and the inner double circle (C, *a*, *b*) as the outskirts of a perforation (A, *a b*) in the deposit layer (*f*)

relief which has before been sought in vain, and what will be still more useful, to give permanence to the sort of molecular arrangement which the filings take, when exposed to magnetic influence.

Instruction can hardly fail to be derived from the use of these means, by aid of which it will be possible to study the figures more advantageously, which are, in some sense, the visible expression of the force animating bodies endued with polarity developed by magnetism.*

Nancy, March, 1860.

ART. IX.—*On some Questions concerning the Coal Formations of North America;* by LEO LESQUEREUX. Continued from Vol. xxviii, p. 21.

Geographical Distribution of the Coal Flora.

To follow the plan exposed in the first part of this memoir (Silliman's Journal, No. 82, July, 1859, p. 21) I should have to examine now the nature of the coal-flora, that is, the anatomical and chemical constitution of the coal plants, first comparing between themselves the groups of species of plants from which the matter of the coal is a compound, and then examining how this vegetation is related to the plants living at this epoch. The distribution of the coal plants, either geographical or stratigraphical, is a question accessory to the former. Nevertheless, it has become now of a greater importance, since it touches upon a problem which is at present discussed by the authority of the highest scientific names. I allude to the theory *of the origin of species* by Mr. Darwin. It evidently concerns the great problem of the inmost nature of man, and thus forces every naturalist to seek, in the sum of facts gathered up by his researches, either confirmatory or contradictory evidence of views which cannot but preoccupy his mind. Thus it is apparently advisable to change the order of examination of the flora of the coal measures of North America, studying it now in its stratigraphical and geographical distribution, and leaving for another opportunity the discussion concerning the nature of its vegetation and the specific and generic value of its representatives.

* This note is extracted from a work now in press and which will soon appear, entitled, *Electro-magnets and Magnetic adhesion*, and accordingly treats of electro-magnets and their application to locomotion upon railways, with the design of increasing the adhesion of locomotive engines. To the experiments which we made public in 1853 (v. this Jour., [2], vol. xvi, p. 337), we shall add new ones which allow us to expect a speedy solution of this problem, so important to railroads.

In regard to electro-magnets, we will only say at present, that we shall mention a great number of new species, which have compelled us to invent a new classification and a nomenclature based upon the principles of the natural method. We have also to make known a great number of new facts respecting the laws and properties of electro-magnets, to say nothing of what we wrote upon this point in 1853 (v. Am. Jour., [2] vol. xv, p. 381, and vol. xx, p. 100). J. N.

I shall not attempt in any way either an exposition or a critical examination of the views of the celebrated English author. This task has already been admirably fulfilled in a former number of this Journal.* I shall merely expose the facts that appear surely ascertained by a long and careful exploration of the coal-fields of North America, leaving the naturalist-philosopher to take from these facts any conclusion that may appear just to him. It is a mite only. But the monuments of humanity, like the mountains of limestone, are built by the slow accumulation of minute remains.

The botanical palæontology of the coal-period and the succession and variation of species in the different strata of the coal-measures, cannot be studied with more advantage and with more chances of reliability than in the coal-fields of the United States. Their immense area, the uniformity of their generally unbroken stratification, the facility of ascertaining in many localities the order of this stratification, the numerous exposures of coal banks, not limited to a particular district, but opened and worked now at distant points over the whole area of the coal-fields; all this affords to a systematic exploration such advantages as cannot be found in any other country of the world.

Moreover, my explorations of the coal-fields of North America have been favored by peculiar circumstances. Connected at different times, during ten years, with the geological surveys of the states of Pennsylvania, Kentucky, Indiana, Arkansas and Illinois; called to survey for comparison the coal-fields of Ohio and part of those of Virginia; constantly limiting my researches to botanical palæontology, I have thus, I suppose, collected on the distribution of the coal-plants in North America, more materials and more reliable accounts than geologists may be able to get at for a long time to come.

The first important question in regard to the coal-plants of America is: what is their relation of forms with the plants of the same formation in Europe? The comparison of the coal flora of both continents has never been made except on few and insufficient data.†

Except two, all the genera of fossil plants of the coal-fields of America are represented in Europe. One of them is the remarkable *Whittleseya elegans* of Dr. Newbury, a flabellate, apparently short pedicillate, cuneiform-oval and truncate leaf, found hitherto always detached from the stem. It evidently differs from the genus *Cyclopteris* by its simple straight nervation and by its up-

* Vol. xxix, p. 1.

† I have attempted it formerly, in my palæontological report of the Geological State Survey of Penn., delivered January 1st, 1854, but only published five years afterwards. As I have been denied the privilege of reviewing and correcting my manuscript before its publication, I cannot consider myself accountable for the errors, and especially for the deficiency of conclusive data, which may be found in it.

per margin being horizontally truncate and regularly wavy-denticulate by the percurrent and slightly emerging nerves. The typical affinity of this plant is unknown. It is perhaps more related to *Cordaites* or even to *Salisburia* than to a fern.

The second genus peculiar to the American coal-flora is my *Scolopendrites*, represented, like the former, by a single species; *Scolopendrites dentata* Lsqx., of which fragments only have been found. The name has no relation to the nervation of the leaf, but to its outline. This leaf is apparently five to six inches long, more than an inch broad, lanceolate, deeply cut by obtuse somewhat regular teeth and marked by a few very thin distant nervules, emerging from a narrow medial nerve in an acute angle, scarcely arched and forking twice. Both these genera represent peculiar types to which no form of the European coal-flora can be compared. I could also mention as a peculiar type of our coal-flora *Crematopteris Pennsylvanica* Lsqx., a thick stem or branch, on both sides of which short, lanceolate, obtuse, thick leaflets, without any trace of nervation, are pinnately attached. The single specimen which I have found of this plant was not well preserved enough, and it would be unsafe to consider the species which it represents as having been seen in its true form and full development.

If we admit the generic distribution of the fossil plants of the coal, as it has been established by Brongniart in his *Tableau des Genres*, (certainly the best that has been attempted either before or after him) all the European genera, even the undefined genus *Aphlebia*, (Sterbg.) have representative species in the coal-fields of America. From the nomenclature of Göppert and Corda, a few European genera, it is true, are hitherto without representative species in our coal-fields. But these genera, established on the form and the position of fructification, always very difficult to identify from even the best preserved specimens of fossil ferns, may be represented by some species of our *Sphenopterideæ* and *Pecopterideæ*. These genera, viz., *Rhodea* Sternb., *Trichomanites* Göpp., *Steffensia* Göpp., *Beinertia* Göpp., *Diplaxites* Göpp., *Woodwartites* Göpp., are no peculiar types. Thus, considering their generic distribution, the coal-plants of Europe and of North America show very little difference indeed. But in examining the species separately and comparing them on both sides of the Atlantic, the number of forms peculiar to America appears much larger than it was at first supposed, and thus the vegetation of our continent, at the epoch of the coal formation and considered in its whole, is far more different than it has been supposed heretofore.

It would be too long and tedious, perhaps, to take one by one and compare all the American species with those of Europe,

mentioning the identity, the relation, or the difference of each of them. I will therefore give in a table the number of species of each genus, belonging either to North America or to Europe, or common to both continents, and complete this general view by a few remarks on some of the species, apparently the most interesting, by predominance of number, of typical form or by a peculiar distribution.

Genera of Coal plants.	Species peculiar to America.*	Species peculiar to Europe.	Species common to both.
1. Noeggerathia Sternb.,	3 + 2*	5	1
2. Cyclopteris Brgt.,	1	2	2
3. Nephropteris Brgt.,	5	4	4
5. Neuropteris Brgt.,	18 + 1*	16	12
6. Odontopteris Brgt.,	4 + 1*	6	3
7. Dictyopteris Gutb.,	1	1	0
8. Sphenopteris Brgt.,	10 + 9*	41	12
9. Hymenophyllites Göpp.,	6	10	2
10. Rhodea Sternb.,	0	1	0
11. Trichomanites Göpp.,	0	4	0
12. Steffensia Göpp.,	0	1	0
13. Beinertia Göpp.,	0	1	0
13. Diplaxites Göpp.,	0	2	0
14. Woodwartites Göpp.,	0	2	0
15. Alethopteris Sternb.,	9 + 2*	20	9
16. Callipteris Brgt.,	2	1	1
17. Tecopteris Brgt.,	12 + 4*	49	12
18. Aphlebia Sternb.,	0	6	1
19. Caulopteris Brgt.,	4	4	0
20. Psaronius Brgt.,	10	6	0
21. Crematopteris Schp.,	1	0	0
22. Scolopendrites Lsqx.,	1	0	0
23. Whittleseya Newb.,	1	0	0
24. Cordaites Ung.,	1	0	2
25. Diplothegium Corda,	0	0	1
26. Stigmaria Brgt.,	5	2	5
27. Sigillaria Brgt.,	12 + 9*	37	17
28. Syrigodendron Brgt.,	0 + 1*	0	2
29. Diploxylon Corda,	0	0	1
30. Lepidodendron Brgt.,	14	10	11
31. Ulodendron Rhode,	0	4	2
32. Megaphytum Artis,	1 + 1*	4	0
33. Knorria Sternb.,	2 + 2*	1	2
34. Halonia Ll. & Hutt.,	0	2	1
35. Lepidophyllum Brgt.,	7	2	4
36. Lepidostrobus Brgt.,	?	1	2

* In this enumeration, I count the species named as new ones in a catalogue published in 1853 by Dr. Newbury (Nos. 8th and 9th of the Annals of Science of Cleveland). As the species have not been described and did not come under my examination, they are still doubtful and separately marked by a *.

Genera of Coal plants.	Species peculiar to America.	Species peculiar to Europe.	Species common to both.
37. Cardiocarpon Brgt.,	2 + 5*	6	0
38. Trigonocarpum Brgt.,	3 + 3*	5	5
39. Rhabdocarpos Göpp. & Brgt.,	1 + 1*	6	1
40. Carpolithes Sternb.,	12 + 1*	52	6
41. Selaginites Brgt.,	0	1	0
42. Lycopodites Brgt.,	1	12	0
43. Lomatophloios Corda,	1	0	1
44. Lepidophloios Sternb.,	0	0	1
45. Bothrodendron Göpp.,	0	1	0
46. Cycadloidea Buckl.,	0	1	0
47. Calamites Suck.,	2	5	11
48. Bornia Sternb. & Göpp.,	1	1	0
49. Equisetites Sternb.,	0	2	1
50. Asterophyllites Brgt.,	5	8	7
51. Annularia Sternb.,	0	0	5
52. Sphenophyllum Brgt.,	2 + 3*	3	3

Noeggerathia Sternb.—Two of the American species are closely related to *N. obliqua* Göpp. A third, *N. Bocksiana* Lsqx., which I referred to *Cyclopteris Bocksiana* Göpp., from the exact likeness of its terminal leaflet with the separate and only leaf on which the author has established his species, is evidently referable to the genus *Adiantites* Göpp. The two species of true *Noeggerathia* belong to the Old Red Sandstone of Pennsylvania; the third found at the base of the millstone grit of Pennsylvania belongs by its typical form to the true coal measures.

Nephropteris Brgt.—Cannot be separated from the genus *Neuropteris*, since it represents large, mostly rounded and deciduous leaflets attached around the stem at the base of secondary pinnæ of some *Neuropteris*. Two of our American species, viz., *Nephropteris fimbriata* Lsqx. and *Nephropteris laciniata* Lsqx. have a typical character which has never been seen on any of the fossil ferns of Europe. As the names indicate, both these beautiful species of leaves are fringed and laciniate on their circumference. The fringes and laciniæ are unequal in length and breadth, flexuous, and do not bear any likeness to the straight and regular points surrounding the fruit-bearing leaves of some ferns of our time.

Neuropteris Brgt.—Our *Neuropteris hirsuta* Lsqx. is, probably at least, the equivalent of *Neuropteris cordata*, *N. Scheuxeri*, *N. angustifolia* and *N. acutifolia*, species of M. Brongniart. A peculiar character of this species, viz., the long, straight, diffuse hairs of its upper surface may help to bring together the numerous and diverse forms of its leaflets, which are generally separated from the stem. Mr. Bunbury had already remarked and mentioned those hairs. I have not been able to detect them on the few, badly preserved specimens of the European *Neuropteris cor-*

data Brgt. which I had opportunity to examine. It may be also that *Neuropteris smilacifolia* Sternb., *N. plicata* Sternb., *N. rotundifolia* Brgt., ought to be referred as varieties to *Neuropteris flexuosa* Brgt. Nevertheless, we have these same scarcely distinct species with just the same characters in America. They are mostly found in the same places where *Neuropteris flexuosa* abounds. Of the other American species of this genus, *Neuropteris Clarksoni* Lsqx. is closely allied to *Neuropteris auriculata* Brgt., and *Neuropteris Desorii* Lsqx., to *Odontopteris Reichiana* Gutb. But *Neuropteris speciosa* Lsqx., *N. rarinervis* Bunby., *N. gibbosa* Lsqx., *N. undans* Lsqx., *N. dentata* Lsqx., *N. Morii* Lsqx. are widely different from any European species, and may be considered as true American forms or types. *Neuropteris adiantites* Lsqx. should perhaps be referred, by its peculiar nervation, to the genus *Sonopteris* of M. Ponsel.

Odontopteris Brgt.—I have counted *Odontopteris Brardii* Brgt., among the species belonging to both continents, on the authority of M. Unger, who indicates it at Mauch-Chunk, Pennsylvania. Nevertheless I doubt of the identity of our species with the true *O. Brardii* Brgt. The small specimen which I formerly referred to it belongs to another species, *Odontopteris crenulata* Brgt., and I would rather suppose that some incomplete specimen of *Odontopteris alata* Lsqx., has been mistaken for the true *O. Brardii* Brgt. Our species, though closely related to the European form, evidently differs from it by its obtuse leaflets, and by the position of two large, opposite, cuneate, truncate leaflets attached to the rachis just below the base of the pinnæ.—*Odontopteris Schlotheimii* Brgt., common to both continents, is one of the few species which, either in its fructified or sterile form, show a perfect identity at any locality where it is found.

Dictyopteris Gutb.—The affinity of the European *Dictyopteris Brongnarti* Gutb. with our *Dictyopteris obliqua* Bunby., is so great that these species could be considered as mere varieties of the same. *D. obliqua* Bunby. has narrower, less obtuse leaflets. These are generally found detached from the stem and spread over the shales in the greatest abundance.

Sphenopteris Brgt.—This genus, to which I have united the *Gleichenites* of M. Göppert, appears from the number of its species, to be far more abundantly represented in Europe than in America. Probably the difference may be accounted for, first by the number of European species which, established on small specimens, represent variable parts of a frond and may be recalled to a common species. Secondly by the insufficiency of our explorations. Since the publication of my catalogue of fossil plants of the coal, in 1858, ten new species of *Sphenopteris* not counted in the table, because they are still undescribed, have come under my examination. From the number of species enu-

merated by Dr. Newberry it would appear also that this genus is largely represented at some places and in restricted areas. Thus we may expect to see the number of American species largely increased.

The essential European types of this genus are all represented in our coal measures, either by identical species, or, by closely related forms. Thus we have: *Sphenopteris spinosa* Ll. and Hutt., *S. tridactylites* Brgt, *S. Davalliana* Göpp., *Sphenopteris irregularis* Gutb., *S. Gravenhorstii* Brgt., *S. Dubuissonis* Brgt., *S. latifolia* Brgt., *S. polyphylla* Ll. and Hutt., *S. artemisiæfolia* Sternb., &c. Besides, as American types, we have *Sphenopteris flagellaris* Lsqx., and especially *Sp. Newberrei* Lsqx. This last species has a ramification different from that of any other kind of fossil fern, viz., two secondary pinnæ, joined at their base and forking in an obtuse angle at the top of a short naked stem. The form of the leaflet and the nervation of this species is also peculiar. One of my species, *Sphenopteris decipiens* Lsqx. has, like *Neuropteris adiantites* Lsqx., the primary nerve folded along the base of the leaflets and the nervules curved and branching upwards, a character ascribed by Brongniart to the genus *Lonopteris* Tom.

Hymenophyllites Göpp.—From analogy of nervation, rather than from a relation of typical form, I have, perhaps wrongly, connected with this genus, some species referable either to *Aphlebia* Sternb., or to *Schizopteris* Brgt., or even to *Selaginites* Brgt. Four American species: *Hymenophyllites fimbriatus* Lsqx., *H. affinis* Lsqx., *H. hirsutus* Lsqx., *H. laceratus* Lsqx., are represented by fronds which form a broad base, divide in ascending, and are thus irregularly cut in simple, ordinarily short, curved, somewhat obtuse laciniæ or lobes. Each of the divisions is marked by a single nerve, ascending to its top. The fronds appear generally of a thick texture; but in *H. giganteus* Lsqx., which may be the same plant as *Schizopteris lactuca* Sternb., they are seemingly very thin. These species ought to constitute a separate genus. In the fossil flora of Pennsylvania I had attempted to group them together under the name of *Pachyphyllum;* but as some species have apparently thin leaves or fronds, the name could not be preserved of course. A discussion concerning the morphology of the plants of the coal would be out of place now. The subject ought to be separately treated. I needed only to mention these peculiar forms, for comparing the distribution of the genus *Hymenophyllites.* Two of our American species are closely related to the *H. elegans* Brgt. of Europe. The others, especially *H. fimbriatus* Lsqx., are apparently peculiar American types. This last, nevertheless, could be compared to *Selaginites Erdmani* Gutb.

Alethopteris Sternb.—All our American species have some affinity with European types of the same genus. Even the re-

markable *Alethopteris serrula* Lsqx. is related, though distantly, to *A. erosa* Gutb., from which it differs, especially by its very long (sometimes 4 to 5 inches), narrow, linear pinnæ. It has been found only near Pottsville, Pennsylvania.

Callipteris Brgt.—One of the American species, *C. Sullivantii* Lsqx., is a beautiful fern of a peculiar character, apparently bi- or tri-pinnate, but of which pinnæ only have been found. The general outline of the pinnæ is like that of *Alethopteris Serlii* Brgt. But the pinnules are twice as broad, rounded at the top, marked by a broad and deep medial nerve, abruptly terminating in the middle of the leaflets, and from which emerge in acute angles, thin arched, forked nervules as closely placed as those of *Neuropteris flexuosa* Brgt. The other American species is closely related to *Alethopteris sinuata* Brgt. *A. nervosa* Brgt. is a common species over the whole extent of our coal fields. As it is generally found connected (though not on the same stem) with *A. Sauveurei* Göpp. (*A. nervosa* var. Brgt.), both forms are referable to the same species.

Pecopteris Brgt.—The identification of the species of this genus is difficult. Here, as with the *Sphenopterideæ*, some species have been established on fructifications, which are seldom found in such a state of preservation that the form and the position of the fruit-dots can be ascertained, and others have been differently named from the branching of the veinlets, which differs in the same species according to the position of the leaflets. Thus identical species have received different names or even been placed in different genera. The number marked in the table represents only species of ours of which the value is ascertained. Some of them show apparently true American types. Thus, *Pecopteris Sillimani* Brgt., *P. Loschii* Brgt., *P. Velutina* Lsqx., *P. distans* Lsqx., *P. decurrens* Lsqx., and *Pecopteris concinna* Lsqx., widely differ from any European fossil *Pecopteridæ* known till now.

Caulopteris Brgt.—Uniting *Stemmatopteris* Corda, to this genus, we have at least four distinct species.

Stigmaria.—I think that the varieties of *Stigmaria anabathra* Corda, described by M. Göppert, are true species, being generally found in our coal-fields at different geological horizons. The five species described as new in the report of the Pennsylvania survey, may be perhaps reduced to three, but some well characterized species have been found since the report was made.

Sigillaria Brgt.—The distribution of this genus does not operate identically on the coal-fields of both continents. We have few species of the narrow-costate *Sigillariæ*, more than 30 species of which are counted in Europe. We have more of the broad-costate forms and especially a large number of species belonging to the peculiar section of the smooth or rather uncostate *Sigillariæ.*

In this last section, three well characterized forms are peculiar to our coal-fields. The one has its surface stellately wrinkled around the scars; the second is wrinkled crosswise, and the third has double, oval, obliquely-placed scars united by a deep groove, and the surface is beautifully reticulated by narrow wrinkles, obliquely intersecting each other. The beautiful *Sigillaria Schimperi* Lsqx., of which the large scars have nearly the form of an eye, is also a peculiar American form. The number of our species, as marked on the table, is too small. About ten new species belonging to the Geological State surveys of Kentucky, of Arkansas and of Illinois are not here counted.

Syrigodendron Brgt.—The two species described by Mr. Brongniart are common in America. I have never seen any other. Dr. Newbury indicates a peculiar species of ours under the name of *S. Americanum* Newb.

Lepidodendron Sternb.—The great number of specimens of this genus collected from the base and the top of the millstone-grit series of our coal measures, has afforded a good opportunity for examining the development and variations of the scars at the different stages of growth of the trees. Except *L. oculatum* Lsqx., which might be referred perhaps to *L. distans* Lsqx., all the new species described in the report of the survey of Pennsylvania are well characterized. Some of them might be considered as American types. *L. distans* Lsqx., is related, by the distance of the scars only, to *Sagenaria rimosa* Sternb.

Megaphytum Artis.—A beautiful and large specimen of a new species of this genus is preserved in the cabinet of the Geological State Survey of Illinois. Another new species is mentioned by Dr. Newberry under the name of *M. discretum* Newb.

Knorria Sternb.—The number of American species is apparently pretty large; but the difficulty of determining the species from specimens generally badly preserved has prevented or retarded the descriptions. *Knorria imbricata* Sternb., is especially common below the millstone grit.

Lepidophyllum Brgt.—We have already seven well characterized American species, and three new and unpublished ones. The number of peculiar forms of these scales or leaves of the cones of *Lepidodendron*, evidently shows that the large proportion of species of *Lepidodendron*, which have been found in America, cannot be considered as resulting from peculiar changes of the same species, according to the age of the scars. *Lepidophyllum hastatum* Lsqx., *L. brevifolium* Lsqx., and *L. plicatum* Lsqx., are American types not related to any European species.

Lepidostrobus Brgt.—The number of cones of *Lepidodendron* is extremely large, especially in the shales of the first bed of coal above the conglomerate. All the species ascertained, from the

form of their scales, apparently the only reliable specific character for a determination, are counted with *Lepidophyllum*.

The fruits distributed among the genera *Cardiocarpum* Brgt., *Rhabdocarpos* Göpp. and Berg., *Trigonocarpum* Brgt., *Carpolithes* Sternb., are generally found broken or flattened or divested of their outer envelope. Consequently the identification of the species is very difficult. The number of these fruits disseminated in the shales and in the sandstone of the low coal of our American basin is considerable. They follow the stratigraphical distribution of the genus *Lepidodendron*, though they do not appear in any way related to this genus. About twenty well marked but undescribed species ought to be added to those counted in the table. Some of them have peculiar forms without relation to any European species. One of the most remarkable, *Rhabdocarpos arcuatus* Lsqx., is described and figured for the fourth volume of the Geological Report of the State Survey of Kentucky, under the direction of Dr. D. Dale Owen.

Lycopodites Brgt.—Nothing, perhaps, shows more evidently the difference in the characters of the coal flora of both continents than the scarcity of species of *Lycopodites* and the abundance of species of *Lepidodendron*, in our coal measures; when a contrary distribution rather predominates in Europe. Both the genera are considered as closely related. Nevertheless we have a single species of *Lycopodites*, very rare indeed, since I found specimens of it only lately on both the extreme limits of the state of Kentucky, at the same geological horizon, viz., in the shale of coal No. 1B. By its concave leaves, decurrent and embracing at the base, it differs from any of the twelve European species of the coal yet described Dr. Newberry has not mentioned any species of this genus in his catalogue.

Asterophyllites Brgt.—As some species of this genus are represented by catkins, scarcely if ever found attached to the stems, and of which therefore the relation is obscure or unknown, I may have counted as peculiar to America a few species which are only fruiting modifications of some others. I consider those fruits as male catkins, attached to large branches, while the true fruit-bearing catkins, which are much smaller, were apparently terminating the branchlets;—a kind of fructification somewhat analogous, but in a position contrary to that of some pines.

Without including the species of Dr. Newberry, the table of distribution shows that from six hundred and fifty-five species of coal plants now determined; more than one hundred and sixty are peculiar to America; three hundred and fifty species are known only in Europe; and one hundred and fifty are common to both. It is certain that future researches will greatly add to the number of species common to both continents, but as much, also, to the number of species peculiar to America. There-

fore, the difference pointed out by the table, may be admitted as fairly representing, in a proportional manner, the general distribution of the coal plants on both continents. The botanical remains of the coal-fields of Europe have been carefully collected and studied by learned naturalists for more than a century, while those of America are only beginning to be noticed by scientific explorers.

In the Introduction to the Fossil Flora of the coal-fields of Pennsylvania, I had already pointed out the great analogy existing between the plants now living on the peat-bogs of America and of Europe. Admitting the peat-formation of our time as being the actual representative of the coal-marshes of the coal-epoch, I was led to the conclusion: that at this last epoch, the flora of both continents was as different and even more different than its representative flora is at our time. Thus, on twenty-five species of mosses growing on the peat-bogs and entering into the formation and composition of the peat, a single one is peculiar to North America. By extending my researches to the South, namely to the latitude of Norfolk, in the great Dismal Swamp of Virginia, I found the proportion changed in some manner; but nevertheless, the most common forms of the genus *Sphagnum*, which in Europe and North America form the principal mass of the peat, were found there also, performing the same work in the composition of the combustible matter. In the family of the Ferns, out of ten species growing on our marshes, five are identical with European species growing in the same situations; and two more are so closely allied to their European congeners that in a state of petrifaction, they could not be distinguished from each other. Even now, in their normal state, they are admitted by some botanists as varieties only. Among the *Junceæ*, *Cyperaceæ* and *Gramineæ*, twenty-six species out of forty-one are common to both continents; and from the other families, of which representatives are found on the peat-bogs, twenty-six species of thirty-one are found in Europe and in America. The likeness of some species of this section, peculiar to both continents, is still remarkable. Thus, *Larix Americana* and *Larix Europæa*; *Nymphæa odorata* and *Nymphæa alba*; *Ledum latifolium* and *Ledum palustre*, *Trientalis Americana* and *Trientalis Europæa*; *Vaccinium macrocarpum* and *V. Oxycoccos* (many others still could be named), are so nearly related that their specific characters can be distinguished only on good and complete specimens. There are, indeed, on the peat-bogs of America, some peculiar types which are not found in Europe: *Xyris bulbosa*, *Taxodium distichium*, *Sarracenia purpurea*, and a few others. But it is even so with the plants of the coal-period where we have seen certain types peculiar to this continent. This peculiarity serves only to render the more strik-

ing the analogy of distribution of the flora of both epochs. It shows the same degree of difference and of analogy. Some species, even a few types, peculiar to each country, the greatest number of them peculiar to America; many identical species, and especially many forms, so nearly related, that it becomes very difficult to separate them by specific characters.

Columbus, Ohio, April, 1860.

(To be continued.)

ART. X.—*On an Oil-Coal found near Pictou, Nova Scotia; and the Comparative Composition of the Minerals often included in the term Coals;* by HENRY HOW, Prof. Chemistry and Nat. Hist., King's College, Windsor, N. S.

THE name given to the substance I purpose describing indicates the use to which it is put, viz., the manufacture of paraffine-oil, and an inquiry into the association of elements in the minerals constituting the sources of this and similar "mineral-oils" and in the bituminous coals, may possess some interest in a chemical point of view. As regards the classification of these it is not necessary to do more than recall the attempt made a few years ago in courts of law, in Scotland, New Brunswick and Nova Scotia, to decide what should and what should not be called a coal. The great array of evidence of various kinds brought to bear on the question rendered it a very interesting one, and it is well known that the opinions of the numerous scientific men consulted on these occasions were so nearly balanced that the point at issue was determined on the commercial, rather than on the scientific merits of the cases. It will be remembered that the substances in dispute were the Torbane-hill "coal," found near Bathgate in Linlithgowshire, Scotland, and the Albert "coal," occurring at Hillsborough, New Brunswick. As respects the former, the result of the trial in Edinburgh, in 1853, was that the jury considered it to be "coal, in the common sense of that word;" and, as regards the latter, it was decided at Fredericton, N. B., 1852, and at Halifax, N. S., to be also a "coal." Notwithstanding these legal decisions, which, from the conflicting opinions of witnesses, were obviously arrived at from other than scientific considerations, the question as to what is and what is not a coal, must be held to be an open one in those sciences in whose province the matter lies; and it will probably long remain so, because it was not from the absence of data, but from differing interpretations of facts about which for the most part there was a general accordance, that there arose the well known want of unanimity among geologists, mineralogists, chemists and microscopists.

Art. XXXIII.—*On some Questions concerning the Coal Formations of North America;* by Leo Lesquereux.

(Continued from page 74.)

Stratigraphical distribution of the Coal-flora.

Details concerning the stratigraphical distribution of the coal-flora of North America, to be intelligible, ought to be prefaced by a few remarks on the order of superposition of the strata of the coal-measures.

A general section, showing the order of stratification in the whole extent of our coal-fields, would appear perhaps merely hypothetical. Such is, nevertheless, the uniformity of the distribution of the strata of our coal-basins, that a section made in Western Illinois or Western Kentucky or in any part of the coal-fields of these States, will prove comparatively similar, (that is with some difference in the thickness of the strata,) to any section made in the coal-fields of Pennsylvania or of Ohio. This analogy of stratification has been fully established by a series of comparative sections, reported for the 4th vol. of the State Geological Survey of Kentucky. Such a comparison of sections had been attempted before, for the State of Pennsylvania, by my friend J. P. Lesley, in his excellent Manual of Coal. But it was not based on palæontological evidence and thus the contemporaneousness of the juxtaposed strata was necessarily problematical. On the contrary, by admitting the similarity of the flora of the coal-strata as a coëval mark and as a basis for juxtaposition of the strata, the result of the comparison of sections gives evidence remarkable in a double point of view. First it shows, by juxtaposition of the coal strata of which the shales contain the same species of fossil plants, the uniformity of stratification in the whole area of the coal-fields of the United States; and secondly it proves that the distribution of the coal plants has followed the same developement, the same successive modification in the whole extent of the same coal-field.

Though plants of carboniferous genera are found below the upper bed of the Archimedes or mountain limestone, as, apparently, no coal has been formed at this low station, I take as the base of the true coal measures this Archimedes limestone, replaced in Eastern Pennsylvania and Northern Virginia by the red shales of the old red sandstone. From the top of the mountain limestone, to the top of the millstone-grit series, including some beds of coal at its base, the average thickness is from three to four hundred feet. The upper part of the millstone-grit series, sometimes its whole thickness, is a compound of coarse sandstone, shales and especially conglomerate, the last predominat-

ing. The conglomerate formation thickens wonderfully at some places, generally increasing westward. Its greatest thickness, in the sharp Mountain near Pottsville, Penn., is 1100 feet.*

To elucidate the details of this general section, we can admit the numbered division of the coal strata, as it has been most satisfactorily established by Dr. D. Dale Owen for the State Geological Survey of Kentucky, vol. iii, p. 18. From the top of the millstone-grit to the base of another great sandstone formation, the Mahoning sandstone, there are generally five workable beds of coal. The lowest is No. 1A; then No. 1B to No. 4 inclusively. No. 1B coal is the Big, or Mammoth coal of the East. Like the conglomerate, it increases in thickness progressively westward. The fourth bed of coal is the Pomeroy coal of Ohio. The Mahoning standstone overlying No. 4 bed of coal, like the millstone-grit is generally conglomerate at its upper part. Its thickness averages from one hundred to one hundred and fifty feet. It might, as well as the true conglomerate, be considered as the basis of a new coal epoch; even more so, perhaps, since the vegetation at its base and at its top shows a greater difference than in the coal strata above and below the millstone-grit. From the Mahoning sandstone upward, the marine influence predominates more and more and the shales of the coal strata more generally contain remains of fishes and of marine shells than of terrestrial plants. This Mahoning sandstone is separated by about 500 feet of strata from another great sandstone formation still resembling in its composition and thickness the Millstone-grit or conglomerate. It is the Anvil-rock sandstone of the State Geological Survey of Kentucky. The 500 feet of measures between it and the Mahoning, are sometimes barren of coal. But westward they contain from Coal No. 6 to No. 12, five workable beds of coal and two, scarcely if ever, of a workable thickness.† The highest coal strata of this section, Nos. 11 and 12 united together, form the great Pittsburg coal bed of Pennsylvania.

Above the Anvil-rock sandstone, there are still 500 to 700 feet of coal measures, in which some thin beds of coal are formed. But this examination of the flora of the coal measures can not be extended higher than the Anvil-rock. The upper division has been locally washed away by erosion and where it is still present, its coal beds are too thin for working and thus their unexposed shales can not be satisfactorily examined. Near Shawneetown, Illinois, the first coal above the Anvil-rock

* H. D. Rogers's final report of the State Geol. Survey of Pennsylvania, vol. i, p. 109.

† In those coal regions of the United States where coal is abundant, a bed of bituminous coal is not remunerative, when under a thickness of three and a half feet. In the Anthracite basin, the working becomes unprofitable for a bed of less than two and a half feet.

sandstone has a roof of laminated sandstone, blackened by broken and undeterminable leaves and small stems of ferns. The second bed at the same place contains only fossil shells and remains of fishes.

The first trace of a terrestrial vegetation in the Palæozoic strata of North America appears in the Marcellus shales or middle Devonian, in a species of *Lepidodendron* named *L. primævis* by Prof. H. D. Rogers.* It has not been described, but only obscurely figured by a wood-cut; and as I have not seen the specimen and could detect at the place where it has been found, near Huntingdon, only detached leaves of this species, its relation or its specific value is unknown to me. In the Devonian black shales of Ohio, and perhaps of Illinois,† large silicified trunks of trees have also been found, always very rare and at far distant localities.

Ascending higher, we find species of *Lepidodendron*, of *Sigillaria*, and especially of *Calamites* and stems (*Bornia* Sternb. and *Stemmatopteris* Göpp.) in the transition series of the Old Red sandstone of Pennsylvania, and especially in the Mountain limestone by which it is represented in the Western States. Leaves are very rare in this formation and of a different type from those of the coal measures. Heretofore, all those which have been found belong to the genus *Noeggerathia* (Sternb.), of which I have never seen a single specimen in the true coal measures.‡ Below the 3d or upper Archimedes limestone, there is in Illinois and in Arkansas a bed of schistose sandstone which, with peculiar species, already contains some others of the true coal measures. In the Cabinet of the State Geological Survey of Illinois, I have seen from this subcarboniferous sandstone, specimens of *Stigmaria anabathra* (Corda), and Göppert's varieties: *minor*, and *undulata, reticulata, stellata;* of *Lepidodendron Veltheimianum* Sternb., a species peculiar to the transition series, both in Europe and America; *of Lepidodendron Worthianum* Lsqx., a beautiful species related to *L. Volkmannianum* Sternb.; one *Lepidodendron* sp. nov.; one *Caulopteris*, one *Megaphytum*, all three new and undescribed species; *Calamites Suckowii* Brgt.; one *Bornia* Sternb.;

* Final report of the State Geol. Survey of Penn., vol. ii, p. 828.

† Mr. A. H. Worthen, State Geologist of Illinois has in his cabinet this Devonian silicified wood without label of locality. It is also in the cabinet of Dr. D. Dale Owen at New Harmony, also without label, All my specimens have been cut from a large tree protruding from Devonian strata near Delaware, Ohio, and discovered by Dr. Mann, who kindly communicated them to me. It is by all appearance the wood of a Lepidodendron, and it will be figured and described with the silicified Psaronius of the coal measures.

‡ Dr. Newberry mentions in his catalogue two species of Noeggerathia found in the coal above the conglomerate. One is *Noeggerathia Beinertiana* Göpp., a species evidently referable to *Cordaites* Ung., and probably only a small form of *Cordaites borassifolia* Ung. The other is *Noeggerathia microphylla* Newb., undescribed and consequently unknown to me.

Cordaites borassifolia Ung., *Knorria imbricata* Sternb., and some undeterminable stems. From these plants, six have been found also above the conglomerate series, ascending to coal No. 1B, or even higher. They are *Stigmaria anabathra*, var. *undulata* Göpp., and var. *minor* Göpp., *Lepidodendron Worthianum* Lsqx., *Knorria imbricata* Sternb., *Calamites Suckowii* Brgt. and *Cordaites borassifolia* Ung. These two last species are present in the whole thickness of the coal measures, as high at least as the 12th coal.

As I have said before, no coal has been seen as yet formed below the 3d Archimedes limestone. But just overlying it, a bed of coal is generally present over the whole extent of the Western coal-fields. In Arkansas, this is the only workable bed of coal, its thickness varying from 18 inches to 4½ feet. In the western part of the Eastern coal-basin of Kentucky, and also in Virginia, two, even three beds of good coal have been formed below the millstone grit. All the species of fossil plants of the shales of these coal strata have been found also in Arkansas. At Pottsville and Mauch Chunk, near the eastern margins of the coal-fields, the coal is formed between strata of conglomerate, and even at the base of this formation.

The shales of the subconglomerate coal contain not only remains of trees of large size, like the subcarboniferous sandstone, but thus early and simultaneously many of the species of ferns which become more and more abundant above the conglomerate series. Thus *Pecopteris velutina* Lsqx., *Neuropteris flexuosa* Brgt., *N. hirsuta* Lsqx., *Sphenophyllum Schlotheimii* Sternb., *Pecopteris nervosa* Brgt., *Annularia sphenophylloides* Ung., *Odontopteris crenulata* Brgt., *Cordaites borassifolia* Ung., *Hymenophyllites furcatus* Brgt.: and *Sphenopteris latifolia* Brgt., all found there in connection with it, ascend to coal No. 1B or higher. Among the trees seen in this coal, and ranging still higher in the measures, there are six species of *Lepidodendron*, two of *Sigillaria*, two *Calamites*, *Stigmaria* and its varieties, and a few species of *Carpolithes* and of *Cardiocarpon*. Though this subconglomerate coal has not been yet explored over a large area, it shows already more than twenty species, representing all the essential genera of our coal-plants, which have a wider range of distribution, and appear still in the coal strata above the conglomerate. It is therefore evident that a separation of the subconglomerate coal, as a peculiar formation and under a peculiar name, is contrary to palæontological evidence. Like every other coal bed the subconglomerate coal has species peculiar to it. Two species of *Lepidodendron*, two of *Sigillaria*, one of *Sphenophyllum*, two species of *Trigonocarpum*, one very large *Cardiocarpum*, one *Stigmaria*, one *Alethopteris*, and three or four *Sphenopteridæ*.* In the shales of this lowest bed of coal, near Frog

* All the new species of this coal, or at least most of them, belong to the State Geological survey of Arkansas, and are reserved for publication in the second volume of that Report.

Bayou, Arkansas, I have found for the first time in America one of those beautiful wings of insects, referred by M. Germar to the genus *Blattina*. Though related to *Blattina didyma* Germ., our American species is new.

The first bed of coal above the conglomerate, our No. 1A, is generally thin (two feet to four feet thick at the most), and overlaid by a stratum of coarse sandstone or of black very bituminous shales. In the shales, I have never found any other remains of plants, than leaves and cones of *Lepidodendron*, six species of *Lepidostrobus* and *Lepidophyllum*. The shales are too bituminous for good preservation of specimens. With the remains of plants, the shales generally contain a few specimens of *Lingula umbonata* Cox, a shell extremely abundant in the shales of No. 1B, and rarely represented by a very few individuals in the coal No. 2. Sometimes coal No. 1A and No. 1B become united together, being separated only by a thin parting of shales, but more generally there is between them a stratum of coarse sandstone, marked with numerous prints or casts of great vegetables of the coal, especially of *Lepidodendron obovatum* Sternb., *L. rimosum* Sternb., *L. rugosum* Sternb., *L. aculeatum* Sternb., *Sigillaria alternans* Ll. and Hutt., *S. reniformis* Brgt., *S. Brardii* Brgt., *S. lævigata* Brgt., *Sirigodendron pachyderma* Brgt., and some fruits, *Carpolithes* and *Trigonocarpon*. Other species, one *Caulopteris*, one *Megaphytum*, some *Calamites*, all rendered undeterminable by the coarse compound of the sandstone, have been seen in this stratum.

Coal 1B. Its horizon appears to mark the epoch of the highest development of the vegetation of the coal formation. Not only is this coal bed the most reliable of all, and consequently the most extensively worked, not only does it attain locally an enormous thickness, justly meriting the name which it bears in some parts of Pennsylvania, viz., the *Big Coal*, the *Mammoth vein*, &c.; but the shales which cover it and sometimes divide it into two, three, or more members, afford to the explorer the greatest amount of species, distributed among nearly all the genera of plants which belong to the coal formation.

The vegetation of coal No. 1B may be characterized: First, by the great number of fruits, found in the strata connected with it, either in the shale above or in the sandstone below. Indeed, nearly all the species of *Trigoncarpum*, *Cardiocarpum*, *Rhabdocarpos* and *Carpolithes* belong to it. Its second characteristic, is the great abundance of species of *Lepidodendron*. Eighteen species of this genus have been found in this bed of coal, and no new species have been, as yet, seen above it. A third character is the constant presence in the shales of our No. 1B of *Alethopteris Lonchitidis* Brgt. which apparently belongs exclusively to it. Generally speaking, the coal has the great forms of the section of the *Pecopterideæ*, viz. *Alethopteris* and *Callipteris*, and is mostly

deprived of the true *Pecopteris* or of the small forms of the order. *Alethopteris Serlii* Brgt., is met in its shales, but is very scarce; the species rather belongs to No. 3. It has *Alethopteris marginata* Brgt., not seen in any other horizon; also *Alethopteris lævis* Lsqx., probably peculiar to it, and *Alethopteris nervosa* Brgt., which ascends higher. Besides the genus *Pecopteris* Brgt., I cannot mention any species peculiar to this coal. *Pecopteris velutina* Lsqx., a fine species, which by its fructification would be referable to a separate genus, was found in its shales; but we have mentioned it also with the subconglomerate coal. *Pecopteris Miltoni* Brgt., or *P. polymorpha* Brgt. (probably the same) is a species found sometimes in its shales; but it is common in the whole thickness of the coal measures. *Pecopteris pennæformis* Brgt., *P. Sillimanni* Brgt., *P. plumosa* Brgt., *P. villosa* Brgt., are connected with it, but are found still higher in the measures. The fourth character of this coal is the great number of species of large *Sphenopterideæ* and of *Hymenophyllites* connected with it. *Sphenopteris latifolia* Brgt., *S. obtusiloba* Brgt., *S. glandulosa* Lsqx., *S. polyphylla* Ll. and Hutt., *S. Newberryi* Lsqx., *S. artemisiæfolia* Brgt., with *Hymenophyllites Hildrethi* Lsqx., and *H. spinosus* Göpp., have not been hitherto found except with this coal.

Of the genus *Odontopteris* Brgt., all the American species are connected with No. 1B, except *O. crenulata* Brgt., which first appears in the subconglomerate coal.

Among the *Sigillariæ*, it has as species peculiar to it, *Sigillaria stellata* Lsqx., *S. Serlii* Brgt., *S. tessellata* Brgt., *S. Brochanti* Brgt., *S. alveolaris* Brgt., *S. oculata* Brgt., *S. polita* Lsqx., *S. obovata* Lsqx., *S. alternans* Ll. and Hutt., *S. discoidea* Lsqx., and *S. catenulata* Ll. and Hutt.

By far the greatest number of specimens preserved in the shales of this coal belong to two species which we have seen already below the conglomerate, viz. the omnipresent *Neuropteris hirsuta* Lsqx., and *N. flexuosa* Brgt. Although these two species are so abundantly represented in our coal No. 1B, that sometimes their remains exclusively, fill the roof of some mines, other species of *Neuropteris* are scarcely found in connection with it. *Neuropteris tenuifolia* Brgt., and *N. smilacifolia* Sternb., belong to it; but both species are very scarce and closely related to *N. flexuosa* Brgt. The last especially may be considered as a variety of it. *Neuropteris lancifolia* Newb. is an undescribed species, found in the shales of this coal, perhaps only one of the numerous forms of *N. hirsuta* Lsqx.

Connected with this remarkable coal bed, we still find *Cordaites borassifolia* Ung., and *Dictyopteris obliqua* Bunby., locally distributed; *Whittleseya elegans* Newb., formerly described and found at one or two places only; species of *Asterophyllites*, *Annularia* and *Sphenophyllum*, but none of them peculiar to it, and species of *Calamites*, especially *C. Suckowii* Brgt., *C. Cistii*

Brgt., *C. nodosus* Brgt., *C. approximatus* Brgt., and *C. cannæformis* Brgt., some of which ascend higher in the coal measures. I never found in it any specimen referable to *Calamites pachyderma* Brgt., which M. Geinitz unites, I think incorrectly, to *C. cannæformis* Brgt. Its true place is within the sandstone of the Millstone grit. Thus also, from dissimilarity of distribution, I would admit with Mr. Brongniart *Calamites decoratus* Brgt., and *C. Suckowii* Brgt., as distinct species, though they are also united by M. Geinitz; the last belonging especially to this coal, the former to a higher bed, No. 3d.

It is perhaps useless to mention that *Stigmaria ficoides* Sternb., is also present with our coal 1B. It has not only penetrated by its leaves the fire clay which the coal overlies; but has filled the coal also by its remains:—moreover, contrary to the assertions of some authors that *Stigmaria*, being a root, is found only in the bottom fire clay of the coal strata,—it has mixed its remains in the shales of this bed, and even sent them into the sandstone by which they are overlaid, or sometimes replaced. Thus, in the absence of other remains, or until I had discovered them, the abundance of *Stigmaria ficoides* in the roof-shales has helped me to identify this coal in many places.

The roof shales of No. 1B coal are occasionally overlaid by a stratum of limestone or argillaceous shale, containing a great abundance of fossil shells. Locally also, and where this limestone is absent, its place is taken by a bed of coal, variable in thickness from one to four feet. As it is rarely formed, and sometimes in close proximity to No. 1B, I consider it still as a member of No. 1B; and it is accordingly ranked in my sections as No. 1C. Though it has no great value,* its combustible matter being a compound of half decomposed stems, mostly transformed into charcoal and rusted by oxyd of iron, it is worth mentioning as an evidence of conformity of composition of the shales and of the coal strata at the same geological horizon over a wide area. The shales of this bed, even the coal itself, appear like a compound of broken, heaped up stems of ferns and *Calamites*. Now, it is found with exactly the same appearance, either of shales or of coal, on the western limits of the eastern coal basin of Kentucky, near Greenupsburg; in Virginia, on the Tug river; and in the middle of the great Apalachian coal basin, near the mouth of Yellow creek, in the Ohio river, above Steubenville, Ohio.

Coal No. 2, is generally placed at about one hundred feet above No. 1B, and separated from it by various strata of shales and sandstone, and occasionally by the limestone mentioned before, or also by a cherty compound named Burrstone. Its roof-shales

* It is particularly well developed in the northern part of the coal basin of Illinois and Indiana where I have seen it lately from four to six feet thick of pretty good coal.

are coarse, micaceous, and generally barren of fossil remains; but it is separated into two by a shale parting, of from two to eighteen inches, which contains a great abundance of broken remains of plants. Here, we have scarcely any trace of *Lepidodendron*, but a remarkable abundance of *Calamites*, *Asterophyllites*, *Neuropteris flexuosa* Brgt., *Neuropteris hirsuta* Lsqx., *Cordaites borassifolia* Ung. I have found with this coal *Lepidodendron obovatum* Sternb., *Sigillaria Brardii* Brgt., with its leaves, and an undescribable *Lepidostrobus* Brgt. Without doubt, it has many peculiar species, but I have never found the shales hard enough for preserving specimens even of a moderate size. As soon as they are exposed to atmospheric influence, they are rapidly broken into minute particles by efflorescence of the sulphuret of iron, generally predominant in this coal. Its vegetation, as far as can be seen, is intermediate between No. 1B and No. 3d coal, the number of predominating species being from the genera *Asterophyllites*, *Annularia*, and especially *Calamites*.

Coal No. 3 is variable in thickness, and is not as generally and as uniformly formed as No. 1B. Wherever it has been seen it is overlaid by a roof of gray soft shales containing a great quantity of well preserved remains of plants. It has still a few species of *Lepidodendron*: *Lepidodendron dichotomum* Sternb., and especially its branches, are abundantly distributed in its shales, with a great number of its long cones, *Lepidostrobus variabilis* Brgt., and its leaves. *Dictyopteris obliqua* Bunb. is still found connected with it and locally distributed as in coal No. 1B. It has also in abundance *Neuropteris hirsuta* Lsqx., and *N. flexuosa* Brgt., and as peculiar species of this genus, apparently belonging exclusively to it, *Neuropteris Clarksoni* Lsqx., *N. gigantea* Sternb., *N. delicatula* Lsqx., and *N. rarinervis* Bunby. The genus *Sphenopteris* Brgt. is represented in this coal by *Sphenopteris flagellaris* Lsqx., *S. Lesquereuxii* Newb., and by an *Hymenophyllites*, intermediate between *H. elegans* Brgt., and *H. Hildrethi* Lsqx., and which is perhaps only a variety of the last species. The section of the large *Pecopterideæ* shows in it numerous remains of some of its species, especially *Alethopteris Serlii* Brgt., *A. nervosa* Brgt. and *A. muricata* Göpp. This last is uncommon and has been found only in connection with this coal. The species of true *Pecopteris* are more numerous than in coal 1B, beginning here to show their predominance. *Pecopteris unita* Brgt., *P. polymorpha* Brgt., *P. Loschii* Brgt., *P. Sillimani* Brgt. are connected with this bed, though none of them except perhaps the first is peculiar to it. *Asterophyllites*, *Annularia* and *Sphenophyllum* have left their remains in its shales, all still more abundant in No. 4 coal, except *Annularia sphenophylloides* Ung., which attains here its greatest development. Among the *Calamites*, it has *Calamites decoratus* Brgt., *C. undulatus* Brgt., the first apparently peculiar to it, with *C. cruciatus* Brgt. and *C. ramosus* in abundance. Thus

far, I have never found with this coal *C. Suckowii* Brgt., which has left so many of its remains in coal 1B. A few of the most common species of *Sigillaria*, viz. *S. Brardii* Brgt., *S. Menardi* Brgt., *S. reniformis* Brgt. and *S. Yardleyi* Lsqx., all species (except *S. Menardi* Brgt.,) which ascend higher or are found also in No. 1B. To this enumeration, I may add two species of fruits, *Carpolithes amygdaliformis* Göpp, and a small *Cardiocarpon*, fruit of an *Asterophyllites*. It is found also with No. 4th coal.

Coal No. 4th is the coal of the small ferns, especially of the small *Pecopterideæ*. It has no more remains of *Lepidodendron*, neither cones, nor leaves of this genus. Still it has some *Sigillariæ*. *Sigillaria lepidodendrifolia* Brgt., *S. Brardii* Brgt., *S. Defrancii* Brgt., *S. sculpta* Lsqx., *S. obliqua* Brgt.; *S. dilatata* Lsqx., *S. fissa* Lsqx., *S. Schimperi* Lsqx. These five last species are peculiar to it. All belong to the sections of the uncostate *Sigillariæ*. Among the costate species, none have been found in the shales but *S. lævigata* Brgt. The remains of *Asterophyllites* and its cones, of *Sphenophyllum* and especially of *Pinnularia capillacea* Ll. and H., are extremely numerous in its shales. This last species scatters its threadlike branches in every direction and mixed with *Neuropteris hirsuta* Lsqx.; and *N. flexuosa* Brgt. still common species of this coal, covers the roof of the Pomeroy vein with a painting of beautiful garlands. *Dictyopteris obliqua* Bunby., still appears with this coal, but is very scarce indeed, a species apparently dying out. Now the *Neuropterideæ* become more predominant and varied than in any other horizon. Thus, *Neuropteris speciosa* Lsqx., the most beautiful of the genus, *N. fissa* Lsqx., *N. plicata* Sternb., *N. rotundifolia* Brgt., *N. Grangeri* Brgt., *N. Cistii* Brgt., *N. Villersii* Brgt., *N. gibbosa* Lsqx., *N. undans* Lsqx., *N. tenuinervis* Lsqx., *N. dentata* Lsqx., *N. Desorii* Lsqx., *N. heterophylla* Brgt., all these species, except perhaps the last, appear for the first time, and are probably contemporaneous with this coal only. It has still *Neuropteris crenulata* Brgt., a species connected also with No. 1B. The *Sphenopterideæ* are represented here by *Sphenopteris tenella?* Brgt. (The only specimen found was indistinct.) *S. Gravenhorstii* Brgt., *S. Dubuissonis* Brgt., *S. abbreviata* Lsqx., *S. intermedia* Lsqx., *S. plicata* Lsqx., all species of the same type with small dissected leaflets, far different from the characteristic type (the large leaflets) of the species of No. 1B. To this coal belong exclusively all the species of doubtful affinity, referred by some authors to *Aphlebia* Sternb., and connected in my catalogue with *Hymenophyllites* Göpp., viz. *Hymenophyllites fimbriatus* Lsqx., *H. affinis* Lsqx., *H. hirsutus* Lsqx. and *H. giganteus* Lsqx.

The *Pecopterideæ* have the first rank for the number of representatives in coal No. 4th. It has *Alethopteris Pennsylvanica* Lsqx., *A. aquilina* Brgt., *A. urophylla?* Brgt., (specimens incomplete,)

A. obscura Lsqx., *A. serrula* Lsqx., *A. rugosa* Lsqx., with *Pecopteris arborescens* Brgt. (abounding), *P. notata* Lsqx., *P. distans* Lsqx., *P. oreopteridius* Brgt., *P. pusilla* Lsqx., *P. dubia* Lsqx., (referable with doubt to *P. arborescens* Brgt.,) *P. cyathæa* Brgt., *P. arguta* Brgt., *P. concinna* Lsqx., *P. incompleta* Lsqx., mostly species peculiar to this coal. *Pecopteris polymorpha* Brgt. is also found in its shales.

The genus *Calamites* is here represented by *Calamites cruciatus* Brgt, *C. dubius* Brgt., *C. bistriatus* Lsqx., *C. disjunctus* Lsqx. These two last species have been found only with this coal; but each has been established on single specimens and thus they are still uncertain.

From this enumeration, it is evident that we have passed at this geological horizon to a vegetation much reduced in the size of its representatives and of a quite different character. The arborescent species belong to the ferns, or to *Sigillaria*, of small size.

Our 4th coal is covered, as was said before, by a thick stratum of sandstone, generally conglomerate in part, varying in thickness from 10 to 150 feet. The vegetable fossil remains of this sandstone afford a new evidence of the predominance of the ferns at this geological horizon, and of the disappearance of *Lepidodendron*. It is the immediate deposit of silicified trunks of *Psaronius*, extending from Ohio to Virginia along the Great Kanawha river. At Shade river, near Athens, Ohio, the broken pieces of these trees are so numerous that they cover in places the bed of the creek.* They appear generally as pieces of small stems horizontally broken, varying from two to eleven inches in thickness. The largest specimen which I was able to find is apparently the base of a tree. It is nearly round, eleven inches in diameter, and perforated, not in its central part, but somewhat on one side, by a regular round hole four inches in diameter. Many of the small specimens have their surface regularly costate like species of *Sigillaria;* but their internal structure is apparently that of *Psaronius*. It would be very interesting to compare with ours the position of the *Psaronius* deposit of Europe, which, I suppose, is contemporaneous.

The five hundred feet of measures intervening between the Mahoning sandstone and the great Pittsburg coal, have not afforded hitherto very abundant materials for the study of their botanical remains. It has been seen already that, in Pennsylvania, this space is occupied by strata of shales, sandstone and limestone which are generally barren of coal, at least of

* Unhappily, I have not as yet been able to obtain for microscopical examination polished lamellæ of sections of the collected species and cannot give an exact account of them. But the work of preparing the specimens is now in progress, and the view of internal structure of those interesting remains will soon afford the possibility of determining the species.

any bed of coal of sufficient thickness to encourage the working. Thus the shales are still unopened and no chance is given of examining them. In Kentucky where in the same space the coal is more developed and has been opened at different places and different geological horizons, the shales roofing the coal-strata are mostly very bituminous and contain especially animal remains, fishes and shells, either with or without few fossil plants. Nevertheless I have been able to find here and there some determinable species affording points of comparison for the distribution of the coal-plants in those higher measures. Thus, the fire-clay of the bottoms of all the coal-strata is always filled with remains (leaves only) of *Stigmaria ficoides* Brgt., and at any place where the coal is formed, it shows on its horizontal sections the carbonized prints of *Calamites*, *Pecopteris* and *Stigmaria*.

Coal No. 6 is covered by a schistose, gray, laminated sandstone, blackened by broken fragments of ferns. Leaflets of *Pecopteris*, *Sphenophyllum*, *Asterophyllites* and crushed branches of *Calamites*, are distinguishable in great abundance among the fragments; but their specific determination is not possible.

Coal No. 8, has in its shales *Pecopteris polymorpha* Brgt. in abundance. Near Marietta, Ohio, its place is occupied by a red soft shale full of the remains of *Asplenites rubra* Lsqx., closely related to *Pecopteris arborescens*. *Neuropteris hirsuta* is there also in its normal form.

Coal No. 9. Its roof shales contain mixed together a great quantity of well-preserved fossil shells, of scales and teeth of fishes, and of remains of ferns evidently floated. Two species of *Sphenopteris*, one of which appears identical with *S. gravenhorstii* Brgt., *Pecopteris polymorpha* Brgt., another *Pecopteris* referable by the small fragments found, to *P. arborescens* Brgt.; *Neuropteris flexuosa* Brgt., leaflets only separated from the stem, a few undeterminable species of *Calamites* and one *Sigillaria*.

Coal No. 11. The great Pittsburg coal has also both animal and vegetable remains, but generally on isolated strata among the shales. At Pittsburg the lower bed is roofed by black bituminous shales which appear formed wholly by remains of stems of *Neuropteris hirsuta* Lsqx. and by leaves of *Cordaites borassifolia*, and in the shales of the upper part of this coal, which corresponds to our No. 12 and which in Kentucky is sometimes separated from No. 11 by a thin and very irregular bed of limestone, there are at Pittsburg well preserved specimens also of *Neuropteris hirsuta* Brgt., *N. flexuosa* Brgt., *Pecopteris polymorpha* Brgt., *P. arborescens* Brgt., *P. cyathæa* Brgt., *Sphenophyllum emarginatum* Brgt., three species of *Calamites* and one *Sigillaria*. The same species with a far greater proportion of *Calamites* and also one

*Sigillaria** are found at Paradise, on Green river, Kentucky, in the shaly or 'brashy' coal separating No. 12th coal from an iron blackband which overlies it. I must not omit to mention with this coal the first appearance of a species somewhat related by its form to the species of the Oolitic series. It is the remarkable *Neuropteris Moorii* Lsqx., which by its pointed leaves and alate primary or secondary rachis, is distinct from any typical form of the coal-plants. It may be compared by its general appearance to *Alethopteris Whitbiensis* Brgt. of the Oolite of England but the affinity is distant indeed, as the American species has no marked medial nerve and some of the forked and arched nervules of its leaflets emerge from the common rachis.

The third great sandstone formation, or the Anvil-rock sandstone, which underlies the highest section of the coal-measures, is from all appearance as distinct a point of division in the distribution of the fossil flora as any one of the other great sandstones, the conglomerate and the Mahoning. From my own observations and from the data collected by other geologists, especially by my friend J. P. Lesley, no trace of *Lepidodendron* appears either in the Anvil-rock sandstone or in the measures above it. At least, none has been found as yet. This sandstone nevertheless is not barren of fossil vegetables. Near Greensburg, Penn., it contains in abundance, petrified trunks half silicified, half transformed into sandstone. Among the specimens which I had an opportunity to examine in the cabinet of Prof. Moore, I found a portion of the base of a small tree which had been evidently imbedded in the sandstone, in its standing position, still preserving the embranchment of three diverging roots. The surface of the tree and of the roots is marked by peculiar scars. Though not perfectly distinct, it was at once evident that this fossil tree did not belong to any of the genera of plants before seen in the coal. It was nevertheless impossible to describe it, in its state of obliteration. Later, Dr. D. Dale Owen, the celebrated geologist of New Harmony, discovered in the Anvil-rock sandstone of Posey Co., Indiana, not far from the Wabash river, three or four standing stumps which by examination proved to belong to the same species of trees as the one found at Greensburg. The specimens of Dr. Owen have been carefully removed and are preserved in his cabinet, with the roots attached to them, just as they were found. The stem is round, about one foot thick, branching at its base in five or six large roots, diverging nearly horizontally. Its surface is narrowly reticulated, and is marked by double oval scars, united by a deep wrinkle, very regular in their position, and about one inch distant from

* It is a costate species which appears to be the same at No. 9th and No. 12th coal. All the specimens have lost the bark and I could never find the scars except those which were too much obliterated for satisfactory determination.

each other. At the point where the roots branch and diverge from the trunk, the double scars become more and more separate, more irregularly placed, and thus the roots take somewhat of the appearance of *Stigmaria*. The difference is well marked, nevertheless; the scars being triangular, marked in the center by a deep point only, and the roots quickly diminishing in size and terminating in a point at a short distance from the base of the tree. The imbedding shales not having been preserved, there is no trace of rootlets. Thus we have here, at this high position in the coal measures, a new typical form which probably indicates a difference of vegetation in the subsequent and last stage of the coal formations.

This enumeration is already too long, and though still incomplete, it must be abruptly closed, for fear of becoming tedious to the reader. In order to be understood by those who are not acquainted with botanical palæontology, it is only necessary to sum up and briefly discuss some of the conclusions which are derived from this examination.

Considering its generic distribution, the American coal-flora is nearly related to the European. We have only two or three peculiar genera, representing distinct types, which have not been seen in Europe. On the contrary, Europe has no peculiar and true generic types of coal-plants which are not represented in the coal-fields of the United States.

Considering its species, a more marked difference in the coal-flora of both continents becomes evident. Some of our species represent marked and peculiar forms or types, which are not seen in Europe, though a much greater number of species has been found in its coal-measures. Thus the predominance of typical or distinctly characterized forms, belongs to our country. By comparison of the flora of our epoch on both continents, we find now the same proportional relation and difference as at the time of the coal formation, that is, on this side of the Atlantic a predominance of well marked types; a predominance of species of trees;* a number of species perfectly identical on both continents, and many American species so nearly related to European congeners that their specific characters can hardly be established.

Though further researches ought necessarily to increase the number of species of fossil plants belonging to our coal measures, the proportional difference is likely to remain as it is established above.

The fossil-flora appears identical at the same geological horizon, over the whole extent of our coal-fields. This proves uniformity of stratification and geological unity of the different coal basins of America.

* The distribution of the genus *Lepidodendron*, at the time of the formation of the coal, has some analogy with that of the Oak in our time.

The first trace of vegetable terrestrial life appears in the middle of the Devonian in a species of *Lepidodendron*, represented by its bark, its leaves, its cones, and large trunks of silicified wood. No remains of any other form of terrestrial vegetation have been seen in strata either inferior or cotemporaneous to this. All the vegetable remains known in the Silurian and lower Devonian belong to species of fucoides or marine plants, mostly of small size, resembling some species of *Fucus* of our time. The first leafy terrestrial plants appear in the Old Red sandstone. All the representatives of this new vegetation belong to a peculiar genus, *Noggerathia* Göpp., more related to Conifers or even to Palms than to Ferns. They are found in the same geological horizon, both in Europe and in America, and entirely disappear at or before the beginning of the coal epoch.

Ascending to the base of the coal-measures, we find there simultaneously in the subcarboniferous sandstone and below the upper Archimedes limestone different species of trees of large size. At the base of the Millstone-grit, where the coal begins to be formed, the number of species of large sized trees, especially of *Lepidodendron*, increases. At the same time, we see here the first species of ferns belonging to the true coal-measures, and already some species which reappear periodically with each bed of coal, in the whole thickness of the coal-measures.

At coal No. 1B, the second above the Millstone-grit, we have apparently the maximum of predominance of species of large size, especially of *Lepidodendron*. From this horizon upwards, *Megaphytum*, *Ulodendron*, *Halonia*, *Caulopteris*, *Lomatophloios* and *Knorria* are not seen any more. The species of *Lepidodendron* diminish in number to coal No. 4, where they are entirely lost; at least they have not been found as yet in any strata of the coal-measures above it. The genus *Sigillaria* follows also from coal 1B the same gradual diminution in the number of its species; but it is preserved in one or two representatives as high as coal No. 12.

As fast as these species of trees decrease in number, the ferns mostly of small size invade the coal-fields. They become predominant and show the greatest number of species at the base of the Mahoning sandstone.

This substitution of species is not the result of any perceptible change in their character or in their relative affinity. The relation of *Lepidodendron* is to *Lycopodites*. Both genera appear or at least disappear at the same time, and are replaced by typical forms, which have no analogy whatever with them.

The distribution of the ferns in the coal-measures is equally contrary to the supposition of a change of species by successive variations. They appear, it is true, grouped together, in a kind of relation between contemporaneous species; but we do not see, either before or after any of them, a trace of an intermediate

form between the lost types and the following ones. The large-leafed *Sphenopterideæ*, the *Odontopterideæ* belong to coal No. 1B with most of the fruits of the coal measures; the *Neuropterideæ*, the *Pecopterideæ* and a peculiar section of small leafed *Sphenopterideæ* belong to coals No. 3 and 4.

As if to show how useless it would be to argue on the distribution of the coal-flora as resulting from successive variations of species and of genera, we find predominant genera represented in the whole thickness and in the whole extent of the coal-fields by species so variable that they can be called polymorphous, and which nevertheless preserve everywhere their identity. Thus appear *Neuropteris hirsuta* Lsqx., *N. flexuosa* Brgt., *Pecopteris polymorpha* Brgt. In the palæontological report of the Pennsylvania geological survey, I have figured eighteen forms of the first of these species, passing by insensible transitions from a small round leaflet to a large, nearly square *Cyclopteris;* then to cordate or reniform leaf of medium size; then to opposite, oval-lanceolate leaflets united by a narrow margin; then to a digitate leaf of which the five divisions are lanceolate-obtuse, and thus *ad infinitum.* Nevertheless, this species is perfectly well characterized and may be identified at first sight in any of its multiple forms.*

There is not in the number of *Neuropterideæ* and *Pecopterideæ* a well characterized species which could be admitted as a modified form of the predominant and variable species. Moreover, the numerous species of *Neuropteris* and *Pecopteris* appear at coal No. 3 and 4 in the middle of the coal-measures, and do not ascend higher, while those species which should be considered as originators or parents and consequently ought to be destroyed (from the law of selection) by their offspring, continue to predominate to the top of the coal-measures. Thus the vegetation of the coal shows at different geological horizons, both a gradual and sudden disappearance of species and even of types; both a gradual and sudden appearance of other species or of peculiar types, without regard to the former or extinct ones, and a continual reappearance in the whole thickness of the coal-measures of well-established species which neither by their form or their nature appear particularly prepared to sustain without varying the successive changes which have acted on the surface of the coal-measures at the time of their formation.

It is certainly possible to suppose that some disturbance, immersion, or upheaval of the coal-marshes, has modified their

* As the specimens are mostly found in simple leaflets detached from the stem, and consequently the species cannot be identified in its varieties by the examination of a stem bearing leaves of different forms, this facility of identifying any single leaflet may answer the reproach made to palæontological Botany, that it is a science directing its researches to variable parts of beings of which the true nature and real form is generally unknown, and that consequently its conclusions are more or less problematic. This reproach was long since conclusively answered in a letter of Prof. Heer to Sir Charles Lyell.

vegetation. But this supposition would not explain how it happened that the most obvious changes in the vegetation of the coal have not followed the formation of those great strata of sandstone, which, like the Millstone-grit or the Mahoning sandstone, must have employed a longer time than any other stratum for the gathering up of their materials.

The supposition may be further extended, and it may be asserted that the disappearance of certain types, or of vegetables of a large size, from the marshes of the coal-fields is only apparent. That in their forced migrations by the gradual submersion of the marshes, some species have been either arrested somewhere, and thus left inhabiting other countries or destroyed for a time by a too slow migrating process, while others, having the faculty of migrating developed in a larger degree, have reappeared again and again on the marshes, living there for a longer period.

The field of supposition is unbounded, but it is a field where science is not permitted to wander. Where have the new types or species come from? How is it, if the disappearance of vegetables like *Lepidodendron* is only apparent, or local, that we do not find any of their remains succeeding the carboniferous epoch.* And admitting that species of *Lepidodendron* have been arrested in their migrations on some dry land, should we not find above our 4th coal some remains of this genus in the strata of sandstone where so many trunks of *Psaronius* have been imbedded.

I wish that I had time to discuss here at length and with the attention which it merits, a subject of importance connected with the examition of the stratigraphical distribution of the plants of the coal-epoch. Are the coal-measures a single, unique formation? Do they belong to a single epoch, or are they composed of a succession of formations separated by immense space of time, and of which the different stages might be compared to those of the recent formations: the Eocene, the Miocene, and the Pliocene, for example? In the last case, can we admit the vegetation of which the remains have been preserved in the shales of the coal, or the vegetation of the coal-marshes, as a true representative of the flora of the various epochs where the coal was formed; or was it then, as the bog vegetation is at our time, composed of a peculiar group of plants, adapted to the formation of the coal, pertaining to the marshes only, while another

* A single specimen of *Stigmaria* is said to have been found in Germany in the Todtliegende or Permian. But the locality has not been ascertained and consequently the statement cannot be relied upon. Moreover for a long time and in many places, as I have seen it myself, the Permian in Germany was taken for the Old Red sandstone and vice-versa, from the difficulty of ascertaining its position and from the want of fossil remains. I cannot take into account as contradicting my assertion. one *Lepidodendron* mentioned by Mr. Murchison as found in the Permian of Russia.

flora of a different character was covering the dry land, if there was any dry land, at the carboniferous epoch?

From the thickness of some beds of coal, representing a mass of combustible matter as great at least as that which is contained in our oldest and deepest peat bogs; from the thickness and various composition of the strata which separate the beds of coal, and from the successive changes in the vegetation of the coal, it appears that the last alternative is admissible. Different hypotheses have been put forward to explain the so-called huge or gigantic vegetation of the coal-formations. But there is nothing in the carboniferous epoch authorizing the supposition that the power of vegetable life was greater than it is at our time. The combustible matter heaped in some of our peat bogs is sometimes sufficiently thick to be equivalent to the coal of a bed of four to five feet. The trees growing in our marshes or on the peat bogs are generally larger than those which have been preserved in the strata of the carboniferous measures. The Dismal Swamp is impenetrable on account of the great compactness of its vegetation. It is not an easy matter either, to get across the heaped, half prostrated or erect and closely pressed trees of our cedar-swamps of the North. If such marshes were extended over the greatest part of the United States, they would present a fair representation of those of the carboniferous period.

The occasional appearance of petrified trees, standing imbedded in sandstone, does not give evidence of a rapid formation either of the coal or of the other strata. Local disturbances may throw a few feet of sand upon a marsh, covered with active vegetation, and thus preserve the stumps from decomposition and by-and-by these may be converted to stone. The bald cypress and other species of trees grow sometimes in the marshes near the sea shore under ten feet of water. Whole forests of those trees have been imbedded in a standing position in the marshes around New Orleans. Thus I do not find in the geological records of the carboniferous period any indication of a rapid process of formation, either cataclysmic or abnormal, and I readily admit that each bed of coal with its accompanying strata of fire-clay and shales has required for its formation a period of time as long as any of our recent geological divisions.*

The question concerning the existence or non-existence of dry land covered with a peculiar vegetation at the epoch of the coal formation, cannot be answered positively or negatively by sufficient evidence. The only fact that would indicate that the

* Thus, if a peculiar nomenclature for a classification of the different strata of the old red sandstone, of the subconglomerate coal, and of the Millstone-grit is admissible, the process of division should be extended to each bed of the coal-measures.

marshes of the carboniferous epoch were surrounded by land-bearing plants of different kind than those living on the bogs is the presence in coal No. 1B and in the sandstone underlying it of a great number of fruits of different species which by their nature have no relation to any of the other remains preserved in the coal. They have been generally referred to species of *Cordaites*. But the two only species of our coal measures are found in abundance at geological horizons where the fruits are entirely absent. And even at coal No. 1B shales appearing entirely composed of heaped remains of leaves of *Cordaites borassifolia* do not contain any fruit. The species of fruit, *Carpolithes Cordai* Gein., referred by M. Geinitz to *Cordaites borassifolia*, *our most common and omnipresent species*, has not been found in the coal measures of America. Therefore, either the fruits of unknown relation, *Carpolithes*, *Trigonocarpa* and *Rhabdocarpos** belong to vegetable species which have grown on the marshes, and of which the remains, leaves and stems, have been entirely obliterated or those fruits belong to species growing out of the marshes, around them, and have been floated and thus disseminated in the shales and in the sandstones. This last opinion appears at first confirmed by a similar process of distribution of species in our deep swamps. I have already mentioned elsewhere† how the hollow trunks of the bald cypress which grows in Drummond lake (Dismal Swamp of Virginia) are filled by fruits, acorns, nuts, &c., of trees which grow on the dry land near its borders. But, it is not presumable that species of fruits only could have been floated and disseminated by the agency of water without any of the branches and of the leaves of the plants to which they belong. And nowhere have the shales, covering what is called the tail of a coal bank, viz: the part abutting against a hill of sand or losing itself in sandstone, exposed any remains of plants of another type than those belonging to the true coal formation. Even where the shales of the coal are covered with remains of shells and of fishes, and consequently formed when the marshes were immersed, all the floated remains of plants which are found with those of animals belong to the common species of the coal. I believe then that the plants preserved in the shales of the coal give us a fair representation of the general flora of the carboniferous epoch, as true and as general at least as the fossil plants of the miocene represent the general flora of the tertiary period. And I suppose that if there was any dry land around the marshes, the vegetation contained only a few species different from those living on the marshes. But this last opinion is merely hypothetical.

[*To be continued.*]

* I consider the *Cardiocarpa* as the fruits of Asterophyllites and probably of some species of Calamites.

† Introduction to the fossil flora of Pennsylvania, Geol. Rep. of Penn., p. 847.

ART. IV.—*On some questions concerning the Coal formations of the United States;* by LEO LESQUEREUX.—(Continued from vol. xxx, 384.)

General Remarks on the Coal Plants and their Study.

IN the memoirs of the Geological Survey of Great Britain, Dr. Hooker has remarked at length on the difficulties attending the study of the fossil plants of the Coal measures.* I can admit, indeed, with the celebrated English author that this study is far more difficult than could be supposed from an examination of some specimens of fossil ferns, which are found sometimes so handsomely painted upon the shales, that they look as perfect as plants preserved in the herbarium. But I cannot share the whole of his views concerning the insufficiency of the data furnished by palæontological botany and their uncertainty compared with those afforded to Geology by fossil animal remains. Remains of fossil plants are preserved in two ways:

First. We find, especially in the shales overlying coal-banks or occupying their place, the flattened surface, the printed outlines of some peculiar vegetable organs. They are mostly leaflets of ferns, either without traces of fructification, or with the fructification obliterated and dimly visible through the parenchyma of the leaves;† or parts of fronds, broken pinnæ detached from the common rootstock; or pieces of flattened stems without leaves, generally bearing on the surface some peculiar striæ or cicatrices left at the point of attachment of the leaves; or a few isolated and broken fruits, apparently nutlets of unknown relation and structure.

Secondly. We find also fossil botanical remains, either silicified or transformed into coal or mineral charcoal. Silicified wood is common enough in some strata of sandstone intervening between some beds of coal. But it represents parts of stems, or of half decayed trunks, of which the bark has generally been taken off or is entirely obliterated. Such specimens of course expose to the student the internal structure of the wood but nothing else. When the remains of fossil plants are found preserved in coal or charcoal, every trace of a complex organism has disappeared, and nothing can be seen by a microscopical examination but isolated vessels of various forms and size.

We have thus either flattened organs of plants of which we can only see the outline, to which we cannot by any means refer the organs that are essential for determination, like stems, flow-

* It is well to recall the fact that the remarks in this paper regard only the fossil coal plants, though some of them may apply to the fossil flora in general.

† The lower surface of the ferns which bears the fruit, is mostly the one inseparably attached to the stone.

ers, and fruits, &c., and of which we cannot study the internal structure. Or we have isolated vessels transformed into coal or pieces of silicified wood of which we can study the internal structure only without possibility of comparing it or of referring it to external organs so as to know the outward appearance of the vegetable to which they belong.*

To show at once in its most unfavorable and discouraging aspect the difficulty of studying the botanical palæontology of the coal, we have still to remark that the broken, separated organs of fossil plants, especially the leaflets of the ferns, generally found detached from the stems, are extremely variable. Some perfectly alike in their outline may belong to different species while some others apparently totally different belong to the same plant or even to the same pinna.

As a compensation to these apparently insurmountable obstacles, we have:

1st. The extraordinary simplicity of the flora of the coal and the small number of species that appear to have contributed to its formation. All the leaves found in connection with the coal measures belong to ferns and to a few genera of unknown affinity.

2d. As every botanist well knows, most of the species of ferns have a peculiar and well marked nervation. In the fossil ferns of the coal this nervation is generally well preserved, visible and characteristic enough for the identification of species.†

3d. In some rare cases where the nervation is nearly alike for different species, each of these may be distinguished by peculiar marks, hairs, scales, tubercles or appendages, &c., which permit their identification.

4th. Moreover, one may truly say, that each species even in its most different parts has a peculiar look, easily known at first sight by the palæontologist, though indeed indescribable. And this is true as well for the leaves of the ferns as for the cicatrices which so peculiarly mark the bark of some trunks.

From this it follows, that the characters on which we have to rely for a determination of the fossil plants of the coal are uncertain, indeed, and of little value for an absolute classification or in

* Brongniart, Hooker, Corda, Göppert and a few other palæontologists have had the opportunity of studying through thin, polished sections, the internal structure of a few species of fossil wood, and cones from specimens still preserving the outward form of their bark. They could thus compare the anatomical structure with some external characters. But the pretence of identifying species or even genera from the characters of isolated vessels appears inadmissible, considering the great likeness of these elementary organs in different species and also their variety according to the age of the stem and to their place within it. This question will be examined in detail hereafter.

† Though the number of species of ferns now living is very great, the nervation is still considered by some botanists as sufficiently characteristic to separate the species of a genus and even of subgenera. (See the opinion of Mittenius in this Journal, vol. 31, p. 133).

comparison with all the species heretofore known, but that they are generally reliable enough for identifying the species of coal plants relatively to each other. This, I think is all that is wanted for an examination of the palæontological botany of the coal. For the flora of the coal-measures constitutes a peculiar group of plants which ought to be studied by itself, whose characters ought to be looked for without any exact relation to plants now living. A certain amount of botanical knowledge, especially of the anatomy and of the geographical distribution of the plants of our epoch, is necessary for that duty; but it can be pursued without the assistance of great and costly botanical cabinets, and even without the acquaintance with a large number of our living plants. Of course the more one knows of botanical science, the more one is prepared to judge of the analogy of the forms of fossil plants or to recall them to an original type. But nobody will attempt the study of fossil plants who has not been prompted by a natural love of the science to devote himself to serious botanical studies.

Comparing now the data furnished by both animal and botanical remains, and considering what is called the insufficiency of botanical palæontology, we have to inquire, first, What results are to be expected from palæontological researches? We reply, nothing less than some more or less precise indications concerning the succession of the beings which have inhabited our globe since the first appearance of life, or a kind of history of the creations or of the modifications of what we may call the *forms of life*. And, as a corollary of the first proposition, some indications of the changes to which the surface of our globe has been subjected, and which, according to the laws governing the forms of life, ought to be attended by the appearance of peculiar beings.

It is indisputable that the external forms of some animals, their shells especially, are generally better preserved in a petrified state than the soft parts of most plants. But animal remains, bones, scales, teeth, are only isolated parts of a whole, and are no better applicable to an exact scientific classification or to a satisfactory identification of a species than a single leaf of a tree. As for the shells, they are simply envelopes, and their affinities to the animal are at best only imperfectly understood. It is true that comparative anatomy has done more for animals than for plants. But the number of leaves is not small of which the outline is so closely related to the form of the whole vegetable that when they are found in a fossil state, they may be immediately and certainly referred to their proper genus. For what concerns families of extinct and unknown forms, I think that the reconstructions offered by comparative anatomy are as reliable for *Lepidodendron*, *Sigillaria*, for whole forests indeed rebuilt from

pieces of bark or from leaves as they can be for whole fishes, and gigantic animals rebuilt from a scale or a bone.

From another point of view, if it is true that the number of animal fossil remains is far greater than that of fossil plants, it cannot be denied that animal remains are mostly marine and are cast, accordingly, in a scarcely variable general mould. If we should judge of the successive developments of the vegetation of our globe by the fossil marine plants only, we should, indeed, come to a very erroneous conclusion; the *Fucoides*, for example, of all the formations are much alike, and preserve even up to our time their original typical characters.

Marine animal remains appear to have been subjected to appreciable changes only by great geological events, of which natural philosophy cannot thus far fully appreciate the amount of influences. Thus, of course, we have not any solid ground from which to draw reliable conclusions concerning the result of those influences upon the forms of animal life. Botanical palæontology has engraved its records on the rocks, only at very distant epochs, and they present only broken links of a chain, which science may perhaps never be able to connect.

From this it appears that when we come to examine the succession of species from their origin, and search for arguments concerning the problematical question of successive changes or of successive creations, the data now furnished by animal and botanical palæontology respectively, give us about the same amount of light and merit the same reliance.

As indicating the succession of the strata of our globe, or as geological marks, animal remains have this advantage: that as most of the strata have been formed by marine deposition, these remains are more generally found in every part of the geological measures. They are thus an ever present if not always a reliable guide. But the most interesting part of the geological field is entirely barren of those *medals of the creation* to which we look for a record not only of the successive deposition of strata but of all the changes which the surface of our earth has undergone. Marine strata have been formed from materials transported and mostly, at least, taken from dry land. Touching this dry land, the multiplicity of changes to which it has been subjected by that potent and most variable agent, the atmosphere; concerning the various appearances of the successive stories built by the Eternal Power for the ultimate end of the structure, viz:—the habitation of man; about some of the materials prepared and heaped up for his welfare and perfect development; concerning the great harmony of all the beings in the different ages, marine remains cannot give much information. Thus, if the data furnished by one of these special branches of palæontology are more numerous, more universal, more easily found and better preserved and stud-

ied—those of the other are more precise and so to speak, more applicable to our humanity. Because they speak a human language. They speak of atmospherical changes, of sun and of rain, of seasons and of their variations. They speak of shores battered by the waves and covered with floating debris, of hills, of green fields, of impenetrable forests, of everything that is now in the fullness of its perfection, belonging to the Eden slowly prepared for our abode.

If this does not prove that fossil botany is as useful to science and as interesting as any other branch of palæontology, the few words I have said in its defense will easily be excused: especially as in this country it has had few followers, and is often looked upon with unmerited discredit.

By far the greatest obstacle to the study of the fossil plants of our coal measures is the difficulty of obtaining good specimens, and, when the specimens have been found, of procuring books to make us acquainted with them. We have indeed some few specimens of fossil plants in geological cabinets. But they have been mostly collected by persons unacquainted with fossil botany and are thus incomplete in many ways and of little use for study. Either they want some part essential for a determination, or they have been collected without a close regard to local and stratigraphical position. Fossil botany ought to be studied in the coal mines, among heaps of shales where remains of the same species can be collected in their different forms. Sometimes hundreds of pieces of the shales have to be split before the part of the frond of a fern which may be desired for a satisfactory determination can be found. In many fossil ferns, especially in the *Neuropterideæ*, the terminal leaflet of the pinnæ has a peculiar and characteristic form; and, as the leaflets of this class of ferns are mostly deciduous, these terminal ones are rare and difficult to find. Though whole strata of shales are covered with leaflets of *Neuropteris hirsuta*, and though this species is found at nearly every geological horizon, it is nearly impossible to find the branches with leaves attached to them, and thus to know something of the general appearance of this species.* With the pieces of the bark of some trees, viz. with specimens of *Lepidodendron*, *Sigillaria*, &c., the difficulty of collecting is still greater. For the points or cicatrices left by the leaves, and generally showing in peculiar forms the deposition of the vessels at their point of emerging from the stems, vary in size and distance according to the age of the vegetable or the place on the trunk from which the specimen is taken. Moreover, the cicatrices have various forms following the process of decortication of the

* I have only two small specimens of this species with branches and leaves; one found by myself the other presented to me. Mr. Bunbury saw for the first time such a specimen in the cabinet of Mr. Brown of Nova Scotia.

vegetable. As it is extremely rare to find in our coal measures a whole tree preserved by petrification, the study of a single species of the great vegetables of the coal ought to be pursued at the same place on a great number of specimens. This is always a difficult task. But if we consider that before we are able to become well acquainted with any species of fossil plant, and especially to get a view of its stratigraphical and geographical distribution, we have to examine it closely at a great number of distant exposures, the difficulties of this study appear far greater.

The collecting of specimens and their study would be greatly encouraged by some good work with descriptions and figures of American fossil plants. Indeed, I have been repeatedly asked what were the books from which we could get that preliminary acquaintance of fossil plants which is necessary to direct such researches. Hitherto nothing has been done in that line in the United States; at least nothing that can be easily obtained by the student, because all that has been published on the botanical palæontology of the coal is disseminated in scientific Journals or State Geological Reports that are not generally accessible.

Before the publication of the Geological report of the State of Pennsylvania, a few species of our fossil plants had been described by Mr. Brongniart in his *Fossil Flora** from specimens sent to him, chiefly by Prof. Silliman, from Wilkesbarre and Zanesville. After this, Mr. Bunbury of England published in the Quarterly Journal of the Geological Society of London (vol. ii, p. 82) some remarks on species of fossil plants collected by Mr. Lyell at Frostburg, Maryland. Very few of these species are described or even determined, for except *Neuropteris cordata*, *Pecopteris arborescens*, *Lepidodendron tetragonum*, *Lepidodendron aculeatum*, *Stigmaria ficoides*, *Asterophyllites* and *Calamites nodosus*, all the species mentioned in Mr. Bunbury's paper are marked with signs of doubt. The general remarks of this celebrated English author are very interesting indeed, but are useless for one beginning the study of the fossil plants of our coal measures. Even the three new species which he has described and figured are uncertain, being made from incomplete specimens. In the third volume of the same Journal, Mr. Bunbury, examining some fossil plants from the Nova Scotia coal measures, sent to him by Mr. Richard Brown, mentions, mostly without descriptions, and with a ?, forty-eight species, of which seven are described and figured. The same remark as above can be applied to these species, except for *Lepidodendron tumidum* and *Neuropteris rarinervis*, satisfactorily described and figured, though still from imperfect specimens. This Journal, vol. iii, No. 1, contains a *Notice of vegetable impressions* by Granger,

* *Histoire des Vegetaux Fossiles.*

who has given some figures, but without names and scientific descriptions. This Journal, vol. xxix, 1st series, contains an excellent and elaborate article by Dr. Hildreth of Marietta.* A number of our common species of fossil plants are figured in the plates accompanying this paper; but the names and the descriptions of the plants are not given. The remarkable observations of Steinhaur in the *Transactions of the American Phil. Soc. of Philadelphia*, (vol. i, new series) apply to plants observed and examined in the coal basin of England; and those of Harlan in the same journal (1831) concern only some *Fucoides* and have no relation to the coal. These are all the materials which were available for studying the American fossil plants of the coal when I began the examination of the fossil flora of Pennsylvania in connection with the Geological survey of that state. The Report made on this subject contains the description of two hundred and thirty-one species of fossil plants, with figures of one hundred and two of them, mostly new. This number certainly embraces the greater part of the fossil plants of our coal measures. But the report made at the time with all the care and the light which the collected materials could afford is still defective in many points.† Some species considered and published as new, had been described and published previously; and some others supposed identical with European species, are now acknowledged as distinct. Moreover this report, like those numerous geological reports published among us at the cost of the States, is not on sale and can be found only in certain public libraries, and in the hands of a few privileged men of science.

About the same time that this report was made, Dr. Newberry of Cleveland, published in the Annals of Science of Cleveland, a series of papers, the two first of which (Feb. 1st, and Feb. 15th, 1853) contain a catalogue of one hundred and twenty-seven species of fossil plants of which twenty-two are marked with a ? or without name. In the same Journal (March 1st, May 1st, May 15th, 1853, and Jan. 1854), the same author gives a description with figures of a few species, especially fruits. These papers are now difficult to obtain.

To complete the list of what has been published on the fossil plants of this continent, I have to mention still, some very interesting papers on species of coal plants in Nova Scotia, and on the traces of vegetable organs found in the coal, by Prof. J. W. Dawson of Montreal. The same author has enumerated in his *Acadian Geology* about one hundred species of fossil plants belonging to the coal fields of Nova Scotia. Lately Mr. Horatio C. Wood has furnished to the Proceedings of the Academy of Natu-

* *Observations on the Bituminous Coal deposits of the Muskingum Valley, &c.*
† This Journal, July, 1860, vol. xxx, p. 64, note.

ral Science of Philadelphia (June, 1860,) a paper containing descriptions and figures of some species of *Sigillaria* and *Lepidodendron.*

If in addition to these local papers scattered in periodical works I mention a catalogue of fossil plants published by the writer for the Scientific Society of Pottsville, Penn., I think that we have here the whole amount of contributions to the fossil flora of our coal measures of America.

The larger number of books on fossil plants have been published in Germany and mostly in the German language. In the beginning of this century, Schlotheim published his *Flora der Vorwelt*, with fourteen plates.* Since then science has made such progress that, with the exception of the figures which have been copied by subsequent authors, this work, very remarkable indeed at the time of its publication, is scarcely of any value to the student. From 1821 to 1838 Count Sternberg labored and gave to the scientific world a *Versuch einer geognostich botanischen Darstellung der Flora des Vorwelt*† in two folio volumes. This work contains a great number of good figures of fossil plants which cannot be found elsewhere, and is indeed very valuable for the great amount of information that it contains. It bears the mark of its early origin, and traces of uncertainty by a close and excellent observer who had to find his path in a new field, and give an account of things that had never been seen before and that have no relation to what we have now on hand for a comparison, in the vegetation of our world. *Sternberg's Versuch* was made with great labor and expense, and with the assistance of two of the best German Palæontologists: Corda, who prepared sketches for comparative phytotomy of the fossil and recent plants;‡ and Presl, who elaborated the greater part of the second volume of the book.

Corda, who has been just mentioned in connection with Sternberg, published afterwards his observations in a separate work, *Beitrage zur flora des Vorwelt.* This book is of great scientific interest for the study of the anatomical structure of the wood of some species of fossil trees. A few of the conclusions of the celebrated German author concerning the affinity of stems of the coal with plants of our time are indeed subjected to controversy, but his work in patience and detail of execution is truly admirable. It is still the best guide to consult for those who have opportunity to study the anatomical fossil botany from ground and polished lamellæ of silicified wood.

* I mention only the most interesting of the works published in Europe on the fossil botany of the coal, and especially those that can be purchased.

† There is a translation of this work in French.

‡ *Skizzen zur Vergleichenden Phytotomie vor und jetztwettlichen Pflanzen Stämme.*

Prof. H. B. Göppert of Breslau has worked immensely upon the fossil flora of the coal. But unhappily some of his memoirs are disseminated in scientific journals. The most important of them which can be got by purchase are, 1st, the *Systema Filicum Fossilium* (1836), descriptions in Latin, explanation in German, and good plates: the *Gattungen fossilien Pflanzen*, (six livraisons have been published), with text both in German and in French. The work is splendidly illustrated; the *Flora des Uebergangs gebirges*, Latin and German: the *Monographie der Fossilen Coniferen*, (Leiden, 1850), and the *Fossile Flora des Silurischen, Devonian*, &c., Leopold Academy, Jena, 1860. This last I have not seen yet, but it is considered as very valuable. It is certain that no living man knows more about the fossil flora of the coal and perhaps of all the formations* than Prof. Göppert. Perhaps his writings are only too numerous and his scientific riches too large. His Genera of Fossil Plants is only commenced and the completion of it is to be ardently desired by every student of fossil botany. In connection with Berger, Prof. Göppert has also published a monography (*De fructibus et seminibus in formatione lithanthracum*) of the fruit of the coal measures which is of great interest.

To Prof. F. Unger, who like Göppert has also published many valuable books on the flora of the recent formations, we owe especially a *Synopsis of the genera and species of fossil plants* which, though made without a clear and fixed method, is very useful as containing an account of all the species of fossil plants known up to 1850, the time of its publication. The descriptions (without figures) are insufficient for the beginner.

Prof. H. G. Bronn has published in his *Lethæa Geognostica* a number of fossil plants of the coal.

From Prof. E. T. Germar we have eight livraisons (the last in 1853) of coal plants. The work in folio has very good plates and descriptions, but progresses very slowly.

Gutbier (Aug. v.) published in 1836 a a small work on the fossil plants of the coal of Zwickau. Though it is printed on poor paper and is without pretention to scientific value, this small book contains a great amount of solid information, and will be consulted with pleasure and profit by those who are interested in our coal flora.

The *Versteinerungen der Steinkohlen Formations in Sachsen*, by Prof. Bruno Geinitz (Leipsic, 1855), is a magnificent folio book with splendid tables and excellent figures. It has been made with great care and from the examination and comparison of a great number of specimens. This is probably the best work to

* I would not even make this restriction, if the admirable work of Prof. Heer on the Flora of the tertiary of Europe had not surpassed all that has been published on the fossil plants of the recent formations.

give a general view of the fossil flora of the coal. Many of our common American species are found described and figured in it. It is indispensable to the student. Prof. Geinitz seems to have taken a point of view entirely different from that of Göppert and both, I believe, have gone too far; this one by multiplying the genera and the species, without characters always sufficient; the other in uniting into one some species certainly distinct. The work of Geinitz is entirely in German. It is to be regretted that it does not give at least a short Latin description for each species.

Goldenberg has made a beginning of a *Flora Sarræpontana Fossilis;* two livraisons only of the work have appeared (1855 and 1857). If it is ever finished it will be a very valuable work indeed. It contains already on the fossil *Lycopodiaceæ* (to which the author refers the genus *Lepidodendron*) and on the fossil *Selagineæ* (to which he refers the genera *Sigillaria* and *Stigmaria*) a great amount of acute and very interesting observations. To Goldenberg we owe the discovery of the fruit of Sigillaria and good details of its structure. He even asserts that he has found the fructification of *Stigmaria ficoides*, and describes it in his generic diagnosis. Goldenberg appears to be one of those true *workmen* of science who spend their time in the mines examining specimens, and collecting them, not for their fine appearance, but to compare and unite the dismembered parts of a species in order to reconstruct the whole; the only way of studying botanical palæontology with advantage to science.

We can scarcely be astonished to find in France only a single representative of the science of the fossil flora of the coal, that of Prof. Ad. Brongniart: for this celebrated author has done so much for the Botany of the Coal measures, that truly his works are beyond comparison and imitation. What a pity that his great *Histoire des Vegetaux Fossiles* has not yet been and probably will never be finished! The last part delivered to science was printed, I think, in 1844. When we look to the details of his comparative botanical anatomy, to the admirable clearness of his classification, to the exactness of his descriptions and of the figures, to every part of his great work, we cannot be astonished that every attempt at classification and description of fossil plants is done in imitation of Brongniart's method, the true foundation of the science. His observations on the *structure of Sigillaria elegans* is a work of anatomical study that is equalled only by that of Dr. Hooker's on the structure of the *Lepidostrobi*, in the memoirs of the Geological Survey of Great Britain. Besides these remarkable works, and among numerous memoirs of Brongniart, the *Tableau des Genres des Vegetaux Fossiles*, and the *Prodrome d'une Histoire des Vegetaux Fossiles* will be studied and

studied again with constant advantage and pleasure. If the great fossil flora of Brongniart was finished, it would suffice for the study of the coal plants, at least for the general acquaintance so desirable to direct the researches.

From England, we have the *Fossil flora of Great Britain*, by Lindley and Hutton, (3 vols. 8vo). Many species of the coal measures and of the oolitic formations are described and figured in this work, which is certainly very valuable. But it is made without any systematic arrangement and without method. The descriptions are moreover far from being satisfactory and the drawings too artistical or imaginary.

I have already mentioned the remarkable memoir of Dr. Hooker, who is certainly one of the greatest botanists of our time. From polished lamellæ of fossil cones of *Lepidodendron*, he has exemplified the fructification of this genus as clearly and as perfectly as it could have been done from living specimens.*

Artis, *Antediluvian Phytology*, &c., is a good book for the plates, but scarcely of any use now to the student of fossil plants. The same may be said of Mammats, *A Collection of Geological Facts and Practical Observations*, &c. But Witham's work on *the Internal Structure of Fossil vegetables* is, like *Corda's Beyträge*, very valuable to direct the researches of comparative anatomy in the study of the internal structure of the fossil woods. A number of fossil plants of the coal are described and figured in English works on Geology by Lyell, Buckland, Miller, Mantell, &c.

(*To be continued.*)

ART. V.—*On the Production of the Ethyl Bases;* by M. CAREY LEA, Philadelphia.

I MENTIONED in a former number of this Journal that while engaged in the examination of the action of ammonia on certain oxy-ethers, I had met with the experiments of Juncadella and De Clermont, and finding that the production of ethylamine by these reactions had been already indicated, I discontinued my investigations. Subsequently however having occasion to prepare a considerable quantity of ethylamine for other examinations, I determined to ascertain whether the action of nitrate of ethyl on ammonia could not be made use of as a convenient process. Juncadella had already proposed to mix nitrate of ethyl with three or four parts of alcohol, saturate the mixture with dry ammoniacal gas, and heat for two days to 212° in the water bath. This was a rather troublesome process, and a few experiments led me to the following very simple method, which I publish as having given me satisfactory results:

* Mr. Lesquereux has apparently overlooked Robert Brown's brief, but very interesting paper, in the *Transactions of the Linnæan Society*, vol. xx, part 3, entitled, *Some Account of an Undescribed Fossil Fruit*, which, in a single specimen, completely demonstrates the structure and affinities of *Lepidostrobus*.—EDS.

Photographs of opaque objects were obtained by concentrating sunlight on the object, either with the concave mirror properly mounted, or with the plane mirror and bulls-eye condenser. The $1\frac{1}{2}$, 1 and $\frac{1}{3}$ inch objectives were employed. The color of microscopic injections for this purpose should be blue or white, though with a long exposure photographs were obtained of yellow injections.

I am indebted to Dr. Wolcott Gibbs and to G. T. Strong, Esq., for valuable suggestions relating to the subject of this article.

As some interest has lately been manifested with regard to eye-pieces, it may be proper to state, that, in the course of this investigation, three eye-pieces were constructed, No. 1, on the general Huyghenian plan, the eye lens being an under-corrected *achromatic*;* the distance between the eye and field lens could be varied at pleasure, as advised by Amici; as a single microscope its power was eight diameters. The general performance of this eye-piece seemed to me somewhat better than that of the plain Huyghenian eye-pieces with which it was compared.

No. 2 was a Kellner eye-piece, the distance between the lenses could be varied; alone it enlarged 12 diameters. The performance was good. No. 3, consisted of two under-corrected achromatic lenses combined in the Huyghenian manner; alone it magnified 25 diameters. When used as the eye-piece of a telescope it gave a pretty good image; as a microscopic eye-piece, it was inferior to No. 2 in spite of its superior magnifying power, except perhaps when used with well corrected objectives of large angular aperture. With all three eye pieces the correction of the objectives remained unaltered in kind.†

Troy, N. Y., July, 1st, 1861.

Art. XXIII.—*On some questions concerning the Coal Formations of North America.* (Continued from p. 25 of this vol.)

By Leo Lesquereux.

Families, Genera and Species of Fossil Coal Plants in the United States.

This general examination is made for a two-fold purpose. First; to see how the remains of fossil plants found in our American coal-measures agree in characters with those of Europe: or rather to find if these remains of ours cannot give some farther light concerning species, genera and families of coal plants, al-

* The orthoscopic eye-piece of Grunow consists of an eye lens partially achromatized in combination with a field lens differing in form from the ordinary Huyghenian.—O. N. R.

† After this article was in print, I received from a friend a paper of Amasa M. Eaton, Esq. (*Proceedings B. S. N. H.*, vol, viii, p. 105.) Mr. Eaton has devoted himself with success to the production of *ambrotypes* of microscopic objects.

O. N. R.

Troy, N. Y., July 23d, 1861.

ready known from European researches. The fossil flora is very similar to the history of olden times. It is known only by fragments and these must be connected by links and repeatedly elucidated by corresponding data, collected from the monuments of various nations.

Second; to present a comprehensive review of the main facts known up to the present time about our coal flora and to establish, by a critical comparison, the essential characters of the families, genera, and even some species of our coal plants.

§ 1. *Fucoides*, Brgt.

Under this name, a number of vegetable remains of the coal have been formerly described and referred to marine plants. Indeed some geologists have applied the term *Fucoides* to every one of those uncertain forms, mostly stems and roots, which could not be referred to some species known and published before. The *Fucoides* are not only very rare in the true coal measures, but I even doubt if a single specimen of a true marine plant has ever been found in these measures. At least I have seen none, and all the numerous specimens sent to me under that name were incomplete fragments, either of stems or of roots, of some true coal plants.* Mr. Brongniart had already remarked that all the vegetable filaments considered as *Confervites*, like those published by Artis under the name of *Hydatica* and *Myriophyllites*, were roots. Mr. Unger in his classification of fossil plants according to geological formations, (*Genera and species*, page 533), quotes among *Fucoides* of the coal: 1st. *Chondrites Prestvici* (Mor. cat.) an undescribed and unknown species, whose locality is not even mentioned. 2d. *Chondrites dissimilis* (Eichw.) from the mountains of Donetzky in Russia. It is published by Eichwald in the Urw. Russia, p. 89, t. 3, fig. 3, but rather resembles a *Hymenophyllites* than a Fucoid. 3. *Chondrites trichomanoides* Göpp., *Systema foss.*, t. 30, fig. 26, a plant formerly described by the author as a *Trichomanites* and which appears to belong to that section of Hymenophyllites which I have called *Pachyphyllum* (Penn. Report). This plant was found in a kind of shale called by Mr. Göppert *stinkende* with remains of fishes. 4 and 5. *Fucoides Alleghaniensis* (Harl.) and *Fucoides Brongniarti* (Harl.), both belonging to the Silurian or Medina sandstone of our country. 6. *Rhodomelites bijugus* (Eichw.) from the mountains of Russia with *Fucoides subtilis* and *Fucoides tæniola* of the same author. These two last species are not described. Though Eichwald is a very good observer, we can but suppose: either that his four species of fucoides are fragments of coal plants, or that the for-

* We cannot call them either marine or fresh water plants. The coal plants as remarked before, had a peculiar nature, like those of the peat bogs and were appropriated to the formation of the coal. They could vegetate with slight modification of forms either in or out of water and probably both in marine and fresh water.

mation where they have been found is not within the true coal formations. In his *Tableau des Genres*, Mr. Brongniart mentions as pertaining to the *Carboniferous period* two *Chondrites* and two *Amansites*. These last two are *A. serra* and *A. dentata* belonging to the Silurian of Canada; the two others also pertain to the transition formations inferior to the Devonian.

I could easily refer to *Fucoides* a number of specimens undeterminable, branches or stems that look like marine plants. I have especially a smooth, flexuous, linear, apparently rounded branch about the fifth of an inch broad, perfectly equal in its whole length, resembling a piece of *Corda filum* or of *Zostera marina*, found in the shales of the upper strata of the Kentucky coal measures with remains of fishes and of marine shells. But describing such remains and referring them to marine plants would be only an hazardous hypothesis. The stems and leaves of some plants of the coal of Pomeroy are covered with a brownish, thick epidermis resembling the thick leaves of some *Fucaceæ*. But this kind of skin is mixed with remains of ferns and cannot be referred to *Fucoides* without a better proof than this leathery appearance. Prof. Geinitz does not mention any *Fucoides* in his fossil flora of Saxony.

2. *Funginеæ* (*Mushrooms*).

As far as the evidence of fossil plants can be trusted, it seems to prove that species of the mushroom family were living during the period of the formation of the coal. It is especially some of those small, mostly round species of the *Hypoxyleæ* tribe, that have been found attached to leaves and stems of fossil ferns. One of them is described by Prof. Göppert (Syst., p. 262, t. 36, fig. 4), with the name of *Excipulites Neesii* on the leaves of *Hymenophyllites Lobelii*. The same is described again by Geinitz (*Verst.* p. 3, pl. 23, fig. 13,) on the leaves of *Sphenopteris tridactilites*. In this last author we have also, belonging to the same tribe, a *Depaxites Rubenhorsti* and especially the *Gyromices Ammonis*, Göpp. This last species is the only one that has been found heretofore in our Coal measures of America and that I have been able to examine. It abounds on the leaves, the stems and even the naked substance of the shales overlying the coal (No. 3) at Colchester, Illinois. I have seen it also on a piece of fossil stem from Carbondale, Penn. (Specimen No. 711 of Amherst College). It was first named by Göppert, then described and figured by Germar (*Verst.* fasc. 8, p. 112, tab. 39, fig. 169) and more recently by Geinitz. It is a small spiral body about the tenth of an inch in diameter, with the spires progressively enlarging and greatly resembling our *Planorbis parvus* (Say) a small shell now living in fresh water under the leaves and on the stems of floating plants. Its outer end, which in the figures of European authors is blunt and obtuse, appears, on our specimens,

abruptly cut and hollow, like the mouth of a thick shelled mollusc. It is finely striated across; and under a strong lens looks like a beautiful small *Ammonites*. From numerous cross sections of good specimens of this small body, I must admit, contrary to the opinions of the learned European authors who have studied it, that it is a true shell, most probably a species of freshwater mollusc. Internally it is hollow, with a hard, thick, parietal substance, generally of lighter color than the shale. It is true that it is often found within the carbonaceous matter of the leaves and of the stems, and thus would appear to have lived within the substance or under the epidermis of the plants like some *Hypoxyleæ*. But at Colchester, at least, it is still oftener found within the naked substance of the shales. Moreover if it was a shell living on the stems and leaves of the coal, it has been of course imbedded by compression as well in the softened woody and carbonaceous matter of the plants as in the soft clay. Germar has already remarked that he found it on shales, without any apparent connection with vegetable substance. But he supposes the possibility of the destruction of all vegetable substance, except that of this small fungus; a supposition which appears somewhat extraordinary. The presence of fresh water shells in the bogs of the coal can not be doubted after the remarkable discovery by Prof. Dawson of a fresh water *Pupa* in the coal fields of Nova Scotia.* And the scarcity of these molluscans in the coal measures is in accordance with what we see on the peat bogs of our time, where the number of fresh water shells is extremely limited. I can not but say again how difficult and hazardous it is to determine such small bodies attached to petrified stems and leaves, from the impossibility of examining their internal structure and of finding the spores. External and variable forms exactly like small fungi are often mere unorganized bodies, produced by some mechanical or chemical action. All the remains of plants and even the shales overlying the semi-anthracite coal of Trevorton, Penn., are covered with small round vesicles, of different sizes, looking exactly like *Spheriæ*, and are filled with a brown powder resembling spores. Sometimes the coal itself is full of them. They have probably been formed by the ebullition of the whole matter accidentally stopped during a strong gaseous emission.

Another very remarkable fungus, *Polyporites Bowmanni*, is described by Lindley and Hutton in the fossil flora of Great Britain, (vol. i, No. 65). This species, or at least one, agreeing exactly with the figure and description of the English authors, was found in black bituminous shales overlying No. 1B coal at Johnstown, Penn. It is an hemispherical or reniform body, marked with concentrical zones, especially distinct near and

* Proceedings of the Geological Society of London, (Dec. 14, 1859).

along the margin. As Prof. Lindley remarked it: "it is like one of those fungi belonging to the genera *Boletus, Polyporus, Thelephora, Dædalea*, &c., (our species rather resembles a zoned *Boletus*), which attach themselves to their support by one side, projecting forward from it and increasing by periodical additions to their margin, in consequence of which that part assumes a zoned appearance." The lower part of these Fungi, the *Hymenium*, is a more or less thick compound of vertical, cylindrical or angular pipes or tubes closely united together and containing the seeds. It separates more or less easily from the upper part or the hat of the Fungus. Our American specimen is more perfect or better preserved than the two which have been found in England. Two-thirds of the surface show the disposition of the zones of what I consider to be the lower part of the hat or *Pileus*. The balance of the surface, just in the middle of the specimen, is occupied by what appears to be a piece of the undetached *Hymenium*. This part, which is concentrical and exactly in concordance with the zones, is even evidently zoned though less visibly than the *Pileus*, and formed of square, radiate and concentrical areolæ, running around a central point and from it to the margin. This confirmation can not be compared to that of a scale of fish. It is exactly that of a compressed and petrified *Boletus*. The celebrated English author was only prevented from giving the same decided opinion by the mark, on the surface of specimens, of some lines *which are not in accordance with the radial lines near the margin*. This appearance is probably caused by the superposition and agglutination of some piece of another plant. The American specimen has nothing like it and it removes the only objection made against the admission of this species as a true Fungus or mushroom. The black bituminous laminated shales where it was found contain together with it abundant remains of *Lepidodendron*, especially of its leaves and cones.

2. *Lichens, Mosses and Liverworts.*

Brongniart and other palæontologists have already remarked as a peculiar phenomenon, the absence of every trace of fossil Lichens, Mosses and Liverworts in the old formation of our earth. A few mosses and Hepaticæ only have been observed in formations no older than the tertiary,* and especially in pieces of amber in Germany.†

Many years ago, I found around Pottsville, Penn., a kind of laminated soft gray shales, splitting in thin lamellæ and resem-

* Heer's Flora tertiary Helvetica and also Ungers' Genera; Dunker's Monegr.; and Brongniart's fossil flora.

† H. R. Göppert and G. C. Berendt, die in Bernstein befindlichen organischen Reste der Vorwelt.—Göppert in Berichte der Berlinen Academy, 1853.—Menge Beitraege zur Benstein flora in den Schriften der Nat. Gesell., zu Danzig. Bd. 6, H. 1.

bling pasteboard, whose surface bears the traces of the remains of very small, innumerable fragments of thin filaments, mixed with an indistinct compound of what appears to be very small detached oval leaflets. At first, I compared them to, and found them to resemble those indistinct forms of leaves and stems, which are seen on the surface of the pieces of peat, when this matter has been formed by the Sphagnaceæ, a tribe of the Mosses. I have come again and again to the examination of those peculiar shales, expecting to find some distinct outline of the plants which cover them with their remains. But nothing more can be seen than what I had discovered at first, and this is not enough to authorize the conclusion that these remains are those of certain mosses.

4. *Filices*, (*Ferns*).

The following remark of Mr. Brongniart in his *Tableau des genres*, (p. 15) is fully confirmed by the examination of all the specimens of fossil-ferns that I have been able to collect from our coal measures. He says: "*that he is satisfied that in the classification of fossil ferns, we must establish genera from the attentive study of the nervation and of its relation with the general form of the pinnules and of the fronds. That we can not look for reliable characters to the fructification, until it has been possible to observe the sporanges or fruit-dots of the great majority of the species,*" &c. The number of fruiting species of fossil ferns, found in the coal measures of the United States, is already great indeed. But I have not been able to observe in a single case anything else about the fructification, except the position of the spores relatively to the nerves. And this, even, seldom. The true characters used for the classification of the living ferns, viz., the form of the fruit-dots, their mode of attachment and their involucre or *Indusium* could not be ascertained in a single case. Among the most remarkable and distinct fruiting specimens of ferns, I have got two at least, and perhaps three, which show the sporanges separated from the leaves, appearing to be born on separate pedicels, as it happens in many species of our time. One is *Staphylopteris stellata* Lsqx.,* from the sub-conglomerate coal of Arkansas. Another, undescribed represents small bunches of round, flattened sporanges, somewhat inflated on the margins, and attached on a bipinnately divided branch, on both sides of a common narrow rachis, resembling the medial nerve of a *Pecopteris*. The whole bears some resemblance to a fruiting branch of our common *Botrychium Virginicum*. It might be supposed from the disposition of the sporanges, which is like that of *Asterocarpus Sternbergii*, Göpp., that the substance of the

* Second vol. of the Geol. report of the State Survey of Arkansas.

leaflets supporting them has been destroyed by maceration; but there is no trace of any such substance and the sporanges are at some place irregularly distributed. A third species, also undescribed, represents a few narrow leaflets, the upper part of a pinna, with very strong, arched, dichotomous, reticulated nerves, marked, in relief on the stone, appearing like the supports of sporanges destroyed by maceration. I consider it as the remains of the fruiting branch of a *Neuropteris*. But all these fruiting branches can not be referred except by mere supposition to species of fossil ferns known by their leaves and classed by their nervation. They must be described separately as fruit and their relation to peculiar species of ferns can not be mentioned, till they are found in connection with their leaves.

Of course this can not change the views expressed above, concerning the classification of the fossil ferns, but only force the admission of one or more of those artificial and unreliable genera, which may be eliminated by the discovery of better specimens and with which fossil botany has to be satisfied for the present.

With the exception of a few species which can be separately classed as species of doubtful affinity, all our fossil ferns may be contained in the three following tribes: 1st, *Neuropterideæ*, 2d, *Pecopterideæ*, 3d, *Sphenopterideæ*. The great Palæontologist Göppert, in reviewing in his *Genera* (liv. 3 and 4, p. 48), a former classification of his *Systema*, has admitted two other tribes, the *Danaeaceæ* and the *Gleicheniaceæ*. But we have not thus far in our coal measures any representative of the first; and our species of the second, like *Gleichenites artemiscæfolius* Göpp., (*Sphenopteris* Brgt.,) belong by their nervation to the *Sphenopterideæ*. Both these divisions may thus be left aside for the present.

1st Tribe. *Neuropterideæ.*

The classification of our American species seems to necessitate a slight modification in the subdivision of this tribe admitted by the European author. I would subdivide it in the following genera: 1st, *Noeggerathia* Sternb., 2d, *Cyclopteris* Brgt., 3d, *Neuropteris* Brgt., 4th, *Odontopteris* Brgt., and 5th, *Dicthyopteris* Gutb.

1st, *Noeggerathia* Sternb. This genus was first established by Sternberg, *Vers.* p. 28 for the description of the figure of its plate 20th; then by a more appropriate description page 33, and definitively page 36th of his 4th book where he limits as follows the genus *of uncertain affinity: Cauder ignotus; rami teretes, pennam anserinam æquantes, lignescentes; folia alterna, approximata, obovata, ramum basi semi-amplexantia, apice pectinato-dentata, integerrima.* The author does not mention the nervation, but his description is completed and somewhat modified by Mr. Göppert

who in his Genera (liv. 5 and 6, p. 107), has described another specimen of Sternberg's species, *Noeggerathia foliosa:* and fixed the genus thus: *Frondes petiolatæ, pinnatæ; pinnæ obovato-cuneiformes vel obovatæ, lateribus petioli applicitis semi-amplexicaules, nervis numerosis teneribus, plerumque simplicibus ab ima basi adscendentibus percursæ.** Göppert then describes two new species of this genus: *N. obliqua* and *N. Beinertiana.* The figure of both represent only part of much longer leaves than those of Sternberg's species. These leaves lacerated on one side have an appearance far different from that of the Ferns, to which nevertheless Mr. Göppert refers this genus. Brongniart, in his *Tableau des genres* has described again this *Noeggerathia foliosa* and from the simple pinnate form of the frond, the rigidity of the leaflets and the mode of nervation, he compares it to a palm or rather to the American *Zamiæ.* He has thus made a separate family of the *Noeggerathiæ*, and places it between the *Cicadeæ* and the *Conifereæ.* This Family contains only two Genera: *Noeggerathia* and *Pychnophyllum*,† this last one replacing the *Flabellaria* of Sternberg or rather including only *Flabellaria borassifolia* Sternb. Mr. Geinitz in the *Versteinerungen*, &c., has apparently admitted Brongniart's views. He places the family of the *Noeggerathiæ* with the Dicotyledonous plants having the same two Genera and refers to *Noeggerathia* a number of fossil fruits of the Genus *Rhabdocarpos.* This variety of opinion and uncertainty of the characters of both the genera *Noeggerathia* and *Cordaites*, is perplexing indeed. But I think that the examination of our American specimens, referred to these Genera may help to fix their true characters and place.

It is evident that both the species published in the report of the State Geological Survey of Pennsylvania as *Noeggerathia minor* and *N. obtusa*, are true *Noeggerathia*, according to the description and the figure of Sternberg's species. They correspond not only with Sternberg's and Göppert's description of the genus, but with the remark of Brongniart about the nervation and the rigidity of the leaves. The branch figured on plate 1 fig. 10, shows that these plants were at least bipinnately divided. Since the publication of this report I have had opportunities to examine better specimens of the same species and especially have lately received from Prof. J. D. Dana of New Haven, the figure of a splendid specimen of *Noeggerathia obtusa*, found in the old Red Sandstone of Montrose, Penn., by Rev.

* The restriction *plerumque simplicibus* can not be admitted for such leaves as those of *Noeggerathia foliosa* when the nerves all come from the base. They must of course much divide in ascending.

† This genus is wrongly ascribed to Göppert by Geinitz in his *Versteinerungen*, &c., p. 40. In the *Tableau des genres*, by Mr. Brongniart (published in 1849), the author establishes the genus *Pychnophyllum* for replacing *Flabellaria.* Mr. Göppert admitted it only in 1852. Brongniart's genus has even the priority over *Cordaites* proposed by Unger in 1850. But this last name should be preserved as a well merited compliment to Corda who has so admirably described and figured the *Flabellaria borassifolia* (Sternb.).

Henry A. Riley. It shows the upper part of a frond with three oblique pinnæ somewhat reflexed from their base and the pinnules or leaves, broadly oval or reniform, the upper one flabellate, all narrowed to the base and pinnately attached on both sides of the rachis by a narrow decurring base. The point of attachment of the leaves is just as I have figured it in my report. This splendid specimen has evidently the general outline and the appearance of a fern and at once puts aside Brongniart's surmise that the simply pinnate form of the leaf, &c., show it to be analogous to the *Zamiæ*.

On the other side, I have been able to find in the Anthracite basin of Pottsville, a stem of *Cordaites* with some of the leaves attached to it. It agrees exactly with the one figured by Corda though less well preserved and entire. It is a simple stem, about half an inch thick, bearing numerous long, ribbon-like, clasping leaves, spirally placed around it, marked with sharp, narrow, parallel, mostly simple nerves. The leaves are scarcely narrowed at the base and thus nearly linear; but, as I have seen it many times and as Corda's figure shows it, the leaves near the top of the stem become shorter somewhat narrowed at the base, spathulate-oblong, just of the same form as both the leaves of *Noeggerathia obliqua* and *Noeggerathia Beinertiana* figured in Göppert's Genera. I will not say that Göppert's species are not true species or belong to the same *Cordaites* as ours; but I believe that all those broken leaves described by Göppert as *Noeggerathia* ought to be referred to the genus *Cordaites* and removed from the Fern-family. I think that the genus *Noeggerathia* should be characterized as follows: *Frond bipinnately divided. Pinnæ, long, linear, oblique, flexuous; pinnules alternately and pinnately placed on both sides of the rachis, enlarged above, obovate, obcordate or reniform triangular, narrowed at the base and obliquely attached to the rachis by a narrow sometimes slightly decurrent base. Nerves equal, numerous, emerging from the base and forking in ascending.* To this genus thus limited I would refer *Noeggerathia foliosa* Sternb., *N. minor* Lsqx., *N. obtusa* Lsqx., *N. flabellata?* Ll. and Hutt., *N. Bockschiana* Lsqx., *Cyclopteris dissecta* Göpp., *C. hybernica*, *C. McCoyana? C. Jacksoni* Daws., with some other *Cyclopteris* with a narrow angular base and even perhaps *Odontopteris imbricata* Göpp. If we except of these species *Noeggerathia flabellata* and *N. foliosa* both of the lower coal, the first of England, the second of Bohemia, all the other species pertain to the Old Red Sandstone and thus the botanical classification very well agrees with the geological distribution. For this reason, especially, I doubt if *Noeggerathia cuneifolia* Brgt., of the Permian of Russia belongs to this genus, or it may be, as I have remarked it formerly, that, as this species is found with a *Lepidodendron*, its geological horizon has not been exactly marked.

To the genus *Cordaites* thus characterized: *stem simple, annulate or marked by the persistent base of the leaves; leaves simple, clasping at the base, long-linear, marked by simple, equal, parallel, rarely forking nerves*:—I would refer all those ribbon-like leaves so abundant in our coal measures, and generally found in broken fragments. *Noeggerathia palmæformis* Gopp., recently found in the coal fields of Illinois, *N. Beinertiana* Gopp., *N. ovata*, *N. abscissa*, *N. dichotoma*, *N. tenuistriata*, *N. Bruckeriana*, *N. crassa*, all species of the same author are referable to *Cordaites*. At least as much as can be seen from the figures that mostly represent fragments of leaves.*

2. *Cyclopteris* Brgt. By somewhat extending the definition of the genus *Cyclopteris*, it would be easy to place in it most of the species, if not all, of the genus *Noeggerathia*. But the name of this last genus has the priority to that of the former, and moreover the fine descriptive name, *Cyclopteris*, represents a kind of leaves far different from those to which Sternberg applied the name of *Noeggerathia*.† At first, it contained a number of species established for isolated round leaflets which a more careful observation showed to belong to species of *Neuropteris*. As the relation of species of *Cyclopteris* to species of *Neuropteris* is not easily ascertained, Brongniart made for these doubtful forms a new genus with the name of *Nephropteris*. Numerous American specimens have furnished satisfactory evidence of the identity of most of the species of *Nephropteris* with some species of *Neuropteris* and *Odontopteris*. They are mostly large, round leaflets, placed at the base of the primary pinnæ at the point of union with the common rachis or sometimes pinnules or leaves of an abnormal form, placed on the common rachis between the primary pinnæ or even on the pinnæ, between leaves of a normal form. We can thus eliminate the genus *Nephropteris* and refer to *Neuropteris* the species formerly belonging to it. I can scarcely refer any American species to the genus *Cyclopteris*, as it has been limited by Brongniart in his *Tableau des Genres*: *frond simple, pedicellate, symmetrical, round, cordiform* or *flabellate, entire* or *lobed, without traces of medial nerve, all* ***the nerves coming out from the basis of the leaf and diverging in dividing or forking to the border.*** I have found only a small incomplete specimen of *Cyclopteris flabellata* Brgt. It is no longer in my possession and I am unable to say if it represents exactly the European species. I know nothing more of it but what is said on p. 855 of the Report of the Pennsylvania survey.

3. *Neuropteris* Brgt. The celebrated Göppert had in his *Systema* admitted a new genus, *Adiantites* for a number of these

* Prof J. W. Dawson has adopted the same views in a paper recently published in the Canadian Naturalist.

† Jac. Nöggerath to whom the genus is dedicated is author of valuable researches on fossil trees and stems published at Bonn, 1820–21.

species intermediate between *Cyclopteris* and *Neuropteris*. But in his *Genera*, liv. 5 and 6, p. 90, he puts the classification aside and admits Brongniart's genus *Cyclopteris* with some modification, so as to place in it a number of species which I consider true species of *Neuropteris*. Indeed, the essential character separating his genus *Cyclopteris* from *Neuropteris* is, for the former, the nerves emerging from the base of the leaves and flabellately diverging and dichotomous in ascending; while in the genus *Neuropteris*, the medial nerve is marked from base up to above the middle of the leaves and disappears near the summit. Now, it is certain that a number of our *Neuropteris* have for the same species the two kinds of nervation that characterizes Göppert's genera. In *Neuropteris hirsuta* Lsqx., the long leaves are generally strongly nerved up to the middle; while the round leaflets, attached at their base, as also the upper leaves of the pennæ, which become simple, have all their nerves flabellate from the base without a trace of a middle nerve. *Neuropteris Clarksoni* Lsqx., bears on the same pinnæ two kinds of leaves, the one longer, narrower and strongly nerved in the middle; the others shorter, broader, with all the nerve flabellate from the base. This *Neuropteris* appears to be the American representative of *Neuropteris auriculata* of Europe, essentially differing from it by the strong medial nerve that marks some of its leaves. In *Neuropteris Loschii* Brgt. so common in our coal-fields, the medial nerve appears only with the larger leaves of the inferior secondary pinnæ. In *Neuropteris Desorii* Lsqx., again, the leaves attached to the primary pinnæ are marked with a strong medial nerve, ascending nearly to the point, while a number of leaves, attached on the primary rachis, have not only all their nerves flabellate from the base, but are enlarged in outline and take the form of *Cyclopteris*. All our species of *Neuropteris* show the same variety of nervation. Accordingly, I think that it would be more convenient and rational at the same time, to fix the genus *Neuropteris* as follows: *Frond pinnately, bi- or tri-pinnately divided; pinnules or leaves of various forms, round, oblong, oval, mostly entire, sometimes lobed, cut or fringed, attached to the rachis only by the middle point of their base. Medial nerve sometimes distinct and vanishing above; secondary nerves numerous, either obliquely emerging from the medial nerve or flabellate from the base, all arched and dichotomous.**

4. *Odontopteris*. The only essential character which separates this genus from the former is that in *Odontopteris* the pinnules or leaves though separated from each other, are attached to the rachis by their whole base or by the greater part of it. The nervation is very variable; the nerves either running from the whole base and straight as in *Odontopteris Schlotheimii*, or emerging

* As the genus is here limited, both the species *Neuropteris Moorii* Lsqx. and *Neuropteris Adiantites* Lsqx., ought to be separated from it and placed elsewhere.

from an enlarged base, flabellate, dichotomous, and arched as in the larger leaves of *Odontopteris Alpina*, Sternb. This last species, a beautiful one, has been lately found in the Anthracite coal measures of Rhode Island,* together with a number of our common coal plants, mostly the species characteristic of No. 3d and No. 4th coal. Our specimens are far more complete than any of those published in Europe. The frond, tripinnately divided has the primary pinnæ very obliquely separating from the common broad, narrowly and equally striated rachis. The secondary pinnæ are alternate and open or perpendicular to the rachis. The leaves or pinnules of the lower pinnæ are distinct, somewhat distant, oblong, obtuse, slightly scythe-shaped outward, one to two inches long, attached to the rachis by two-thirds of the rounded base. In the upper part of the frond, the secondary pinnæ are shorter and their leaves or pinnules are also much shorter, reniform or ovate, sometimes united together by the decurrent base, the terminal pinnule is very long, oval-lanceolate, obtuse. Generally the pinnules are shorter on the upper side of the pinnæ, a character already slightly marked in Sternberg's figure. The leaves of the lower pinnæ have exactly the nervation of the genus *Cyclopteris* of Göppert or of the *Neuropteris* with flabellate nervation. On the upper pinnæ, the leaflets even in the same pinna have either a flabellate nervation from the middle of the base, or more generally the nerves emerge from the rachis along the whole base of the leaflets, thus showing that the species is a true *Odontopteris*, as Geinitz has remarked it.

Large specimens of *Odontopteris Schlotheimii* Brgt., obtained from our coal-measures, show that this species found only in fragments in Europe, is tripinnately divided. The primary pinnæ about one foot long are lanceolate, half open; the secondary ones are linear, pinnately lobed with the lobes round or oval, united together near the base or distinct. In this species as in the upper pinnæ of *Odontopteris Alpina*, the first leaflets near the point of attachment of the rachis are generally distinct and their nerves run out from a point in the middle of the base of the leaflet and not along the whole base as in the other divisions.

Another fine and remarkable species of *Odontopteris* was also found recently in connection with No. 1B at Murphysboro, Ill. It is *Odontopteris heterophylla* Lsqx., (in MSS. report of the Geol. State survey of Illinois, pl. 2, fig. 2 to 5). The frond appears bipinnately divided. Pinnæ lanceolate in outline or cordate-ovate. Pinnules or leaves, either entire, obovate-obtuse decurrent on the rachis, becoming broader, shorter, cuneiform-oval near the base of the pinnæ; or elongated, diversely lobed, with unequal, linear-long, or short-lanceolate-oval divisions; terminal

* I am indebted for the communication of a fine specimen of it to Mr. James H. Clark of Newport, R. I.

pinnule large, deltoid, obtuse, alternately lobed on each side. Nerves sharply marked, inflated near the base two or three times forked; in the decurrent leaflets, the nerves are also a little decurrent along the rachis; in the other leaflets they run out from the whole base.

5. *Dictyopteris* Gutb.—This genus so well characterized by its nervation has still but one representative species, abundantly found in the whole extent of our coalfields, *Dictyopteris obliqua* Bunb. The form of the leaves is variable like their size. The upper pennæ are only pinnately lobed and the lobes separated to the middle, and short and nearly round.

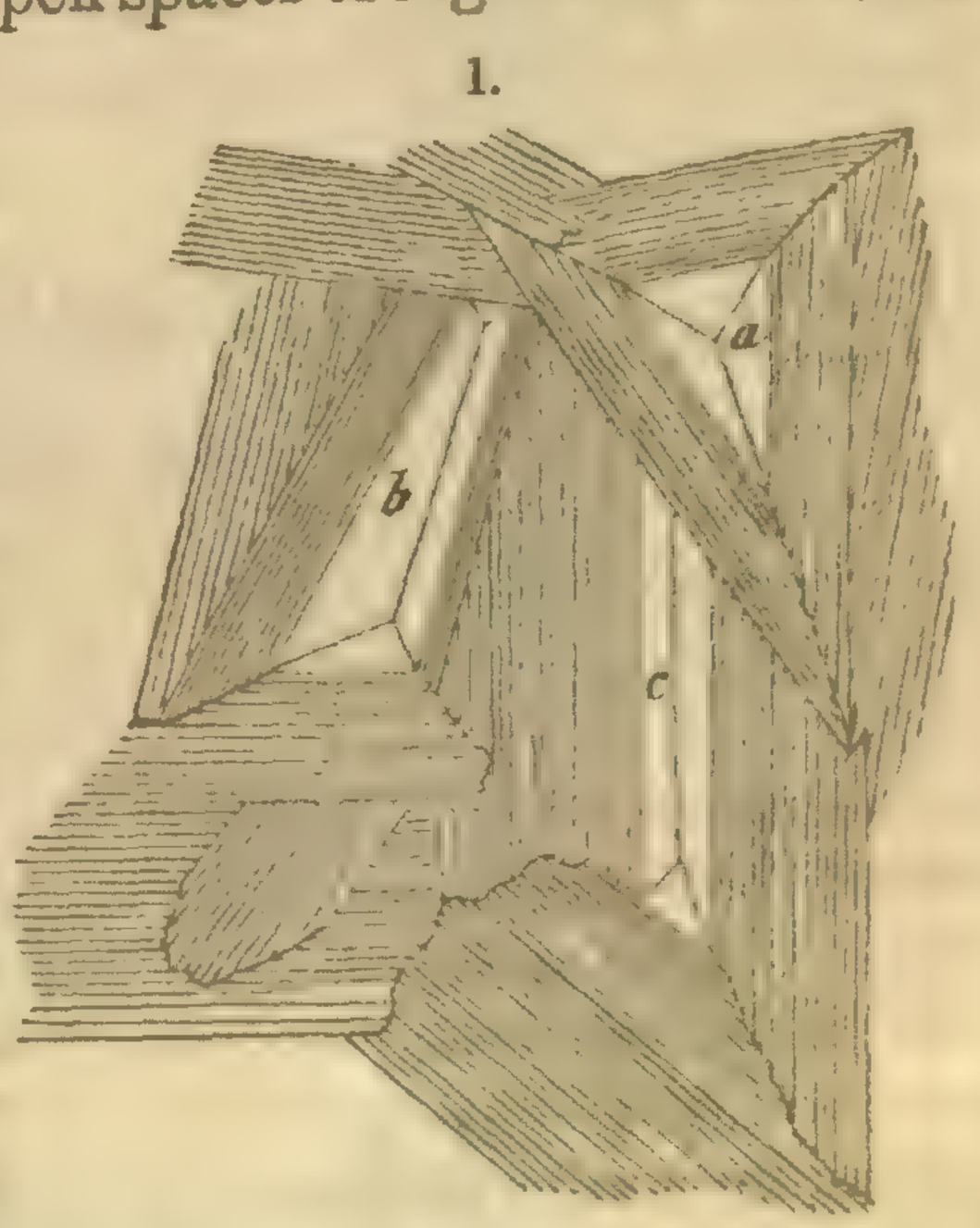
Columbus, Ohio, July 4, 1861.

(To be continued.)

ART. XXIV.—*Observations upon the Freezing of Water at the Passaic Chemical Works, Newark, N. J.;* by ARTEMAS BIGELOW.

ONE of the furnaces having been stopped in the early part of the month of Jan., 1860, the cistern for cooling acid before it is bottled, became frozen on its surface about two inches deep. The cistern was within the building and near the side of it. The weather but moderately cold. On the side farthest from the building the water had oozed up through and overspread the surface, slowly freezing at the same time. Attracted by the appearance of this portion of the ice, I examined, and found it composed of plates or laminæ lying one against the other obliquely to the surface of the water. The masses of plates were also at various angles to each other, leaving many open spaces of regular forms, *a*,*b*,*c*, fig. 1, whose faces were beautifully smooth and perfect, meeting below from their obliquity. The origin of each mass of plates being independent of the others, and extending from below obliquely upwards in three or four different directions, a cavity would consequently be left between the divergent masses, (fig. 1). These laminæ were free, except below, so that a knife thrust underneath lifted them out separately. Also as often as the thumb was applied with pressure to their upper edges, the lines would disappear and the ice at the place of pressure look solid,

1.



a, *b*, *c*, are cavities, the inclined sides meeting at the bottom.

is the more surprising from the fact that Prof. J. D. Dana has at my request examined a specimen with the microscope, but could not detect any admixture of quartz, and that it consisted of quite small glassy crystals or grains, which appeared to be purely the *baulite* (1st Suppl. to Dana's Mineralogy, this Journal, [2], xix, 356). Baulite *is a crystallized feldspar* with the oxygen ratio of $\dot{R}:\dot{R}:\dot{S}i = 1:3:24$.

On page 1019 he remarks that the zamtite, a hydrocarbonate of nickel from Spain is probably *identical* with nickel-gymnite (*a silicate*); it is more likely identical with emerald-nickel.

Amongst the omissions I notice the analyses of the meteoric iron from New Mexico, the nickel meteorite from Octibbeha, Miss., platinum from Oregon, orthoclase from N. C., etc. etc.

Philadelphia, Nov. 30th, 1861.

ART. XX.—*On some questions concerning the Coal Formations of North America. Families, Genera and Species of Coal Plants of the United States;* by LEO LESQUEREUX. (Continued from vol. xxxii, p. 205.)

Pecopterideæ.

IF we continue to follow Brongniart's principle for the classification of the fossil ferns, attempting to fix the divisions *from the nervation, in relation with the general form of the fronds and of the pinnules*, the tribe of the *Pecopterideæ* and its generic sections appear fixed by reliable and sufficient characters.

The *Pecopterideæ* have a bi- or tri-pinnatifid frond with unequal, open pinnæ and equal, oblong or linear-obtuse pinnules, generally united together near the base and thus attached to the rachis by the whole enlarged, sometimes decurrent, very rarely narrowed base. The medial nerve is strong, straight, generally ascending to the top of the leaflets, and the veinlets are either straight and perpendicular to the medial nerve, simple or forking once or twice, or somewhat oblique, arched and dichotomous. The fructification is apparently punctiform; sometimes marginal and continuous as in the genus *Pteris*.

This definition is, with slight modification, that of Prof. Brongniart. Though the last remark about the fructifications has been generally repeated by European authors, I do not know of any species of *Pecopterideæ* that has been seen with evident marginal fructifications. The likeness of form and nervation of some of our fossil species of the coal-measures with species of *Pteris* living at our time is undeniable; but it is the only reason we have to suppose that their fructification may be sometimes marginal. If species of this tribe were found with evident mar-

ginal fructifications, they should be at once separated and put into a peculiar division.

The *Pecopterideæ* that by their general form and nervation most resemble the genus *Pteris* constitute a separate group. Generally larger than the other species of the tribe, their fronds are broad at the base, lanceolate pointed in the upper part, nearly triangular in outline. The lower pinnæ are bi-pinnately or pinnately divided with long-linear obtuse, rarely somewhat acute leaflets, while the upper pinnæ become pinnatif and then simple with shorter and broader pinnules. Thus the fronds in the lower part are bi- or tri-pinnately divided while the upper part is only bi-pinnately or even pinnately parted. The strong medial nerve of the leaflets ascends to the point and the nervules generally perpendicular to the medial nerve, or nearly so, are strongly marked and simple or forked once.

The name of *Alethopteris* given to this division by Sternberg and Göppert has been admitted by Brongniart; and the section itself considered by this author as forming a well characterized genus, provided it be restricted to species agreeing with the above definition and not extended beyond its limits, as has been done by Unger. The known American species belonging to this genus are: *Alethopteris lonchitidis* Sternb., *A. aquilina* Göpp., *A. Serlii* Brgt., the largest of our species with pinnæ sometimes longer than one foot and pinnules two inches long; *A. marginata* Brgt., very rare indeed and perhaps not even belonging to our coal-measures, the specimen referred to this species being obscure and incomplete. These four species are common to both continents. As exclusively American species we have: *Alethopteris Pennsylvanica* Lsqx., *Alethopteris species nova*, (ined:) formerly referred to *A. urophilla* Brgt., (Penn. Geol. Rep., p. 864) but differing by twice forked veins and by a broader, shorter and pointed terminal pinnule. *Alethopteris Owenii* Lsqx., (Ark. Geol. Rep., vol. ii, p. 309, pl. 2, fig. 1), *A. Coxiana* Lsqx., (Ky. Geol. Rep., vol. iv, ined:) and *A. distans* Lsqx., if this species founded on two small and imperfect specimens proves to be a good one. Our *A. Coxiana* Lsqx., somewhat resembles *A. sinuata* Brgt. Its secondary veins are more oblique than those of any other species of the genus. It is thus intermediate between this and the following division.

The genus *Callipteris*,* proposed by Brongniart for another group of fossil ferns, is related to the *Neuropterideæ* by the nervation, and to the *Pecopterideæ* by the leaflets attached to the rachis by their whole base and generally united together. Prof. Göppert formerly referred the species of this group to a peculiar section of *Neuropteris*, and I admitted the same views in the

* This name Callipteris is given also by Mr. John Smith to a genus of living ferns (Hook. Mem. on the Geol. of Great Brit. p. 410).

Pennsylvania report. But this last genus is far more natural if preserved with this characrer: (*leaflets attached to the rachis by the middle of their base or by the base of the medial nerve only*); and the group of species forming the genus *Callipteris* find also a more natural place as the first of the *Pecopterideæ*, serving for a link of union between this and the *Neuropterideæ*.

In comparing the species referable to the genus *Callipteris* Brgt., it is evident that they present two somewhat different types of nervation and thus should be separated in two sections. The one characterized by a thick straight medial nerve, ascending above the middle of the leaflets and by thin, close, arched, dichotomous forking veinlets, is more closely related to *Neuropteris;* the other with a thinner, somewhat flexuous medial nerve, dichotomously forking in ascending and veinlets oblique, a little arched, distant and forking only once or twice, is related to *Odontopteris*. Of European species: *Pecopteris gigantea* Brgt., *P. punctulata* Brgt., *Neuropteris conferta* Göpp., and *N. obliqua* Göpp., (four species extremely alike and perhaps identical). *Pecopteris sinuata* Brgt.,* *Neuropteris* (*Pecopteris* Brgt.) *ovata* Germ., are referable to the first section of this genus with a single American species: *Callipteris Sullivantii* Lsqx.† In the second section represented in the coal-measuaes of Europe by *Neuropteris conjugata* Göpp., I would place our *Neuropteris Moorii* Lsqx., *N. adiantites* Lsqx., and *Alethopteris rugosa* Lsqx. This last species was formerly described and figured from very incomplete specimens first as *Ale-*

* No good good specimens of these species have been thus far found in our coal measures. The specimen from Pennsylvania, referred to the last species, is indistinct.

† It is on the stems and leaves of this species that the small body, *Gyromices Ammonis* Göpp., alluded to in a former paper (No. 95, page 105 of this Journal), is especially found in the coal-measures of Illinois. Since the publication of my former paper where this species is considered as a small freshwater shell, I have received from Prof. J. W. Dawson of Montreal a kind note on this subject, with specimens showing that the Nova Scotian species is the same as ours. He says: "This species *Spirorbis carbonarius* formerly *Microconchus carbonarius* abounds in the Carboniferous rocks of Nova Scotia, occurring in the lower coal-measures under the Carboniferous limestones and thence up to the upper Coal-measures. It is usually found attached to the leaves and stems of land plants or to shells of the Univalve and Modiola-like Mollusks of the Coal-measures (*Naiachites* Daw.). A similar species is found in the Devonian at Gaspé and St. Johns, New Brunswick, attached to land plants. I first observed this shell in 1844 and noticed it as a *Spirorbis* (Journ. of the Geol. Soc. of London, vol. i, 1845). Mr. Binney referred the British shell to *Spirorbis* in 1852. In 1853 I noticed the resemblance of the Nova Scotian to the British species (Journ. of the Geol. Soc., vol. x) and in my Supplement to Acadian Geology, have stated my belief in their identity, (Acad. Geol., p. 147, Supl. p. 43)." As I formerly stated, it is certain that *Gyromices Ammonis* of the German authors is the same species as ours, and from Prof. Dawson's specimens it is evident also, that his *Spirorbis carbonarius* of Nova Scotia is identical with it. The remarks of the distinguished Professor establish beyond a doubt that the species is a shell. Judging from the figure in Acadian Geology, p. 147, that shows the mouth of the spirorbis as being cut in an undulating line, and especially from Lyell's figure (Manual of Geol., p. 525), I supposed that the Nova Scotian and the English species were different from ours whose mouth is exactly oval, with a thick obtuse margin. If Lyell's figure is exact, I think still that it cannot represent the same species as ours.

thopteris obscura, in the Penn. Geol. Rep., (p. 865, pl. 1, fig. 13 and 14) representing the upper part of a pinna, and later as *Alethopteris rugosa* in the Catalogue of fossil plants of the coal-measures of America (p. 11, tab. 1, fig. 2 and 3) showing only the lower part of a separate pinna. But better and more complete specimens of this fine species have since been obtained presenting its different parts. Like the other species of *Callipteris*, it is by the general outline of its frond and the form of its divisions a true *Alethopteris*, while its nervation is that of a *Neuropteris*. It has a tripinnately divided frond, with open, flexuous, ovate-lanceolate primary pinnæ and linear secondary pinnæ. The pinnules, united together up to the third of their length, are ovate-oblong, entire, somewhat obtuse, with a deltoid, obtusely pointed terminal pinnule. The lower and inferior pinnules are sometimes of an abnormal form or a little broader and more obtuse and as the upper pinnæ are decurrent on the rachis, they often become attached to the main stem. The medial nerve is thin, flexuous, forking in ascending (dichotomous) and the veinlets somewhat distant are oblique, arched and forked once or twice. Our *Alethopteris Sullivanti* Lsqx., has not yet been found with pinnæ attached to the rachis and it is still uncertain if these are decurrent as in the other species. In *Neuropteris Moorii* Lsqx., and *Neuropteris adiantites* Lsqx., this character is well marked and the main rachis is winged by decurrent leaflets.

I consider as a third well established division of the *Pecopterideæ* of the coal, the genus *Pecopteris* Brgt., as it is fixed in the following definition slightly modified from Brongniart, in his *Tableau des Genres*, page 24. Frond bi-tripinnatifid; pinnæ long, pinnatifid, with pinnules attached to the rachis by their whole base, generally united together at the base, oblong, obtuse, entire, equal, not decurrent. Medial nerve thick or well marked; veins oblique or perpendicular, simple, once, twice, rarely thrice, forked.

The modification of Brongniart's definition concerns only the characters taken from the form of the pinnules: oblong, entire, obtuse, and equal; permitting the grouping of the species of our coal-measures in a more simple and natural way. The only species that apparently differs from these characters is *Pecopteris arguta* Sternb., whose leaflets are sometimes sharply serrate. As will be seen below, this fossil fern has its pinnules sometimes entire, and thus the serrature of part of the leaflets may be considered as abnormal.

Prof. Brongniart in his *Tableau des Genres* has farther subdivided the genus *Pecopteris* into three subgenera, according to the direction and the number of the divisions of the veins. As these characters are not always permanent in the same species, these

subdivisions can be preserved for convenience sake only. They are :—

§ 1. *Aplophlebis. Pecopteridis* species with straight medial nerve and secondary veins simple, oblique or perpendicular to it. As belonging to our coal-measures, we have in this section: *Pecopteris arguta* Brgt., *P. unita* Brgt., *P. acuta* Brgt., *P. æquulis* Brgt., *P. concinna* Lsqx., *P. arborescens* Brgt., *P. cyathea* Brgt., *P. affinis* Brgt., *P. pusilla* Lsqx., *P. dubia* Lsqx., and *Asplenites rubra* Lsqx. These last five species may be varieties of *P. arborescens*, or at least are considered as such by some authors. To this section, I would still add: *Pecopteris longifolia* Brgt. and its identical species *Diplaxites emarginatus* Göpp.

§ 2. *Dicrophlebis:* containing species with twice or thrice forked veins. Our American species agreeing with it are: *Pecopteris oreopteridis* Brgt., *P. pennæformis* Brgt., *P. plumosa* Brgt., (identical with *P. dentata* Brgt.), *P. villosa* Brgt., and *P. decurrens* Lsqx.

To the third subgenus *Cladophlebis* Brgt., with pinnules sometimes free at the base, nervules more oblique on the medial nerve, more divided, generally arched and dichotomous, we could refer as species from our coal-measures: *Pecopteris Cistii* Brgt., *P. polymorpha* Brgt., *P. distans* Lsqx., *P. Sheafferi* Lsqx., and perhaps *P. velutina* Lsqx., whose nervation is entirely obsolete and unknown.

A number of species of *Pecopterideæ*, especially belonging to our coal-measures, should, I think, from their peculiar appearance, be grouped together in a separate genus. They are all thick-leaved ferns, and their pinnules though mostly entire have a tendency to become irregularly lobed, when they increase in size, especially the lower and inferior one of each pinnæ. The pinnules are unequal in size and varied in form. They have a strong medial nerve, dichotomous or forking in ascending, generally straight and the secondary nerves or veins diverging in an acute angle and once or twice forked, according to the size of the pinnules. In this group, I would place *Pecopteris nervosa* Brgt., *P. muricata* Brgt., *P. Pluckneti* Brgt., *P. Loschii* Brgt., commonly found both in the European and the American coal-measures, with the following species belonging exclusively to ours: *Pecopteris Sillimani* Brgt., *P. callosa* Lsqx., (Ill. Geol. Rept. ined. pl. 3, fig. 1,) nearly related to *P. Loschii*, *Sphenopteris Lesquereuxii* Newb., scarcely distinguishable from *P. Sillimani*, and likely a variety of the same, *Sphenopteris Newberrii* Lsqx., and *Pecopteris dimorpha* Lsqx. This last species is related to *Pecopteris bifurcata* Sternb., referred by Prof. Geinitz to *P. Pluckneti*. The nervation and the form of some of the leaflets is the same, but it differs by peculiar and apparently persistent characters. The leaflets generally free at the base are sometimes distant and have a different form on each side of the pinnæ. The upper ones are shorter, broader, broadly obtuse at the top, variously and irregularly lobed,

enlarged and somewhat decurrent at the base; those of the lower side of the pinnæ are longer, lanceolate, mostly entire, slightly pointed and also a little decurrent on the rachis. In the upper pinnæ only the shorter, generally triangular, pinnules are apparently united at the base, at least continuous; but they preserve the same difference of form on both sides of the pinnæ, broadly triangular on the upper, longer lanceolate triangular on the lower side. This remarkable species, which comes from the coal-measures of Rhode Island, varies as much in its ramification as in the form of its different parts. On one specimen, showing the part of a frond, the pinnæ are alternate, distant, very oblique on the main rachis; on another, the alternate pinnæ, more than six inches long, are perpendicular to the rachis, and placed very close to each other. It is probable that this last part is that of a large, primary pinna, and that the first one shows the upper part of the frond. In that case the frond is tripinnate or even quadripinnately divided, the lobes or divisions of the pinnules being sometimes deep and regular on both sides.

The only one of our species that might appear out of place in this newly proposed group is *Sphenopteris Newberrii* Lsqx., especially from the peculiarity of its ramification. The leaflets also, though sometimes irregularly lobed, are less so than in the other species and the enlarged main rachis appear narrowly winged by the inferior decurrent pinnules like that of some *Sphenopteris*. Except this last character, which cannot be considered as generic, the essential features of this fern refer it to this group. Its nervation is nearly exactly like that of *Pecopteris nervosa* Brgt., though less deeply marked, and its pinnules unite near the base. The ramification also of *Pecopteris nervosa* and *Pecopteris Loschii*, is, if not dichotomous, at least forked at the upper part of the fronds, into two diverging branches as in the *Gleichenites* of Göppert. In *Sphenopteris Newberrii*, these branches are united in a more open angle at the top of an apparently naked pedicel in the form of an upturned crescent.

If, as I think, this peculiar group of fossil ferns of our coal ought to be separated as a genus, the name of *Aspidites* Göpp. would be appropriately preserved for it. It was formerly established by the author, in his Systema, p. 348, and afterwards abandoned, because, characterized as it was, especially by its fructification either known or supposed, it contained species that had not sufficient affinity to be grouped together. Nevertheless the definition characterizing the second section of this old genus would without hardly any modification agree with the species of the new one. Frond bi-tripinnate. Pinnules generally enlarged at the base, united, decurrent or separated and sessile; medial nerve somewhat flexuous, thinning upwards and becoming bifid at the upper end; secondary nerves emerging from it

in an acute angle, dichotomous; branches simple or forking, more or less arched. *Pecopteris Pluckneti* Brgt., was already placed in this section by Prof. Göppert, and some of the species appear nearly related to species of *Aspidium* of our time.

There are still some other species that have been placed by Brongniart in a separate section of the *Pecopterideæ*, named by him *Sphenopteroides*. These species are true *Sphenopteris*, and have been generally considered thus by European authors. Mr. Brongniart himself says, in his *Tableau des Genres*, that they would find perhaps a more natural and better place with the genus *Sphenopteris* than with the *Pecopterideæ*. We have only two American species referable to this section, and they are of course mentioned with the genus *Sphenopteris*.

It would be out of place to examine critically now the other genera proposed for the classification of the *Pecopterideæ*. A few only, on which our American specimens furnish some interesting data, can be mentioned here.

Göppert has separated his genus *Diplaxites*, especially from the pinnules united nearly in their whole length, and the medial nerve pinnately branching, with simple veinlets a little curved inwards and ascending to the margin of the leaflets. Mr. Bunbury, in his examination of some fossil ferns of Frostburg, Md., (Quart. Journ. of the Geol. Soc. of London, vol. 2, p. 82,) has made some very interesting remarks on this genus, referring to it as likely to be new, one of our American species. From numerous specimens collected in various parts of our coal measures it is evident, first, that our species and *Diplaxites emarginatus* Göpp., are identical, and secondly, that *Diplaxites emarginatus* Göpp., and *Pecopteris longifolia* Brgt., are also the same species. It is true that hitherto we have found this fossil fern only in pinnæ separated from the common rachis. But they are sometimes in great numbers on the same slate and both the broad-leaved and narrow-leaved forms, to which both names have been applied, are found mixed, together with those of an intermediate size, serving as transition. In some of the leaflets the inferior veins do not ascend to the top of the pinnules but diverging against the borders meet those of the contiguous pinnule half way, or below the point of union of the leaflets. In that case the species has exactly the nervation and the form of some pinnæ of the very variable *Pecopteris unita* Brgt. It is thus a true *Pecopteris*, perhaps identical with the last species.

The genus *Asplenites* Göpp., was separated from *Pecopteris* on account of the lengthened or linear fruit-dots. I formerly admitted it for one of our fossil ferns: *Asplenites rubra* Lsqx. But from the examination of a great number of specimens, it is evident that the narrow linear marks on the upper surface are mere irregular impressions from the fruit-dots, placed under the leaflets, varied indeed by contraction of the epidermis, and do not

show the real form of the dots. Both the linear and the round impressions are seen on the same specimens. Our species in this case is undistinguishable from *Pecopteris arborescens*. The *Asplenites nodosus* of Göppert has been also recalled to it by Geinitz.

In the genus *Polypodites* Göpp., still preserved by Unger, we find *Polypodites elegans* Göpp., when another species which appears to be identical with it, *Pecopteris arguta* Sternb., is left by the same author with the genus *Pecopteris*. The only difference that separates both species is that in the first, the leaflets are entire, and in the second evidently and sharply serrate. On some specimens of ours, both the forms are found on the same frond, viz., sharply serrate leaflets becoming entire either by the pressure of the teeth against the margin of the leaflets or by insensibly passing to an undulate and then to a perfectly smooth margin. The great and splendid specimens figured by Germar, of *Polypodites elegans*, are extremely like specimens of our *Pecopteris unita* Brgt.

It is still doubtful if the genus *Crematopteris* Schp., with a frond simply pinnate and leaflets vertically placed, ovate, oblong, very entire, without any trace of nerves, should be referred to the *Pecopterideæ* as it has been generally done. It is still more uncertain if our species *Crematopteris Pennsylvanica* Lsqx., belongs to this genus or is referable to it. The only specimen ever found of this fossil plant is figured Tab. 3, fig. 5, of the Penn. Report. It may be part of an undeveloped frond or even part of a root. This species like *Scolopendrites grossi-dentata* Lsqx., (same Rep., p. 868, tab. 8, fig. 7,) ought to be left as plants of undetermined affinity, till better specimens shall have been found.

Sphenopterideæ Brgt.

The fossil plants referable to this tribe are, even for the same species, extremely variable in their characters. This causes a great difficulty in their classification. Prof. Brongniart has remarked indeed that a division of the *Sphenopterideæ* would be possible, in combining characters drawn from the form of the pinnules and from the nervation; but he has not proposed any one himself. Prof. Göppert has divided the *Sphenopterideæ* in three genera only: *Sphenopteris*, *Hymenophillites*, and *Trichomanites*. With the exception of this last genus to which none of our species can be referred, this classification is admitted for our *Sphenopterideæ*.

The genus *Sphenopteris* Brgt. is still subdivided by Göppert in three sections, named here in an order contrary to that of the author.

1st. *Dicksonioides*: frond bi-tripinnate, pinnules suboblique, sessile, often united together at the base, entire or lobed or pinnately divided. Nerves pinnate, flexuous, distant, the inferior ones forking or dichotomous, the superior ones simple. This sec-

tion makes a link of union between the *Pecopterideæ* and the *Sphenopterideæ*, containing, as before said, some species referred by Brongniart to the genus *Pecopteris*. Of this section we have in our coal-measures: *Sphenopteris paupercula* Lsqx., (Geol. Rep. of Ill. ined. pl. 5, fig. 4 and 4*a*,) related to *Pecopteris Shoenleiniana* Brgt. *Sphenopteris* spec. nov. (ined.), distinguishable from *Pecopteris Murrayani* Brgt. only by the *slightly pointed and once-toothed* lobes of the pinnules that in the European species are roundish and entire. *Sphenopteris abbreviata* Lsqx., *S. plicata* Lsqx., a species established from a too small and incomplete specimen with nerves entirely obliterated and perhaps referable to *Pecopteris Pluckneti* Brgt.; *Sphenopteris intermedia* Lsqx., *Sp. Davalliana* Göpp, *Sp. Dubuissonis* Brgt., *Sp. Gravenhorstii* Brgt., and *Sp. flagellaris* Lsqx. I would even join to this division *Alethopteris serrula* Lsqx., a beautiful species that has some relation of form and nervation with this last one and that has no natural affinity with *Alethopteris*.

2d. *Cheilanthoides* Göpp. Frond bi-tripinnate with sometimes entire, mostly pinnately lobed pinnules. Nerves pinnate and secondary nerves mostly geminate in each lobe and forked near the top. Our American species of this section are: *Sphenopteris latifolia* Brgt., *Sp. acuta* Brgt., *Sp. obtusiloba* Brgt., *Sp. irregularis* Sternb., *Sp. polyphylla* Ll. and Hutt., *Sp. glandulosa* Lsqx., and *Sp. squamosa* Lsqx.*

3d. *Davalloides* Göpp. Frond bi-tripinnate, pinnules or lobes of the pinnules wedge-form; nerves oblique, ascending, single or double in each lobe. As referable to this section, we have: *Sphenopteris trilactylites* Brgt., *Sp. spinosa* Göpp., *Sp. distans* Sternb., *Sp. dilatata* Lsqx., *Sp. decipiens* Lsqx., and *Sp. rigida* Brgt.

If the American species do not throw any new light on the genus *Sphenopteris*, scantily represented in our coal-measures, it is I think different with those referable to the genus *Hymenophyllites* Göpp.

This genus is nearly related to existing species of *Hymenophyllum* and *Trichomanes*. According to Göppert, it has for characters: a frond bi-tripinnate, either irregularly cut-lobed or pinnatifid, with the divisions decurrent on a filiform rachis. Nerves pinnate or dichotomous, simple in each lobe or excurrent. I have formerly (page 69, vol. xxx, of this Journal) alluded to some species of disputed affinity, that were at first separated in a peculiar genus, *Pachyphyllum* Lsqx., (Penn. Geol. Rep. p. 863,) and afterward referred to a separate section of the genus *Hymenophyllites* Göpp., (Cat. of Fossil Plants,) for the following reasons:

1st. Living species referable to the genus *Hymenophyllum* have two different typical forms to which both the proposed sections

* The nervation of this species is unknown. The general form of its divisions is that of *Pecopteris Sillimani*.

of *Hymenophyllites* are evidently related. The species belonging to the first have a lanceolate, bi-tripinnate frond with forked pinnules. All its divisions are dichotomous, linear and decurrent upon a narrow, half round or flattened rachis. The nerves divide according to the divisions of the frond and the nervules simple in each lobe are excurrent. Of species referable to this section we have from our coal-measures: *Hymenophyllites Hildrethi* Lsqx., *H. flexicaulis* Lsqx., (Geol. Rep. of Ark., p. 309, pl. 1, fig. 1 and 1*a*,) *Hymenophyllites pinnatifidus* Lsqx., (Geol. Rept. of Ill. ined., pl. 2, fig. 2 and 2*a*,) *Hymenophyllites furcatus* Göpp., and *H. artemisiæfolius* Brgt. The other typical form of the genus *Hymenophyllum* to which another section of our fossil *Hymenophyllites* is related has for characters: a simple, cartilaginous frond, nearly round or oval-lanceolate in outline, irregularly pinnately cut-lobed in short obtuse divisions. The medial nerve at its base is the continuation of a short, naked pedicel, emerging from a creeping rhizome. The nerves are dichotomous, forking and thinning in ascending and the nervules simple and decurrent in each division. Indeed, although the general appearance of the species belonging to both these sections is far different, it results only from a greater or lesser expansion of the limb of the frond. In the first case, there is only a narrow strip of it extending on each side of the nerves and following them in their divisions, in the second, the *derma* is broader and sometimes fill the space between the nerves except near their extremities. It appears evident that all our species related to the second section of *Hymenophyllites* have the same characters as described above. All have a strong generally inflated basilar nerve, dichotomous or forking in ascending, with simple nerves, decurrent to the top of more or less irregular divisions; all also appear to have had a cartilaginous frond. Some authors assert that species like *Hymenophyllites giganteus* Lsqx., (*Schizopteris lactuca* Göpp.) cannot belong to the ferns. But our American specimens have apparently either a pinnate frond with large pinnæ attached on a common rachis, or a compound of simple fronds attached to one side of a creeping rhizome, and thus are fern-like. Our other American species are still more related to the ferns than the former.

With *Hymenophyllites giganteus* Lsqx., we have from our coal-measures: *Hymenophyllites laceratus* Lsqx., *H. hirsutus* Lsqx., *H. affinis* Lsqx., *H. fimbriatus* Lsqx., *H. adnascens* Ll. and H., and a new species from Rhode Island, related to the *Hymenophyllites giganteus*, but with broad obtuse lobes.

Another reason for abandoning the genus *Pachyphyllum* is, that some of the species now under examination have already been referred by European authors to five different genera, *Schizopteris*, *Aphlebia*, *Filicites*, *Fucoides*, and *Algacites*. The two first

only have been preserved for *Hymenophyllites giganteus*, but their characters are entirely at a variance with those of this and of the other species of this group. Brongniart characterizes his genus *Schizopteris* thus: Frond irregularly forking, sub-dichotomous or pinnately lobed; lobes fastigiate, elongated, enlarged-cuneiform at the top, truncate, without rachis and primary nerves; nervules very thin, parallel, equal, forking, &c. The genus *Aphlebia* Sternb., is from its character still less adapted for our plants, its characters being: frond lobate or flabellate, pinnatifid or pinnate, lobes or laciniæ plane, nerves and veins none; rhizome filiform, ascending. Moreover, both these genera characterized as they are, have no affinity with any other of the fossil plants and thus their place is uncertain.

(*To be continued.*)

ART. XXI.—*Abstract of a Meteorological Journal, kept at Marietta, Ohio:* lat. 39° 25′ N., and long. 4° 28′ W. from Washington City, for the year 1861; by S. P. HILDRETH, M.D.—[Thirty-fifth annual Report.]

MONTHS.	THERMOMETER. Mean.	Maximum.	Minimum.	Fair days.	Cloudy days.	RAIN. Inches.	Thous'ths.	WINDS.	BAROMETER. Maximum.	Minimum.	Range.
January,	32°·33	51	10°	12	19	2·704		W., N. & S.	29·75	28·84	·75
February,	38·20	69	2	12	16	2·316		S., S.W. & E.	29·75	28·85	·90
March,	43·00	75	15	12	19	2·278		S., S.W. & N.	29·78	28·95	·83
April,	52·70	82	30	14	14	6·372		N., N.W., S. & E.	29·60	28·95	·65
May,	56·39	86	28	15	16	5·619		N., N.E. & S.	29·65	28·65	1·00
June,	70·25	92	44	16	14	3·961		S., S.W. & N.	29·68	29·15	·43
July,	68·17	90	48	16	15	5·146		S., S.W. & N.	29·60	29 20	·40
August,	71·00	94	50	18	13	3 031		S., S.W. & E.	29·60	29·10	·50
September,	66·00	89	36	18	12	4·312		S.,S. E., & N.	29·84	28·88	·92
October,	44·20	79	28	15	16	4·433		S., S.W. & E.	29·80	28·95	·85
November,	41·33	71	25	14	16	4·631		N., N.W. & W.	29·64	28·85	·79
December,	37·00	69	12	21	10	1·618		S., S.W. & N.	30·00	29·10	·90
Mean for the year,	51·71			185	180	46·441					

The mean temperature for the year is 51°·71, being not far from the average of a series of years.

The amount of rain and melted snow is 46·441 inches and considerably above the mean for this locality.

Winter months.—The mean temperature for the winter is 33°·55. It was a very mild winter—the mercury being at no time at zero, though very near that point. The Ohio river was not closed, so as to prevent navigation, but contained at times considerable floating ice, lasting only a few days. There was but little snow.

13·45	Long. 81°	Long. 77°·5	
	Lat. 39 31′	Lat. 39 07′	
13·50	Long. 81°	Long. 77°·5	Long. 74°
	Lat. 40 37′	Lat. 40 13′	Lat. 39 49′
13·55	Long. 81°	Long. 77°·5	Long. 74°
	Lat. 41 43′	Lat. 41 19′	Lat. 40 55′
13·60	Long. 81°	Long. 77°·5	Long. 74°
	Lat. 42 49′	Lat. 42 25′	Lat. 42 01′

The observed and computed values of φ, at the stations where the bar and cylinder were employed, compare as follows:

Station.	Φ observed.	Φ computed.	Observed − computed.
Philadelphia,	13·45	13·50	−0·05
Harrisburg,	13·44	13·50	−0·06
Huntingdon,	13·51	13·51	0·00
Homewood,	13·49	13·50	−0·01
Johnson's Tavern,	13·54	13·48	+0·06
Irwin's Mill,	13·40	13·48	−0 08
Baltimore,	13·49	13·46	+0·03
Williamsport,	13·55	13·55	0 00
Curwinsville,	13·55	13·53	+0·02
Mercer,	13·64	13·53	+0·11
Erie,	13·57	13·57	0·00
Ellicottsville,	13·77	13·59	+0·18
Bath,	13·72	13 60	+0·12
Silver Lake,	13·47	13·58	−0·11
Milford,	13·50	13 56	−0·06
Schenectady,	13·45	13·63	−0·18
Syracuse,	13·61	13 63	−0·02
Geneva,	13·63	13·62	+0 01
Niagara Falls,	13·64	13·62	+0·02
Toronto,	13 84	13·65	+0·19

The probable error of any representation is $\pm 0{\cdot}066$.

ART. XXXVIII.—*On some questions concerning the Coal Formations of North America;* by LEO LESQUEREUX. (Continued from vol. xxxiii, p. 216.

Concluding Remarks on the Fossil Ferns.

THE examination of the fossil ferns of the coal, as far as it has passed under review in the former papers,[1] would apparently authorize the three following conclusions.

1st. That the family of the Ferns was represented, at the coal epoch, by species whose forms are easily referred to very few typical forms. For, if we consider only the figure of the leaves, viz., their contour and nervation, the only part generally preserved in the shales of the Coal Measures, all the species may

[1] Vol. xxxii, p. 193, Sept., 1861, and vol. xxxiii, p. 206, March, 1862.

be comprised in the three sections formerly examined: the *Neuropterideæ*, the *Pecopterideæ* and the *Sphenopterideæ*.

2d. That, from the scarcity of fructified specimens of fossil ferns in the Coal Measures, it would be supposed that most of the species were without fruit. If not, how can we account for the total destruction of the sporanges, either borne on peculiar stems, or attached to the lower surface of the leaves, as we find them in the species of our time?

3d. That the scarcity of large stems that have been or might be referred to ferns would lead us to suppose that, during the formation of the coal, the fern trees were of rare occurrence, at least when compared with the great number of ferns, which, in opposition to arborescent species, can be called herbaceous or shrubby.

These three questions must be considered separately.

1st. If it is certain that characters taken from the form of the leaves and from their nervation are sufficient for a kind of general classification, applicable to the stratification of the Coal Measures, it is true also that this classification fails to give us a clear insight into the true relation and the affinity of our fossil species. To be exact and scientific, an analysis of the ferns must take into account the form and the position of the fructifications; and when these are absent or undiscernable, as is generally the case with the specimens found in the Coal Measures, we are not authorized to believe that all the species, referable by their nervation and the form of the leaves to a common type, are equally related to it, by more essential but unknown characters. Indeed, though the attempt at a classification of the fossil ferns of the coal, from their fructifications, has been till now an abortive effort, the little we know of these fructifications shows a far greater diversity of typical and generic forms than are indicated by the leaves and their nervation. The fruiting leaves of the *Neuropteridea* are known, from European specimens, only for the genus *Odontopteris*, which, as Mr. Brongniart has remarked, do not bear any relation to ferns of our time. Species of this genus have their spores enclosed in a kind of bladdery sporange, or between the surfaces of the leaflets, which, thus inflated, wrinkled and without any trace of nerves, entirely lose their original shape. American specimens of this species perfectly agree with the beautiful figures that Mr. Gœppert has given of it in his *Genera*. The peculiar shape of the fructifications of this genus is still more remarkable on the fruiting specimens of *Odontopteris Britannica* Gutb., a species which has not yet been found in our American Coal Measures. Its sporanges, placed along a strong rachis and on both sides of it, have the form of an oval-pointed nutlet and rather resemble a raceme of fruit, or rather a branch bearing buds of flowers, of a dicotyledonous

species. Fine specimens of these supposed *Antholites* have been published by Lindley and Hutton, from the Coal Measures of England, and by Dr. Newberry, from our own coal fields. I have found also some small specimens of these peculiar remains at Pomeroy, Ohio, and at Port Carbon, Penn. All these, either naked or bracteated nutlets, appear to be only branches of fruiting stems of some ferns of an unknown type.

The fructifications of the genus *Neuropteris*, which, by the form of the leaves and the nervation, is closely allied to *Odontopteris*, appear to have a far different character. These fructifications, I think, are not known from European specimens; but we have a few from the American Coal Measures, which can be reliably considered as the remains of fruiting parts of some species of this genus. Two of them represent reduced forms of the upper part of a penna of *Neuropteris hirsuta* Lsqx. The leaflets are longer and narrower; the rachis and the medial nerve are flat and broad, and look rather like the branches and divisions of a panicle bearing sporanges. The veins are prominent, granulate, just as if a series of small fruit dots connected together had been placed either along them, or in the narrow space that separates them. If this appearance is real, these fructifications would bear a likeness of position to those of the *Danaeæ* of our time. But not of direction, indeed; for, in this species of our Coal Measures, the nervules are arched and dichotomous or forking like those of a true *Neuropteris*. Another remarkable specimen, preserved in a pebble of carbonate of iron, from Morris Co., Illinois, represents also a branch of a species of fructified *Neuropteris*. In this, the short, ovate, slightly pointed leaflets, about one inch long, and deeply cordate at the base, are attached to the rachis by a short pedicel. They are slightly convex or inflated in the middle, with a narrow margin apparently reflexed, but at the same time flattened all around. The scarcely visible veins are distant and apparently forked once, or the surface, generally quite smooth, is marked by irregular undulate cross-wrinkles, somewhat resembling those of the fructifications of an *Odontopteris*. In this case, the spores appear to be placed in large flakes, covering, except a narrow border, the whole of the lower surface of the leaves, as is the case with the fruit-bearing leaves of some species of *Osmunda* of our time. Thus, in the same genus, there are apparently two far different types of fructifications.

A peculiar specimen of fruiting fern, belonging to the Cabinet of Amherst College, and labelled, Mansfield,? Mass., shows a pinnately divided frond or rather panicle, whose secondary rachis is pinnately subdivided into short branches, bearing numerous groups of fruit dots, placed four by four on each side of a common branchlet. They appear attached to it, each by a very slender pedicel; and, round as they are, with a depressed point

in the middle, they look, at first sight, like the fruit dots placed on both sides of the medial nerve of a *Pecopteris*, whose derma or foliaceous tissue has been entirely destroyed. As no trace of this tissue can be seen, as the pedicels do not resemble veins, but are curved in a peculiar way, and as the fruit dots are at some places scattered and not in regular order, this fossil raceme is more likely the fruit-bearing part of a species whose sterile frond is possibly known with other characters. If it is so, this species would have a relation to the genus *Aneimia* of the living ferns, and thus, it could not enter into any of the three general divisions mentioned above.

The same can be said of *Staphylopteris stellata* Lsqx., of the low coal of Arkansas.[2] The figured specimen represents a smooth, main stem or branch, pinnately divided into short, thick, horizontal branchlets, each bearing at its extremity a group of four or five oval sporanges, attached to a common receptacle. This species has no affinity whatever with any other fossil remains of ferns, found in the Coal Measures, and thus it is without a place in our general classification.

From a number of fruiting branches of still undescribed fossil ferns, I will only briefly describe another remarkable species recently found at Mason Creek, Morris Co., Ill., by Mr. Even, who has sent, from the same locality, many interesting specimens, beautifully preserved in pebbles of carbonate of iron.[3] The specimen shows the upper part of a pinnately divided frond. The divisions are short, (one inch) and comparatively broad, (one-sixth of an inch) linear, obtuse, spreading, decurring in preserving the same breadth on a slender rachis, which, thus broadly winged, looks rather like the primary nerve of a secondary pinna. The veins, emerging in a broad angle from this common rachis, are straight, pretty thick, ascending to the top of the divisions and pinnately branching. The distant simple veinlets, no more than three or four on each side, slightly arched, diverging in a broad angle, bear at their extremity a group of six oval sporanges, placed just on the borders of the divisions. These sporanges, united by their margins around a common receptacle, appear, by this disposition, like small stars with round lobes. Considering only the form of the leaves, this species should be

[2] Geological Report of the State Survey of Arkansas, ii, 309, pl. 2 fig. 2.

[3] A deposit of the same nature, a bank of clay iron ore with pebbles of carbonate of iron, is also found in Southern Ohio, northwest of Marietta. Nearly all the pebbles have as a matrix a piece of fern or of some other fossil plant. As the species are the same both in Illinois and in Ohio, I consider both these strata, from palæontological evidence, as having the same geological horizon. Their place, according to the same evidence, is at or near the level of Coal No. 4, just below the base of the Mahoning sandstone. The most abundant species are *Pecopteris unita* Brgt., *Neuropteris hirsuta* Lsqx., *Pecopteris arborescens* Brgt., *Pecopteris Miltoni* Brgt., *Hymenophyllites hirsuta* Lsqx., *Alethopteris Serlii* Brgt., *Asterophyllites*, *Sphenophyllum*, *Annularia* and *Neuropteris Loschii* Brgt.

placed in the genus *Alethopteris*. But it differs widely from it by its nervation and especially by its fructifications. These would bring this species near the genus *Asterocarpus* of Gœppert, or the *Heptocarpus* of Braun, to which it has no affinity whatever by the leaves and the nervation. From examples like this, which, though few in number, are nevertheless every day multiplied by new discoveries, we can admit, I think, for the coal epoch, a far greater diversity of typical forms than could be supposed at first sight and from superficial researches.

2. What is said above is already an answer to the second question concerning the scarcity of fruiting specimens of ferns in the Coal Measures. This scarcity, like the paucity of typical forms in the fossil ferns, is rather casual than real. By careful researches at some places, where the remains of a species are found in abundance, one may generally succeed in finding traces of fructifications. They are especially preserved on specimens found as matrix of iron agglomerations, which have not been exposed to maceration in water for too long a time. This of course confirms the validity of the conclusions arrived at by Prof. Lindley and Prof. Gœppert from their experiments on the action of the maceration in destroying or preserving the forms of some species of plants. Most of the species of ferns of our time, under a protracted and continual immersion, have preserved well enough the forms of their leaves with evident traces of their nervation; but they have lost their fructifications. The sporanges have been detached from their supports and destroyed.

It is moreover known that, nearly always, the fern leaves are attached to the shales by their lower surface. Thus, even when the fructifications are preserved, we cannot see them, or we have only an indistinct outline of their form, printed in relievo through the carbonized tissue of the leaves. This of course renders the study of the fossil fruiting ferns very difficult.

3. Is the small proportion of fossil remains of true arborescent ferns in the Coal Measures, compared with the great quantity of leaves and stalks or petioles of the same family, a proof that, contrary to the opinion generally admitted, the arborescent ferns were not a predominant character of the vegetation of the coal epoch? If we consider as remains of true arborescent ferns, only those whose bark is marked by large oval cicatrices, left at the base of the fronds, at the point of their parting from the main stem, in short those known under the family name of *Caulopterideæ* or *Protopterideæ*, it is certain that they are very scarce in the Coal Measures both of Europe and of America. In his *Genera*, Mr. Unger counts in the *Protopterideæ* of the coal ten species only, distributed in five genera. And from these species, five are considered by Brongniart, Lindley and other authors as pertaining to *Sigillaria* or *Lepidodendron*. In his

Tableau des genres, Brongniart enumerates only six species of *Caulopterideæ;* Geinitz in his *Wersteinerungen von Sachsen*, four species, three published by Brongniart as *Sigillaria*, and one, a *Megaphytum*, by Artes; and Gœppert, in his *Fossil Flora des Uebergangsgebirges*, has none. In my examination of the fossil plants of our Coal Measures, I have seen, from the roof shales of the coal, only three specimens of two different species found at Carbondale,[4] and one found in Illinois.[5] And from the sandstone of the Coal Measures, I have in my cabinet a single specimen from Ohio, and there is another of a different species in the Illinois State Cabinet.[6] A few others, like *Sigillaria Cistii* Brgt., from Wilkesbarre, Penn., *Sigillaria discoidea* Lsqx., from Summit Lehigh, Penn., *Megaphytum protuberans* Lsqx., *Megaphytum Wilburianum* Lsqx., and *Lepidodendron radicans* Lsqx., from Illinois; these three last figured and described in the Geological Report of that State, may still be referable to this group of plants.

If, on the contrary, we admit with most of the European authors, that the fossil trunks, generally comprised in the genus *Psaronius*, did belong to arborescent ferns, we have to come to quite a different conclusion, concerning the distribution of the vegetation of the ferns at the coal epoch; for these trunks are found in great abundance in some parts of the Coal Measures. But Prof. Brongniart, judging from their internal structure, considers *Psaronius* as a genus related to the *Lepidodendra* rather than to the *Protopteridæ* or ferns. As the *Psaronius* species have their stems generally encased in a thick coat of roots or rootlets, grown and petrified together, the surface of the stems and the cicatrices with which they were originally covered are scarcely to be seen. Nevertheless, among the great quantity of specimens which I have examined in Southern Ohio, I have found a few, the smallest in size, whose uncovered stems evidently bear the long oval scars, the external character of the arborescent ferns.

Now, admitting the species of *Psaronius* as true arborescent ferns, the question of their distribution in the Coal Measures and of the place and importance which they occupied in the vegetation of the coal epoch is still unsolved. Where did they come from, all these trunks of the same genus; all with the same peculiar structure; all horizontally broken in fragments varying from one inch to one foot in length, and thus scattered at some peculiar and isolated localities, where they appear as if they had been heaped by some wonderful and unaccountable agency? I do not know in our Coal Measures of another deposit of petrified trunks of fern trees except that of Shade river, Ohio. It begins at Athens and extends southward as far as Charleston, Va. At least, I have seen trunks of *Psaronius* scattered along

[4] Penn. Geol. Rept. p. 869, pl. 13, figs. 1 and 2.
[5] Ill. Geol. Rept. ined., pl. 13, fig. 1, under the name of *Caulopteris insignis.*
[6] *Caulopteris Worthenii*, sp. nov., Ill. Geol. Rept. ined., pl. 14, fig. 1.

the banks of the Great Kanawha from its mouth to Charleston. The geological horizon of the strata with which they are connected is not satisfactorily determined; though it is certain that their place is not far above the top of the Mahoning Sandstone. They are apparently imbedded in a kind of soft sandstone, which at Shade river is separated by a covered space of 10 feet from a bed of coal 10 inches thick, which I consider as the equivalent of Coal No. 5. I say apparently, because it is not certain that they were originally derived from this bed of soft sandstone or hard clay, exposed on the high water of Shade river, where they are seen in great quantity, heaped in all possible positions and directions, just as if they had been transported and deposited there by a strong eddy. Nevertheless, they do not bear any trace of erosion by water. The fracture is clean and often sharply marked all around their circumference. When they appear eroded, this erosion is evidently due to the process of maceration, at or before the time of petrification. As no remains of this genus are found in connection with the shales of the coal strata, I think that forests of these peculiar arborescent ferns did cover some dry, sandy places of the Coal Measures, in the vicinity of some hot springs perhaps, or under the influence of peculiar atmospheric action. There they may have lived around the marshes, and their prostrated stems have been petrified afterwards by a local influence. I believe that if we could satisfactorily explain the dispersion and the transformation into silex of the fossil woods of the Tertiary, whose specimens abound in some parts of Arkansas, Mississippi, &c., this explanation would apply as well to the silicified trunks of the Coal Measures. In any case, and though we know but little about the distribution of the vegetation at the coal epoch, we are authorized to conclude, from the former remarks, that the species of ferns predominant in the marshes of the coal were especially shrubby or herbaceous species of small size, while those of the sandy or dry solid ground were especially arborescent.

Before leaving the *Caulopterideæ* I have still a few words to say of the size of the cicatrices of their bark, compared with the diameter of their stems. These cicatrices, generally distant, placed on the stems in the spiral order two-fifths, are, when found in a good state of preservation, nearly oval or obovate and elongated at both ends, by a somewhat deep furrow. They bear in the middle the mark of a simple fascicle of vessels in the form of a horse-shoe, and the central scar is surrounded by an oval annulus. Of the two specimens formerly mentioned as having been found in the sandstone of our Coal Measures, and whose somewhat flattened stems have preserved their form as well as the cicatrices of the bark, the one, four inches in its greatest diameter, has the scars just one inch broad. In the second, three inches and a half

in diameter, the scars are not quite one inch broad. Now the largest and most remarkable specimen of a *Caulopteris* that I have ever seen and a notice of which has ever been published (*Caulopteris insignis* Lsqx.), shows a piece of bark with a single but entire cicatrice of just three inches in diameter. Admitting that the proportion of the cicatrices to the stem is, in this species, the same as in the former ones, this must have belonged to a trunk of fern of less than one foot in diameter. This agrees well with the size of the trunks of *Psaronius* of Shade river, whose diameter is mostly between four and eight inches, rarely reaching one foot.

The genus *Megaphytum* Art., should, according to Prof. Brongniart's opinion, be united with the genus *Bothrodendron* or *Ulodendron* and referred to *Lepidodendron*, as representing merely a modification of this last genus. Our American specimens do not authorize this conclusion. *Megaphytum protuberans* Lsqx., of the State Cabinet of Illinois, has the cicatrices closely placed above each other, oval, convex, with their top somewhat squarely cut at the point of junction. They bear, near the upper end, the scars of fascicles of vessels, in the form of a horse-shoe; just like the *Caulopterideæ*, but without a marked annulus. These scars were evidently left at the base of large petioles or fronds, and are not cicatrices of leaves or of adventive buds as Mr. Brongniart supposes. It is even evident, from the forms of the cicatrices, which are a little flattened at their base and more elevated at the upper part, that the fronds which were originally attached to them were ascendent and closely appressed upon each other at their base. Moreover, this species has its surface deeply and irregularly striated and furrowed as if it had been covered by rootlets, just like the surface of a *Psaronius*. The cicatrices of *Megaphytum Wilburianum* Lsqx., still more nearly resemble those of a large *Caulopteris*. They are 4 inches broad, round, or square with rounded corners, flattened, with the scars of the vessels placed in the middle, and surrounded by an annulus. From this, it appears evident, that these remarkable stems did belong to a genus of the fern family, bearing two-ranked or distichous fronds. Prof. Geinitz has already admitted the genus *Megaphytum* as intermediate between the *Lycopodiaceæ* and the ferns.

Calamitariæ.

The species of this group of fossil plants have as common characters: the stems hollow, regularly striated, articulated, with articulations more or less distant, marked by a depressed or circular ring, or by an elevated margin, bearing whorls of leaves more or less united at their base. The five principal genera of fossil plants of the Coal Measures, which have been placed in

this group, *Equisetites*, *Calamites*, *Asterophyllites*, *Sphenophyllum* and *Annularia*, have between themselves no evident and acknowledged relation. Considering the first two of these genera as belonging to the family of the *Equisetaceæ*, Mr. Brongniart has separated from it the last three, placing them with the dicotyledonous gymnospermous plants. The essential reason for this separation is, that species of *Asterophyllites* sometimes bear, in the axils of their leaves, small, flattened, oval, somewhat winged seeds, resembling those of the Yew, and, at the extremity of these branches, a kind of cone containing a pulverulent matter, which this great author considers as pollen. An inflorescence of this kind resembles that of the conifers. If we consider only the more evident characters, viz: the hollow, striated, articulated stems; the leaves more or less united at the base and placed like sheaths around the articulations, this separation appears inadmissible. It is for this reason that most of the European authors have put it aside. Nevertheless, it is evident, from good though small specimens found in our Coal Measures, that, at least, two species of *Asterophyllites* bear, in the axils of their leaves, those small oval or cordate-oval seeds, observed by Mr. Brongniart, and far different from the cones of the same genus which he considered as male flowers. It is certain also, that, from the examination of a great number of these cones, very common at some places in the shales, in connection with branches and large stems of *Asterophyllites equisetiformis* Ll., they contain nothing under their scales but a pulverulent matter, as Mr. Brongniart has seen it. Possibly the flattened seeds, in the axils of the leaves of *Asterophyllites*, could be considered as a kind of tubercles; but I really believe they are true seeds and that all the species of the genus *Cardiocarpum* are referable, if not to the genus *Asterophyllites*, at least to plants related to it. At some places where *Asterophyllites* are abundant, these seeds are seen sometimes in plenty, varying in form from round or oval to cordiform, generally bearing a narrow wing, emarginated at the top, and even broadly winged, as shown by the beautiful specimens figured and described by Dr. Newberry.[7] They vary much in size, being generally as small as a pea, but sometimes as large as a walnut. If then, as is evident, these fruits belong to *Asterophyllites*, or to plants related to this genus, it is not possible to refer them to *Equisetaceæ*, and so the opinion of Mr. Brongniart is confirmed. But now, the fruits of the genus *Calamites* are still entirely unknown. A single specimen, figured in Sternberg's *Flora*, vol. ii, pl. 14, fig. 1, under the name of *Volkmannia arborescens*, apparently coming from a stem of *Calamites*, has the form of a long ear or cone, bearing whorls of narrow, linear, obtuse, somewhat open leaves, resembling the cones of *Asterophyl-*

[7] Annals of Science, No. 13, (May 1, 1853), p. 152, No. 2.

lites and, as I believe, of the species *Ast. lanceolata* Lsqx., of the *Pennsylvania Geological Report.* The only difference is in the form of the leaves. In our American specimens they are linear, *pointed*, never obtuse as Mr. Sternberg figures and describes them. In my specimens of *Asterophyllites lanceolata* the ears are always attached to a curved, half an inch thick, articulated and striated pedicel, having just the same form as a small branch of *Calamites approximatus* Art. The form of the pedicel, curved upwards, shows that these cones were attached to the side of a large stem and not placed at the top of some branches, and thus explains the reason and the form of large cicatrices, irregularly placed above the articulations of stems of some species of *Calamites*. But species of this same genus have also smaller, round cicatrices regularly placed around their articulations. Though, according to Prof. Geinitz, these scars are left as the point of attachment of some roots, they may nevertheless be only the marks left by fruits like those of *Asterophyllites*. Thus the relation of both genera, a relation so striking, if we consider the other appreciable characters, would be complete. But, even if this affinity of forms was perfectly ascertained, the question concerning the true relative place of these plants would not be settled. For the internal structure of the *Calamites*, as far as it is known, removes them evidently from the *Dicotyledonous* and establishes their relation with the *Equisetaceæ*. It is one of those numerous dilemmas offered for a solution, to the patience and long researches of the Palæontologist.

American specimens do not add much to what was already known of the different genera of this group. I have not seen in our Coal Measures a single trace of an *Equisetites*. I did not even suppose that species of this genus could be found in the Coal Measures. The beautiful specimens figured and described by Geinitz do not leave any doubt on this question.

There is near Carbondale a forest of standing *Calamites* imbedded in a bank of compact, coarse, hard sandstone. Numerous fragments of their stems have been taken out from a tunnel cut in this sandstone. These fragments show nothing but the external surface of the stems. Even the coaly matter which sometimes covers it has disappeared. The species are *Calamites Suckowii* Brgt., *Calamites ornatus* Brgt., which Mr. Geinitz considers as the same species; *Calamites Cistii* Brgt., and *Calamites approximatus* Art. The size of the stem varies from three to six inches, rarely attaining eight inches. A number of them appear to have been crushed upon themselves when still standing, for the bark, or rather the external surface, is often pushed and folded within the stem, all around the circumference. This, of course, proves that the stems of the *Calamites* were hollow cylin-

ders, covered with a thin but strong bark. No remains at all of roots, of fruits, or of leaves, are found in this sandstone and in connection with the *Calamites*.

It is very difficult to establish the relation of the cones of *Asterophyllites* with the branches, to which they are rarely found attached, and thus to fix the true species. For this reason, I think it more convenient, though less scientific, to give different names to each of the parts of the plants, as long as they have not been found in evident connection. The roots and floating filaments, formerly known under the names of *Hydatica prostrata* Art., are now considered by Prof. Geinitz as the roots of *Asterophyllites foliosa* Lindl. They have been found attached to large stems apparently belonging to this species. The roof shales of the coal at Pomeroy, Ohio, are, in some places, covered with these radiculose filaments, and, though I have not seen them attached to the stem, the abundance of branches of *Asterophyllites foliosa*, found on the same shales, confirms the views of the celebrated German author. But Mr. Geinitz also refers the cones known as *Asterophyllites tuberculata* Ll. & H., to the same species, and these cones are not found at Pomeroy. Per contra, they abound on the shales of the red ash coal at W. W. Woods and at the Salem vein of Port Carbon, near Pottsville, where *Asterophyllites equisetiformis* is plentiful, and where I have not found *Asterophyllites foliosa* or *Hydatica*. At W. W. Woods, with numerous remains of *Calamites*, the three species of cones named *Asterophyllites tuberculata* Ll. & H., *Asterophyllites aperta* Lsqx., and *Asterophyllites lanceolata* Lsqx., are also in great quantity of fragments.

A beautiful species of *Sphenophyllum*, *S. bifurcatum* Lsqx., has been found in the coal inferior to the Millstone Grit of Arkansas. It may be the same species as the small specimen figured and described in the *Pennsylvania Report* as *Sphenophllum trifoliatum* Lsqx. Difficult as it is to fix the specific characters of a *Sphenophyllum*, this species, from the great number of specimens examined, may be considered as a true one. It shows that the leaves of this genus are united at the base by a narrow margin. This union exists for the leaves of *Asterophyllites* and of *Annularia*; and thus their whorls of leaves are more of the nature of sheaths, deeply cut in laciniæ of various forms, than of true leaves.

Since the time (1854) when I delivered my report on the fossil plants of Pennsylvania, I have seen nothing in our fossil plants to change my opinion concerning the fructifications of the genus *Annularia*. I supposed then, and still suppose, that these fructifications were borne on the top of the leaves, within the inflated and hollowed medial nerve, in a kind of funnel-like cavity, like the spores of some species of *Hymeno-*

phyllaceæ of our time. Prof. Geinitz, indeed, has published, in his magnificent work on the fossil plants of Saxony, as fructifications of *Annularia*, (pl. 18, figs. 8 and 9) a beautiful cylindrical long ear with an articulated and striated stem, bearing, at the articulations, whorls of short, linear, pointed leaves, and in their axils round sporanges or fruits. These fruits are undoubtedly of the same kind as those of the fragments described above, and, to my belief, belong to the genus *Asterophyllites*. Against my opinion, still is this fact: that nothing, among our recent ferns, would lead us to suppose that there ever lived species of ferns with whorled leaves. But we see, in the vegetation of the coal epoch, some peculiar features of a far more abnormal and unexplainable character. The question can be decided only by well preserved specimens. And though I have recently seen two specimens of *Annularia sphenophylloides* Ung., the one from Newport, R. I., the other from Illinois, whose appearance did perfectly agree with what I suppose to be the fruit-bearing leaves of *Annularia*, this appearance is not distinct enough to permit a positive assertion. If my supposition concerning the fructifications of *Annularia* should be confirmed, this genus would appear as a link of transition between the *Equisetaceæ* and the Ferns, as the genus *Sphenophyllum* appears to be one between the *Lycopodiaceæ* and the Ferns.

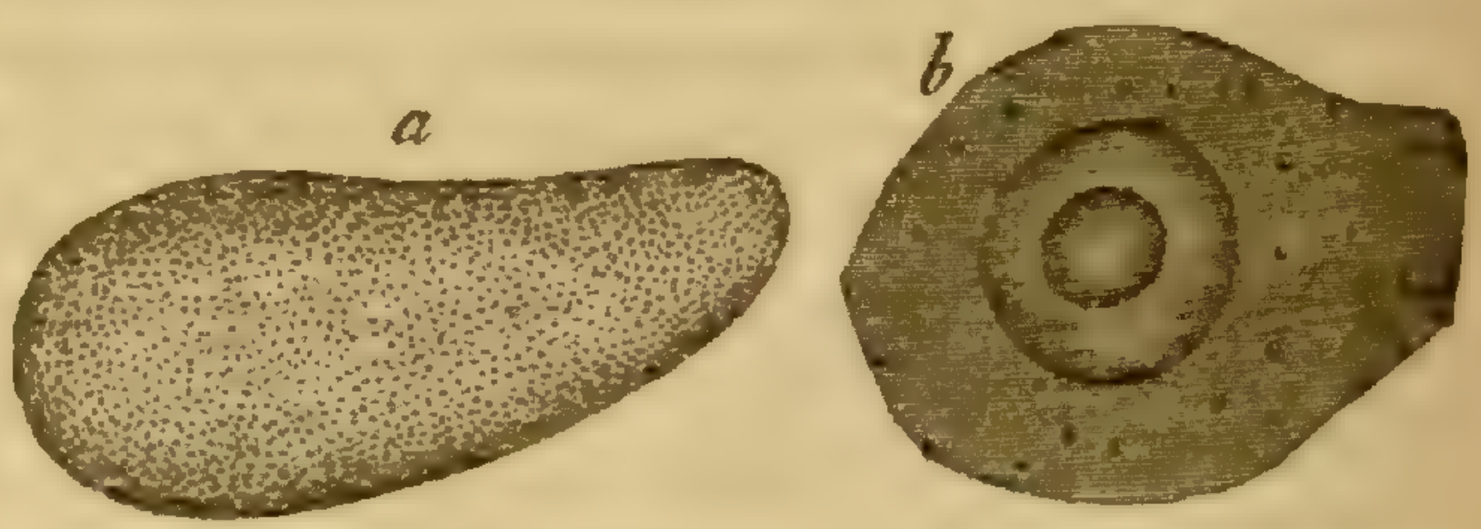
Art. XXXIX.—*On two Oceanic species of Protozoans related to the Sponges;* by James D. Dana.

The Sphærozoum figured below (fig. 1*a*) was collected by the writer in the Pacific, near latitude 30° N. and longitude 178° W., during a calm, on the 26th of May, 1841.

Figure 1*a* represents the gelatinous globule of natural size.

Fig. 1.

Fig. 2.



The ocean's waters were filled with this species, and another represented in figure 2*a*. The minute dots covering the globule, one of which is magnified in figure 1*b*, were closely crowded, as shown in figure 1*a*. In this respect, the species differs widely