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OBSERVATIONS ON FOSSIL PLANTS FROM THE DEVONIAN OF EASTERN NORTH AMERICA

IV. PLANT REMAINS FROM THE CATSKILL DELTA DEPOSITS OF NORTHERN PENNSYLVANIA AND SOUTHERN NEW YORK

BY
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By CHESTER A. ARNOLD

THE plants described in this report were secured from several localities scattered throughout the northern and northeastern portions of Pennsylvania and adjacent New York. The rocks in this area are the solidified sediments of the great Catskill delta, a structure which commenced to form during upper Middle Devonian (Hamilton) time, but which was not completed until the Mississippian. Although plants occur throughout the entire vertical sequence of this formation, they are more abundant at some levels than at others, and their relative abundance seems to have been determined by local conditions at the time of deposition rather than by the luxuriance of the vegetation as it then occurred in that region.

Much of the material here described was made available through the assistance of several individuals. Most of that from Port Allegany, Pennsylvania, was collected under the guidance of, or furnished by, Mr. J. C. Galloway, florist and local naturalist of that place, and it was he who first informed the author of the occurrence of fossil plants in that vicinity. Through his coöperation some excellent material was obtained. Dr. Bradford Willard, of the Topographic and Geologic Survey of Pennsylvania, supplied considerable information concerning localities in northeastern Pennsylvania and offered valuable suggestions about the strati-

graphic position of the beds at several places. Similar assistance was secured from Mr. Irving G. Reimann, of the Buffalo Museum of Science. The opportunity to study the *Archaeopteris* material of the R. D. Lacoe Collection was afforded through the courtesy of Dr. Charles B. Read, of the United States Geological Survey; and to Dr. H. E. Vokes the author is indebted for the privilege of examining and describing James Hall's specimens of *"Sphenopteris laxus"* and *"Sigillaria" chemungensis*, which are in the collections of the American Museum of Natural History. Miss Winifred Goldring, of the New York State Museum, very generously offered the loan of the material of *Barinophyton citrulliforme*. Mr. Lowell Bailey gave helpful field assistance during the summer of 1936, and Dr. W. C. Darrah informed the author of the location of the *Archaeopteris* bed near Ohiopyle, Pennsylvania.

The present paper is mostly descriptive. Several of the forms treated (e.g. *Hostimella crispa* and *Aphyllopteris delawarensis*) are known only as single occurrences, although others, such as certain of the species of *Archaeopteris*, are more widely distributed. Because the remains are scattered and are scarce at most places, it is not feasible to attribute much significance to the species as stratigraphic markers. Future investigations may reveal more definite relations between the species and the formations, but until we gain a better understanding of the stratigraphic sequence in the Upper Devonian and the lower Mississippian of Pennsylvania and New York, and until a more satisfactory separation of some of the so-called species is possible, the rather meager flora should be generally regarded as a feature pertaining to the greater part of the Catskill delta as a unit. A few possible exceptions to this generalization will be noted from time to time. For example, the plant assemblage in the beds of Hamilton age at Gilboa, New York, which contains *Eospermatopteris* and *Gilboaphyton*, is not known at any higher level, although it would be unwise to presuppose that any of these forms are confined strictly to this one formation.

The oldest plants to be identified with any degree of certainty in the New York Devonian are those from Gilboa, and small stem fragments with structure preserved in the Ludlowville shale

and the Tully pyrite in Erie County. The plants in Erie County were probably preserved under extreme stagnation where the sulphur compounds had reached the point of saturation. Conditions probably similar are known to exist in certain of the deep lakes in central New York at the present time.

There is a suggestion of a floral break above the Tully pyrite horizon, because *Dadoxylon Hallii* of the Ludlowville and the Tully pyrite apparently does not pass upward into the succeeding beds. Most of the differences visible in the sequence above the Tully pyrite can be accounted for as a direct reflection of the environment during deposition. Beginning with the Genesee shale, calcified remains of *Callixylon* make their appearance and become very abundant in the Genundewa limestone in the vicinity of Canandaigua Lake (1) and at the same horizon along Seneca and Cayuga lakes. In western New York *Callixylon* extends into the Gowanda shale (5) and may be recognized even in the sandy shales of the Cattaraugus. The highest known occurrence of *Callixylon* in the Catskill delta deposits is in the Oswayo sandstone near Port Allegany, Pennsylvania, where it is found in the pyritized state with *Archaeopteris* (2). In these higher beds, which represent the subaërial phases of the delta, the preservation is usually poor.

Fragmentary lycopod imprints are occasionally encountered in the shales above the Genesee, but they are not known to exist at any place in numbers sufficient to characterize the horizons.

Long strips of carbonized wood are common throughout the Upper Devonian of eastern North America, and they are especially abundant in the Portage. In the Middlesex shale southeast of Buffalo these remains present the same rather characteristic appearance as those in the Antrim shale of Michigan. They are marked with prominent cross lines, which are usually interpreted as joints, and although the fossils are commonly spoken of as "*Calamites*," they are really large stems of various kinds which have become cross-cracked as a result of severe weathering (3).

Callixylon probably existed with *Archaeopteris* throughout most of the Upper Devonian. Conditions which prevailed during the early and middle portions of the Upper Devonian were more

favorable for the petrifaction of *Callixylon*, however, than for the preservation of the large delicate and highly compound fronds of *Archaeopteris*. Consequently *Archaeopteris* is virtually unknown from the lower beds (Genesee, Rhinestreet, Middlesex, etc.) of western New York, whereas *Callixylon* occurs there in relative abundance. As the delta was built up and deposition was confined more to small and temporary embayments and estuaries, the fronds of *Archaeopteris* were preserved in greater quantity. But such conditions were not so favorable for the preservation of woody trunks of *Callixylon*, partly because of the scarcity of petrifying minerals and partly because the branches and trunks decayed more rapidly in the shallow water. Frequently, however, sufficient structure may be recognized in the carbonized remains to attest the coexistence of *Callixylon* and *Archaeopteris*.

Although the Upper Devonian flora of eastern North America consists predominantly of *Archaeopteris* and *Callixylon*, *Psilophyton* has been frequently reported. It may be stated at the outset that the present author is of the opinion that the occurrence of *Psilophyton* in the region under consideration is not satisfactorily established. Dawson (10, p. 315) identified as *Psilophyton* remains collected from several localities by Hall. He also records it from Ohio and from Perry, Maine. Penhallow (27) described from the supposed Hamilton of Ulster County, New York, specimens which he interpreted as a new species of *Psilophyton*. The genus is mentioned by other authors, including White (29), who is justly dubious concerning the identity of the so-called *Psilophyton* remains from Perry, Maine. Examination of the figures and the descriptions by these various authors fail to reveal undoubted *Psilophyton* remains from any of the Upper Devonian deposits. The general practice seems to have been to place within that genus almost anything having an appearance of dichotomous branching, regardless of whether any other distinguishing features were present. Fructifications sometimes assigned to *Psilophyton* are probably the poorly preserved remains of *Archaeopteris*. Although the distinction once made between the *Archaeopteris* and the *Psilophyton* floras has largely broken down, there is as yet no satisfactory evidence that the two genera overlapped to any extent in North

America. The affinities of *Hostimella crispa* and *Aphyllopteris delawarensis* are unknown, but in certain respects they may be suggestive of psilophytes.

In Pennsylvania the Pocono (or Knapp) overlies the Devonian. The Pocono flora is more luxurious than that of the Devonian, and contains distinctive lycopods (*Lepidodendropsis*) and foliage supposed to belong to pteridosperms. Of the latter, *Triphyllopteris* predominates, and one or more species may usually be found in any plant-bearing horizon. There are also forms of the *Adiantites* type, and seed cupules referable to *Lagenospermum*. The Pocono flora is quite distinct, therefore, from that of the Upper Devonian, which is characterized by *Archaeopteris*, and at no place where the flora has been studied are the two definitely known to overlap. The floral evidence also, meager though it is, definitely supports the recent tendency on the part of some stratigraphers to eliminate the Pocono from several of the northern counties of Pennsylvania. This separation of the Pocono and the Devonian floras is based principally upon leaf types. The Devonian lycopods are for the most part too poorly preserved to permit exact comparisons with the Pocono forms, although there appears to be a greater degree of resemblance between the lycopods of the two ages than between the ferns or pteridosperms.

Localities and Horizons

Material from the following localities has been examined:

1. Cut of the Western Maryland Railroad along the south bank of the Youghiogheny River, two and one-half miles southeast of Ohiopyle, Fayette County, Pennsylvania. The remains of *Archaeopteris* occur in a Devonian outlier of Chemung or later age.

2. Middlesex shale, Amsdel Creek, and Rhinestreet shale, Springbrook, Erie County, New York. These shales have yielded material referable to *Archaeosigillaria primaeva*.

3. Sandstone quarry about one mile northeast of Rock City, near Olean, Cattaraugus County, New York. The beds belong to the Cattaraugus (Conewango) and lie beneath the Salamanca

conglomerate. They have yielded *Barinophyton* and *Archaeopteris*.

4. Cut in state highway No. 59 between Smethport and Port Allegany, McKean County, Pennsylvania, at a place known locally as Bush Hill, about six miles west of Port Allegany. The plant-bearing beds probably belong to the upper Chadakoin or Cuba (Conneaut) and are overlain in the same cut by the red Cattaraugus beds, which were formerly designated as "Catskill." This locality has yielded *Archaeopteris latifolia, Hostimella crispa,* pyritized secondary wood of *Callixylon,* and seedlike objects (*Calathiops*) of undetermined affinity.

5. Campbell Hollow and Steele Hollow, both near Port Allegany, McKean County, Pennsylvania. Although originally placed in the Pocono, the sandstones at these localities belong to the Upper Devonian. Apparently they overlie the Cattaraugus red beds, and they have been placed in the Oswayo (upper Connewango). *Archaeopteris hibernica* has been secured from Steele Hollow, and *A. latifolia, Prolepidodendron breviinternodium, Lepidostrobus Gallowayi* (4), and pyritized wood of *Callixylon* have been collected at Campbell Hollow.

6. Cut along the Pennsylvania Railroad between Allegrippus and Kittanning Point, west of the Horseshoe Curve, Blair County, Pennsylvania. In the Ebensburg Folio (No. 133, U. S. Geol. Surv., 1905) the *Archaeopteris* horizon at this place is included within the lower Pocono, but it is certainly Devonian, although post-Chemung. The only material examined from this place was collected by M. R. Campbell in 1903; it is in the collections of the United States Geological Survey.

7. Coxton Narrows, along the Susquehanna River, north of Pittston, Pennsylvania. This is one of the localities cited by Lesquereux as a source of *Archaeopteris minor.* The stratigraphic sequence is described by I. C. White in *The Geology of the Susquehanna River Region,* Report of Progress G7, p. 157, Second Geological Survey of Pennsylvania, 1883. White placed the *Archaeopteris* beds in the Cherry Ridge red shale of the so-called "Catskill," but they are now considered Canadaway, either Damascus or Honesdale.

8. Meshoppen, Pennsylvania. Much of the material in the Lacoe Collection was secured from quarries in the vicinity of Meshoppen, but Lesquereux cites no exact localities. In the reference given under No. 7 White mentions the occurrence of *Archaeopteris* at several places (p. 119), but in 1935 only a few small plant fragments could be found. The beds are listed as "Catskill," but are probably Chemung or Canadaway.

9. Factoryville tunnel. The now abandoned tunnel of the Delaware, Lackawanna, and Western Railroad at Factoryville is cited as the source of part of the material of *Archaeopteris macilenta* and *A. minor* in the Lacoe Collection. The remains were probably gathered during construction of the tunnel. The age is given as "Catskill," although it is probably older (Chemung or Canadaway).

10. Sexton's quarry, Pine Valley, Chemung County, New York. This brief notation by Hall (14, p. 275) is the only information available concerning the source of "*Sphenopteris laxus*" (the type of *A. Halliana*). The formation is cited as "Chemung."

11. Wisner's quarry, near Elmira, New York. Hall (14) cites this quarry as the locality for "*Sigillaria*" *chemungensis*, which is described here as *Knorria chemungensis*. The age is also "Chemung."

12. The "Hawk's Nest." This locality is on the east side of the Delaware River about four miles north of Port Jervis, New York. Several hundred feet of the Delaware River flags (upper Portage) are exposed. *Archaeopteris sphenophyllifolia* and *Aphyllopteris delawarensis* have been secured from here.

13. Gilboa, Schoharie County, New York. This is the only Middle Devonian locality included in the present report. A lycopod resembling *Protolepidodendron* is recognized. Previously described plants include *Eospermatopteris*, a *Sigillaria*-like plant, and *Gilboaphyton*. The formation is of Hamilton age.

LYCOPODIACEOUS REMAINS

The deposits of the Catskill delta have yielded, with other plant types, several primitive lycopods of the types which were probably the forerunners of the later Carboniferous forms. With

a single notable exception (the "Naples tree") the remains are fragmentary and very poorly preserved. The characters which are commonly employed for generic and specific determination of fossil lycopods are often obscure, and examination under any degree of magnification seldom reveals more than the coarseness of the matrix. Several of these obscure and poorly preserved forms were assigned by the earlier authors (Dawson, Lesquereux, Rogers, Hall, and others) to such conventional genera as *Lepidodendron, Cyclostigma, Sigillaria,* and *Stigmaria,* but recent investigators have appreciated their primitive character and have preferred such designations as *Archaeosigillaria* and *Protolepidodendron.*

PROLEPIDODENDRON, gen. nov.

Prolepidodendron breviinternodium, comb. nov.

(Pl. I, Figs. 2, 4)

1933. *Trochophyllum breviinternodium* Arnold, Pap. Mich. Acad. Sci., Arts, and Letters, Vol. XVII, p. 54, Pl. X, Fig. 2.

The name *Prolepidodendron* is here proposed for lycopod remains from the Oswayo sandstone which appear closely related to the true *Lepidodendra* of the Carboniferous. Two specimens are referred to this genus. One of them (Pl. I, Fig. 2), a leafy twig, was previously assigned to *Trochophyllum* (2) on the basis of the apparent whorled arrangement of the leaves. The other (Pl. I, Fig. 4), a more recent discovery, is leafless and shows the form and arrangement of the foliar scars and cushions.

The leaf-bearing specimen (Pl. I, Fig. 2) was originally described as follows (2, p. 54): "Stem slightly less than one centimeter in diameter; nodes two millimeters apart. Leaves about fifteen millimeters long, two millimeters broad at the apex and narrowing gradually to the point of attachment; about twenty per whorl."

Reëxamination shows that the leaves have two veins. They diverge gradually from the base toward the apex, where they are about 0.75 mm. apart. Whether the tip of the leaf is bifurcated is unknown.

On the defoliated specimen (Pl. I, Fig. 4) the shape and ar-

rangement of the small but well-preserved cushions resemble those of *Lepidodendron*, the principal difference being the apparent absence of ligule and parichnos prints. Such structures could easily be obscured, however, by the coarseness of the matrix.

The rhomboidal cushions are about 2 mm. long and slightly less than that in width. The upper and lower angles are acute, and the lateral angles of those in alternate rows nearly touch. The alignment lengthwise of the stem appears to be spiral. The leaf scar is relatively large and is prominently situated upon the summit of the cushion at about the mid-portion. The shape of the scar is not clearly shown, but it appears to be slightly broader than long and nearly as broad as the cushion itself. The lateral alignment of the scars produces the aspect of a stem with prominent nodes separating short internodes. The trace scar is a shallow pit in the center of the leaf scar. Extending downward from the lower margin of the leaf scar are two short furrows separated by an interval about equal to the diameter of the trace scar.

Prolepidodendron resembles *Lepidodendron* so closely that one hesitates somewhat in setting it aside as a separate genus, although the double vein is a feature which definitely distinguishes it. In this respect there may be some connection between this leaf type and *Sigillariopsis*, but the form and arrangement of the cushions do not suggest sigillarian relations. As has been stated, the absence of ligule and parichnos scars might be due to lack of preservation. The prominent leaf scar upon a raised cushion constitutes a combination of features not characteristic of *Protolepidodendron*, *Sublepidodendron*, or *Lepidodrendropsis*, or any other pre-Pennsylvanian lycopod, with the possible exception of *Archaeosigillaria*, from which it is excluded by the distinctly lepidodendrid appearance.

Prolepidodendron is believed to represent an early lepidodendrid type which is more advanced than *Protolepidodendron* (in which no definite abscission layer had developed), but which is somewhat more generalized than the typical Carboniferous forms. The fructification of *Prolepidodendron* may be of the type recently described as *Lepidostrobus Gallowayi* (4), a heterosporous cone from the same formation and locality which bears the sporophylls

in whorls in a manner similar to the arrangement of the leaves on the *Prolepidodendron* stem.

Locality. — No. 5.

Archaeosigillaria primaeva (Rogers) White

(Pl. I, Figs. 1, 5)

Two imprints of fragments of decorticated stems, one from the Middlesex shale (Pl. I, Fig. 1) and the other from the Rhinestreet shale (Pl. I, Fig. 5), both in Erie County, New York, are referred to *Archaeosigillaria primaeva* as the species was emended by White in 1907 (31).

The specimen from the Middlesex shale had been briefly described as an "undetermined lycopod" (5). It is merely an imprint on a slab of black shale measuring 4 × 8 cm. The markings consist of shallow, vertically aligned oval depressions which represent the imprints of foliar cushions. These depressions are alternately arranged in vertical rows, which are spaced at intervals of 3.5 to 4 mm. laterally. The individual depressions are about 2 mm. wide and 6 or 7 mm. long. The adjacent rows are separated by undulating ridges, which correspond to the furrows between the rows or raised leaf cushions on the original stem surface. A suggestion of obliquity is obtained if the specimen is illuminated from certain angles. This condition, however, is too obscure to constitute proof of a lepidodendrid stem; it is more likely the result of oblique compression. The specimen is here assigned to *A. primaeva* because of its resemblance to certain of White's figures of the transition zone on the trunk of the "Naples tree" (31, Pl. 8; Pl. 9, Fig. 1).

The specimen from the Rhinestreet shale apparently represents a more advanced stage of decortication. It is referred to *A. primaeva* with some doubt. The ribbing is entirely absent, and the surface markings, though spaced like those described above, are shorter and narrower, and are separated by smooth surface portions. It probably represents the *Knorria* condition of some lycopod similar to *A. primaeva*, but it differs somewhat from the *Knorria* state as figured by White for this species. Such structures, however, have little taxonomic value. Zalesskij (32,

Pl. 7, Fig. 5) and Dawson (12, Pl. 8, Fig. 83) show similar appearances in *Heleniella Theodori* and *Lepidodendron gaspianum*, respectively.

The nomenclature of the "Naples tree," and, consequently, that of the material under consideration here, is somewhat unsettled. White considered it specifically identical with "*Lepidodendron*" *primaevum* of Rogers (28), but transferred it to Kidston's genus *Archaeosigillaria*. Zalesskij (32) and Corsin (9) have criticized the latter course on the ground that the presence of ligule and parichnos prints exclude it from that genus. Furthermore, concerning the specific reference, it may be pointed out that the type of "*Lepidodendron*" *primaevum* of Rogers was a mere fragment, and it seems quite uncertain or even improbable that there exists sufficient evidence to enable one to assume (as White did) that the two specimens are specifically identical. White would have been fully justified, in the opinion of the present author, had he chosen a new name for the "Naples tree." Zalesskij considers the specimen similar to *Helenia*, a genus which, however, is based upon decorticated material in the *Syringodendron* condition and which is rather unsatisfactory for comparison. Berry (8) and Knowlton (21) both refer it to *Protolepidodendron*, but aside from the name having priority, the same objections exist to placing the "Naples tree" in this genus as in *Archaeosigillaria*.

White's nomenclature is here adopted for the two fragments under consideration because any attempt at the formulation of a revised description should be based upon a reëxamination of the type material, which is unavailable at present. Another reason for the tentative continuation of the use of White's name is that there may be some question whether the concept of *Archaeosigillaria* as a genus should necessarily be confined to *A. Vanuxemi* as defined by Kidston (20) or whether it may be broadened to embrace other similar forms. The name implies an "ancient *Sigillaria*," and, in the absence of knowledge of anatomical structure and even of some surface features, the name *Archaeosigillaria* would seem appropriate for many pre-Carboniferous lycopods which exhibit a strictly vertical as opposed to a spiral alignment of the leaf bases. On the other hand, many Devonian lycopods,

even most of those assigned to *Protolepidodendron*, show vertically aligned leaves, so that, unless *Archaeosigillaria* be restricted to the *A. Vanuxemi* type, it appears impossible to draw an exact distinction between the two. This would institute the name *Protolepidodendron* as a catchall for any form not referable to *A. Vanuxemi* or to any more clearly defined genus. The generic identity of many Devonian plants is entirely a matter of definition, and it seems logical that the concept of *Archaeosigillaria* should be sufficiently broadened to include forms suggestive of sigillarian affinities even though distinct from *A. Vanuxemi*.

The sigillarian affinities of the "Naples tree" can scarcely be doubted, and the question may be raised whether the supposed spiral arrangement of the leaf cushions toward the apex of the trunk is truly lepidodendrid or whether it is merely an appearance resulting from oblique compression along the sloping sides of the trunk. A careful examination of the figures suggests the latter possibility. In his description of the "Naples tree" White mentions the fact (31, p. 331) that even below the mid-portion of the trunk the compressed cushions often present a more lepidodendroid form near the borders. Since the area midway between the borders was subjected to pressure more nearly in a direction at right angles to the plane of the surface, it seems that less distortion would take place there, and it so happens that along this zone a more distinct vertical alignment persists even to the topmost portions. It is believed, therefore, that the leaf cushions of the "Naples tree" are essentially sigillarioid and that the supposed transition to the lepidodendrid arrangement is the result of compression along the sloping borders of the trunk.

A reason of more practical nature for retaining the "Naples tree" within *Archaeosigillaria* is that the name *A. primaeva* has become well established and that nothing would be gained by transferring it to some equally indeterminate category. The specimen is probably the largest and one of the best-preserved Devonian lycopods known to science, and the variety of appearances presented by isolated fragments may very well be due to their origin on different parts of the plant.

Locality. — No. 2.

Knorria chemungensis (Hall), comb. nov.

(Pl. II, Figs. 1–2)

1843. *Sigillaria chemungensis*, Hall, Geol. New York, Pt. IV, pp. 274–275, Fig. 127 (2) and illustration No. 68.
1863. *Lepidodendron chemungense*, Hall, Sixteenth Annual Report of the Regents of the University of the State of New York on the Condition of the State Cabinet of Natural History, pp. 110, 113, Fig. 6.
1880. *L. chemungense*, Lesquereux, Coal Flora, p. 396.
1929. *L. chemungense*, Jongmans, Fossilium Catalogus, II: Plantae. Lycopodiales II, p. 135. Berlin.

The specimen which Hall (14) described in 1843 as *Sigillaria chemungensis* came from a quarry in the so-called "Chemung" near Elmira, New York. The only figures of this specimen known to exist are Hall's original, which is one half of natural size, and a later copy of it (15, p. 113, Fig. 6). The specimen is a flattened and slightly curved sandstone cast measuring 35 cm. in length. It is 5.7 cm. broad at the base and tapers to 4.4 cm. at the top. Owing to the disappearance of the outermost tissues surface details are indistinct, and only the vertical alignment of the leaves is revealed, since nothing remains of the leaf bases except the ends of the traces, which produce a slight roughening of the surface of the cast. The spindle-shaped leaf bases which are positively depicted in Hall's figure are only very faintly suggested by the specimen, although the spacing of the traces indicates that the bases were small and probably not more than 1.5 mm. in width. The distance between ends of the traces in the same row is about 7 mm. These figures give, therefore, an approximate notion of the leaf-base size. A vertical alignment is apparent along the central portion of the flattened surface of the cast, but a more oblique arrangement appears along the margins. This obliquity is obviously the result of pressure (as has been explained in the discussion of *A. primaeva*).

Although the specimen is possibly a lycopod of the *Protolepidodendron* type, the decorticated condition makes it necessary to assign it to the indeterminate category of *Knorria*. The leaf bases were probably smaller than those of *Archaeosigillaria primaeva*, but it is not impossible that the smaller branches of the

latter plant might have resembled the stem represented in Plate II, Figure 2.

A specimen referred by Dawson (12, Pl. 8, Fig. 84a) to this species appears indeterminate.

The specimen of *K. chemungensis* is in the collection of the American Museum of Natural History, and the figures in Plate II are given by permission.

Locality. — No. 11.

Cf. *Protolepidodendron sp.*

(Pl. I, Fig. 3)

A few slender branches bearing alternately arranged, elongated tubercles and apparently belonging to the same form as the material figured by Vanuxem (30, p. 157, Fig. 38; p. 191, Fig. 55) were collected from the sandstone quarry at Gilboa, Schoharie County, New York. Vanuxem reported these fossils from several localities, some from formations belonging to the Hamilton, but others from beds designated as "Catskill." He gives no name to this material, but merely refers to the specimens as representing a plant "whose external markings or structure resembled those of terrene origin." Because of very poor preservation and the lack of detail it is impossible to assign these plants with certainty to any genus, although some points of resemblance to certain Paleozoic forms may be noted.

The stems are narrow, seldom exceeding 5 mm. They are straight, and an occasional dichotomy may be seen. The oval surface tubercles, which are alternately arranged and measure approximately 1 by 3 mm., are separated by zigzag furrows. No other markings are visible.

These stems bear some resemblance to smaller branches of such forms as *Cyclostigma hercynium* and *C. ursinum* (*Bothrodendron kiltorkense* of Nathorst), but exact comparisons cannot be made. Strikingly like the Gilboa form is a specimen from Yunnan figured by Halle (16, Pl. II, Fig. 1) as *Protolepidodendron scharyanum*. Some of the twigs appear to be leafy and show a slight similarity to the small stems of *Gilboaphyton*, with which they are intimately associated.

Locality. — No. 13.

REMARKS ON SOME ADDITIONAL FORMS

A few miscellaneous lycopods are listed in the literature as from the Devonian of New York and Pennsylvania, but no material is available. Comments pertaining to two of them seem in order.

Lepidodendron corrugatum is listed by Dawson (10) and by Lesquereux in Volume III of the *Coal Flora* (p. 849) as from the Hamilton and the Chemung of New York. This species was originally described from the Lower Carboniferous, and its occurrence in the Devonian has never been established. It properly belongs to the genus *Lepidodendropsis* and is found in abundance in the Pocono of Pennsylvania and Virginia.

Sigillaria simplicatis is the name given by Vanuxem (30, p. 190) to a specimen of questionable nature from the "Catskill" of southern New York. The figure shows straight furrows separating unornamented ridges. The specimen may not represent a plant.

PLANTS OF UNDETERMINED AFFINITY

Barinophyton citrulliforme, sp. nov.

(Pl. IV, Figs. 1–5)

Material of *Barinophyton* was collected by K. E. Caster and J. G. Woodworth from a sandstone quarry near Rock City, Cattaraugus County, New York. The beds belong to the Conewango and lie just beneath the Salamanca conglomerate, and hence in the higher beds of the Upper Devonian. The roughly oval block containing the material measures about 15 by 30 cm. in breadth and length and about 5 cm. in thickness. Apparently it had been broken from a larger slab. The remains of parts of at least five stems lying parallel to one another and running the greater part of the length of the block are visible. Since some details of the structure of the spore-bearing parts of the branches are not well preserved no attempt is made to formulate a specific diagnosis. The following description will serve instead.

The straight smooth axes are 6 to 7 mm. in diameter and show no surface markings except a central thickening, which apparently represents the vascular strand. The fertile branches, which are

alternately arranged, bear no vegetative foliage. They are all spread in one plane, with the angle of departure from the central axis between 40 and 60 degrees. The preserved fragments of the branches are about 6 cm. long, and it seems improbable that they were much longer when complete. The upper surface of each branch is about as broad as the main axis.

The lower surface of the lateral branch is fertile; on this surface are borne two marginal rows of sporangia closely appressed between fleshy appendages. Viewed from one side, the fertile branch with its suspended appendages presents the appearance of a comb (Pl. IV, Figs. 1, 5). The appendages, which are about 8 mm. long and 2 mm. thick, are attached to the underside of the fertile branch at nearly right angles to it. Some of them are slightly curved (Pl. IV, Fig. 3). The appendages of the two rows spread a little from the surface of attachment, and, when the branch is viewed from above, the compressed and laterally divergent objects have a false appearance of being pinnate (Pl. IV, Fig. 3 at left).

Preservation is not sufficient to reveal the exact relation of the appendages and the sporangia, but between adjacent appendages there is an intervening carbonaceous layer, within which spores were found. It seems that most of the tissue of the appendages had disappeared, leaving only the carbonized sporangial remains, which are separated by a slightly thicker zone of shale matrix, although at some places a thin outline, which may represent a cutinized epidermis, is visible. It probably marks the surface of the appendages (Pl. IV, Fig. 3 at right). At certain places on the slab the fertile branches are broken transversely, so that they reveal the flat surfaces of the appendages with the sporangia against them (Pl. IV, Fig. 4). The outlines of the carbonized sporangia are clearly revealed when thus viewed. They appear to be oval bodies measuring about 5 mm. in width and 7 mm. in length, and apparently are attached at their upper extremities to the lower surface of the branch. The laterally placed sporangia of the two marginal rows may be attached by a cross connection such as Kräusel and Weyland (24, Pl. XXV, Fig. 3) show in *Pectinophyton norvegicum*, but this feature cannot

be positively demonstrated in our material. The sporangia bear a striking though superficial resemblance to the seeds of the domesticated *Citrullus vulgaris*, from which the suggestion for the specific name was derived.

Embedded within the carbonaceous remains of the sporangia are a few spores, which measure 0.3 to 0.4 mm. in diameter. The exine is smooth and heavily cutinized, and although no triradiate ridge was observed these spores were probably produced in tetrads in the usual manner. Unfortunately the few spores isolated from the carbonized sporangia were lost during an attempt to transfer them to a permanent mount, and consequently no figures were prepared. These spores certainly occurred *in situ*, however, because when first noticed they were protruding from a freshly broken surface of the carbonized sporangial mass between the appendages. It is probable that dispersal of the spores had occurred before preservation and that only a few happened to be retained.

B. citrulliforme is a striking example of a large fertile branch system destitute of vegetative foliage. Whether or not the axes were produced on a larger trunk is unknown, but their straightness and their parallel position in the rock are suggestive of an upright habit. They may be the aërial shoots from a horizontal rhizome. In the absence of vegetative stems it seems possible that separate sterile and spore-bearing stalks were produced, as they are in certain species of *Equisetum*. Although the sporangia are borne on the dorsal surface of the fertile branch, there is some indication of twisting of several of these branches (particularly the higher ones) in such a manner that the sporangia and appendages are directed to one side (Pl. IV, Figs. 3, 5). This is probably due to bending brought about by the weight of the heavily laden uppermost branches. The appendages of the lower branches are directed nearly downward, in a more normal manner.

Although Kräusel and Weyland (24) assigned very similar material from the Middle Devonian of Elberfeld to *Pectinophyton*, the fertile stems from Rock City are referred to *Barinophyton*, mostly on the basis of White's figures and descriptions of *B. Richardsoni* and *B. perrianum* (29). Kräusel and Weyland figure

several thick, fertile, unattached axes bearing two rows of appendages along one side. Between the appendages are bodies resembling sporangia, although neither the exact mode of attachment nor spores were observed. They compare this material very briefly with *Barinophyton*, but in a preliminary account (22) they had assigned it to that genus. It seems unmistakable, however, that the form which Kräusel and Weyland refer to *Pectinophyton* is generically identical with our material, and whatever distinctions are thought to exist between these genera are chiefly the result of different interpretations.

Although a casual examination of White's account of *Barinophyton* may lead to the belief that it is separate from *Pectinophyton*, a more critical comparison shows that the differences are not so great as they at first appear. According to White, the appendages of *Barinophyton* (he refers to them as "bracts") are ventral (i.e. on the upper or adaxial surface of the fertile branch). In our material, as in *Pectinophyton*, they are obviously dorsal. One of White's figures of *B. Richardsoni* (29, Pl. IV, Fig. 3) shows two rows of appendages spread in opposite directions from the fertile axis, and this positively reveals the same arrangement seen in our material when the fertile branches are viewed from above (as in Plate IV, Fig. 3). The apparent ventral position of the appendages in the other figures of *B. Richardsoni* may be due to any one of several possible causes. It may be a specific difference, or, as seems more probable, it may be the result of twisting of the branches during deposition. Our material makes it clear that the appendages on the uppermost fertile branches are directed to one side, apparently as a result of the flexing of these branches due to their own weight, and, were they to droop sufficiently, the appendages might become so twisted under pressure of accumulating sediments that they would appear to point forward. This interpretation is also favored by the fact that the fertile branches of *B. Richardsoni* are shown arched slightly forward. Had these somewhat lax spikelike structures been twisted the other way, the original dorsal position would have been retained. In the light of this interpretation the supposed distinction between *Barinophyton* and *Pectinophyton* disappears. The

position of the sporangia of both is probably dorsal, but whether, in a given specimen, they happen to be directed forward or backward may perhaps be determined by the factors mentioned on page 288.

It seems that White did not suspect any relation between the appendages on the fertile branches and the sporangia, because he suggests the possibility that the sporangia are attached to small ventral pits or pockets at the bases of the "pinnules" on the borders of the very broad and thick keel. Nothing that may be interpreted as sporangial scars exists, however, on the fertile branches of *B. citrulliforme.*

Although the interpretation of the morphology of *Barinophyton* given here differs from that proposed by White, it has been made possible only because of more adequate material, and it is evident that when the habit of the plant is taken into consideration the structures described by White are not essentially different from those recorded here.

So far as we know, *Barinophyton* is restricted to the Devonian. It is a relatively rare genus, although when all known occurrences are assembled a wide geographical distribution is indicated. It occurs in eastern Canada and at Perry, Maine. *Pecopteris? obscura* (13), from New South Wales, is certainly *Barinophyton,* and it appears very similar to *B. citrulliforme. Pectinophyton norvegicum,* certainly indistinguishable from *B. citrulliforme,* is known from Norway and Germany. Dawson's *Ptilophyton Thomsoni,* once questionably assigned to *Barinophyton,* has been referred to *Protopteridium* by Kräusel and Weyland (24).

Concerning the affinities of *Barinophyton,* little may be said other than to disprove White's original belief of lycopodiaceous relationship. There is scarcely anything lepidophytic about it, and the mode of branching and the large spores rather suggest a pteropsid form. Unfortunately, no foliage is preserved, although the mode of branching does somewhat resemble that of *Archaeopteris,* the remains of which are associated with *Barinophyton* in Maine and New York. The flattened branches and the structure of the fructifications are different, however, from anything ever known in connection with *Archaeopteris.* Were it not for the

presence of the spores, the flattened oval masses of carbonized tissue between the appressed appendages might readily be interpreted as seeds, and the possibility that the remains are the seed-bearing branches of *Archaeopteris* would be favorably considered. Such, however, does not seem to be the case, and there is no evidence, other than mere association, of any affinity between the two. Kräusel and Weyland's suggestion that *Pectinophyton* might be the fertile branch of *Asteroxylon* is not supported by the associations of *Barinophyton* in North America. All the known American species are Upper Devonian, and do not occur to any extent with psilophytalean remains.

The material of *B. citrulliforme*, which is in the collection of the New York State Museum, is included in this account with the permission of the Museum.

Locality. — No. 3.

Hostimella crispa, sp. nov.

(Pl. III, Figs. 1–8)

In association with the remains of *Archaeopteris latifolia* from the new highway cut at Bush Hill west of Port Allegany, Pennsylvania (Locality 4), are numerous smooth, forked branches with recurved tips. The branches are all small, only the larger ones being as much as 1 mm. in diameter. The recurved tip portions may be 0.25 mm. in diameter, or even less. Since these small fragments are not attached to larger stem parts, it is impossible to form a concrete opinion concerning the appearance of the plant. No fructifications are present.

The branching is essentially dichotomous (Pl. III, Figs. 2, 4), although one fork may frequently assume the proportion of a main axis and the other member terminate as a curled tip. Very often the entire branch may terminate as a pair of tips recurved in opposite directions, with one slightly longer than the other. In such branches the bifurcation is at a wide angle, sometimes as much as 60 degrees (Pl. III, Figs. 1, 3).

The diameter of the curved part of the tips is nearly constant from the point of bifurcation almost to the apex, although frequently there may be a slight enlargement just back of the tip

(Pl. III, Fig. 5). This enlargement suggests the formation of a terminal sporangium, but such a structure cannot be demonstrated. The extreme apical part tapers rather abruptly.

Some of the material shows early stages of branching (Pl. III, Fig. 6), which seems to originate in slightly enlarged tips. The branches then proceed to grow at two points, and thus form two diverging arms. One arm may be slightly larger than the other and extend in an upward direction, whereas the other bends away from it to produce the recurved tip.

A few microscopic details are rendered visible by treating the material with Schulze's reagent. Such preparations reveal a heavily cutinized epidermis of elongated cells. Stomata are not visible. Extending lengthwise along the central portion is a darker band, which probably marks the position of the vascular strand (Pl. III, Figs. 5–6).

In the absence of fertile parts the affinities of *Hostimella crispa* can be inferred only from the dichotomous branching and the curling of the tips. These features are suggestive of the Psilophytales, although this type of growth is exhibited by so many Devonian plants that its value as an indicator of relationship is limited. Attention should be directed to a specimen of an alga, *Thamnocladus Clarkei*, figured by Kräusel and Weyland (23, Pl. XXI, Fig. 2), which shows similar branching of the larger portions. It does not have such prominently curled tips, however, and the likelihood of any close relationship between these forms seems slight. The presence of a cutinized epidermis in *H. crispa* indicates a vascular plant.

H. crispa is similar to the plant which Høeg described from the Middle Devonian of Norway as *Dawsonites Ellenae* (17, Pl. I, Figs. 2, 6). Its most probable affinities, however, are with *Protopteridium*, a form which Kräusel and Weyland have interpreted as showing indications of relationship with the ferns. *P. Thomsoni*, one of the forms they have recently described in detail (24), exhibits similar curling of the bifurcated branchlet tips. Reference of the Pennsylvanian material to *Hostimella* is, therefore, purely tentative pending the discovery of fertile parts.

Locality. — No. 4.

Aphyllopteris delawarensis, sp. nov.

(Pl. X, Figs. 2–3; text Fig. 1)

Some straight, narrow, smooth stems with short recurved lateral branches from the bluffs of the Delaware River at the "Hawk's Nest" in eastern New York (Locality 12) are referred to *Aphyllopteris,* in the absence of any other appropriate name. A single slab bearing several of the flattened stems was found near the north end of the high bluff, but since it was not in place the exact stratigraphic level from which it came is unknown. The rocks exposed at the "Hawk's Nest" belong to the Delaware River flags of the Upper Portage, and it is assumed that the specimen is of local origin.

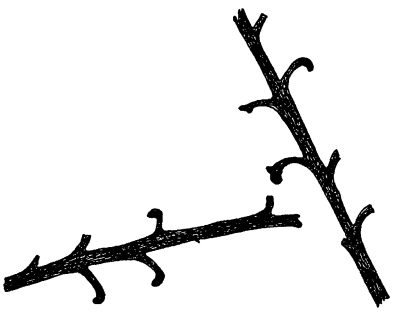

FIG. 1. *Aphyllopteris delawarensis* Arnold, sp. nov. × 1

The stems maintain a rather constant diameter and vary in width only from one to two millimeters. A few preserved portions are as much as 10 cm. long, but the complete length of any of the stems is unknown. The lateral branches are at intervals of one to two cm., and the arrangement varies from opposite to alternate. They are recurved at the tips, are about 5 mm. long, and have about one half the diameter of the main stems (text Fig. 1). Some of the lateral branches show evidence of the attachment of appendages on the upper side not far back from the tip, but just what was borne there is unknown. The possibility exists, of course, that this was the location of the sporangia.

The straight slender central axis gives the plant the appearance of having grown in close stands with straight upright stems arising from horizontal rhizomes. Such rhizomes have not been observed, however.

The curling of the lateral branches is somewhat like that of *Hostimella crispa,* although the plant differs in other respects.

A. delawarensis is a larger plant and is distinguished by its monopodial habit. In the absence of fructifications its affinities are of course unknown, but it is rather suggestive of a psilophyte. It is certainly distinct, however, from the more typical members of the Psilophytales, which are characteristically dichotomous. The monopodial habit is the basis for assigning it to *Aphyllopteris* but the distinction between this and the dichotomous habit of *Hostimella* is only one of degree.

Locality. — No. 12.

ARCHAEOPTERIS DAWSON

The presence of Archaeopteris in the Upper Devonian Deposits of New York and Pennsylvania has been known since the middle of the nineteenth century. Apparently the first record of its occurrence is by Vanuxem (30), who figured a small fragment from Susquehanna County, Pennsylvania, in 1842. In 1843 Hall figured a larger specimen under the name "*Sphenopteris laxus.*" This has subsequently become known as *Archaeopteris Halliana* (Pl. V, Fig. 1). In 1858 Lesquereux described additional material of *Archaeopteris* under the name *Noeggerathia* (Rogers, 28, p. 854), and in the *Coal Flora*, published in 1880 and 1884, he gave a comprehensive treatment of *Archaeopteris* as it was then known in New York, Pennsylvania, and adjoining regions. Although his account is as nearly complete as was possible with the material and facilities then available, it is now very unsatisfactory for the study of new collections. The illustrations are crude, and several of the forms described are not figured. Aside from the treatment in White's later work on the Devonian plants from the Perry Basin, and more casual references to the genus, very little mention of *Archaeopteris* is to be found in recent literature. A number of specimens in the collections of the United States National Museum were studied by White, but never described. As a result of the lack of any satisfactory treatment of the genus, investigators have been obliged to refer new material to the inadequately defined and poorly understood species as they were originally designated by Dawson and Lesquereux. Naturally, this has resulted in frequent misplacement.

In carrying out the present study an attempt was made to examine as much material as possible from the region under consideration. A number of specimens, including a few types, were supplied for study by the United States National Museum, and Hall's specimen of "*Sphenopteris laxus*" (*Archaeopteris Halliana*) was loaned by the American Museum of Natural History. In addition, considerable material has been secured by recent collecting expeditions. One excellent specimen of *A. latifolia* (Pl. VII, Fig. 3) was donated by the Buffalo Museum of Science. Although the material at hand is probably only a small part of that known to exist in the collections of various museums, it is nevertheless believed to be representative and adequate for a partial revision of the genus.

Lesquereux (25, Vol. III, pp. 771–772) stressed the following as the features distinguishing the species of *Archaeopteris:* (1) the rachis, whether smooth, striate lengthwise or crosswise, or distinctly rough; (2) the venation; (3) the form and position of the pinnules and the character of the margin; (4) the distribution of the fructifications; and (5) the presence or the absence of interpinnate or rachial pinnules.

Concerning the first of these characters, the surface of the rachis, the position is taken here that such surfaces as are commonly exhibited by the remains have little or no diagnostic value. The surface irregularities which Lesquereux emphasized as diagnostic could readily be due to a combination of factors, for example, the conditions prevailing at the time of preservation and the maturity of the plants. This belief is supported by the inconstancy of such features as may be observed even among the specimens handled and determined by Lesquereux himself. As for the second point, the venation, Lesquereux states that it is of little value since it is quite similar in all species. Venation characters are practically ignored in the present account. The form and position of the pinnules and the character of the margin are probably as useful as any other combination of factors, but the tendency of the pinnules to overlap and the fact that they are frequently twisted away from the plane of the frond often result in the edges being broken. As a consequence, they are rather

commonly assumed to be more slender and less rounded than they actually are. Complete, unbroken pinnules are difficult to find in much of the material. The spore-bearing branches do not always afford such satisfactory diagnostic features as Dawson and Lesquereux believed, because they are usually too fragmentary and disintegrated to show the sporangial characters adequately. The fructifications, if well preserved, may sometimes reveal important characters, as, for example, those of *A. latifolia.* With regard to the presence of rachial pinnules, it is believed that they occur sporadically throughout the genus and are not limited to certain species. Lesquereux apparently failed to observe them on several specimens in which they are present (Pl. VI, Fig. 2). They may often be noted in abundance along the terminal portions of the fronds.

On the basis of the characters enumerated above Lesquereux described nine species of *Archaeopteris* in Volume III of the *Coal Flora.* These do not include certain forms recognized by Dawson only in Maine and Canada. Four of the forms described by Lesquereux, *A. denticulata, A. sphenophyllifolia, A. macilenta,* and *A. obliqua,* are not figured. *A. denticulata,* however, is probably a sphenopterid from the lower Pottsville of Ohio, and does not belong to *Archaeopteris.* The specific status of *A. obliqua* is uncertain, although Lesquereux's brief account (25, Vol. II, p. 300; Vol. III, p. 773) suggests the possibility of a plant of the *A. obtusa* or the *A. hibernica* type, with portions of the lateral margins of the pinnules broken away. The remaining forms, *A. sphenophyllifolia* and *A. macilenta,* are accepted as valid species (7).

In attempting to revise or reclassify the forms of *Archaeopteris* from the Catskill delta deposits two primary considerations have been kept constantly in mind. The first is the unsatisfactory status of the species as they were instituted by Dawson and by Lesquereux, and the second is the scarcity of dependable characters for specific separation. Lesquereux's classification of the nine so-called species not only is largely artificial, but was based upon inconstant and quite variable characters which are not generally applicable. The rachis features, which he used for the primary separation of the genus, are, in all probability, the result of con-

ditions of preservation. Moreover, the illustrations in the *Coal Flora* are hopelessly inadequate, and many of them do not accurately portray even the specimen reproduced. *A. hibernica*, for example, is illustrated by one detached pinnule which might equally well be attributed to *A. Halliana* or *A. obtusa*. Furthermore, Lesquereux distinguished *A. Rogersi* solely by the transverse rugosity of the rachis and the tertiary branches, although the original material upon which this species was founded by Dawson was too fragmentary to permit a complete description of even a small part of the frond. It must be stated, however, that White (31) apparently saw fit to accept the specific designations set forth by Dawson and Lesquereux, but stresses the vagueness of the descriptions and the inadequacy of the figures.

It is known from studies of *Archaeopteris* in Europe that the plant grew to a considerable size (18). It is only to be expected, then, that the large and rather delicate fronds should show considerable variation, not only on different plants, but on different parts of the same plant. State of maturity, rapidity of growth, local environment, etc., are all contributing factors. Another consideration is that these large fronds are seldom found in their entirety, but usually are preserved only as small parts, and circumstances of preservation are largely responsible for the fragmentary condition of the material that occurs in the Catskill delta deposits. The considerable variety of form and appearance is not, therefore, necessarily to be construed as indicative of a large number of species. This condition of the material produces some unsurmountable difficulties in preparing specific diagnoses, and it is believed that when the apparent differences might have been caused by one or more of the factors mentioned above the material should be lumped into large comprehensive species, even at the risk of including more than one biological form. Such procedure is, in brief, simply an admission of our ignorance of what actually constitutes a species of *Archaeopteris*, but at the same time it is a realization of the fact that a large and comprehensive, even though artificial, grouping is preferable to one based on inconstant criteria which are impossible of general application. This principle is only partly adhered to, however, in

the present account; the more sweeping alterations of the established scheme are withheld for future communications.

SYNOPSIS OF THE SPECIES OF ARCHAEOPTERIS

(Species with an asterisk (*) were discussed in previous reports and are not included here.)

1. Pinnules of medium size, rarely exceeding 1.5 cm. in length
   - *a.* Margin smooth or rarely finely serrate; rounded above, acute below; considerably longer than broad; fertile pinnae, where known, without sterile tips ..... *A. Halliana* (*A. Rogersi*) (*A. Jacksoni*)
   - *b.* Margin serrate; rounded or broadly obovate; fertile pinnae prolonged into sterile tips ..... *A. latifolia*
   - *c.* Margin deeply cut; rounded or broadly obovate ..... *A. macilenta*
2. Pinnules larger, often exceeding 2 cm. in length
   - *a.* Pinnules rounded or obovate, somewhat overlapping; fertile pinnae prolonged into sterile tips ..... *A. hibernica*
   - *b.* Pinnules distant, flabelliform, proximal margins straight or concave, apex undulate ..... *A. obtusa**
   - *c.* Pinnules wedge-shaped, often split apically, distant and rigid ..... *A. sphenophyllifolia**

Archaeopteris Halliana (Goeppert) Dawson emend.

(Pl. V, Figs. 1–3; Pl. VI, Figs. 2–3; Pl. VII, Figs. 1–2; Pl. VIII, Fig. 1)

1842. Fossil Plant, Vanuxem, Geol. New York, Pt. III, p. 192, Fig. 58.
1843. *Sphenopteris laxus*, Hall, Geol. New York, Pt. IV, p. 275, Fig. 1.
1852. *Cyclopteris Halliana*, Goeppert, Nova Acta Acad. Caes. Leop. Nat. Curios, Vol. XXII, Suppl., p. 498.
1862. *C. Halliana*, Dawson, Quart. Journ. Geol. Soc. London, Vol. XVIII, p. 318, Pl. XVII, Figs. 54–55.
1863. *C. Halliana*, Dawson, Sixteenth Annual Report of the Regents of the University of the State of New York on the Condition of the State Cabinet of Natural History, p. 117, Fig. 10.
1871. *C. (Archaeopteris) Halliana*, Dawson, Foss. Pl. Canada, p. 45, Pl. XV, Fig. 170.
1880. *A. Halliana*, Lesquereux, Coal Flora, Vol. I, p. 304.
1884. *A. Halliana*, Lesquereux, Coal Flora, Vol. III, p. 773.
1858. *Noeggerathia minor*, Lesquereux, in Rogers, Geol. Penna., Vol. II, p. 854, Pl. I, Fig. 10.
1879. *Archaeopteris minor*, Lesquereux, Coal Flora, Atlas, Pl. XLIX, Fig. 5; Pl. L, Figs. 1–3,4 ?
1880. *A. minor*, Lesquereux, Coal Flora, Vol. I, p. 302.
1884. *A. minor*, Lesquereux, Coal Flora, Vol. III, p. 773.

1863. *Cyclopteris Jacksoni (?)*, Hall, Sixteenth Annual Report of the Regents of the University of the State of New York on the Condition of the State Cabinet of Natural History, p. 115, Fig. 9.

Archaeopteris Halliana, as here emended, is a plant of fern-like aspect and of dense and tufted or of open habit. None of the material gives much of an idea of its size. The largest rachis portions noted are about 8 mm. in diameter, and could not have supported very large fronds like those of *A. hibernica* observed in Ireland. The surface of the rachis is either smooth or striate.

The arrangement of the sterile pinnae is alternate, subalternate, or opposite, often changing from one to another of these patterns on the same specimen. They are 15 cm. or less in length, and are spaced at intervals of 3 cm. or less. The angle of departure from the main rachis varies from 30 to 40 degrees. All the pinnae on one frond are spread in the same plane. They are linear and taper slightly toward the apex from a short distance above the middle. They often present a slightly lax appearance.

The pinnules are small to medium-sized or sometimes rather large. Those of average size are approximately 15 mm. long; the larger ones may exceed 20 mm. The smaller ones usually occur toward the apices of the pinnae, although at times they are on short pinnae attached to a stout rachis (Pl. VI, Fig. 3), which apparently represents stunted growth. The pinnule margin is smooth, but sometimes there is an apparent serration, which is believed to be due to circumstances of preservation. Serration has not been observed on well-preserved material. The distal portion is rounded, and the proximal part tapers gradually to the narrow point of attachment. The typical pinnules are slightly more than twice as long as broad, with the broadest part at about the upper third of the pinnule. Most of them are somewhat oblique and curve slightly away from the pinna rachis, although many are nearly straight. A scant overlapping of the pinnules may ordinarily be observed, but they may at times coalesce in the basal parts of the frond to form a feather-like pinna with a continuous lamina (Pl. VII, Fig. 1). At the apex of the main rachis large pinnules replace the pinnae (Pl. V, Fig. 1).

Rachial or interpinnate pinnules are usually present on the

main rachis opposite the alternate or the subalternate pinnae. They appear to be most abundant toward the summit of the frond.

The fertile pinnae are similar in size and arrangement to the sterile ones. The sporangia are borne in clusters of three or four on short individual pedicels arising from the adaxial surface of the reduced pinnule. Sterile rachial pinnules may also be observed in the fertile frond portions (Pl. V, Fig. 3).

The foregoing description is based principally upon specimens in the R. D. Lacoe Collection in the United States National Museum and upon Hall's "*Sphenopteris laxus.*" These were supplemented with recent collections. As shown by the synonymy given above, *A. Halliana* is defined so as to include "*Sphenopteris laxus*" and the material in the Lacoe Collection assigned to *A. minor* by Lesquereux and by White. Inasmuch as it is believed that both so-called forms represent a single species, the name *A. Halliana* is selected on grounds of priority. The specific term *Halliana* was proposed by Goeppert in 1852, whereas *minor* was applied by Lesquereux in 1858. The "*Sphenopteris laxus*" of Hall (1843) was invalid at the time of publication since the name had previously been used for a different plant. "*Cyclopteris Halliana*" is, therefore, the oldest valid name to be applied to this species. Consequently "*Archaeopteris laxus*" as used by White (29, p. 42) is preceded by an older validly published name. Dawson (12) first included the species in *Archaeopteris.*

The type specimen of *A. Halliana* (Pl. V, Fig. 1) was collected previous to 1843 from Pine Valley in Chemung County, New York, and was figured by a woodcut in Hall's well-known volume, *Geology of New York* (14). As may be seen by comparing the reproduced photograph with Hall's original, the woodcut shows the gross features satisfactorily, the chief defects being in the venation. The specimen represents the topmost part of the frond bearing at the tip subopposite pinnules, which are considerably larger than those on the lateral pinnae. The terminal pinnule is lacking. Smaller pinnules continue in rather regular sequence on down the rachis between the pinnae, which feature is the one generally pointed out as distinguishing *A. Halliana* from *A. minor* and *A. Rogersi.* It may be mentioned, however,

that this specimen is the only one observed which shows the terminal part of the frond, and consequently the abundant rachial pinnules lose their significance as specific characters. The lateral pinnae are short and are provided with pinnules similar in size and shape to those on material designated by Lesquereux as *A. minor*. They appear to overlap somewhat, although the broken margins produce the appearance of a rather open frond.

Among the material in the Lacoe Collection available for study are some twelve specimens of *A. minor*, several of which had been determined by Lesquereux and others by White. A few were from the original collection from Coxton Narrows, which is mentioned in the *Coal Flora* and which Lesquereux used in describing that species. Three of them (Nos. 698a, 698b, and 698c) are figured in part in the *Coal Flora* as Figures 1, 2, and 3 on Plate L. One specimen (Pl. V, Fig. 3, of this report; shown in part as Figure 3 on Pl. L of the *Coal Flora*) is a portion of a fertile frond bearing pinnae on both sides of a rather broad rachis. To judge from the width of the rachis (about 9 mm.), the preserved portion probably represents a part of the base of the frond. At the base of some of the fertile pinnae are two vegetative pinnules which, however, are lacking in others. The form, arrangement, and attachment of the sporangia are correctly figured by Lesquereux (*Coal Flora*, Pl. L, Fig. 3), although in the specimen these features are less conspicuous than is implied by the partly restored figure. The figure also fails to show the fragments of rachial pinnules apparently attached to the main rachis. There is no evidence of the presence of a reduced bladelike extension of the fertile segment beyond the attachment of the sporangia such as exists in *A. hibernica* and *A. latifolia*.

Another undescribed fertile specimen from Meshoppen (Pl. VII, Fig. 2) in the Lacoe Collection had been referred to *A. minor* by Lesquereux but not described. Apparently he had intended to figure it in another publication, which never appeared. The slender rachis is 16 cm. long though incomplete. It bears five pairs of opposite fertile pinnae, which are entirely devoid of sterile pinnules. Rachial pinnules are also lacking. The fertile pinnae are similar in size to those just described from Coxton Narrows,

but they depart from the rachis at a wider angle. The specimen apparently represents that portion of the frond where the transition from sterile to fertile structure had become complete.

Figure 2 on Plate VI shows a fairly large part of a frond from Coxton Narrows. The uppermost portion is illustrated in the *Coal Flora* as Figure 2 of Plate L. At the bottom of the specimen may be seen a few rachial pinnules, which apparently had escaped the attention of Lesquereux. In this region of the frond where a few of the pinnules exceed 15 mm. in length, they overlap very slightly and become somewhat larger. The pinnae are 12 cm. long and show a subalternate arrangement. The specimen gives a much more adequate idea of the appearance of the frond than is afforded by Lesquereux's figure.

Lying in an opposite direction on the slab and partly overlapping the frond described above is another fragment, which probably came from low down in the frond. Along the thick rachis are rather closely spaced pinnae, the pinnules of which are coalescent laterally and form a crenulate lamina continuous the length of the pinnae (Pl. VII, Fig. 1). This is a feature heretofore unmentioned for this species, although a similar condition has been reported by Johnson (19) in Irish material which he thought belonged to *A. Tschermaki*. Johnson's figures are not convincing, however, and the material may belong to some other species, probably to *A. hibernica*. *A. Tschermaki*, according to Kidston, belongs to *Archaeopteridium*, which occurs in the Lower Carboniferous.

The specimen constituting the basis for Figure 1 on Plate L of the *Coal Flora* is shown here as Figure 3 of Plate VI. It has a rather stout rachis bearing small, closely set pinnae with small pinnules. Apparently it represents stunted growth, and can hardly be regarded as a typical specimen of the species.

A. Halliana, which is probably one of the most abundant and widespread species of *Archaeopteris* throughout certain horizons in New York and Pennsylvania, appears to exhibit considerable diversity of form. The seeming diversity, however, may be increased to some extent by the various conditions under which the material was preserved. When all the variations in form

and appearance are taken into consideration *A. Halliana* can scarcely be distinguished from *A. Rogersi* and *A. Jacksoni*, and it is possible that all three may ultimately prove to be the same species. *A. Rogersi* is said to be distinguished by the transverse striations of the rachis, a feature of very doubtful diagnostic value. The most obvious characters of *A. Jacksoni* are a rather pronounced overlapping and decurrency of the pinnules, but they are present to some extent in *A. Halliana*.

The closest European equivalent of *A. Halliana* is probably *A. Roemeriana*. As is true of several of the American species of *Archaeopteris*, *A. Roemeriana* was also originally described from a fragment. It, however, is supposed to be distinguished by the rather small nonoverlapping pinnules. Regardless of the variability of such characters Johnson positively states (19) that the pinnules of *A. Roemeriana* never overlap, and that material having pinnules which do should be referred elsewhere. Reference, however, to Nathorst's figures of *A. Roemeriana* from Bear Island (26) does show a slight amount of overlapping. Upon casual examination a deceptive appearance of narrowness and lack of overlapping may be noted in almost any form of *Archaeopteris* because of the frequent breaking away of the margins of adjacent pinnules. However, most of the material of *A. Halliana* probably does exhibit a greater degree of overlapping than is ordinarily observed in *A. Roemeriana*, but this particular feature may not be universally applicable as a means of distinction. The majority of the published figures of *A. Roemeriana* show the pinnae departing from the main rachis at a rather steep angle, which suggests an erect habit.

The stratigraphic range of *A. Halliana* is incompletely understood, although most of the known occurrences of the species are in rocks designated as Chemung or Canadaway, and for that reason it may be tentatively regarded as predominantly a middle Upper Devonian form. It seems to appear less frequently in the higher of the Upper Devonian formations in New York and Pennsylvania.

Localities. — Nos. 1, 7, 8, 9, 10.

Archaeopteris Rogersi (Dawson) Dawson

(Pl. VI, Fig. 1; Pl. VII, Fig. 4; Pl. VIII, Figs. 2–3)

As has been mentioned in connection with the discussion of *A. Halliana*, it is very doubtful whether *A. Rogersi* is a distinct species or whether it should be merged with *A. Halliana*. Most of the available evidence points to the latter probability, but in the present account the distinction is retained in deference to Lesquereux and to White.

A. Rogersi was originally described by Dawson (11) from Perry, Maine. His brief description is as follows: "Habit of growth resembling that of *Cyclopteris Jacksoni*, but the pinnules are more elongated and almost cuneate in form, also less densely placed, and with veins more nearly parallel. Stipe stout, woody, furrowed longitudinally, and marked with strong transverse bars or punctures."

Dawson states that *A. Rogersi* is less abundant at that locality than *A. Jacksoni* and that the stipe is less leafy, with the pinnules and pinnae not so densely placed. It is about the same size as *A. Jacksoni*, but the markings on the rachis resemble those of *A. Roemeriana*.

The fundamental weakness of the specific status of *A. Rogersi* is the vague account of the fragmentary material upon which it was based. Dawson figured only two very small pieces, which cannot be satisfactorily distinguished from similar material of *A. Halliana* or *A. Jacksoni*. The close resemblance was realized by Lesquereux (*Coal Flora*, Vol. III, pp. 774, 776), but he assumed that the transverse markings on the rachis were sufficient for separation. It is true that, if the transverse marks on the rachis are due to differences in anatomical structure, they might then serve very satisfactorily to distinguish *A. Rogersi* as a species, but the uncertainty lies in the fact that such anatomical differences have not been demonstrated, and it is entirely unknown whether the transverse rugosity is due to peculiarities of structure or is merely the result of conditions of preservation. These marks are not always present even on specimens which Lesquereux himself referred to *A. Rogersi* (Pl. VI, Fig. 1). Conversely, they may

sometimes be seen to a certain extent on the rachises of *A. Halliana*. If the transverse marks were accompanied by other constant distinctive features they would then be more convincing as a specific character, but so far no such features have been recognized.

It should be mentioned that in describing the *Archaeopteris* remains from Perry, Maine, White stressed the difficulties of distinguishing between *A. Rogersi* and *A. Jacksoni*, and he expressed an opinion that both represent variations within the same species. He also realized that the main distinguishing feature, the transverse markings on the rachis, is probably a result of conditions of preservation. The fructifications which he referred to *A. Rogersi* (29, Pl. III, Figs. 5–5a) do not, however, show a transversely corrugated rachis, and, furthermore, there seems to exist no valid reason for assigning these fructifications to this species, especially in view of its very questionable status.

A. Rogersi is an example of the acceptance of a species because of the prominence of the name in the literature rather than because of clearly defined characters. Had all the facts been available at the time, it would probably never have been described.

In the Lacoe Collection all specimens assigned to *A. Rogersi* are from Meshoppen and bear the number 832. A few of them (Pl. VIII, Fig. 2) show the transverse rachis markings, but on others they are obscure or lacking. The preservation in general is slightly inferior to that of the plants from Coxton Narrows or Factoryville, a fact which may at times have influenced identification.

The specimens referred to above, although showing general resemblances to *A. Halliana*, do, in some respects, show a number of minor differences. They have a slightly more delicate appearance in that the pinnae and pinnules tend to be somewhat smaller, and are suggestive of attachment to plants with less rank vegetative growth. On some specimens (Pl. VIII, Fig. 2) the rather small pinnae are closely spaced on the main rachis. Others (Pl. VI, Fig. 1) show very long slender pinnae on a fairly stout rachis. The pinnules often stand out somewhat from the pinna rachis, and they lack the slight curvature usually seen in those of *A. Halliana*. Although such relative and variable features seem

too indefinite to warrant much consideration, they are nevertheless mentioned by Dawson, and are probably those used by Lesquereux and White for assigning material on which the transverse markings do not show to *A. Rogersi.* Some of the pinnules, especially those illustrated on Figure 4 of Plate VII, have indications of a serrate edge. Another specimen (Pl. VIII, Fig. 3) bears several rachial pinnules, structures absent from *A. Rogersi,* according to Dawson and Lesquereux. But as stated before, it is believed that these structures have no specific significance.

One specimen (Pl. VI, Fig. 1, No. 832a of the Lacoe Collection) bears two rather poorly preserved fertile pinnae. The sporangia are indistinct, but the pinnae appear somewhat more slender and less lax than those of *A. Halliana* from Coxton Narrows (Pl. V, Fig. 3). One pinna bears several sterile pinnules at the base.

If it could be proved that the Meshoppen material which Lesquereux and White referred to *A. Rogersi* is different from *A. Halliana,* the question would arise whether it is the same form as the material upon which Dawson based the species. Inevitably one must conclude that these species cannot be satisfactorily distinguished in the present state of our knowledge of what constitutes a species of *Archaeopteris.*

Locality. — No. 8.

Archaeopteris Jacksoni (Dawson) Dawson

(Pl. X, Fig. 4)

A specimen from an unrecorded locality, but labeled as from the Montrose sandstone of northern Pennsylvania, is tentatively assigned to *A. Jacksoni* because of its close resemblance to the species as it has been figured from Gaspé, in Canada (6), and Perry, Maine (29). Had the specimen come from either of these localities it would be referred to *A. Jacksoni* without hesitation.

The stout rachis appears to bear lengthwise furrows or striations, and the rather closely spaced pinnae depart from the main rachis at an acute angle, but bend outward. The slightly curved pinnules, which are of medium size, overlap somewhat. The curvature of the pinnules is one of the assumed distinguishing features of *A. Jacksoni.*

A. Jacksoni and *A. Halliana* closely resemble each other. The length and curvature of the pinnae and the extent of overlapping of the pinnules are all features which may be subject to considerable variation, depending upon local environment or habitat. The fructification supposed to belong to *A. Jacksoni* (29, Pl. III, Fig. 4; 6, Pl. III, Fig. 4) appears to consist of rather dense spikes quite similar to those on the specimen attributed to *A. Rogersi* (Pl. VI, Fig. 1). These present an appearance slightly different from that of the more lax fertile pinnae of *A. Halliana*, although satisfactory comparisons cannot be made because of poor preservation of *A. Rogersi* and *A. Jacksoni*.

Archaeopteris macilenta Lesquereux
(Pl. VI, Fig. 4)

Material of *A. macilenta*, one of the rarer species, was secured near Ohiopyle (Locality 1). In this species the pinnule margin is deeply incised or cut, with some of the indentations extending to or beyond the middle of the broadly wedge-shaped pinnules. The pinnules are of medium size, and no appreciable overlapping exists.

A. macilenta appears to be so very close to *A. fimbriata*, a Bear Island form described by Nathorst (26), that an intimate relationship, if not actual identity, is to be suspected.

This is one of the species described, though not figured, in the *Coal Flora* (Vol. III, p. 775), but an excellent specimen from the Lacoe Collection (No. 830) has recently been figured by the present author (7). Hitherto it has been known only from Factoryville and Meshoppen.

Locality. — No. 1.

Archaeopteris hibernica (Forbes) Dawson
(Pl. VIII, Fig. 4)

Some fragments from Pittston and Meshoppen were referred to *A. hibernica* by Lesquereux (25, pp. 305, 776, Pl. L, Fig. 5), but the material was not adequately figured, and its identity is questionable. In fact, the actual occurrence of this species in North America has never been conclusively demonstrated.

Material closely resembling the Irish species has been collected from the so-called "Pocono" or Oswayo sandstone in the vicinity of Port Allegany. Large frond specimens comparable in size to those figured from Ireland have been observed in privately owned collections, but the only material available for publication consists of small fragments. The pinnules are similar in size and shape to those of the Irish material. They are obovate and slightly unequilateral, and adjacent ones overlap considerably.

A. hibernica and *A. latifolia* are closely related species, and in both the fertile pinnae terminate in a sterile tip. The sterile pinnules resemble each other except that those of *A. latifolia* tend to be smaller and more rounded. It is possible that continued investigation may reveal intermediate forms which would render separation of the American material impossible.

A. obtusa is sometimes confused with *A. hibernica*, although the two appear quite different. Both have large pinnules, but they are readily distinguished by the fact that the pinnules of *A. obtusa* are flabelliform structures with somewhat concave proximal margins, and the terminal portion is often undulate and slightly cut. The regular oval outline of *A. hibernica* is lacking. Little is known of the specific status of *A. obtusa*, although it is apparently one of the rarer types, but it may be simply a vegetative phase of one of the other species. The terminal pinnules of the type specimen of *A. Halliana* (Pl. V, Fig. 1), though smaller, bear a striking resemblance in general outline to the large ones assigned to *A. obtusa*.

Locality. — No. 5.

Archaeopteris latifolia, sp. nov.

(Pl. VII, Fig. 3; Pl. IX, Figs. 1–16; Pl. X, Fig. 1)

1933. *Archaeopteris sp.* (cf. *A. Roemeriana* forma *conferta*), Arnold, "Fossil Plants from the Pocono (Oswayo) Sandstone of Pennsylvania," Pap. Mich. Acad. Sci., Arts, and Letters, Vol. XVII, p. 52; Pl. X, Fig. 1.
1933. *Rhacopteris? sp.*, Arnold, *ibid.*, p. 53, Fig. 30; Pl. X, Fig. 3.

The name *Archaeopteris latifolia* is proposed for a form which has been recognized at several localities and which appears distinct from any of the other species. Vegetative and fruiting ma-

terial was found in quantity in the highway cut west of Port Allegany (Locality 4). Two specimens from Meshoppen in the Lacoe Collection (Nos. 699a and 699b), labeled "*Archaeopteris minor* var." by Lesquereux, also probably belong to this species.

A. latifolia is closely related to *A. hibernica* and differs from it mainly in its slightly smaller size and a somewhat more pronounced rotundity of the pinnules. The species may be described as follows:

Fronds probably large, with a smooth or longitudinally striated primary rachis at least 1 cm. in diameter at the base, but more slender in the higher portions. Sterile pinnae alternate, subalternate, or opposite, sometimes exceeding 15 cm. in length; spaced at intervals of $2\frac{1}{2}$ to 6 cm. and departing from the main rachis at an angle of from 30 to 55 degrees; all spread in one plane, slightly tapering from the base toward the apex. Pinnules mostly of medium size though variable, 1 to 2 cm. long; those at base of pinna largest and somewhat overlapping, those more distant becoming successively smaller and farther apart; rounded or broadly obovate; margin serrate; apex round, but the basal portion tapering obtusely or the basal margins concave; narrowing to a short though distinct attachment stalk; venation fine, a single vein terminating in each marginal serration. Rachial pinnules present, sometimes in pairs between the pinnae, and abundant on the basal portion of the main rachis. Fertile pinnae without sterile pinnules (so far as observed), but prolonged into a sterile projection beyond the attachment of the sporangia. Sporangia oval to elongate, about 2 mm. long and 0.3 to 0.5 mm. broad. Associated spores of two kinds, the smaller being 0.03 mm. in diameter and numerous in the sporangia, and the larger being 0.3 mm. in diameter and 8 to 16 per sporangium.

The most important distinguishing features of the vegetative foliage of *A. latifolia* are the rather pronounced rounding of the pinnules and their attachment by an abruptly narrowed pedicel (Pl. IX, Figs. 1–2, 5). Some of the pinnules are as broad as long, for which reason a specimen was once suspected of belonging to the Lower Carboniferous genus *Rhacopteris* (2). On some of the pinnae a complete gradation may be observed from large

slightly overlapping pinnules to small distantly placed ones (Pl. IX, Fig. 2).

The extension of the fertile pinna into a sterile projection beyond the sporangia (Pl. IX, Figs. 3–4) is an additional point of resemblance to *A. hibernica*, and is likewise a feature which distinguishes it from *A. Halliana*.

Some well-preserved fructifications (Pl. IX, Fig. 3) were found in the highway cut west of Port Allegany (Locality 4), where, scattered throughout the shale matrix in association with the sterile and fertile branches, are numerous detached sporangia agreeing in size and appearance with those attached (Pl. IX, Figs. 4, 6–16). That these detached sporangia belong to *A. latifolia* is attested not only by the absence of other plants to which they might belong, but also by the fact that they are identical in appearance with those which are attached. When the attached sporangia are removed from the fertile branches and mounted side by side with detached ones (which have been released by dissolution of the shale with hydrofluoric acid), it is impossible to distinguish between them. The conclusion is, therefore, that they all belong to *A. latifolia*.

Two forms of sporangia may be recognized. One form, which is slender, averages about 2 mm. in length and 0.3 mm. or slightly more in width (Pl. IX, Figs. 6–8). By treatment with Schulze's reagent the spore contents frequently become visible (Pl. IX, Figs. 9, 11). The spores are small, 35 micra in diameter, and numerous. No accurate estimate of the number is possible, but there are probably a hundred or more. The triradiate ridge becomes visible under high magnification (Pl. IX, Fig. 10).

The other type of sporangium is about as long as that described above, but is broader, averaging somewhat more than 0.5 mm. In appearance, therefore, the two forms are quite different, one being slender and the other more oval (Pl. IX, Figs. 6, 13). The two sporangia reproduced in the figures are average specimens, although both types show some variation in the ratio of length to breadth. On Figure 4, Plate IX, the two types may be observed in position side by side on the fertile branch. The actual connection between sporangia and pinna stalk is not visible

because of a small amount of overlying shale, but their perfect alignment is ample proof of attachment. This figure is an enlargement of one of the fertile segments (indicated by a black line) shown near the top and on the left of Figure 3. (It should be explained that when Figure 4 was prepared part of the carbonaceous film had fallen from the upper part of the large sporangium, although it was still in place when Figure 3 was made.)

The difference in the size of the spores is even more striking than the difference in size of the sporangia. In contrast to the numerous small spores of the narrow sporangia, those of the broad form are large and few (Pl. IX, Figs. 12, 14–16). The number of spores in large sporangia seems to range from eight to sixteen, but whether the range extends beyond these limits is unknown. The spore exines are heavily cutinized and slightly roughened, though no highly developed appendages are present. The large spores, like the small ones, seem to be held together by a gelatinous matrix which does not dissolve readily in Schulze's mixture. They average slightly more than 0.3 mm. in diameter, or about ten times that of the small ones.

It is thus evident that a definite correlation exists between the shape of the sporangium and its contents, the slender form containing numerous small spores and the others a few large ones. It is extremely unfortunate that no spores could be found in place within the attached sporangia, and the assumption that both forms were produced on the same plant is based upon the outward similarity between attached empty sporangia and the detached spore-containing ones. Apparently the attached sporangia were mature and had lost their contents before fossilization. In spite of this unfortunate condition, which prevents positive demonstration of the two spore forms *in situ* on the parent plant, it is believed that the sporangial characters are sufficient to establish identity between the attached and the detached ones, and the probability of this connection is further strengthened by the absence of other plants to which either of them might belong.

The apparent production of two kinds of spores by *A. latifolia* has special significance in view of the fact that the affinities of *Archaeopteris* are not well understood. Opinion seems about

equally divided whether the genus is a fern or a pteridosperm. It would not be especially surprising to discover on *Archaeopteris* fructifications not strictly in accord with either, and it might not be amiss to venture a suggestion that the genus possibly represents one of the so-called "missing links" in the evolutionary sequence of the plant kingdom which are frequently postulated but seldom seen.

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EXPLANATION OF PLATE I

FIG. 1. *Archaeosigillaria primaeva* (Rogers) White. Amsdell Creek, Erie County, New York

FIG. 2. *Prolepidodendron breviinternodium* (Arnold) Arnold. Port Allegany, Pa. Holotype. No. 15110

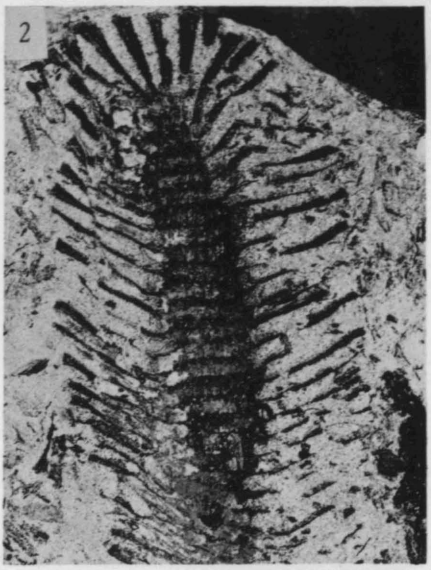
FIG. 3. Cf. *Protolepidodendron sp.* Gilboa, Schoharie Co., New York. No. 11764.

FIG. 4. *Prolepidodendron breviinternodium* (Arnold) Arnold. Portion of defoliated stem, showing lepidodendroid cushions and scars. Port Allegany, Pa. Paratype. No. 20914. × 2

FIG. 5. *Archaeosigillaria primaeva* (Rogers) White. Completely decorticated specimen. Springbrook, Erie County, New York

PLATE I


1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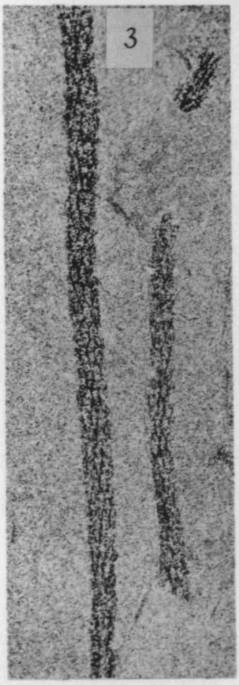
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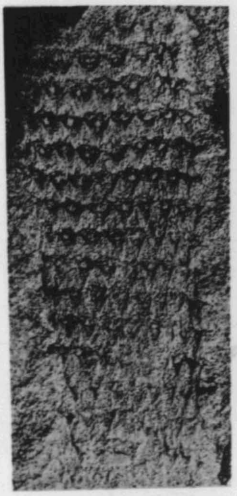


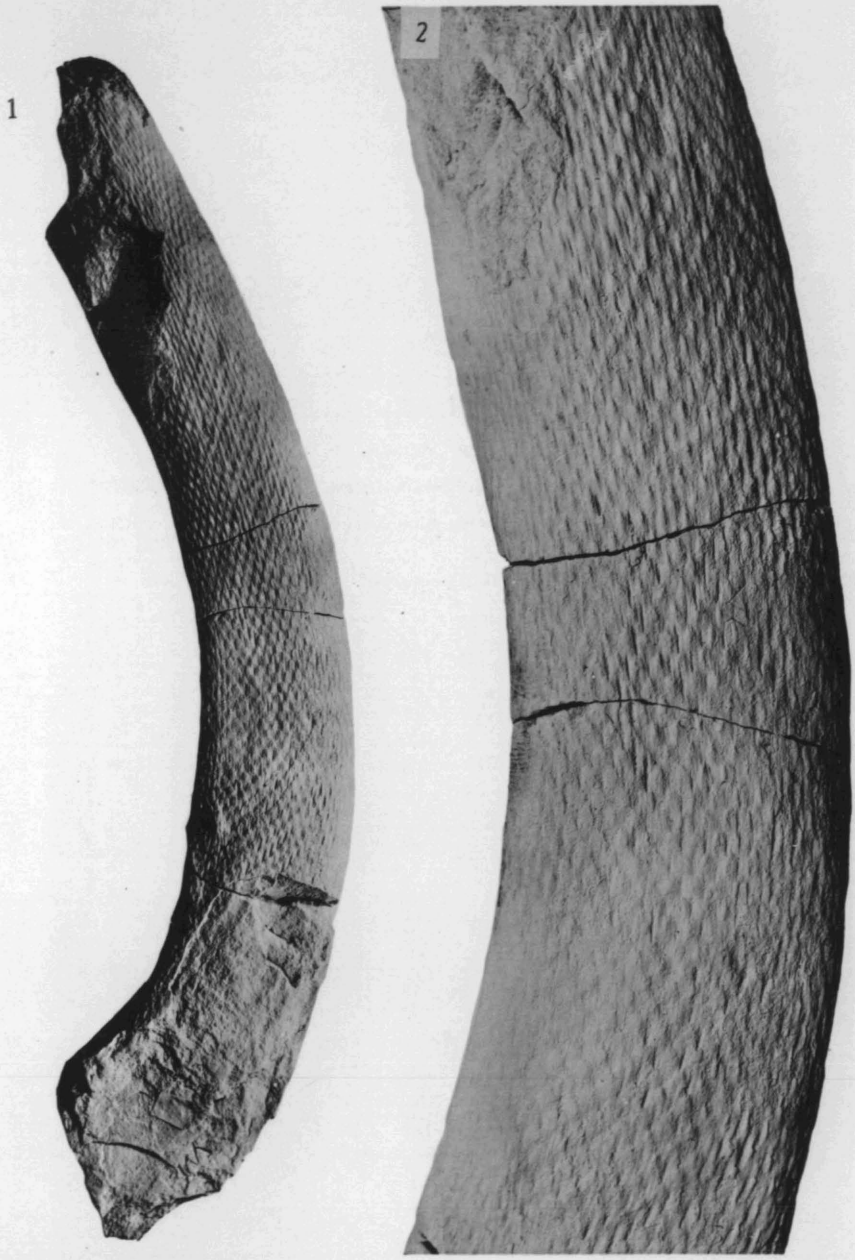
5

EXPLANATION OF PLATE II

FIG. 1. *Knorria chemungensis* (Hall) Arnold, comb. nov. Photograph of the specimen figured by Hall (Fig. 127 (2), *Geology of New York*, Pt. 4, 1843). Reduced

FIG. 2. Part of specimen shown in Figure 1. Specimen in the American Museum of Natural History. Reproduced by permission. Holotype. × 1

PLATE II



EXPLANATION OF PLATE III

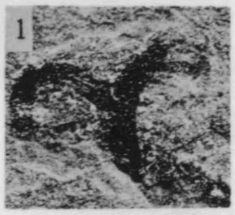
Hostimella crispa Arnold, sp. nov.

(All specimens from Bush Hill, McKean Co., Pa. Syntypes. No. 20797.)

FIGS. 1–4. Small branchlets, showing dichotomous branching and curling of the tips. × about 8½

FIGS. 5–8. Specimens subjected to maceration. × 20

PLATE III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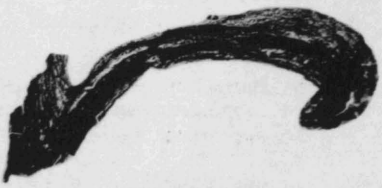
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EXPLANATION OF PLATE IV

Barinophyton citrulliforme Arnold, sp. nov.

(Material in New York State Museum; figured by permission. Syntypes.)

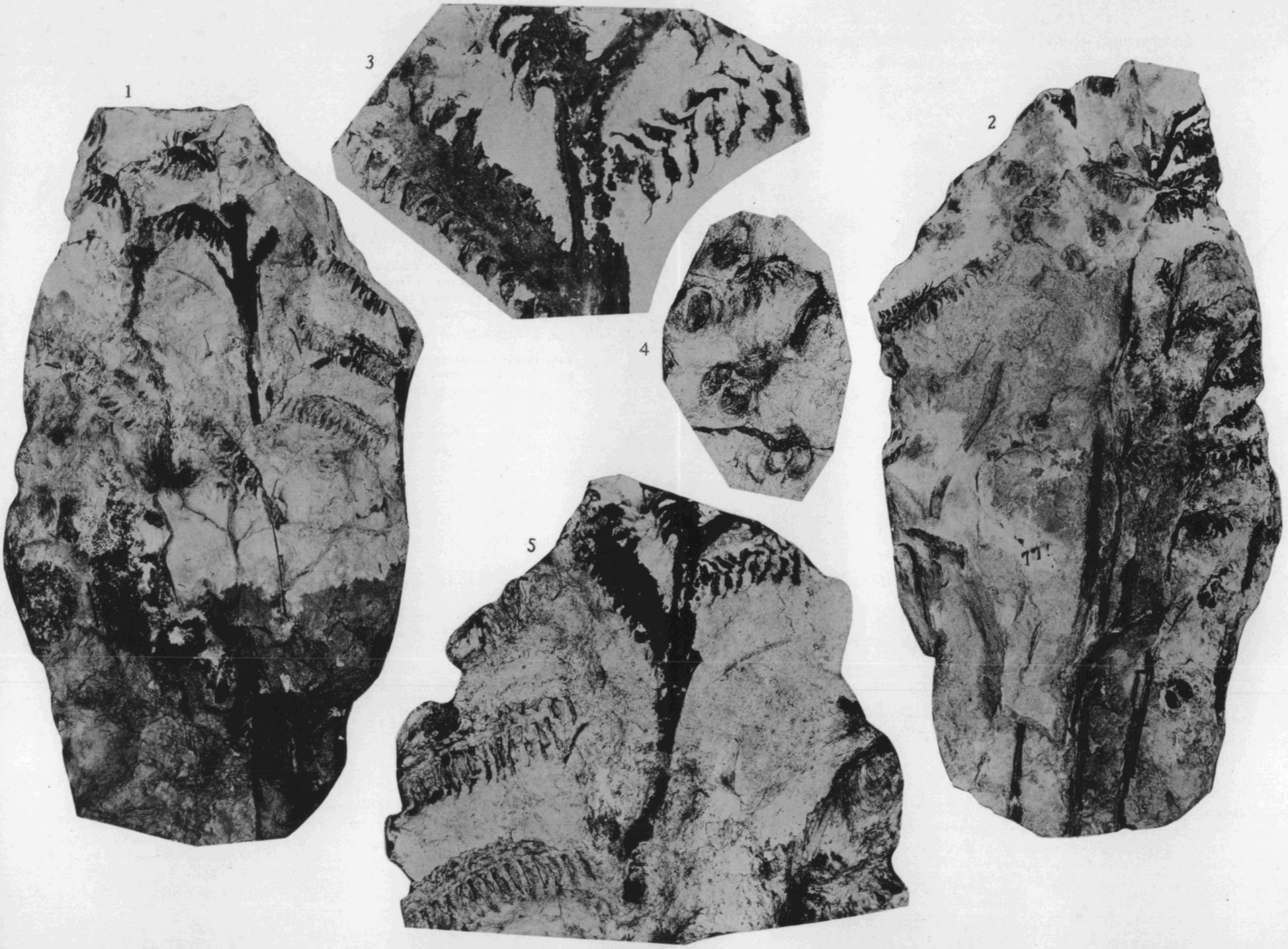
FIGS. 1–2. Opposite surfaces of shale slab bearing branched stems and detached branches. Slightly reduced

FIG. 3. Terminal portion of stem, showing parts of four fertile branches. At left, ventral surface of fertile branch, showing marginal appendages spread somewhat laterally and projecting slightly into the matrix. At right, a similar branch broken below the plane of the axis and revealing appendages and carbonized sporangia in approximate cross section. Slightly enlarged

FIG. 4. Fertile branches broken to show serial arrangement of sporangia and appendages. × 1

FIG. 5. Surface revealed by splitting the slab. Stem shown in Figure 3 at top. Two detached fertile branches shown in side view present the comblike appearance produced by the appendages. × 1

PLATE IV



EXPLANATION OF PLATE V

FIG. 1. *Archaeopteris Halliana* (Goepp.) Dawson. Photograph of Hall's specimen figured in *Geology of New York*, Pt. 4, 1843. (Hall's Fig. 1, p. 275.) Specimen in American Museum of Natural History. Reproduced by permission. Holotype

FIG. 2. *A. Halliana* (Goepp.) Dawson. Locality 4. Hypotype. No. 20918

FIG. 3. *A. Halliana* (Goepp.) Dawson. Fertile portion of frond. From Coxton Narrows, Locality 7. Figured in *Coal Flora*, Pl. L, Fig. 3. (Det. *A. minor* by Lesquereux.) Hypotype. No. 698a of Lacoe Collection

PLATE V

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EXPLANATION OF PLATE VI

FIG. 1. *Archaeopteris Rogersi* (Dawson) Dawson. Meshoppen, Locality 8. (Det. *A. Rogersi* by Lesquereux.) Hypotype. No. 832a of Lacoe Collection

FIG. 2. *A. Halliana* (Goepp.) Dawson. Coxton Narrows, Locality 7. Figured in *Coal Flora* (in part), Pl. L, Fig. 2. (Det. *A. minor* by Lesquereux.) Hypotype. No. 698c of Lacoe Collection

FIG. 3. *A. Halliana* (Goepp.) Dawson. Coxton Narrows, Locality 7. Figured in *Coal Flora*, Pl. L, Fig. 1. (Det. *A. minor* by Lesquereux.) Hypotype. No. 698b of Lacoe Collection

FIG. 4. *A. macilenta* Lesq. Locality 1. Hypotypes. No. 20570

PLATE VI

EXPLANATION OF PLATE VII

FIG. 1. *Archaeopteris Halliana* (Goepp.) Dawson. Portion of frond, with coalesced pinnules producing a continuous lamina. Coxton Narrows, Locality 7. Same slab bearing specimen shown in Pl. VI, Fig. 2. Hypotype. No. 698c of Lacoe Collection

FIG. 2. (?) *A. Halliana* (Goepp.) Dawson. Portion of fertile frond. Meshoppen, Locality 8. (Det. *A. minor?* by Lesquereux.) No. 698e of Lacoe Collection

FIG. 3. *A. latifolia* Arnold, sp. nov. Port Allegany, Pa. Exact locality unrecorded. Hypotype. No. 20681

FIG. 4. *A. Rogersi* (Dawson) Dawson. Meshoppen, Locality 8. (Det. *A. Rogersi* by White.) Hypotype. No. 832b of Lacoe Collection

PLATE VII

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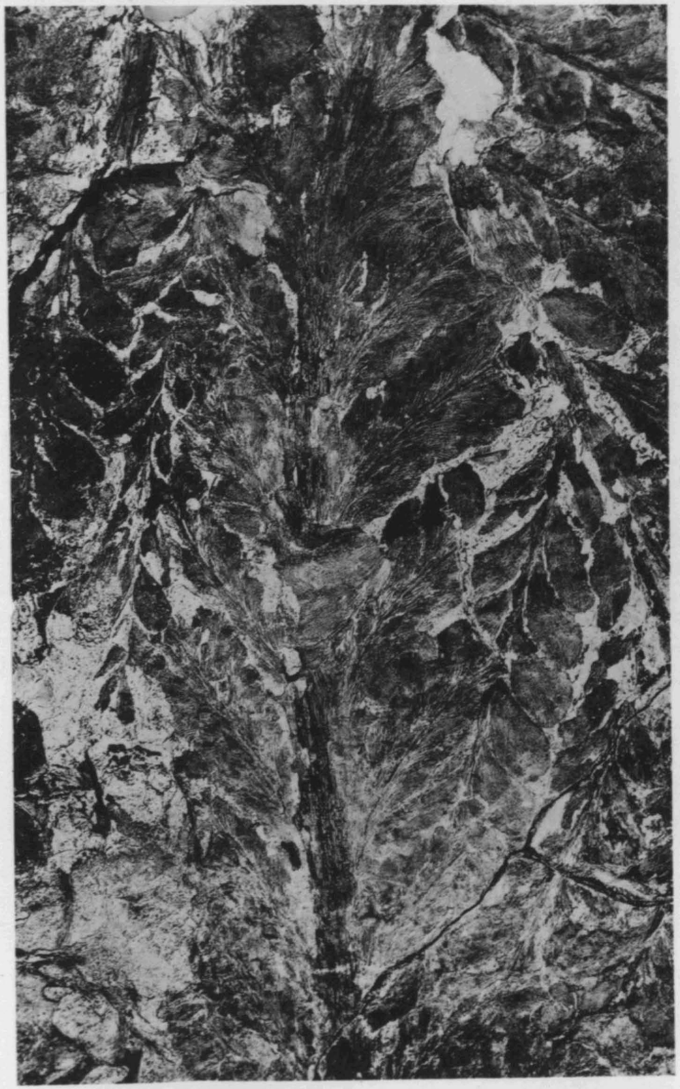

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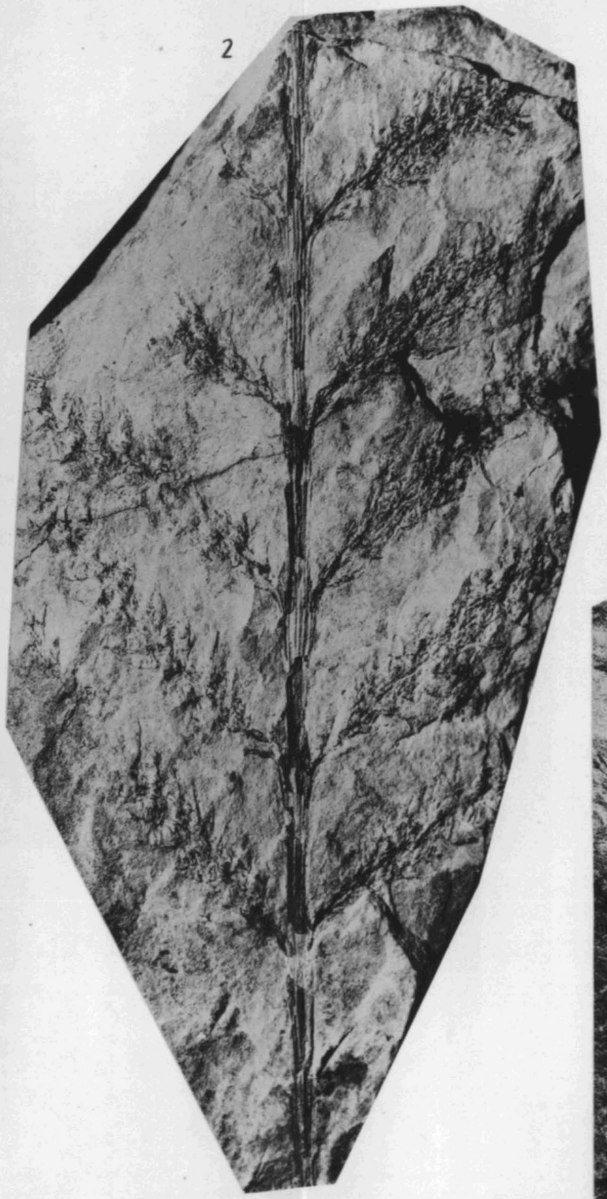

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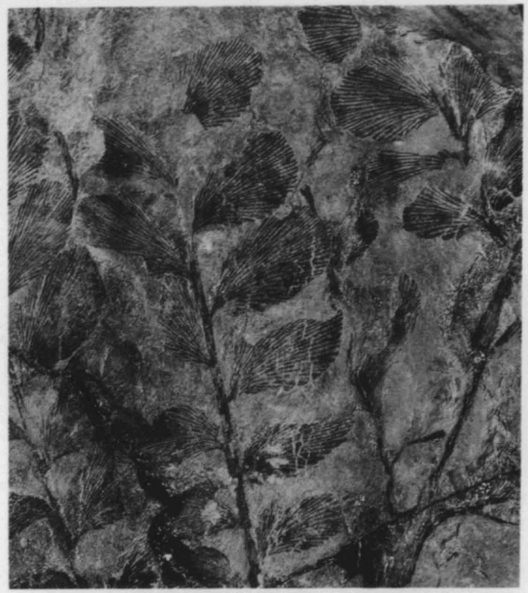

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EXPLANATION OF PLATE VIII

FIG. 1. *Archaeopteris Halliana* (Goepp.) Dawson. Factoryville tunnel, Locality 9. (Det. *A. minor* by White.) Hypotype. No. 698g of Lacoe Collection

FIG. 2. *A. Rogersi* (Dawson) Dawson. Meshoppen, Locality 8. (Det. *A. Rogersi* by Lesquereux.) Hypotype. No. 832c of Lacoe Collection

FIG. 3. *A. Rogersi* (Dawson) Dawson. Shows interpinnate pinnules. Depot Quarry, Meshoppen. (Det. *A. Rogersi* by White.) Hypotype. No. 832n of Lacoe Collection

FIG. 4. *A. hibernica* (Forbes) Dawson. Port Allegany, Pa., Locality 5. Hypotype. No. 20796

PLATE VIII


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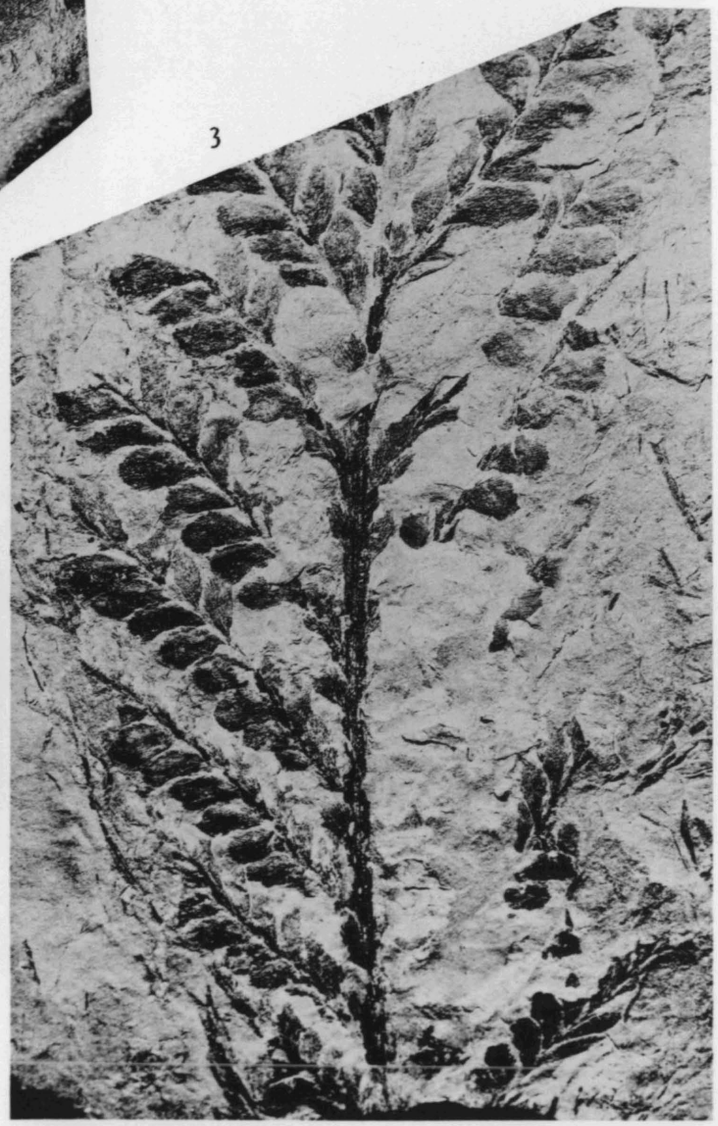
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EXPLANATION OF PLATE IX

Archaeopteris latifolia Arnold, sp. nov.

FIG. 1. Locality 6. Collected by M. R. Campbell in 1903; in collection of U. S. Geol. Surv. Syntype

FIG. 2. Vegetative pinnule, showing decrease in pinnule size and extent of overlapping from base toward tip. Locality 4. Syntype. No. 20921

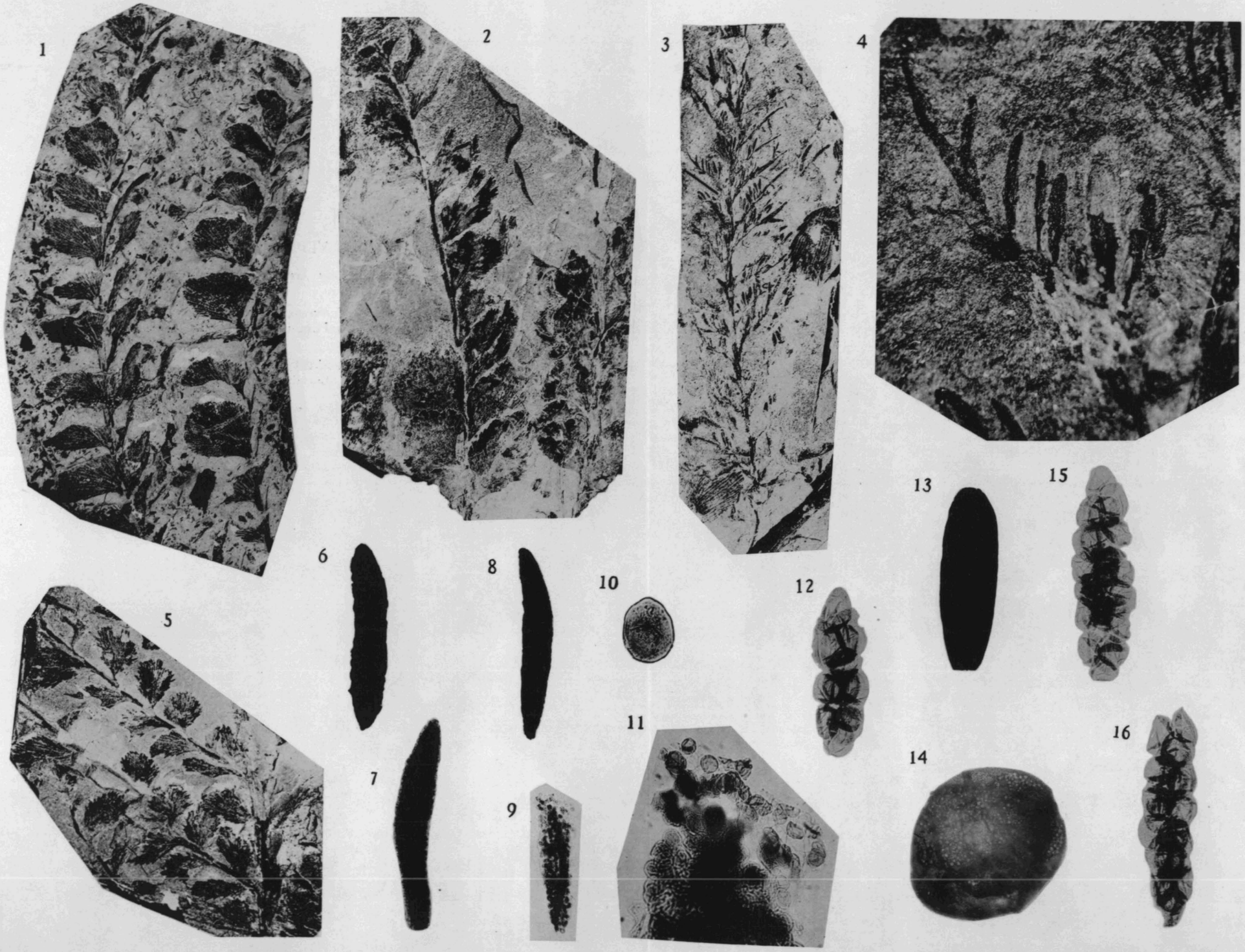
FIG. 3. Fertile branch bearing attached sporangia. Locality 4. Syntype. No. 20919. Slightly enlarged

FIG. 4. Fertile pinnule from specimen reproduced in Figure 3, greatly enlarged and showing difference in size of sporangia. The apex is prolonged into a sterile bifurcate tip

FIG. 5. Vegetative foliage, showing small nonoverlapping pinnules with serrate margins. Locality 4. Syntype. No. 20920

FIGS. 6–16. Sporangia and spores. Locality 8. Fig. 6, small slender sporangium, × 21. Figs. 7–8, masses of small spores (untreated), × 21. Fig. 9, mass of small spores cleared with Schulze's mixture, × 21. Fig. 10, single small spore of type shown in Figure 9, × about 400. Fig. 11, portion of spore mass shown in Figure 9, × about 80. Figs. 12, 15–16, masses of large spores treated with Schulze's mixture, × 21. Fig. 13, large sporangium, × 21. Fig. 14, single large spore, × 90

PLATE IX



EXPLANATION OF PLATE X

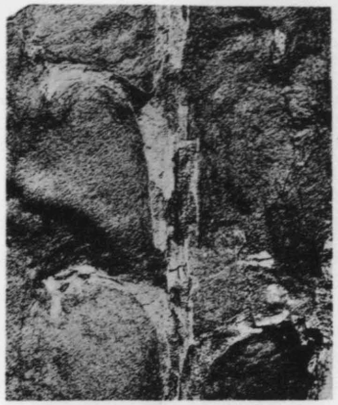
FIG. 1. *Archaeopteris latifolia* Arnold, sp. nov. Locality 5. Hypotype. No. 14468

FIGS. 2–3. *Aphyllopteris delawarensis* Arnold, sp. nov. Portions of straight axes bearing curved lateral branches, × about 3. Locality 12. Syntypes. No. 20906

FIG. 4. *Archaeopteris Jacksoni* (Dawson) Dawson. Montrose sandstone of northern Pennsylvania. Locality unknown. Hypotype. No. 11103

PLATE X


1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(*Continued from inside of front cover*)

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