GEOLOGICAL SURVEY OF NEW JERSEY

HENRY B. KÜMMEL, STATE GEOLOGIST

BULLETIN 3.

The Flora of the Raritan Formation

BY

EDWARD W. BERRY

OF THE

JOHNS HOPKINS UNIVERSITY

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Letter of Transmittal.

TRENTON, N. J., MARCH 17, 1911.

The State Printing Board,
Trenton, N. J.

GENTLEMEN—Chapter 46, Laws of 1910, provides that in addition to an annual administrative report, the State Geologist shall prepare or cause to be prepared such scientific reports as are pertinent to the work of his department, and that the State Printing Board shall have authority, on recommendation of the Board of Managers of the Survey, to order printed such scientific reports.

The Board of Managers of the Survey, on December 6, 1910, adopted the following motion: That the publication of reports on the Plant Remains of the Cretaceous Clay Beds, and on the Fossil Fishes of the Cretaceous and Miocene Formations of South Jersey, already prepared or in process of preparation under the direction of the State Geologist, be recommended for printing to the State Printing Board, as provided in Chapter 46, Laws of 1910.

In accordance with the above, I request that the State Printing Board order printed 1,500 copies each of the two reports above mentioned, 100 to be bound, the balance in stiff covers sewed, as provided in the specifications for printing the Geological Survey reports.

Respectfully submitted,

HENRY B. KÜMMEL,
State Geologist.

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STATE OF NEW JERSEY,
OFFICE OF COMPTROLLER OF THE TREASURY.
TRENTON, MARCH 20, 1911.

Henry B. Kümmel, Esq.,
State Geologist,
Trenton, N. J.

DEAR SIR—Your communication of the 17th inst., addressed to the State Printing Board, was laid before the Board at its meeting held on Friday, last, and, on motion, it was ordered that the publications referred to in your letter be printed and bound as requested. The work will be done by MacCrellish & Quigley, who were awarded the contract last fall.

Very respectfully,
E. J. EDWARDS,
Comptroller, as Secretary, State Printing Board.

NEW JERSEY GEOLOGICAL SURVEY

PART I.

The Raritan Flora.

GENERAL RELATIONS.

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I. INTRODUCTION.

The clays of New Jersey constitute the basis of a most important element in the State's mineral wealth and have long furnished the raw material for a variety of industries, and given employment to a large force of labor, both skilled and unskilled. The most conspicuous clay deposits in the State are those known as the Raritan, or Amboy, clays. Very early they attracted the attention of the State Geological Survey, and we find considerable space devoted to them in the Geology of New Jersey, published in 1868, in the Clay Report of 1878, and in the various later reports.

The only comprehensive treatment of the flora of the Raritan formation is that of Prof. Newberry[1], published posthumously in 1896, his active work on it having been stopped by failing health in the fall of 1890. In the interval of twenty-one years which has elapsed, both geology and paleobotany have made prodigious progress in this country, and it is no discredit to the pioneer workers that revision becomes a necessity. One of the imperfections of Prof. Newberry's work, along with that of his colaborers in the field of paleontology, was their neglect in stating the precise localities and horizons from which their specimens were collected. It has been possible to supply some of these deficiencies in frequent visits to the various pits, others remain as Prof. Newberry left them.

Considerable material collected by the U. S. Geological Survey has furnished a number of additions to the flora, for which acknowledgement is gratefully made at this point. All of Prof. Newberry's types are in the museum of the New York Botanical Garden, where they are well arranged and easily accessible. The author's thanks are due Dr. Hollick, the curator of the paleo-

[1] Newberry, The Flora of the Amboy Clays, Mon. U. S. Geol. Survey, Vol. XXVI (1895), 1896.

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botanical collections, for free use of this material. The balance of the type material is to be found in the U. S. National Museum, and the writer is under obligations to Dr. Knowlton for the privilege of studying it, as well as for many other favors. Acknowledgement is also gratefully made for the constant interest and encouragement of Dr. Henry B. Kümmel, the State Geologist, who has been keenly cognizant of the importance of a modern treatment of the Paleontology of the State, both palezoological and paleobotanical. The accompanying plates make no pretense at completeness, but aim to show only the more characteristic Raritan species, or forms never before described or figured.

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II. HISTORICAL SKETCH.

The Raritan and allied formations have been the subject of numerous contributions to science during the past fifty years, while scattered references to these deposits, which extend back over a century and a half, may be found in the older works.

The Royal Academy of Sciences of Sweden sent the distinguished naturalist, Peter Kalm, who is commemorated in the generic name of our beautiful laurels *(Kalmia)* to America, in 1749, and the results of his travels and investigations were subsequently published in three volumes at Stockholm, and afterward translated into English and French. His was, perhaps, the first contribution to Coastal Plain geology which is worthy of mention. Twenty-eight years later a German naturalist, Johann David Schoepf, visited this area, and in a book published at Erlangen, ten years later, he records many observations of interest. The first geologist to attempt any correlation with Europe was William Maclure, who in various publications covering the period from 1809 to 1817, referred the Coastal Plain deposits collectively to the "Alluvial formation," the fourth of the main divisions of Werner's classification.

Samuel Akerly, in 1820, and James Pierce, in 1823, discussed the "alluvial deposits" in the vicinity of Raritan Bay without, however, having added much that was new.

The first author to recognize even in slight measure the complexity of the Coastal Plain formations was John Finch, an Englishman, and an ardent collector of fossils. He read a paper before the Philadelphia Academy in 1824, at the close of his travels, and on the eve of his departure for England, which was subsequently published.[1] Some years later he published a book on the same subject. He condemns the term "alluvial" and points out that the Coastal Plain deposits of Maclure and others are identical with the newer Secondary and Tertiary formations of Europe. The non-marine Cretaceous he correlates on the

[1] Amer. Jour. Sci. (I), VII: 31–43, 1824.

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basis of its contained amber and lignite with the Baltic Tertiary of Europe.

The credit for the first definite recognition of the Cretaceous age of any of the Coastal Plain deposits belongs to Vanuxem and Morton. Together, in 1828, they published a paper in the Journal of the Philadelphia Academy,[1] in which the Coastal Plain deposits are classified as follows:

Modern Alluvial.
Ancient Alluvial.
Tertiary.
Secondary { Lignite. / Marl.

Both Vanuxem and Morton published subsequent papers, but their chief interest, however, centered in the fossil remains of the Marl series, which they correlated with the Lower Chalk, or Ferruginous Sand formation of Europe.

In 1832 Conrad divided the Coastal Plain into six formations, i. e.:

Alluvium.
Diluvium.
Gravier Coquillier, of Brong. Crag (mouth of the Potomac.)
Upper Marine, or Upper Tertiary (Peninsula of Maryland, etc.)
Middle Tertiary, or London Clay and Calcaire grossier (Ft. Washington, Claiborne, etc.)
Lower Tertiary, or Plastic Clay (Bordentown, White Hill, N. J.; Cape Sable, Md., etc.)

Lignite, pyrite and amber are mentioned from the Plastic Clay formation. This was the first classification which even hinted at the true complexity of the Coastal Plain, and from this time onward the latter has been treated not as a single, or, at most, a few formations, but as a long series of deposits of varied composition and age.

In 1835[2] and again in 1842[3] Morton set forth his views on the classification of the Cretaceous, dividing it into an Upper,

[1] Jour. Acad. Nat. Sci., Phila., (I) Vol. 6 : 59-71, 1828 (1829).
[2] Amer. Jour. Sci. (I) Vol. 28: 276-278, 1835.
[3] Jour. Acad. Nat. Sci. Phila. (I), Vol. 8: 207-227, 1842.

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Medial and Lower series, the former of which is now known to be largely Eocene, while the latter included not only part of the present marine Cretaceous, but the Raritan and Magothy formations as well.

During the decade of 1830 to 1840, geological surveys were organized in New York, New Jersey, Delaware and Maryland and these were directed, or taken part in, by William M. Mather, Henry D. Rogers, J. C. Booth, and J. T. Ducatel, respectively. Professor Rogers' first report, published in 1836, and his final report of four years later, recognized the following Cretaceous formations in New Jersey:

Brown Sandstone.
Ferruginous Sand.
Limestone.
Greensand.
Clays and Sand.

The lowermost of these, in a vague manner, corresponds to the Raritan formation of modern authors. Ducatel, in his report for 1837, records the Cretaceous from the eastern shore of Maryland, and Booth, in his report, which was published in 1841, divides the "Upper Secondary" of Delaware into the "Red Clay" and "Greensand" formations. In his first reports (1837 and 1838) Mather mentions the clays and sands of Staten and Long Islands, and he points out their probable equivalency with those "of Cheesequake and Matavan Point, on the New Jersey shore." The earlier New Jersey Survey having come to an end, a considerable interval elapsed during which local geological activity was at a standstill. The second survey was organized under William Kitchell, with George H. Cook as assistant geologist, and in the first report for the year 1854, Cook commenced his series of contributions to the Cretaceous belt of New Jersey, which continued year by year until his death, in 1889, after a service as State Geologist extending over twenty-five years.

Considerable space is devoted to the Woodbridge and South Amboy clays in Professor Cook's Geology of New Jersey, published in 1868. His divisions were as follows:

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Plastic Clay { Lignite. / Potters' Clay. / Lignite.

The first fossil plant from the Raritan to receive scientific description was the *Podozamites,* described by Conrad from the banks of South River, in 1869. Fossil plants had been described and figured from Marthas Vineyard by Hitchcock as long ago as 1841 (Final Rept. Geol. of Mass., Vol. 2, 1841), and various authors had mentioned vegetable remains in Maryland and Virginia and other southern states.

These leaf impressions in the Raritan Clays early attracted the attention of Professor Cook, and large collections were made. Unfortunately, like the leaves in so many of the unlithified plant beds of the Coastal Plain, those of the Raritan are usually represented by a more or less thick sheet of carbonaceous matter, which, when dry, soon shrinks, cracking and weathering away and leaving faint and almost worthless impressions behind. This has always been an obstacle to their proper study, as it was in the study of Professor Cook's collections which were submitted to Lesquereux. Professor Lesquereux prepared a list of species, which was published in the Clay Report of 1878, but because of this poorness of preservation, little reliance can be placed upon his determinations. Several of these species have never since been observed, and they are ignored altogether in the systematic part of the present report.

The following is a list of Lesquereux's determinations:

Andromeda.
Araliopsis.
Cinnamomum Heerii Lx.
Daphnophyllum?
(Dryophyllum.)
Glyptostrobus gracillimus Lx.[1]=Widdringtonites Reichii of this report.
Laurus sp.
Leaves of a peculiar new kind of fern.
Magnolia alternata Heer.[1]
Magnolia Capellinii Heer.
Myrica, or *Lomatia.*

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Persea nebrascensis Lx.
Platanus Heerii Lx.
Proteoides daphnogenoides Heer[1]=Ficus daphnogenoides of this report.
Proteoides, undeterminable.
Quercus, dentate leaves.
Rootlets.
Rootlets of *Equisetum.*
Salix proteæfolia Lesq[1]=Salix Lesquereuxi of this report.
Sassafras (Araliopsis.)
Seed of *Conifer.*
Sequoia condita Lx.
Sequoia Reichenbachi Heer.[1]
Sequoia rigida Heer.
Sequoia Smithsiana Heer (sic.)
Sequoia subulata Heer.
A *Sequoia* with thick leaves.
Sterculia sp.
Sterculia, undetermined species.

This list was published in the special volume of the Clays of New Jersey, by Cook and Smock. The Raritan area was treated at length in this work, and the deposits were classified substantially as they are at the present time. Following is Professor Cook's somewhat generalized section of 1878:[2]

Stoneware clay,	30 ft.
Sand and sandy clay,	50 ft.
South Amboy fire clay,	20 ft.
Sandy clay with leaf-impressions,	3 ft.
Sand and "kaolin,"	10 ft.
"Feldspar,"	5 ft.
Micaceous sand,	20 ft.
Laminated clay and sand.	30 ft.
Pipe clay,	10 ft.
Sandy clay with leaf impressions,	5 ft.
Woodbridge fire clay,	20 ft.
Sand,	15 ft.
Raritan fire clay,	15 ft.
Sandy lignitic clay,	4 ft.
Potters clay,	20 ft.

[1] Known members of the Raritan flora.
[2] Cook and Smock, Rept. on Clays, 1878, p. 34.

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The next author to take up a study of the Raritan flora was Professor Newberry, whose work extended over a number of years, during which several minor papers were published, and which culminated in his Flora of the Amboy Clays, issued in 1896, as Monograph XXVI. of the U. S. Geological Survey, after the death of its eminent author. In this work, 156 species were described. These included, however, species outside the Raritan formation and younger in age, in one instance even including a Pleistocene species from the Fish House Clays. Then, too, Professor Newberry, through failing health, was unable to complete his work, and the posthumous monograph too often lacks information regarding the localities from which the various forms were collected.

The name Raritan, as a formational name, was proposed by Prof. W. B. Clark, in 1893, to replace Professor Cook's lithological term, Plastic Clays, although the boundaries of the formation remained practically the same. The former author at one time considered the Raritan the uppermost formation of the Potomac group, the older formations of which are so largely developed in Maryland and to the southward. In this he was followed by Prof. L. F. Ward and others, but the Potomac group has subsequently been restricted to include the Lower Cretaceous Patuxent, Arundel and Patapsco formations.

In 1904 the present State Geologist, Henry B. Kümmel, in collaboration with Heinrich Ries and G. N. Knapp, published a very complete report on the Clays and Clay Industry of New Jersey, in which the Raritan is fully treated. In this report the Raritan is divided into the following members in Middlesex County:[1]

Amboy stoneware clay,	30 ft.
Sand bed No. 3 (at times argillaceous and lignitic),	50 ft.
South Amboy fire clay,	25 ft.
Sand bed No. 2,	45 ft.
Woodbridge clay,	30 to 60 ft.
Sand bed No. 1,	35 ft.
Raritan clay,	35 ft.

[1] Final Rept. State Geol., Vol. VI, 1904, p. 166.

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More recently the fauna of these deposits was described by Stuart Weller, in his volume on Cretaceous Paleontology.

The lower boundary of the Raritan has never been questioned, but its upper limits have been more uncertain and have called forth considerable discussion, the present writer having indicated this upper boundary in 1905.

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III. THE RARITAN FORMATION.

INTRODUCTORY.

New Jersey has been divided into four physiographic zones. The oldest of these, known as *The Highlands,* dates from remote geological time, its constituent rocks consisting for the most part of highly metamorphosed crystalline schists. This zone occupies a broad belt across the northern central portion of the State, and includes the eastern part of Sussex and Warren counties, the northern part of Passaic County, most of Morris County, and the northern part of Hunterdon County. It corresponds in age with the Piedmont Plateau of the states to the southward, and is represented by the basal part of the section in Figure 1. Following the emergence of this belt of land in early geological times, sediments were laid down along its western borders, and it is these Paleozoic sediments, since much folded, which today make up the *Appalachian zone,* comprising the Kittatinny valley and mountain of the northwestern portion of the State, in Sussex and Warren counties.

The third and next younger zone, which is known as the *Piedmont Plain,* was laid down on the eastern flanks of the Highland area at a much later date. Topographically, it corresponds to the Piedmont Plateau region of the states to the southward, but consists, in New Jersey, of much younger rocks of late Triassic age, and includes roughly all or a part of Bergen, Passaic, Essex, Union, Somerset, Middlesex, Hunterdon, and Mercer counties.

The fourth and youngest zone, known as the *Coastal Plain,* includes the remainder of the State and extends from the present coast inland to the exposed area of the Triassic rocks. It is made up of unconsolidated and undisturbed sediments, ranging in age from Cretaceous to Recent.

A glance at the geological column shown in Figure 1, which is drawn approximately to scale, will show the relative position

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ERAS	PERIODS	SECTION	MATERIALS	BIOTIC CHARACTERS
Cenozoic	Quaternary		Glacial products	Appearance of man
	Tertiary		Sands and Clays	Rise of Mammals
	Cretaceous		Sands, Clays and Glauconite	Rise of Angiosperms
	Jurassic	Absent		Age of Cycads and Reptiles
Mesozoic	Triassic		Sandstones and Shales Extrusive and Intrusive lava flows	Age of Conifers
Paleozoic	Permian	Absent		Pteridophytes and Primitive Seed-plants of the Coal
	Carboniferous	Absent		
	Devonian		Sandstones, Shales, Limestones and Conglomerates	Ancestors of the Coal Flora
	Silurian		Limestones, Shales and Sandstones	The First Land Plants
	Ordovician		Limestones and Slates	Marine Life
	Cambrian		Quartzites and Limestones	Marine Life
Proterozoic	Unknown but very great thickness of rocks			Indications of Organic Life
Archæozoic	embracing an enormous lapse of time			

Fig 1.—Diagram Showing the sequence and relative thickness of the Geological divisions in New Jersey.

of the strata of the Raritan formation, and could the duration of geological time which has gone before it be expressed in years, we would obtain a still more vivid picture of the comparative youth of the Cretaceous period, even though this is offset with the reflection that the Cretaceous is removed several million years from the present, and the plants described in the following pages antedate all of the higher animals, and were the

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contemporaries of the huge and uncouth reptilia, the Dinosaurs, Mososaurs, etc., which have long since vanished.

In leading up to a consideration of the Raritan formation, we need not go back farther than the close of the Triassic period. After the deposition of these Triassic sandstones and shales with their accompanying intrusions and extrusions of igneous rock, the whole region was elevated (the post-Triassic uplift). The rising land was immediately subjected to erosion, which went on during the whole of the Jurassic and Lower Cretaceous periods until at length the surface was essentially a vast plain, the Schooley peneplain, as it is called. At some time about the close of the Lower Cretaceous there was a subsidence, or warping, of this Schooley plain, and deposition along its eastern flank succeeded erosion. What remains of these sediments now constitute the Raritan formation of the Coastal Plain, its outcrops forming the western border of the latter. Its strata, dipping to the southeast, are successively overlain by younger sediments so that in wells, like that at Asbury Park, several hundred feet of more recent materials are passed through before the Raritan clays and sands are encountered by the driller.

DESCRIPTION.

The Raritan formation is made up for the most part of alternating beds of clay and sand, with local lignitic deposits and gravel. They vary greatly horizontally, as well as vertically, so much so that the different members which are reasonably well defined in Middlesex County cannot be traced with any degree of assurance to the southwest. The clays are of various kinds, ranging from arenaceous, pyritiferous, at times laminated and lignitic clays, suitable only for the manufacture of common brick, to almost white, massive, high-grade fire clays. All of the clay beds are lenticular and some thin out and disappear in comparatively short distances. The sands are equally variable, some are sharp, nearly pure quartz, others are highly micaceous or lignitic or arkosic, and cross-bedding is frequently seen. The materials, as a whole, in both their character and rapid lateral variation, are just such deposits as would probably be found

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along a subsiding estuary shore line. Comparable deposits are being laid down at the present time in Delaware Bay, Chesapeake Bay, the Gulf of California, and similar more or less land-locked estuarine bodies of water. The preserved fauna, while comparatively meager, shows fresh or brackish aquatic types with local instances of strictly marine forms which show that the country was low-lying and not much above sea level and subject to occasional inroads of the ocean waters. While it is not feasible to map the shifting members of the Raritan formation, it is still possible, especially in Middlesex County, where so many openings have been made, to divide the formation into the seven members shown diagrammatically in Figure 2. The basal con-

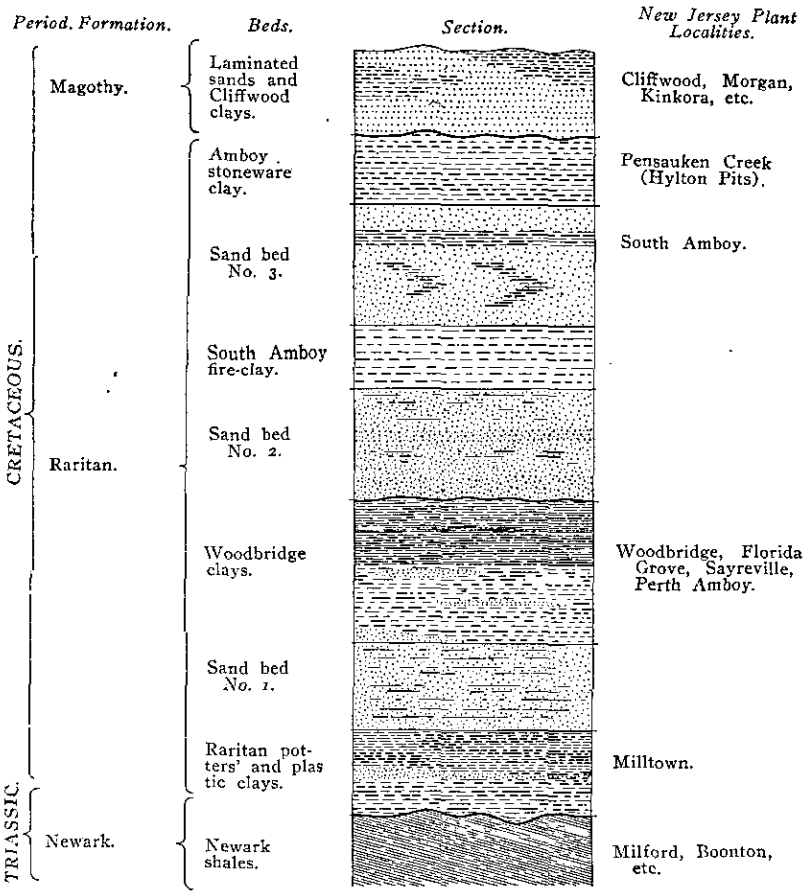

Fig. 2.—Ideal generalized columnar section of the Raritan and adjacent formations in Middlesex county, showing levels from which fossil plants have been collected.

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tact, while usually deeply buried, is shown at a few localities in Middlesex County and is frequently encountered in well borings. South of Trenton the basal Raritan beds, in the absence of the Triassic, lie unconformably on the Philadelphia gneiss, or schist. The thickness of the formation varies considerably. Toward the northeast it is probably in the neighborhood of 260 feet, while just south of Trenton it is probably not over half that thickness. In a well boring in Delaware, a much (cf. Ft. Dupont) greater thickness has been encountered, but it must be admitted that the correlation of this section possesses considerable uncertainty. There seems to be evidence of a considerable thickening down the dip, if the well records can be relied upon. What the original thickness of the Raritan formation was is conjectural. It is certain, however, that post-Raritan erosion has removed much material.

At the close of Raritan sedimentation, the region was sufficiently elevated for erosion to attack the Raritan materials. This interval was not of long duration, however, when measured by geological standards, and the land was soon under water again, receiving the sediments that make up the Magothy formation and which toward their close mark the inauguration of true marine conditions, which became widespread in the succeeding formations of the Upper Cretaceous.

CORRELATION.

Passing over the somewhat diverse views of the older writers who were inclined to regard the Raritan as of Jurassic age,[1] we find Prof. Newberry, in 1890, recognizing the Amboy Clays as Cenomanian[2] in age and synchronous with the Dakota Group

[1] This age was also claimed for it by the late Prof. Marsh in several papers published a score of years ago.

[2] In continental Europe the Cretaceous system is divided as follows:

Upper Cretaceous.	Danian.
	Senonian.
	Turonian.
	Cenomanian.
Unconformity.	
Lower Cretaceous.	Albian.
	Aptian.
	Barremian.
	Neocomian.

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of the West. Prof. Ward was the first to point out that the Raritan was older than the Dakota Group, which is undoubtedly the case, and it has been customary in recent years to regard the Raritan as roughly corresponding to the Gault of England and the Albian of continental Europe. The view here presented is that the Raritan flora is much more closely allied with the Cenomanian of the old world than it is with the Albian or Gault. At the same time it is quite obviously older than the Magothy flora, that of the Dakota Group and those of the South Atlantic Coastal Plain,[2] unless possibly the lower Tuscaloosa, of western Alabama, is equivalent to the upper Raritan in the vicinity of South Amboy, so that if these latter are to remain in the Cenomanian, they are to be regarded as Upper Cenomanian, in which case the Raritan may be regarded as Lower Cenomanian. European geology furnishes a similar case in the division of the Cenomanian into the substages Rotomagian and Caretonian, although probably the parallelism of substages cannot be carried across the ocean. European paleontology furnishes abundant and well characterized Cenomanian and Senonian floras for comparison, and by this standard the Raritan, as well as the somewhat younger Dakota and Magothy floras, are clearly Cenomanian floras. The Turonian stage of European geology, on the other hand, has thus far yielded so meager a flora that it is practically useless as a basis for comparison, and it may well be that the flora of the Dakota Group, along with its southern and eastern representatives—the Woodbine, Tuscaloosa, Eutaw, Middendorf, Bladen and Magothy floras, represent the Turonian stage of Europe. Stratigraphically, there is no contrary evidence and more or less of the Dakota sandstone would simply go with the overlying Benton, which invertebrate paleontologists have long considered as representing the Turonian of Europe. If this view is adopted it seems probable that the Raritan is to be correlated with a part of the upper Cenomanian of Europe.

The paleobotanical evidence for the Cenomanian age of the Raritan formation is briefly as follows: On general grounds,

[2] Older Cretaceous deposits are known from North Carolina to Alabama, but these are, in-so-far as known, unfossiliferous.

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we find the Raritan flora more complex and modern in its composition than any known Albian flora; for example, dicotyledons make up 68% of the Raritan flora, while not a single dicotyledon is known from the English Gault, and the representation of this group of plants in the Albian of France and Spain is very meager indeed, and comparable to the display of these plants in the Patapsco formation of Maryland and Virginia, the latter showing a striking parallelism with the Albian of the old world, with at least one identical species and closely allied representatives in several identical genera.

Species which are peculiar to the Raritan formation number 54, as follows:

Acer amboyense Newb.
Aralia patens Holl.
Aralia rotundiloba Newb.
Asplenium raritanensis Berry.
Asplenium jerseyensis Berry.
Bauhinia gigantea Newb.
Cæsalpinia Cookiana Holl.
Caespalpinia raritanensis Berry.
Calycites diospyriformis Newb.
Calycites parvus Newb.
Carpolithus ovaeformis Newb.
Carpolithus pruniformis Newb.
Carpolithus woodbridgensis Newb.
Celastrophyllum grandifolium Newb.
Celastrophyllum minus Holl.
Celastrophyllum spatulatum Newb.
Chondrites flexuosus Newb.
Chondrophyllum obovatum Newb.
Chondrophyllum reticulatum Newb.
Cornophyllum vetustum Newb.
Dewalquea trifoliata Newb.
Diospyros amboyensis Berry.
Eucalyptus parvifolia Newb.
Fontainea grandifolia Newb.
Hedera obliqua Newb.
Ilex elongata Newb.

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Ilex amboyensis Berry.
Laurophyllum lanceolatum Newb.
Laurophyllum minus Newb.
Leguminosites raritanenis Berry.
Liriodendron quercifolium Newb.
Menispermites Wardianus Hollick.
Myrica acuta Hollick.
Myrica cinnamomifolia Newb.
Myrica fenestrata Newb.
Myrica Hollicki Ward.
Myrica Newberryana Hollick.
Myrica raritanensis Hollick.
Myrsine oblongata Hollick.
Newberryana rigida (Newb.) Berry.
Passiflora antiqua Newberry.
Planera Knowltoniana Hollick.
Persoonia spatulata Hollick.
Phyllites trapaformis Berry.
Phyllites undulatus Newb.
Podozamites acuminatus Hollick.
Populus orbicularis (Newb.) Berry.
Protophyllum obovatum Newb.
Prunus ? acutifolia Newb.
Quercus raritanensis Berry.
Rhamnites minor Hollick.
Salix pseudo-Hayei Berry.
Sphaerites raritanensis Berry.
Williamsonia Smockii Newb.

Obviously these are of little service in correlation, nevertheless all but one or two are dicotyledons of genera, which in Europe are found only in the Cenomanian and Senonian. Allied forms are largely represented in the Magothy formation, the Dakota Group, and the Atane beds of Greenland.

There are 10 Lower Cretaceous species which persist into the Raritan. These are:

Asplenium Dicksonianum Heer.
Celastrophyllum Brittonianum Hollick.
Frenelopsis Hoheneggeri (Ettings.) Schenk.

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Gleichenia giesekiana Heer.
Gleichenia micromera Heer.
Gleichenia Zippei Heer.
Podozamites Knowltoni Berry.
Podozamites lanceolatus (L. & H.) F. Braun.
Sequoia Reichenbachi (Gein.) Heer.
Thuyites Meriani Heer.

Of these the ferns and the gymnosperms, which make up the bulk of the list, are to be regarded primarily as Lower Cretaceous types which survived into the Upper Cretaceous. Among the generic types of ancient lineage which are represented in the Raritan, are *Baiera*, primarily a Triassic and Jurassic genus, the Raritan species of which is closely related to forms found in the Older Potomac, *Williamsonia* a Jurassic and Lower Cretaceous genus, *Brachyphyllum* a Triassic and Jurassic genus, the Raritan species of which is closely related to and clearly descended from *Brachyphyllum crassicaule* Font. of the Patapsco formation, and finally *Czekanowskia* a Triassic and Jurassic (chiefly Oolitic) genus.

In no part of the world has a single representative of any of these genera been found as late as the Senonian, and it is significant that two of them, *Brachyphyllum*[1] and *Czekanowskia* furnish their last known record in the Cenomanian of Portugal, while the last occurrence of *Baiera* and *Williamsonia*[2] is in the Cenomanian Atane beds of Greenland.

When the Raritan flora is compared in detail with the Patapsco flora of Maryland and Virginia, many common features are brought out which at first sight tend to be obscured by the preponderating dicotyledonous element in the former. In addition to the identical or closely related forms previously mentioned, we find among the dicotyledons five Raritan genera

[1] The Raritan species *B. macrocarpum* Newb. is recorded from the following American horizons: Montana Group of Wyoming, Dakota Group of Kansas, Magothy formation of Long Island, New Jersey and Delaware, the Middendorf of South Carolina (?), the Bladen of North Carolina (?), and the Patoot beds of Greenland (?), the former of course of Senonian age.

[2] A questionable species is recorded from the Dakota group and another species occurs in the Magothy formation.

NEW JERSEY GEOLOGICAL SURVEY

which make their first appearance in the Patapsco. These are *Aralia, Celastrophyllum, Cissites, Eucalyptus* and *Ficus*. The genus *Celastrophyllum*, with a large display of forms in both the Patapsco and the Raritan, has one identical species, *C. Brittonianum* Hollick, while *C. Hunteri* of the former is very close and ancestral, if not actually identical, with *C. augustifolium* Newb. of the Raritan.

Among the conifers the widespread *Widdringtonites ramosus* (Font.) Berry, of the Patapsco, is closely related, if not identical, with the equally common *Widdringtonites Reichii* (Ettings.) Heer of the Raritan and succeeding formations. The genus *Frenelopsis* has closely related species in both, while *Sequoia* and *Thuyites* have already been mentioned as well as the cycadean genus *Podozamites* which extends back to the Triassic. Two Raritan species are recorded from the European Albian. These are *Sequoia Reichenbachi* (Gein.) Heer and *Eucalyptus angusta* Velen., the former a very wide ranging form and the latter recorded from the Albian of Portugal and the Cenomanian of Bohemia.

Turning to the elements in the Raritan flora which ally it with younger floras, we find that 6 of the Raritan species persist as late as the Senonian of Europe, and 15 are found in the Patoot beds of Greenland, which are also usually regarded as of Senonian age. All but 4 of these are, however, found in the Cenomanian beds of that country, and practically all of the others and those from the Senonian of Europe as well, occur somewhere in Cenomanian strata. There are 34 species common to the Raritan flora and that of the Dakota Group, the former lacking more particularly the numerous forms of *Betula, Quercus, Platanus*, etc., which characterize the latter. There are 32 species common to the Raritan and to the Atane beds of Greenland, the latter formation being usually regarded as Cenomanian in age, and there are 67 species common to the Raritan and Magothy floras, although these latter figures are somewhat obscured by the difficulty of determining the probable age of many of the species recorded from Long Island and other areas in the vicinity of the terminal moraine and by the additional fact that the Upper Raritan at South Amboy furnished many

NEW JERSEY GEOLOGICAL SURVEY

of these identical species, and it is quite likely that some of the species credited to South Amboy, on the authority of Prof. Newberry, may really have come from within the Magothy formation, since the Morgan locality, which is of Magothy age, would not have been kept distinct from South Amboy as a place name in Prof Newberry's day. The following table of distribution gives in detail the geological and geographical distribution of all the species known to occur in the Raritan formation at the present time. The species found recorded from "near Keyport," in Prof. Newberry's report, are all excluded, as this outcrop is now known to be of Magothy age, while the *Tiliaephyllum* recorded from Fish House is now known to be Pleistocene. As previously mentioned, no account is taken of the determinations of Lesquereux, published in the Clay Report of 1878, since the material was so unreliable and embraced a number of forms which would be most unlikely to occur in these beds.

NEW JERSEY GEOLOGICAL SURVEY

	Locality Unknown.	South Amboy.	Hylton Pits on Pensauken Creek.	Perth Amboy.	Woodbridge.	Florida Grove.	Sayreville.	Milltown.	Staten Island.	Long Island.	Magothy of L. I., N. J., Del., Md., Block Is., & Martha's Vineyard.	North Carolina.[1]	South Carolina.[1]	Georgia.[1]	Alabama.[1]	Dakota Group.	Atane Beds.	Patoot Beds.	Europe. Albian.	Cenomanian.	Turonian.	Senonian.
Acer amboyense Newb.,	—	—	—	—	—	—	—	—	—	—	?	—	—	—	—	—	—	—	—	—	—	—
Acerates amboyense Berry,	—	X	—	—	—	—	—	—	—	—	—	X	—	—	—	—	—	—	—	—	—	—
Andromeda grandifolia Berry,	—	—	—	—	X	—	—	—	—	—	—	X	—	—	—	—	—	—	—	—	—	—
Andromeda Cookii Berry,	—	—	—	—	—	—	—	—	—	?	—	—	—	—	—	—	—	—	—	—	—	—
Andromeda novæ-cæsareæ Holl.,	—	—	—	—	X	—	—	—	—	?	—	—	—	—	—	—	—	—	—	—	—	—
Andromeda Parlatorii Heer,	—	—	X	—	—	—	—	X	X	X	X	X	X	—	X	—	—	—	—	—	—	—
Aralia formosa Heer,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	X	—	—
Aralia grœnlandica Heer,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Aralia Newberryi Berry,	—	—	—	—	X	—	—	—	X	—	X	X	—	—	X	—	—	—	—	—	—	—
Aralia patens Hollick,	—	—	—	—	X	—	—	—	—	?	—	—	—	—	—	—	—	—	—	—	—	—
Aralia quinquepartita Lesq.,	—	—	—	—	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Aralia rotundiloba Newb.,	—	—	—	—	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Aralia Wellingtoniana Lesq.,	—	—	—	—	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
**Asplenium Dicksonianum* Heer,	—	—	—	—	—	—	—	X	—	—	—	—	—	—	X	—	—	—	—	—	—	—
Asplenium Fœrsteri D. & E.,	—	X	—	—	X	—	—	—	—	—	X	—	—	—	—	—	—	—	—	X	—	—
Asplenium raritanensis Berry,	—	—	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Asplenium jerseyensis Berry,	—	—	—	—	—	—	—	X	—	—	—	—	—	—	—	—	—	—	—	—	—	X
Baiera incurvata Heer,	—	—	—	—	X	—	—	—	—	—	—	—	—	—	X	—	—	—	—	—	—	—
Bauhinia cretacea Newb.,	—	—	—	—	X	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Bauhinia gigantea Newb.,	—	—	—	—	X	—	—	—	X	X	X	X	X	X	X	X	—	—	—	—	—	—
Brachyphyllum macrocarpum Newb.,	—	X	—	—	—	—	—	—	X	X	X	X	X	X	X	X	—	—	—	—	—	—

[1] The range of a number of the species in the accompanying table has been extended to North Carolina, South Carolina, Georgia or Alabama since the table was prepared in 1908.

* Occurs in the Lower Cretaceous.

NEW JERSEY GEOLOGICAL SURVEY

TABLE OF DISTRIBUTION—*Continued.*

	Locality Unknown.	South Amboy.	Hylton Pits on Pensauken Creek.	Perth Amboy.	Woodbridge.	Florida Grove.	Sayreville.	Milltown.	Staten Island.	Long Island.	Magothy of L. I., N. J., Del., Md., Block Is., & Martha's Vineyard.	North Carolina.[1]	South Carolina.[1]	Georgia.[1]	Alabama.[1]	Dakota Group.	Atane Beds.	Patoot Beds.	Europe. Albian.	Cenomanian.	Turonian.	Senonian.
Cæsalpinia Cookiana Holl.,	X																					
Cæsalpinia raritanensis Berry,		X																				
Calycites diospyriformis Newb.,					X																	
Calycites parvus Newb.,					X																	
Carpolithus floribundus Newb.,					X						X											
Carpolithus hirsutus Newb.,					X																	
Carpolithus ovæformis Newb.,					X																	
Carpolithus pruniformis Newb.,					X																	
Carpolithus woodbridgensis Newb.,					X																	
Celastrus artica Heer,									X		X											
**Celastrophyllum Brittonianum* Holl.,	X																					
Celastrophyllum crenatum Heer,		X					X					X	X		X		X					
Celastrophyllum cretaceum Lesq.,	X				X			X								X						
Celastrophyllum decurrens Lesq.,		X			X			X								X						
Celastrophyllum grandifolium Newb.,								X														
Celastrophyllum minus Holl.,	X							X														
Celastrophyllum Newberryanum Holl.,		X					X				X						?					
Celastrophyllum spatulatum Newb.,		X					X															
Celastrophyllum undulatum Newb.,					X		X					X			X							
Chondrites flexuosus Newb.,																						
Chondrophyllum obovatum Newb.,																						
Chondrophyllum reticulatum Holl.,	X																					

* Occurs in the Patapsco formation of Virginia.

NEW JERSEY GEOLOGICAL SURVEY

TABLE OF DISTRIBUTION—*Continued.*

	Locality Unknown.	South Amboy.	Hylton Pits on Pensauken Creek.	Perth Amboy.	Woodbridge.	Florida Grove.	Sayreville.	Milltown.	Staten Island.	Long Island.	Magothy of L., I., N. J., Del., Md., Block Is., & Martha's Vineyard.	North Carolina.[1]	South Carolina.[1]	Georgia.[1]	Alabama.[1]	Dakota Group.	Atane Beds.	Patoot Beds.	Albian.	Cenomanian.	Turonian.	Senonian.	Europe.
Cinnamomum Newberryi Berry,		X			X		X								X	X							
Cissites crispus Velen.,		X			X																		
Cissites formosus Heer,		X			X		X																
Citrophyllum aligera (Lesq.), Berry,																X	X						
Colutea primordialis Heer,					X		X									X	X						
Comptonia microphylla (Heer), Berry,		X			X												X						
Cornophyllum vetustum Newb.,		X			X			X									X						
Cycadinocarpus circularis Newb.,		X			X							X					X						
Czekanowskia capillaris Newb.,		X			X							X					X						
Dammara borealis Heer,		X			X				X			X					X						
Dalbergia apiculata Newb.,		X			X				X			X					X						
Dewalquea grænlandica Heer,		X			X				X			X					X						
Dewalquea trifoliata Newb.,		X			X				X			X					X						
Dicksonia grænlandica Heer,		X			X							X					X						
Diospyros primæva Heer,		X			X							X					X						
Diospyros amboyensis Berry,		X			X							X					X						
Eucalyptus angusta Velen.,		X			X							X					X						
Eucalyptus attenuata Newb.,		X			X							X					X						
Eucalyptus Geinitzi Heer,		X			X							X					X						
Eucalyptus linearifolia Berry,		X			X							X					X						
Eucalyptus parvifolia Newb.,		X			X							X					X						
Ficus daphnogenoides (Heer), Berry,		X			X							X					X						

NEW JERSEY GEOLOGICAL SURVEY

TABLE OF DISTRIBUTION—*Continued.*

	Locality Unknown.	South Amboy.	Hylton Pits on Pensauken Creek.	Perth Amboy.	Woodbridge.	Florida Grove.	Sayreville.	Milltown.	Staten Island.	Long Island.	Magothy of L. I., N. J., Del., Md., Block Is., & Martha's Vineyard.	North Carolina.[1]	South Carolina.[1]	Georgia.[1]	Alabama.[1]	Dakota Group.	Atane Beds.	Patoot Beds.	Europe. Albian.	Cenomanian.	Turonian.	Senonian.
Ficus myricoides Holl.,	X																					
Ficus ovatifolia Berry,			X																			
Ficus Woolsoni Newb.,																						
Fontainea grandifolia Newb.,																						
**Frenelopsis Hoheneggeri* (Ett) Schenk,											?											
Geinitzia formosa Heer,																						
**Gleichenia Gieseckiana* Heer,																						
**Gleichenia micromera* Heer,																						
**Gleischenia Zippei* Heer,																						
Hedera obliqua Newb.,																						
Hedera primordialis Sap.,																						
Hymenea dakotana Lesq.,	X																					
Ilex elongata Newb.,																						
Ilex amboyensis Berry,																						
Juglans arctica Heer,																						
Juniperus hypnoides Heer,																						
Laurophyllum angustifolium Newb.,																						
Laurophyllum elegans Holl.,																						
Laurophyllum lanceolatum Newb.,																						
Laurophyllum minus Newb.,																						

* Occurs also in the Lower Cretaceous.

[1] The range of a number of the species in the accompanying table has been extended to North Carolina, South Carolina, Georgia or Alabama since the table was prepared in 1908.

NEW JERSEY GEOLOGICAL SURVEY

TABLE OF DISTRIBUTION—*Continued.*

	Locality Unknown.	South Amboy.	Hylton Pits on Pensauken Creek.	Perth Amboy.	Woodbridge.	Florida Grove.	Sayreville.	Milltown.	Staten Island.	Long Island.	Magothy of L. I., N. J., Del., Md., Block Is., & Martha's Vineyard.	North Carolina.[3]	South Carolina.[3]	Georgia.[3]	Alabama.[3]	Dakota Group.	Atane Beds.	Patoot Beds.	Europe. Albian.	Cenomanian.	Turonian.	Senonian.
Laurophyllum nervillosum Holl.,																						
Laurus plutonia Heer,																						
Leguminosites atanensis Heer,	X	X	X		X				X		X		X				X	X		X		X
Leguminosites coronilloides Heer,	X																					
Leguminosites omphalobioides Lesq.,					X																	
Leguminosites raritanensis Berry,			X		X																	
Liriodendron oblongifolium Newb.,			X		X																	
Liriodendron quercifolium Newb.,						X				?												
Liriodendropsis angustifolia Newb.,							X															
Liriodendropsis retusa (Heer), Newb.,								X	X													
Liriodendropsis simplex Newb.,									X													
Magnolia alternans Heer,										?												
Magnolia Hollicki Berry,										X	X											
Magnolia Isbergiana Heer, ?											?											
Magnolia Boulayana Lesq.,											X											
Magnolia Lacœna Lesq.,											X											
Magnolia longipes Holl.,											?											
Magnolia Newberryi Berry,											X											
Magnolia speciosa Heer,											?											
Magnolia woodbridgensis Holl.,											X											
Menispermites borealis Heer,																						
Menispermites Wardianus Holl.,																						
Microzamia gibba (Reuss), Corda,																						
Mexicania cyclotoxon D. & E.,																						

NEW JERSEY GEOLOGICAL SURVEY

TABLE OF DISTRIBUTION—*Continued.*

	Locality Unknown.	South Amboy.	Hylton Pits on Pensauken Creek.	Perth Amboy.	Woodbridge.	Florida Grove.	Sayreville.	Milltown.	Staten Island.	Long Island.	Magothy of L. I., N. J., Del., Md., Block Is., & Martha's Vineyard.	North Carolina.[1]	South Carolina.[1]	Georgia.[1]	Alabama.[1]	Dakota Group.	Atane Beds.	Patoot Beds.	Albian.	Cenomanian.	Turonian.	Senonian.	Europe.
Myrica acuta Holl.,	×																						
Myrica cinnamomifolia Newb.,		×		×																			
Myrica emarginata Heer,	×																						
Myrica fenestrata Newb.,							×	×	×								×						
Myrica Hollicki Ward,									×														
Myrica Newberryana Holl.,		×																					
Myrica raritanensis Holl.,	×																						
Myrsine borealis Heer,		×		×	×			×	×	?	×	×	×		×	×	×						
Myrsine Gaudini (Lesq.), Berry,	×																						
Myrsine oblongata Holl.,		×			×																		
Newberryana rigida (Newb.), Berry,	×																						
Ophioglossum granulatum Heer,					×	×	×																
Passiflora antiqua Newb.,																							
Phegopteris Grothiana Heer,																							
Phyllites undulatus Newb.,																							
Phyllites trapaformis Berry,		×																					
Pinus raritanensis Berry,																							
Planera Knowltoniana Holl.,					×																		
Persoonia spatulata Holl.,	×																						
Persoonia Lesquereuxii Knowlton,		×									×					×							
Phascolites manhassettensis Holl.,								×		?													
Podozamites acuminatus Holl.,				×	×																		

NEW JERSEY GEOLOGICAL SURVEY

TABLE OF DISTRIBUTION—*Continued.*

	Locality Unknown.	South Amboy.	Hylton Pits on Pensauken Creek.	Perth Amboy.	Woodbridge.	Florida Grove.	Sayreville.	Milltown.	Staten Island.	Long Island.	Magothy of L. I., N. J., Del., Md., Block Is., & Martha's Vineyard.	North Carolina.[1]	South Carolina.[1]	Georgia.[1]	Alabama.[1]	Dakota Group.	Atane Beds.	Patoot Beds.	Albian.	Europe. Cenomanian.	Turonian.	Senonian.
Podozamites Knowltoni Berry,																						
Podozamites lanceolatus (L. & H.), F. Braun,																						
Podozamites marginatus Heer,																						
Populus apiculata Newb.,		X														X						
Populus orbicularis (Newb.), Berry,					X																	
Protophyllocladus subintegrifolius (Lesq.), Berry,					X																	
Prunus ? acutifolia Newb.,					X																	
Pterospermites obovatus (Newb.), Berry,					X																	
Quercus raritanensis Berry,																						
Rhamnites minor Holl.,	X																					
Raritania gracilis (Newb.), H. & J.,																						
Salix flexuosa Newb.,																						
Salix inæqualis Newb.,																						
Salix Newberryana Holl.,																						
Salix raritanensis Berry,																						
Salix Lesquereuxii Berry,																						
Salix pseudo-Hayei Berry,																						
Sassafras acutilobum Lesq.,																						
Sassafras hastatum Newb.,																						
Sassafras progenitor Holl.,																						
Sequoia concinna Heer.	X									?												

[1]The range of a number of the species in the accompanying table has been extended to North Carolina, South Carolina, Georgia or Alabama since the table was prepared in 1908.

NEW JERSEY GEOLOGICAL SURVEY

TABLE OF DISTRIBUTION—*Continued.*

	Locality Unknown.	South Amboy.	Hyiton Pits on Pensauken Creek.	Perth Amboy.	Woodbridge.	Florida Grove.	Sayreville.	Milltown.	Staten Island.	Long Island.	Magothy of L. I., N. J., Del., Md., Block Is., & Martha's Vineyard.	North Carolina.	South Carolina.	Georgia.	Alabama.	Dakota Group.	Atane Beds.	Patoot Beds.	Europe. Albian.	Cenomanian.	Turonian.	Senonian.
Sequoia heterophylla Velen.,	—	—	—	—	—	—	—	—	—	—	X	X	X	X	X	X	—	—	—	—	—	—
[1]*Sequoia Reichenbachi* (Gein.), Heer,	—	X	—	—	X	—	—	—	X	—	X	—	—	—	—	—	—	—	X	X	X	X
Smilax raritanensis Berry,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Sphærites raritanensis Berry,	—	X	X	—	X	—	—	—	—	—	X	—	—	—	—	—	X	—	—	—	—	—
Tricalycites papyraceus Newb.,	—	—	X	—	X	—	—	X	X	—	X	—	—	—	—	—	X	X	—	—	—	—
Tricarpellites striatus Newb.,	—	—	—	—	—	—	—	—	X	?	X	—	—	—	—	—	—	—	—	—	—	—
Thuya cretacea (Heer), Newb.,	—	—	X	—	X	—	—	—	—	—	X	—	—	—	—	—	—	—	—	—	—	—
[1]*Thuyites Meriana* Heer,	X	—	—	—	—	—	—	—	—	?	X	—	—	—	—	—	—	—	—	—	—	—
Viburnum integrifolium Newb.,	—	—	—	—	—	—	—	—	—	—	X	—	—	—	—	—	—	—	—	—	—	—
Widdringtonites Reichii (Ett.), Heer,	—	—	X	—	X	—	X	X	X	—	X	—	X	—	X	—	X	X	—	X	—	—
Widdringtonites subtilis Heer,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Williamsonia Smockii Newb.,	X	—	—	—	—	—	—	—	—	—	X	—	—	—	X	—	X	—	—	X	—	—
Williamsonia problematica (Newb.), Ward,	X	—	—	—	—	—	—	—	—	—	X	—	—	—	—	—	—	—	—	—	—	—

[1] Recorded also in the Lower Cretaceous.

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IV. BOTANICAL CHARACTER.

The present enumeration of Raritan plants embraces between 160 and 170 species. Of this number there are from 15 to 20 whose botanical relations are unknown. The balance show the following disposition in the great phylæ of the vegetable kingdom: Two Thallophytes are recorded, one a fungus and the other an alga. Doubtless other representatives of this great plant phylum were abundant during Raritan time, and possibly other species could be recorded, but they are so vague in their characters as to be of little value, except in so far as they show the presence of these types of plants at this remote epoch.

The Pteridophytes, or fern-plants, are represented by 9 species, or .055% of the whole flora. In the existing flora of New Jersey the percentage is .038%, but this is lowered by herbaceous plants which are absent from the fossil record. Thus the Raritan record shows a remarkable shrinkage as compared with floras of the older Mesozoic. The species present in the New Jersey beds are all wide-ranging forms of little peculiar interest in this connection, and they fall in those Cretaceous groups which represent the modern families, Gleicheniaceæ, Cyatheaceæ, Polypodiaceæ and Ophioglossaceæ. The ferns are more abundant in the Raritan formation than they are in the Magothy formation or the Dakota group, while they are considerably less abundant than in the flora of the Atane beds of Greenland, where they constitute 11% of the whole flora.

As might be expected, the great bulk of the Raritan plants belong to the Spermatophyta, or seed-plants, and of these 24 are referred to the Gymnospermæ, almost twice as many as are present in the recent gymnospermous flora of the State. These are relatively much more abundant, both in individuals and in species, than they are in the Tertiary or recent floras. Six are referred to the cycads, one of which is based on a cone, one on seed remains, and the balance on frond fragments. The older Mesozoic abounded in cycadophytes, which at that time were

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world-wide in their distribution, and they maintained their position with unabated vigor during most of the Lower Cretaceous. During the Upper Cretaceous, however, they commenced to wane, a prophetic hint of their minor position and restricted range in the floras of the modern world, where they have only 9 genera and less than 100 species. Two of the Gymnospermæ, a *Baiera* and a *Czekanowskia,* are referred to the Ginkgoales, that singular order whose sole surviving representative is the Maidenhair tree indigenous in eastern Asia, and commonly cultivated as an ornamental tree in our parks. This order was a very important element in the older Mesozoic, and its two representatives in the Raritan are to be regarded as surviving elements from the Jurassic. They are both confined to the lower Raritan. This leaves 16 species of the order Coniferales, or true conifers, the order to which all of the gymnosperms in the recent flora of New Jersey belong. The family Taxaceæ, which is well represented in the older Potomac formations of Maryland and Virginia, has but one species in the Raritan, *Protophyllocladus subintegrifolius* (Lesq.) Berry, of the sub-family Taxæ. Its botanical affinity is not established with certainty, although superficially it is strikingly like the modern antipodean genus *Phyllocladus.* The balance of the Coniferales are referred to the family Pinaceæ, 4 sub-families being represented. The sub-family Abieteæ includes a species of *Pinus,* which is first seen in the Upper Raritan at South Amboy and which persists into the Magothy formation and is also present in the Upper Cretaceous deposits in the Carolinas. Other species are also present in the Magothy formation along with fossil wood, and it is to this genus that the abundant amber of that formation is said to owe its origin. The sub-family Araucarieæ, at the present day confined to the southern hemisphere, but cosmopolitan in the older Mesozoic, is represented by 2 Raritan species, *Dammara borealis* Heer, based on deciduous cone scales, and *Brachyphyllum macrocarpum* Newb., based on leafy twigs. The latter is known only from the Upper Raritan, but, nevertheless, represents a Jurassic and Lower Cretaceous type, of which it is about the last representative.

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The sub-family Taxodieae is represented by 2 or 3 species of *Sequoia* and 1 of *Genitzia,* all forms with a considerable geographical range. The sub-family Supresseae makes the greatest display in species during Raritan time, with no less than 8 recorded forms. These include a species of *Thuja,* another of *Thuyites,* a wide-ranging *Juniperus, Moriconia,* and 2 species each in *Widdringtonites* and *Frenelopsis.* Modern botanists include both of the latter genera as synonyms of the genus *Callitris,* but there is considerable advantage and good arguments for maintaining their distinctness. *Widdringtonites Reichii* (Ett.) Heer is abundant throughout the Raritan and Magothy formations and is undoubtedly descended from the closely allied form of the older Potomac. *Widdringtonites subtilis* Heer, although present in the lower Raritan at Woodbridge, is more characteristic of the somewhat later Upper Cretaceous deposits of the Atlantic Coastal Plain. One species of *Frenelopsis* is a survivor from the Lower Cretaceous, and the other is a characteristic form in the overlying Magothy formation in New Jersey, Delaware and Maryland. In some respects the most interesting member of the sub-family is *Moriconia cyclotoxon* Deb. & Ett. described originally from the European Senonian of Aachen and thought to be a fern. Afterward discovered by Heer in both the Cenomanian and Senonian beds of Greenland, it appears in the upper Raritan at South Amboy.

The Angiospermae, or plants with closed ovaries, usually designated as "flowering plants," make up the balance of the flora. These are nearly all dicotyledons. Monocotyledons are usually less fully represented in fossil floras than are the dicotyledons, which not only have leaves differentiated into blade and leaf stalk, but have these parts more resistant to maceration, so that the absence of monocotyledons may simply mean that none were preserved, although there are very plausible theoretical reasons for regarding the monocotys as a comparatively modern offshoot from the older dicotys. The monocotyledon known from the Raritan formation is the single species of *Smilax* to which genus the writer has transferred Prof. Newberry's species of *Paliurus,* and as this is a rare and not especially significant element in the flora, it may be passed without further consideration.

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Turning to the Dicotyledonæ, we find the old group Amentiferæ, which by some authors are thought to be reduced higher plants and by others considered primitive and as partially bridging the gap between the Angiospermæ and the order Gnetales of the Gymnospermæ, has 18 species, or 14%, in the Raritan. These include 8 species of Myricales, 1 of Juglandales, 8 of Salicales and 1 of Fagales. This is a considerable less showing than is made by this type in the flora of the Dakota Group, where there are 10 species of Myricales, 6 of Juglandales, 24 of Salicales and 44 of Fagales.

The order Urticales has a species of *Planera* and 4 species of *Ficus* in the Raritan, the latter including both the lanceolate pinnately-veined forms and those with a palmate venation. This order is much more fully represented in immediately succeeding floras, the Dakota Group having over a score of species, and the Senonian, both at home and abroad, a great variety.

The order Proteales, which in modern floras is confined to the southern hemisphere, has but 2 Raritan species, while there are 6 in the Dakota Group. Later geologic time shows a considerable development of this order, especially in the Tertiary of Europe.

The order Ranales, recently given a prominent place in phylogenetic speculations by English authors, who, on purely theoretical grounds, would connect the Angiospermae through this medium with the Mesozoic Cycadophyta, has 24 species in the Raritan, or 19% of its known flora. This is a much less number than is present in the Dakota Group, from which 81 species are recorded. In the Raritan there are 2 species of *Dewalquea*, 9 or 10 of *Magnolia*, 2 of *Liriodendron*, 3 of *Sassafras*, and 2 species of *Menispermites*. At the present day this order is represented in the latitude of New Jersey by mostly herbaceous forms of the family Ranunculaceae, the arborescent forms related to those of the Raritan being largely warm-temperate or subtropical species of wide distribution, strongly represented in northern South America.

The large modern order Rosales has 431 species in the area covered by Britton and Brown's Illustrated Flora of the United States, while in Small's Flora of the Southern United States

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over 800 species are recorded. The Raritan flora furnishes 16 species, or 13% of the total, and these belong for the most part to the various families into which the old family Leguminoseae has been split by modern systematists. A large number of these Raritan species are based upon leaflets, whose generic relations are not determinable with certainty. Deserving of special mention are the 2 species of *Bauhinia* which have such striking bilobate leaves and which are well characterized and closely related to existing forms in the American tropics.

The order Geraniales is represented in the upper Raritan of South Amboy by a single specimen of *Citrophyllum aligera* (Lesq.) Berry, a widespread species in the overlying Magothy formation and in the Dakota Group, and with modern subtropical affinities.

In the order Sapindales there are 13 species, or 11% of the total. They include a somewhat doubtful species of *Acer*, 2 of *Ilex*, and a *Celastrus*, which is very abundant and is characteristic of the upper Raritan. The genus *Celastrophyllum*, which appears in abundance in the Older Potomac flora of Maryland and Virginia, is especially abundant in the Cretaceous of the Atlantic Coastal Plain. There are 9 species in the Raritan flora, several of which are especially well marked and some are of large size. *Celastrophyllum crenatum* Heer ranged from Greenland to South Carolina, and *Celastrophyllum Newberryanum* Hollick is an especially abundant leaf in the upper Raritan at South Amboy, occuring also in the older Raritan deposits at Sayreville. It has not been possible to determine from what horizons in the Raritan *Celastrophyllum Brittonianum* Hollick, and *cretaceum* Lesq. were collected, which is unfortunate, since the former has also been found in the older Patapsco formation and the latter in the younger Dakota Group.

There are 5 species of Rhamnales and 1 species of Parietales in the Raritan, the genera present being *Rhamnites, Hedera, Cissites*, and *Passiflora*.

The order Myrtales, which includes quite a number of herbaceous species in the modern flora of this region, is represented in the Raritan by 6 species of *Eucalyptus*, 4 of which are confined to the upper Raritan at South Amboy. This genus has

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been recorded from a large number of Cretaceous localities and becomes even more cosmopolitan in the Tertiary, but is restricted in modern times to the Australian region.

There are 9 Raritan species of Umbellales, forming 7% of the angiosperms represented. This is about one-third the number present in the Dakota Group. These include 7 species of *Aralia* whose modern relatives are to be found in allied genera of the warmer regions of the globe. There is a very doubtfully identified species of *Viburnum* and a species of *Cornophyllum* which is closely allied to species of *Cornus* found in the Magothy and Tuscaloosa formations, the Atane beds and the Dakota Group.

The order Ericales has 4 species of *Andromeda* in the Raritan flora, and the order Primulales has 3 species of *Myrsine*, all with an outside distribution and with modern representatives in warmer climes.

The order Ebenales is represented by 3 species of *Diospyros*, one of which is very abundant both in New Jersey and elsewhere; and the order Gentianales is represented by a single species of *Acerates*.

While the flora as a whole differs from any modern American flora with which it may be compared by the association of forms which have since become segregated by the diversified climate of later geological time, it is distinctly suggestive of existing floras, meaning by this that it is the earliest known flora in which the same plant groups which dominate in the present flora of the globe are largely represented.

Of the 78 genera known from the Raritan formation, only 32 are extinct, and 11 of these genera are gymnosperms, or lower plants, and of the remainder about a dozen belong to genera like *Calycites, Carpolithus, Palaeanthus, Leguminosites*, etc. Of the 45 known genera of Raritan Angiospermae, only 11 have since passed entirely away.

With the exception of the Araucarieæ, Proteaceæ and Eucalyptus, which have since become gradually restricted to the southern hemisphere, we would have no difficulty in acclimitizing the Raritan flora in our present Gulf States, and the modern representatives of the groups since become antipodean would flourish

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in such an environment if they were reintroduced, at least the only adverse factor would be the pressure of a more complex flora. This, incidentally, seems to have been the ancient factor which largely explains their present distribution.

With regard to the climate of the Raritan, the data for forming any adequate opinion are altogether insufficient. Although *Widdringtonites* and *Frenelopsis* suggest a certain amount of aridity, this is overwhelmingly opposed by the ferns and cycads and a host of other forms. The climate was certainly more uniform than at present, both as regards seasonal changes and zonal differentiation.

When large numbers of identical species range from Greenland through southern New England, New Jersey, Maryland, and the Carolinas to Alabama, and when we find identical Dakota Group forms in Minnesota and Kansas and then in Texas, and then in the Upper Cretaceous of Patagonia, it would seem that the proof that Cretaceous climate was very different, as a whole, from modern climate rested on a very secure foundation.

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V. GEOGRAPHICAL DISTRIBUTION.

OCCURRENCE IN NEW JERSEY.

Identifiable remains of leaves are by no means uniformly distributed in the Raritan formation, even in the argillaceous beds. On the contrary, good material is extremely local. Traces of former vegetation are much more abundant, as shown by the black clays, with "hacksel," as the Germans term comminuted vegetable material, and by beds of lignite which are sometimes several feet in thickness. Usually, however, where leaf remains occur in these black clays or in the presence of much lignite, they are so impregnated with ulmic or carbonaceous matter that they are very perishable. This is especially true of material collected around Sayreville and applies with equal force to numerous other leaf-bearing outcrops. The bulk of Prof. Newberry's material came from one pit in the Woodbridge district (Cutter pit), and the writer's best material comes from a single pit at South Amboy (Allen and Clark pit).

There are 24 species for which there are no exact data as to locality or horizon. These include a number of species which occur elsewhere in older or younger strata and whose position in the Raritan would be a matter of considerable interest. Among them may be mentioned:

Celastrophyllum Brittonianum Hollick.
Celastrophyllum cretaceum Lesq.
Delwalquea groenlandica Heer.
Hymenaea dakotana Lesq.
Sequoia concinna Heer.
Thuyites meriani Heer.

What appears to be one of the lowest leaf-bearing horizons in the Raritan is that near its western border, at Milltown, from which the following species have been collected by Charles H. Mead of that place and by Ward and White of the U. S. Geo-

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logical Survey, all collected during 1892 and contained in the collections of the U. S. National Museum:

Andromeda Cookii Berry.
Andromeda grandifolia Berry.
Andromeda Parlatorii Heer.
Asplenium Dicksonianum Heer.
Asplenium jerseyensis Berry.
Celastrophyllum angustifolium Newb.
Celastrophyllum minus Hollick.
Cornophyllum vetustum Newb.
Diospyros primaeva Heer.
Eucalyptus Geinitzi Heer.
Ficus ovatifolia Berry.
Ficus myricoides Hollick.
Ficus daphnogenoides Berry.
Gleichenia micromera Heer.
Laurophyllum lanceolatum Newb.
Laurophyllum nervillosum Heer.
Laurus plutonia Heer.
Liriodendropsis simplex Newb.
Magnolia isbergiana Heer (?)
Myrica fenestrata Newb.
Myrica Hollicki Ward.
Myrica Newberryana Hollick.
Myrsine borealis Heer.
Myrsine elongata Newb.
Phaseolites manhassettensis Hollick.
Salix Newberryana Hollick.
Salix membranacea Newb.
Salix pseudo-Hayei Berry.
Sassafras acutilobum Lesq.
Widdringtonites Reichii Heer.

This florule of but 30 species is far from representative and contains no elements which can be regarded as allying it with the older Potomac flora as developed in Maryland and Virginia.

The following species are recorded from the north bank of the Raritan, just east of Florida Grove, from the upper layers of the Woodbridge clay series:

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Protophyllocladus subintegrifolius (Lx.) Berry.
Magnolia woodbridgensis Hollick.
Ilex (?) *elongata* Newb.
Liriodendropsis angustifolia Newb.

These were striking enough when collected, but very perishable and furnish no data of especial interest, since much larger collections have been made from approximately the same horizon at Woodbridge and Sayreville.

From the immediate vicinity of Sayreville, where the material is much like that from the preceding locality, and comes from the same general level, the Woodbridge clays, the following species have been obtained:[1]

Andromeda grandifolia Berry.
Andromeda Cookii Berry.
Celastrophyllum crenatum Heer.
Celastrophyllum Newberryanum Hollick.
Celastrophyllum undulatum Newb.
Chondrites flexuosus Newb.
Cinnamomum Newberryi Berry
Cissites formosus Heer.
Comptonia microphylla (Heer) Berry.
Eucalpytus Geinitzi (Heer) Heer.
Ficus daphnogenoides (Heer) Berry.
Ficus Woolsoni Hollick.
Gleichenia micromera Heer.
Ilex elongata Newb.
Ilex amboyensis Berry.
Magnolia alternans Heer.
Myrica fenestrata Newb.
Populus orbicularis (Newb.) Berry.
Quercus raritanensis Berry.
Salex Newberryana Hollick.
Salex membranaceae Newb.

[1] Some few of these were collected by the writer from the Sayre & Fisher pits. The balance are credited to this locality on the authority of Professor Newberry's collections and undoubtedly are from this same locality and horizon.

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Salex Lesquereuxi Berry.
Widdringtonites Reichii (Ettings.) Heer

Among these the *Gleichenia* is the only striking old form, and a number like *Salix Lesquereuxi* range considerably higher than the Raritan.

Only *Juniperus macilenta* Heer, described originally from the Atane beds of Greenland, is recorded from Perth Amboy.

By far the largest number of species from a single locality is that recorded from Woodbridge, where the Woodbridge clays have furnished the basis of an important industry for so many years. This locality has yielded 94 species, most of which were collected from Prof. Newberry or his assistants from the Cutter pits:

Acer amboyense Newb.
Andromeda grandifolia Berry.
Andromeda Cookii Berry.
Aralia groenlandica Heer.
Aralia Newberryi Berry.
Aralia patens Hollick.
Aralia quinquepartita Lesq.
Aralia rotundiloba Newb.
Aralia Wellingtoniana Lesq.
Asplenium Dicksonianum Heer.
Asplenium Foersteri Deb. & Ettings.
Biera incurvata Heer.
Bauhinia cretacea Newb.
Bauhinia gigantea Newb.
Calycites diospyriformis Newb.
Calycites parvus Newb.
Carpolithus floribundus Newb.
Carpolithus hirsutus Newb.
Carpolithus ovæformis Newb.
Carpolithus pruniformis Newb.
Carpolithus woodbridgensis Newb.
Celastrophyllum decurrens Lesq.
Celastrophyllum undulatum Newb.
Chondrites flexuosus Newb.

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Chondrophyllum obovatum Newb.
Cinnamomum Newberryi Berry.
Cissites crispus Velen.
Cissites formosus Heer.
Colutea primordialis Heer.
Cornophyllum vetustum Newb.
Cycadinocarpus circularis Newb.
Czekanowskia capillaris Newb.
Dammara borealis Heer.
Dalbergia apiculata Newb.
Dewalquea trifoliata Newb.
Dicksonia groenlandica Heer.
Diospyros amboyensis Berry.
Eucalyptus Geinitzi (Heer) Heer.
Ficus daphnogenoides (Heer) Berry.
Ficus ovatifolia Berry.
Ficus Woolsoni Hollick.
Fontainea grandifolia Newb.
Frenelopsis Hoheneggeri (Ettings.) Schenk.
Geinitzia formosa Heer.
Gleichenia Gieseckiana Heer.
Gleichenia Zippei Heer.
Hedera obliqua Newb.
Hedera primordialis Sap.
Juglans artica Heer.
Juniperus hypnoides Heer.
Laurophyllum angustifolium Newb.
Laurophyllum lanceolatum Newb.
Liriodendrom oblongifolium Newb.
Liriodendrom quercifolium Newb.
Liriodendropsis angustifolia Newb.
Liriodendropsis retusa (Heer) Hollick.
Liriodendropsis simplex (Newb.) Newb.
Magnolia alternans Heer.
Magnolia Hollicki Berry.
Magnolia Boulayana Lesq.
Magnolia Lacoena Lesq.
Magnolia longipes Hollick.

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Magnolia Newberryi Berry.
Magnolia speciosa Heer.
Magnolia woodbridgensis Hollick.
Menispermites borealis Heer.
Microzamia gibba (Reuss) Corda.
Myrica cinnamomifolia Newb.
Newberryana rigida (Newb.) Berry.
Passiflora antiqua Newb.
Phegopteris Grothiana Heer.
Phyllites undulatus Newb.
Planera Knowltoniana Hollick.
Podozamites lanceolatus (L. & H.) F. Braun.
Podozamites marginatus Heer.
Populus apiculata Newb.
Protophyllum obovatum Newb.
Prunus acutifolia Newb.
Raritania gracilis (Newb) H. & J.
Salix inæqualis Newb.
Salix Newberryana Hollick.
Salix raritanensis Berry.
Salix Lesquereuxii Berry.
Sassafras acutilobum Lesq.
Sassafras hastatum Newb.
Sassafras progenitor Hollick.
Sequoia Reichenbachi (Gein.) Heer.
Tricalycites papyraceus Newb.
Tricarpellites striatus Newb.
Viburnum integrifolium Newb.
Widdringtonites Reichii (Ettings.) Heer.
Widdringtonites subtilis Heer.

As determined by the stratigraphy, these are approximately of middle Raritan age. Paleontologically they are closely allied with the more meager florules previously enumerated, the weight of the paleobotanical evidence showing that the Raritan flora falls naturally into two divisions, an older and a younger. There are 76 species which do not occur in the Upper Raritan, of which 10 occur in the Lower Cretaceous.

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The younger or Upper Raritan flora is known from two localities, the one at the Allen Pits at South Amboy, which has furnished the bulk of the species; the other at the Hylton Pits along Pensauken Creek (near Palmyra), where the top of the Raritan is slightly exposed and unconformably overlain by the arenaceous strata of the Magothy formation, which makes up the bulk of the exposure. The following species are recorded from these two localities:

Acer amboyensis Newb.
Acerates amboyense Berry.
Andromeda novæ-cæsareæ Hollick.
Andromeda Parlatorii Heer.
Aralia formosa Heer.
Aralia patens Hollick.
Aralia quinquepartita Lesq.
Arelia rotundiloba Newb.
Asplenium Foersteri Deb. & Ettings.
Asplenium raritanensis Berry.
Brachyphyllum macrocarpum Newb.
Cæsalpinia raritanensis Berry.
Celastrus arctica Heer.
Celastrophyllum crenatum Heer.
Celastrophyllum decurrens Lesq.
Celastrophyllum Newberryanum Hollick.
Celastrophyllum spatulatum Newb.
Cinnamomum Newberryi Berry.
Cissites crispus Vel.
Cissites formosus Heer.
Citrophyllum aligerum Berry.
Colutea primordialis Heer.
Diospyros primæva Heer.
Eucalyptus angusta Vel.
Eucalyptus attenuata Newb.
Eucalyptus Geinitzi (Heer) Heer.
Eucalyptus linearifolia Berry.
Eucalyptus parvifolia Newb.
Ficus daphnogenoides (Heer) Berry.

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Ficus Woolsoni Hollick.
Laurophyllum elegans Hollick.
Laurophyllum minus Newb.
Laurus plutonia Heer.
Leguminosites raritansis Berry.
Liriodendropsis simplex Newb.
Moriconia cyclotoxon Deb. & Ettings.
Myrica cinnamomifolia Newb.
Myrica Newberryana Hollick.
Myrsine borealis Heer.
Myrsine elongata Hollick.
Newberryana rigida Berry.
Pinus raritanensis Berry.
Persoonia Lesquereuxii Knowlton.
Phyllites trapaformis Berry.
Prunus acutifolia Newb.
Raritania gracilis (Newb.) H. & J.
Salix flexuosa Newb.
Salix Newberryana Hollick.
Salix Lesquereuxi Berry.
Sequoia heterophylla Vel.
Sphærites raritanensis Berry.
Tricalycites papyraceus Newb.
Thuja cretacea Newb.
Widdringtonites Reichii Heer.
Widdringtonites subtilis Heer.

Of these 56 species 27 do not occur in the more abundant material from the lower Raritan horizons, and many of them are species which characterize more particularly the overlying Magothy formation or were described originally from the Cenomanian of Europe, the Atane and Patoot beds of Greenland, or the Dakota Group of the West, all of which are younger in age. Twelve of the genera are not even represented in the older Raritan, and, aside from these, certain species like *Andromeda novæ-cæsareæ* Holl, *Brachyphyllum macrocarpum* Newb., *Citrophyllum aligera* (Lesq.) Berry, *Eucalyptus angusta* Velen., *Salix flexuosa* Newb., *Sequoia heterophylla* Velen. are the character-

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istic fossils of the Magothy and allied Upper Cretaceous formations over a wide area. This is interpreted as due to the gradual evolution of the Raritan flora, and does not seem of sufficient weight to warrant the uniting of the Upper Raritan beds with the Magothy formation, since, as previously mentioned, some of Newberry's data are questionable, and the only well-marked stratigraphic break occurs above the South Amboy plant horizon at the eroded summit of the Amboy stoneware clay.

ORIGIN AND RADIATION.

A great many of the Raritan species appeared at approximately the same time in the western interior, the Arctic regions and central Europe. The fact that these floras are all so different from those of Lower Cretaceous age and that they contain so predominating an element of dicotyledonous plants renders any inquiry into their place of origin or their ancestral forms a subject of surpassing interest.

There are no adequate data for a phylogenetic discussion which is not purely speculative, the present desideratum being a knowledge of those primitive forms from the Older Potomac and an acquaintance with the flora which flourished while the Schooley peneplain was being developed.

A number of the immediate ancestors of Raritan species are, however, represented in the flora of the Patapsco formation of Maryland and Virginia, others are undoubted immigrants from elsewhere. Where did this mid-Cretaceous flora take its origin? A number of answers are suggested. First, it may have originated in eastern or central Asia, which is an old continental mass, and spread from there westward into Europe and northeastward into the Arctic regions and North America. As previously mentioned, it is recorded from Europe, America and the Arctic regions. It may have originated in Europe and migrated from thence across the Arctic to America, or it may have originated in America and migrated in a reverse direction. The somewhat earlier appearance of more modern types toward the close of the Lower Cretaceous and the somewhat more advanced organization of the Upper Cretaceous floras of America as compared with those of Europe renders the former supposition improbable

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Eastern America during the long interval of elevation and erosion, which occupied all of Jurassic time, offers many potential possibilities as a theater of evolution, as it undoubtedly was, but the simultaneous appearance of identical types in the mid-Cretaceous of Europe and America and Greenland is hard to understand if either America or Asia was the center of dispersal. The remaining alternative is that of regarding the Arctic area as the scene of evolution and center of dispersal of the modern flora, and, possibly, the fauna as well. The facts, while suggestive, are insufficient for definite conclusions. They serve to explain, for instance, the presence of the oldest known *Comptonia* in deposits in Greenland, New Jersey, Sweden and Bohemia, which are probably all of Cenomanian age; the presence of *Moriconia* from Greenland southward to South Carolina on this continent and in central Europe at the same time. In fact, numberless parallels could be drawn between the Albian and Cenomanian of America and Europe, so that at least tentatively we may picture successive waves of plant migration sweeping southward from the Arctic region somewhat as indicated by the arrows in Figure 3, the recorded floras of middle and later Cretaceous age being indicated by the solid black areas.

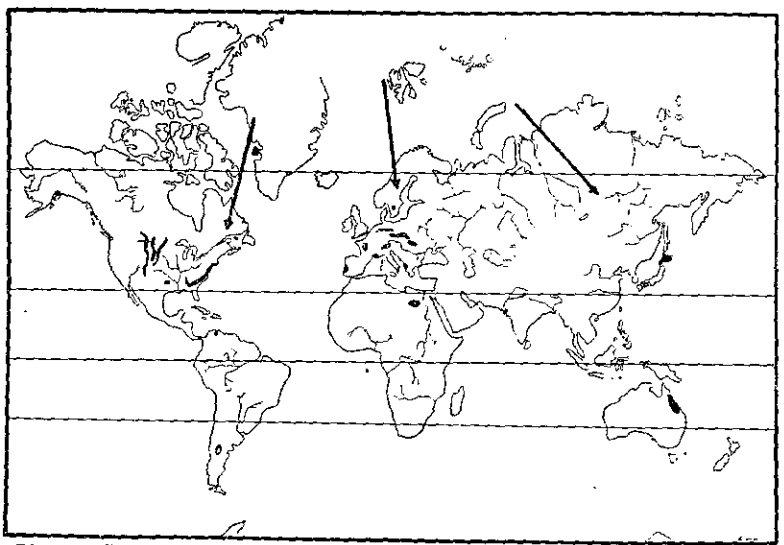

Fig. 3.—Sketch map of the world, showing approximate location of mid-Cretaceous plant-bearing deposits (in black). Arrows indicate possible directions of migration.

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PART II.

Systematic Paleobotany.

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SPECIES DESCRIBED.

PHYLUM THALLOPHYTA.
Class Fungi.
Order Pyrenomycetes.
Sphærites raritanensis Berry.
Class Algæ.
Chondriteæ.
Chondrites flexuosus Newb.

PHYLUM PTERIDOPHYTA.
Order Filicales.
Family Ophioglossaceæ.
Ophioglossum granulatum Heer.
Family Gleicheniaceæ.
Gleichenia Giesekiana Heer.
Gleichenia micromera Heer.
Gleichenia Zippei Heer
Family Cyatheaceæ.
Dicksonia groenlandica Heer.
Family Polypodiaceæ.
Asplenium raritanensis Berry.
Asplenium Dicksonianum Heer.
Asplenium jerseyensis Berry.
Asplenium Foersteri Deb. & Ett.
Phegopteris Grothiana Heer.

PHYLUM SPERMATOPHYTA.
Class Gymnospermæ.
Order Cycadales.
Podozamites Knowltoni Berry.
Podozamites lanceolatus (L. & H.) F. Braun.
Podozamites marginatus Heer.
Podozamites acuminatus Hollick.

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Microzamia gibba (Reuss) Corda.
Cycadinocarpus circularis Newb.
Order Coniferales.
Family Pinaceæ.
Sub-family Araucarieæ.
Dammara borealis Heer.
Brachyphyllum macrocarpum Newb.
Sub-family Abieteæ.
Pinus raritanensis Berry.
Sub-family Taxodieæ.
Sequoia heterophylla Velen.
Sequoia Reichenbachi (Gein) Heer.
Sequoia concinna Heer.
Geinitzia formosa Heer.
Sub-family Cupresseæ.
Thuya cretacea (Heer) Newb.
Thuyites Meriani Heer.
Juniperus macilenta Heer.
Moriconia cyclotoxon Deb. & Ett.
Widdringtonites Reichii (Ett.) Heer.
Widdringtonites subtilis Heer
Frenelopsis Hoheneggeri (Ett.). Schenk.
Raritania gracilis (Newb.) H. & J.
Family Taxaceæ.
Sub-family Taxeæ.
Protophyllocladus subintegrifolius (Lesq.) Berry.
Order Ginkgoales.
Baiera incurvata Heer.
Czekanowskia capillaris Newb.
Class Angiospermæ.
Sub-class Monocotyledonæ.
Order Liliales.
Family Smilaceæ.
Smilax raritanensis Berry.

NEW JERSEY GEOLOGICAL SURVEY

Sub-class Dicotyledonæ.

Order Myricales.

Family Myricaceæ.

Myrica Hollicki Ward.
Myrica emarginata Heer.
Myrica Newberryana Hollick.
Myrica fenestrata Newb.
Myrica cinnamomifolia Newb.
Myrica acuta Hollick.
Myrica raritanensis Hollick.
Comptonia microphylla (Heer) Berry.

Order Juglandales.

Family Juglandaceæ.

Juglans artcica Heer.

Order Salicales.

Family Salicaceæ.

Populus orbicularis (Newb.) Berry.
Populus apiculata Newb.
Salix flexuosa Newb.
Salix Lesquereuxii Berry.
Salix raritanensis Berry.
Salix inæqualis Newb.
Salix Newberryana Hollick.
Salix pseudoHayei Berry.

Order Fagales.

Family Fagaceæ.

Quercus raritanensis Berry.

Order Urticales.

Family Ulmaceæ.

Planera Knowltoniana Hollick.

Family Moraceæ.

Ficus daphnogenoides (Heer) Berry.
Ficus ovatifolia Berry.
Ficus Woolsoni Hollick.
Ficus myricoides Hollick.

NEW JERSEY GEOLOGICAL SURVEY

Order Proteales.
Family Proteaceæ.
Persoonia spatulata Hollick.
Persoonia Lesquereuxii Knowlton.
Order Ranales.
Family Ranunculaceæ.
Dewalquea groenlandica Heer.
Dewalquea trifoliata Newb.
Family Magnoliaceæ.
Magnolia speciosa Heer.
Magnolia Hollicki Berry.
Magnolia alternans Heer.
Magnolia longipes Hollick.
Magnolia Isbergiana Heer (?).
Magnolia Lacoena Lesq.
Magnolia Newberryi Berry.
Magnolia woodbridgensis Hollick.
Magnolia Boulayana Lesq.
Liriodendron oblongifolium Newb.
Liriodendron quercifolium Newb.
Family Lauraceæ.
Sassafras acutilobum Lesq.
Sassafras progenitor Hollick.
Sassafras hastatum Newb.
Laurus plutonia Heer.
Laurophyllum nervillosum Hollick.
Laurophyllum elegans Hollick.
Laurophyllum lanceolatum Newb.
Laurophyllum angustifolium Newb.
Laurophyllum minus Newb.
Cinnamomum Newberryi Berry.
Family Menispermaceæ.
Menispermites borealis Heer.
Menispermites Wardianus Hollick.
Order Rosales.
Family Leguminosæ.
Leguminosites coronilloides Heer.
Leguminosites atanensis Heer.

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Leguminosites omphalobioides Lesq.
Leguminosites raritanensis Berry.
Colutea primordialis Heer.
Liriodendropsis retusa (Heer) Hollick.
Liriodendropsis simplex Newb.
Lirodendropsis angustifolia Newb.
Cæsalpinia Cookiana Hollick.
Cæsalpinia raritanensis Berry.
Bauhinia cretacea Newb.
Bauhinia gigantea Newb.
Dalbergia apiculata Newb.
Hymenæa dakotana Lesq.
Phaseolites manhassettensis Hollick.
Prunus ? acutifolia Newb.

Order Geraniales.

Family Citraceæ.

Citrophyllum aligerum (Lesq.) Berry.

Order Sapindales.

Family Ilicaceæ.

Ilex ? elongata Newb.
Ilex amboyensis Berry.

Family Celastraceæ.

Celastrus arctica Heer.
Celastrophyllum minus Hollick.
Celastrophyllum Newberryanum Hollick.
Celastrophyllum undulatum Newb.
Celastrophyllum decurrens Lesq.
Celastrophyllum cretaceum Lesq.
Celastrophyllum crenatum Heer.
Celastrophyllum spatulatum Newb.
Celastrophyllum grandifolium Newb.
Celastrophyllum Brittonianum Hollick.

Family Aceraceæ.

Acer amboyense Newb.

NEW JERSEY GEOLOGICAL SURVEY

Order Rhamnales.
Family Rhamnaceæ.
Rhamnites minor Hollick.
Family Vitaceæ.
Hedera obliqua Newb.
Hedera primordiales Sap.
Cissites formosus Heer.
Cissitus crispus Velen.
Order Malvales.
Family Sterculiaceæ.
Pterospermites obovatus (Newb.) Berry.
Order Parietales.
Family Passifloraceæ.
Passiflora antiqua Newb.
Order Myrtales.
Family Myrtaceæ.
Eucalyptus Geinitzi (Heer) Heer.
Eucalyptus linearifolia Berry.
Eucalyptus parvifolia Newb.
Eucalyptus angusta Velen.
Eucalyptus attenuata Newb.
Order Unbellales.
Family Cornaceæ.
Cornophyllum vetustum Newb.
Family Araliaceæ.
Aralia Newberryi Berry.
Aralia quinquepartita Lesq.
Aralia groenlandica Heer.
Aralia rotundiloba Newb.
Aralia patens Hollick.
Aralia formosa Heer.
Aralia wellingtoniana Lesq.
Order Ericales.
Family Ericaceæ.
Andromeda novæ-cæsareæ Hollick.
Andromeda grandifolia Berry.
Andromeda Cookii Berry.
Andromeda Parlatorii Heer.

NEW JERSEY GEOLOGICAL SURVEY

Order Primulales.
Family Myrsinaceæ.
Myrsine borealis Heer.
Myrsine oblongata Hollick.
Myrsine Gaudini (Lesq.) Berry.
Order Ebenales.
Family Ebenaceæ.
Diospyros primaeva Heer.
Diospyros raritanensis Berry.
Calycites diospyriformis Newb.
Order Gentianales.
Family Asclepiadaceæ.
Acerates amboyense Berry.

Unknown Affinities.
Calycites parvus Newb.
Carpolithus pruniformis Newb.
Carpolithus woodbridgensis Newb.
Carpolithus ovaeformis Newb.
Carpolithus hirsutus Newb.
Carpolithus floribundus Newb.
Chondrophyllum obovatum Newb.
Chondrophyllum reticulatum Hollick.
Fontainea grandifolia Newb.
Newberryana rigida (Newb.) Berry
Phyllites undulatus Newb.
Phyllites trapaformis Berry.
Tricalycites papyraceus Newb.
Tricarpellites striatus Newb.
Viburnum integrifolium Newb.
Williamsonia Smockii Newb.
Williamsonia problematica (Newb.) Ward.

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PHYLUM THALLOPHYTA

Class FUNGI.

Order PYRENOMYCETES.

Genus SPHÆRITES Unger.

(Gen. et Sp., 1850, p. 37.)

SPHÆRITES RARITANENSIS sp. nov.

Description.—Viewed megascopically these remains appear as oval or circular umbilicate dots from .25 mm. to .5 mm., in diameter, with depressed margin and enlarged central portion, the latter occupying two-thirds of the total diameter.

Found in abundance on the under side of leaf fragments (sp. indet.) in the matted layers of fossil leaves from the upper Raritan at the Hylton Pits. Conclusively congeneric with the forms usually referred to this genus and very similar to *Sphærites problematicus* (Knowlt.) Knowlt., from the Dakota Group of Kansas. The latter is, however, more irregular in outline, larger in size and infests *Sterculia* which is not the host of the Raritan species. While remains of this sort are of little botanical interest to some, they nevertheless have a considerable biological significance in the evidence which they afford of the existence during the Mid-Cretaceous of fungi of this order.

Occurrence.—Hylton Pits.

Collections.—Johns Hopkins University.

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Class ALGAE.

Genus CHONDRITES Sternberg.

(Fl. d. Vorw., vol. ii, 1833, p. 25.)

CHONDRITES FLEXUOSUS Newb.

Chondrites flexuosus Newb., Fl. Amboy Clays, *34, pl. 1, f. 1, 4*, 1896. Berry, Bull. N. Y. Bot. Gardens, vol. 3: 100, 1903 (?).

Description.—The remains so-named by Professor Newberry consist of rather indefinite ramifying vegetable fibers supposedly algal in their nature, but poorly defined and of uncertain biological significance. They are strictly comparable with similar remains described from abroad and so named from their resemblance to the modern genus *Chondria* Harvey of the Rhodomelaceæ.

Schimper[1] forty years ago listed eleven European species, mostly Tertiary in age. A number of additional species have been described since that time, including one from the Magothy formation[2] which is very similar to a Lower Senonian species of Westphalia. Most of these species are, however, poorly preserved, and vague in their affinities.

Occurrence.—Woodbridge, Sayreville.

Collections.—N. Y. Botanical Garden.

[1] Pal. Vègèt. t. I, 1869, p. 154.

[2] Berry, Amer. Nat., vol. xxxvii, 1903, p. 677, fig. 9.

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PHYLUM PTERIDOPHYTA.

Order FILICALES.

Family GLEICHENIACEÆ.

Genus GLEICHENIA Smith

(Mem. Ac. Turin, vol. v, 1791, p. 418.)

GLEICHENIA ZIPPEI (Corda) Heer.

Gleichenia Zippei Heer, Fl. Foss. Arct., vol. i; 79, *pl. 43, f. 4*, 1868; Ibid., vol. 3, ab. 2: 44, 90, 97, *pl. 4; 5; 6, f. 1–3; pl. 7, f. 2; pl. 25, f. 1–3; pl. 26, f. 10–13*, 1874; Ibid., vol. 4: 49, *pl. 32, f. 6, 7*, 1877; Ibid., vol. 6, ab. 2: 36, *pl. 3, f. 2*, 1882; Ibid., vol. 7: 7, 1883.

Velen, Farne böhm, Kreidef. 6, *pl. 3, f. 3–7*, 1888.

Newb., Fl. Amboy Clays, 37, *pl. 3, f. 5*, 1896 (?).

Ward, 19 Ann. Rep. U. S. Geol. Surv., pt. 2: 664, *pl. 162, f. 9*, 1899 (?).

Berry, Bull. Torrey Club, vol. 31: 67, *pl. 4, f. 6*, 1904; Ibid., vol. 33: 164, 1906.

Pecopteris Zippei Corda in Reuss, Versteinerungen, 95, *pl. 49, f. 1*, 1846.

Unger, Kreidepflanzen aus Oestreich, Sitzungsb. Acad in Wein, 1867: 8, *pl. 2, f. 1.*

Description.—"Gl. foliis bipinnatis, pinnis valde approximatis, elongatis, linearibus, parallelis, pinnatisectis, pinnulis obliquis, lanceolatis, acutiusculis, integerrimus, basi vix unitis; nervis pinnatis, nerv. secund. utrinque 3–5, inferioribus furcatis." Heer 1868.

Professor Newberry's determination of this species in the Raritan material is based upon very fragmentary specimens, although some of them have traces of the sori preserved. One specimen is figured in his flora of the Amboy Clays. These are sharply contrasted by the beautiful Gleichenia material obtained by Professor Heer from Greenland. As far as the New Jersey

NEW JERSEY GEOLOGICAL SURVEY

material goes it corresponds exactly with the more typical material from other regions, and until specimens are collected showing adequate grounds for separation, we are justified in assuming the presence of this species in New Jersey in Raritan times. The genus *Gleichenia* was a prominent one during the Cretaceous with many characteristic species, some with a wide range. The present species, which ranges through the Greenland Cretaceous series from the Kome beds to those of Patoot, occurs also in the Lower Cretaceous of Spitzbergen and the Black Hills; the Cenomanian of Bohemia; the Senonian of Bohemia, Saxony and Bulgaria; the Magothy formation of New Jersey and Delaware; and it has recently been collected in the Upper Cretaceous of the Western Interior. It is not contained in any recent collections from the Raritan.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

GLEICHENIA GIESEKIANA Heer.

Gleichenia Giesekiana Heer, Fl. Foss, Arct., vol. 1: 78, *pl. 43, f. 1a, 2a, 3; pl. 44, f. 2, 3,* 1868; Ibid., vol. 3, ab. *2*: 43, *pl. 3, f. 1d, 8; pl. 7, f. 1,* 1874; Ibid., vol. 6, ab. *2*: 35, *pl. 2, f. 9a, b; pl. 13, f. 4b,* 1882; Ibid., vol. 7: 7, *pl. 50, f. 1–3,* 1883.

Newb., Fl. Amboy Clays, 36, *pl. 4, f. 12,* 1896.

Description.—"Gl. fronde dichotoma, bipinnatipartita, pinnis elongatis, linearibus, parallelis, pinnatipartitis, pinnulis patentibus, subindefalcatis, oblongis, apice rotundatis, obtusis, integerrimis, basi unitis, nervulis furcatis, soris biseriatis, rotundis." Heer 1868.

The presence of this species in New Jersey, like the preceding, is based upon very fragmentary specimens. It is much larger than the other Gleichenia-like fragments from the Raritan and agrees closely with Heer's species which ranged through the Greenland Cretaceous occurring in the Kome, Atane and Patoot beds. It has also been collected recently from the Upper Cretaceous of the Western United States.

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Possibly the Raritan material should be correlated with the genus *Cladophlebis,* which is so abundant in the older formations of the Potomac Group, but until decisive material comes to light Professor Newberry's determination should stand.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

GLEICHENIA MICROMERA Heer.

Gleichenia micromera Heer, Fl. Foss. Arct. vol. 3, ab. 2: 55, *pl. 10, f. 14, 15,* 1874.

Newb., Fl. Amboy Clays, 36, *pl. 3, f. 6,* 1896 (?).

Description.—"Gl. fronde bipinnata, rachi tenui, pinnis valde approximatis, patentissimis, linearibus, pinnulis minutis, horizontalibus, liberis, ovatis, basi utrinque rotundatis, apice obtusis, nervis secundariis simplicibus." Heer, 1874.

Like the two preceding species this is also based on fragmentary specimens. These are of a delicate fern with narrow linear right angled pinnules of very small size which agree exactly with the type material.

This species was described originally from the Kome beds of Greenland, which are correlated with the Urgonian of Europe, but this offers no obstacle to its occurrence in the New Jersey Raritan since characteristic specimens of other species of this genus show an equal range.

Occurrence.—Sayreville, Milltown.

Collections.—N. Y. Botanical Garden.

Family CYATHEACEÆ.

Genus DICKSONIA Presl.

(Pterid., 1836, p. 135.)

DICKSONIA GROENLANDICA Heer.

Plate IV, Fig. 1.

Dicksonia groenlandica Heer, Fl. Foss. Arct., vol. 6, ab. 2: 23, *pl. 35, f. 8, 9,* 1882. Ibid., vol. 7: 2, *pl. 48, f. 1–3,* 1883.

Berry, Bull. Torrey Club, vol. 36: 245, 1909.

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Dicksonia borealis Heer, loc. cit., vol. 6, ab. 2: 23, *pl. 44, f. 2*, 1882 (not *D. borealis* Heer, 1878, a very different, Jurassic species).

Anemia stricta Newb., Fl. Amboy Clays, 38, *pl. 3, f. 1, 2*, 1896.

Description.—"D. foliis bipinnatis, pinnulis erectis, oblongo-lanceolatis, basi attenuatis, integerrimis, nervis subtilissimis, nervillis angulo acuto egredientibus, erectis." Heer, 1882.

Both of Heer's types, which are here united with Newberry's species, are small fragments of ultimate pinnæ, which their author confesses are very similar, a fact well brought out by a comparison of the figured specimens. The material from Woodbridge is more ample, and as may be seen lower down on the frond the pinnules become toothed and finely pinnatifid, a feature not seen in the Greenland material. There is slight reason, however, for doubting their identity, Newberry himself pointed out that *Dicksonia borealis* of Heer was probably identical with his Amboy clay species. Although common at Woodbridge, N. J., this species has not been found elsewhere in the Coastal Plain except for a single specimen which the writer discovered recently in the Tuscaloosa formation of Alabama. It is present at both the Atane and Patoot horizons of Greenland.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Family POLYPODIACEÆ.

Genus PHEGOPTERIS Presl.

(Pterid., 1836, p. 179.)

PHEGOPTERIS GROTHIANA Heer.

Phegopteris Grothiana Heer, Fl. Foss. Arct., vol. 7: 3, *pl. 48, f. 12, 13*, 1883.

Newb., Fl. Amboy Clays, 42, *pl. 3, f. 4*, 1896.

Description.—"P. foliis bipinnatis, pinnulis patentibus, liberis, basi æqualibus, 4 mm. latis, 20–22 mm. longis, linearibus, crenatis; nervis secundariis ramosis, nervillis simplicibus." Heer, 1883.

NEW JERSEY GEOLOGICAL SURVEY

Like most of the Raritan fern-remains, those representing the present species are fragmentary and inconclusive, resembling, as far as it is possible to judge, Heer's type material which came from the Patoot beds of Greenland. As the latter is supposed to be of Senonian age, it is possible that the New Jersey forms belong to a different species of this genus, but of this it is impossible to form a satisfactory conclusion. It is to be hoped that additional and better material will some day be collected which will definitely settle the question.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Genus ASPLENIUM Linnè.

(Sp. Pl., 1753, p. 1078.)

ASPLENIUM DICKSONIANUM Heer.

Plate V, Figs. 3, 4.

Asplenium Dicksonianum Heer, Fl. Floss. Arct., vol. 3, ab. 2: 31, *pl. 1, f. 1–5*, 1874; Ibid., vol. 6, ab. 2: 3, 33, *pl. 2, f. 2; pl. 32, f. 1–8*, 1882.

Dawson, Trans. Roy. Soc. Can., vol. 1, sec. 4: 11, 1883; Ibid., vol. 3, sec. 4: 5, *pl. 3, f. 1*, 1885; Ibid., vol. 10, sec. 4: 91, 1892; Ann. Rept. Can. Geol. Surv., N. S., vol. 1: 76, 1886.

Lesq., Fl. Dakota Group, *24, pl. 1, f. 1*, 1892.

Newb., Fl. Amboy Clays, 39, *pl. 1, f. 6, 7; pl. 2, f. 1–8*; *pl. 3, f. 3*, 1896.

Ward, 19th Ann. Rept. U. S. Geol. Surv., pt. 2: 704, *pl. 170, f. 1*, 1899; Journ. Geol. vol. 2: 259, 261, 1894.

Fontaine in Ward, 19th Ann. Rept. U. S. Geol. Surv., pt. 2: 664, *pl. 162, f. 6–8*, 1899 (non Font. 1888).

Kurtz, Contrib. Palæophyt. Argentina III, Rev. Museo La Plata, vol. 10: 49 (1899) 1902.

Description.—"A. foliis triplicato-pinnatis, stipite firmo, rigido; pinnis primariis secundariisque ovato-lanceolatis, pinnulis anguste lanceolatis, inferioribus acute serratis, superioribus integerrimis, acutis." Heer, 1874.

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This species was described originally by Heer from the Kome beds of Greenland and was subsequently identified by the same author from the much later Atane beds; Dawson reports it from a number of localities in the Kootanie of British Columbia, and Fontaine and Ward describe it from the Lower Cretaceous of the Black Hills. It is also reported by both Lesquereux and Ward from the Dakota Group and by Kurtz from Argentina. It seems very doubtful if these can all be the same plant, and the gelogical range alone suggests that the earlier and the later forms may be distinct. The Lower Cretaceous forms certainly suggest a relationship with those wide-spread types of sterile fronds variously identified as *Thryrsopteris* or *Onychiopsis,* while those from the Upper Cretaceous suggest *Anemia* rather than *Asplenium.* However, in the absence of representative material from the different horizons, it seems unwise to attempt any segregation at the present time.

The specimens from the Raritan are abundant at the Woodbridge horizon and many excellent figures are given by Newberry in his Flora of the Amboy Clays.

Occurrence.—Woodbridge, Milltown.

Collections.—N. Y. Botanical Garden.

ASPLENIUM FOERSTERI Deb. & Ettings.

Plate V, Figs. 1, 2.

Asplenium Foersteri Deb. & Ettings, Urwelt. Acrobry. v. Aachen, 13, *pl. 2, f. 4–7,* 11, 1859.

Schimp., Pal. Vègèt., I: 658, 1869.

Heer, Fl. Foss. Arct., vol. 3, ab. 2: 93, *pl. 26, f. 1,* 1874; Ibid., vol. 7: 174, 266, 1883.

Velenovsky, Farne böhm Kreidef, 15, *pl. 1, f. 14,* 1888; Květena ceského cenomanu, 48, 52, 60, 1889.

Newb., Fl. Amboy Clays, 41, *pl. 4, f. 1–11,* 1896.

Zeiller, Ann. Mines, March, 1905, p. 7, *pl. 7, f. 1.*

Description.—"A. fronde pinnata (v. pluries pinnata?), pinnis regulariter alternis, confertis, subdecurrentibus, subangulo

NEW JERSEY GEOLOGICAL SURVEY

50° circiter arrectis, late frondosis, lineari-lanceolatis, lobato-dentatis vel basi pinnatifidis vel pinnati-partitis, laciniis ovato-obtusis apice denticulatis, vel ovato-acuminatis, sub-alternis, confertis, terminalibus longe lineari-lanceolatis, angustissimis, remote dentatis; nervis venisque strictis, arrectis, simplicibus vel sæpius furcatis, creberrimis." Debey and Ettings, 1859.

A considerable number of specimens, which Professor Newberry identified as this species, were found in the Raritan. They are more complete than the material so identified from elsewhere and show several minor differences. The lower pinnæ of the former are widely separated, opposite or sub-opposite, and markedly decurrent as well as unsymmetrical. Higher up, however, the pinnæ become closer until they finally unite, passing from notched to simple lobes, and these latter are very similar to the type of the species. The texture is coriaceous and the venation fine and largely obsolete.

The species is recorded from the Cenomanian of Greenland and Bohemia and the Senonian of Prussia and Bulgaria. The remains referred to this species by Lesquereux from the much older horizon at Cape Lisbourne, Alaska, are found to be identical with *Cladophlebis Huttoni* (Dunk.) Font.

Occurrence.—Woodbridge, South Amboy.

Collections.—N. Y. Botanical Garden.

Asplenium raritanense Berry.

Asplenium raritanense Berry, Bull. Torrey Club, vol. 36: 246, *pl. 18, fig. 1,* 1909.

Description.—Frond or pinnæ unknown. Pinnules small 1.33 cm. long by 10 mm. in greatest breadth, ovate in outline with narrow somewhat straight-sided base, palmately divided into 1 terminal and 2 pairs of lateral, rounded, not deeply parted, lobes. Margin entire at base and in sinuses, sharply toothed on the lobes. Venation flabellate, about 7 veins enter the base of the pinnule, these soon fork dichotomously, the ultimate divisions terminating in the marginal teeth.

NEW JERSEY GEOLOGICAL SURVEY

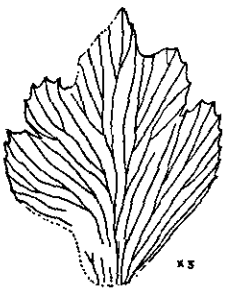

Fig. 4.—Asplenium raritanense Berry. Hylton Pits, Pensauken Creek.

This species, which is quite unlike anything heretofore known from the Raritan, is unfortunately based on the single tiny pinnule figured. The general form and habit remain unknown. It is markedly distinct from any described fossil species known to the writer, although showing some points of resemblance to various arctic species referred to this genus by Professor Heer. Since the chances of more representative material being found are remote, it has seemed best to describe it under the above name.

Occurrence.—Hylton Pits.

Collection.—Johns Hopkins University.

ASPLENIUM JERSEYENSIS sp. nov.

Description.—Frond compound (?). Pinnæ linear in outline, made up of alternate triangular somewhat falcate pinnules. The latter have acute tips and entire margins; they are attached by their entire base. Rachis very stout. Texture extremely thick and coriaceous.

Midrib stout, branching from the rachis in the proximal half of the pinnule, giving off alternate, apparently forked secondaries on either side.

This species is based upon the incomplete specimen figured and its counterpart. In appearance it is exactly like so many Cretaceous fern-fragments which are referred to the genus *Gleichenia,* as for example *Gleichenia gracilis* Heer or *Gleichenia acutiloba* Heer, it being particularly close to the Bohemian re-

NEW JERSEY GEOLOGICAL SURVEY

mains referred to the latter species by Velenovsky.[1] The New Jersey species is clearly not a *Gleichenia,* however, since the tiny fragment preserved is part of a fruiting plant, and while the preservation is too poor for discerning the details, it is sufficiently

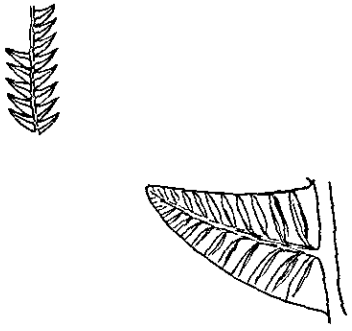

Fig. 5.—Asplenium jerseyensis sp. nov. Milltown, N. J.

good to show the remains of oblong-lanceolate sori on the lateral veins of the pinnules exactly as in many species of *Asplenium,* to which genus it is consequently referred. It differs from any previously described Cretaceous forms, although a similar but larger Asplenium in fruit has been collected by the writer from the Magothy formation at Grove Point, Maryland.

Occurrence.—Milltown.

Collection.—U. S. National Museum.

Family OPHIOGLOSSACEÆ.

Genus OPHIOGLOSSUM Linné.

(Sp. Pl., 1753, p. 1062.)

OPHIOGLOSSUM GRANULATUM Heer.

Ophioglossum granulatum Heer, Fl. Foss. Arct., vol. 7: 8, *pl. 57, f. 8, 9,* 1883; Newb., Fl. Amboy Clays, 43, *pl. 9, f. 11–13,* 1896.

[1] Velen. Die Farne der Böhm, Kreideform, p. 7, pl. iii, figs. 8-10, 1888.

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Description.—"O. spica fertili elongata, sporangiis distichis, ovalibus granulatis, 1½ mm. longis." Heer, 1883.

This species described originally by Professor Heer from the Patoot beds of Greenland and compared with the fertile frond of *Ophioglossum vulgatum* has been found in considerable numbers in the Raritan clays, although Professor Newberry failed to indicate the exact localities. There can be no question of the identity of the Greenland and the New Jersey material. The reference to *Ophioglossum* is not so conclusive, and many students will echo Newberry's supposition that these remains are those of staminate cones of some species of conifer. Since no new light can be shed on their systematic position, they are retained where Heer and Newberry placed them.

Occurrence.—Locality unknown.

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PHYLUM SPERMATOPHYTA.

Class GYMNOSPERMAE.

Order CYCADALES.

Genus PODOZAMITES F. Braun.

(In Münster, Beitrage, Vol. II, 1843, p. 28.)

PODOZAMITES MARGINATUS Heer.

Podozamites marginatus Heer, Fl. Foss. Arct., vol. 6, ab. 2: 43, *pl. 16, f. 10,* 1882.

Newberry, Fl. Amboy Clays, 44, *pl. 13, f. 5, 6,* 1896.

Berry, Bull. N. Y. Bot. Garden, vol. 3: 99, *pl. 46, f. 1–3,* 1903.

Description.—"Z. foliis magnis, foliolis elongato-lanceolatis, 23 mm. latis, apicem versus sensim angustatis, multinerviis, late et fortiter marginatis." Heer, 1882.

Leaflets large, 15 cm. to 20 cm. in length by 2.3 cm. to 4 cm. in breadth, lanceolate in outline, somewhat falcate. Apex obtusely pointed. Proximally somewhat abruptly narrowed to an apparently thickened base. Veins numerous, close, fine, parallel.

Remains of a large parallel-veined leaf, apparently a leaflet of *Podozamites,* are not uncommon in the Raritan deposits, although unfortunately they are usually fragmentary. They seem to be identical with the type material of this species described by Heer from the Atane beds of Greenland, which ranges southwards along the Atlantic coastal plain as far as Alabama.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

PODOZAMITES KNOWLTONI Berry.

Podozamites angustifolius (Eichw.) Schimper, Pal. Végét. vol. 2: 160, 1872 (non Schenk, 1868).

Lesq. Cret. & Tert. Fl., 28, 1884; Fl. Dakota Group, 27, *pl. 1, f. 4,* 1892.

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Newb., Fl. Amboy Clays, 44. *pl. 13, f. 1, 3, 4,* 1896 (non f. 2).

Zamites angustifolius Eichwald, Lethæa rossica, vol. 2: 39, *pl. 2, f 7.*

Podozamites Knowltoni Berry, Bull. Torrey Club, vol. 36: 247, 1909.

Description.—"Foliolis elongato-lineali-lanceolatis, centim. 6 circiter longis, infra medium millim, 5 latis, basimversus margine inferiore subitius angustatis quam superiore, decurrentibus, sat approximitis et erecto-patentibus." Schimper, 1870.

In 1870 Schimper referred the *Zamites angustifolius* of Eichwald to this genus, overlooking the fact that Schenk four years earlier had described and named a species of *Podozamites angustifolius.* The natural impulse would be to call this *P. Eichwaldi,* but Eichwald has already had a species of *Podozamites* named for him in consequence of which the above name is proposed in honor of Dr. F. H. Knowlton of the U. S. National Museum. This species has a wide range, both geological and geographical. It is common in the Jurassic of high latitudes in Russia, Siberia, Bornholm, and Spitzbergen, and in the Upper Cretaceous indistinguishable remains are widely distributed in America. The abundant Raritan remains are long-lanceolate, 5 cm. to 15 cm. in length by 6 cm. to 1.2 cm. in width, the base narrowed to a short petiole, the summit being long pointed and the venation fine. They are similar to the leaflets of *Podozamites lanceolatus,* but are usually longer, narrower and more flexuous in outline.

All of the Raritan species of *Podozamites,* in common with those from other localities and horizons, which are based on detached leaflets, are extremely unsatisfactory from the standpoint of the botanist, since their true position remains doubtful. It has been suggested by more than one author that some of these remains ascribed to *Podozamites* were not cycad leaflets at all, but were probably referable to the Araucarieæ or some other sub-family of the Coniferales, but the available facts do not warrant any definite conclusion at the present time, and until positive

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information is at hand it would be unwise to alter the present nomenclature.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

PODOZAMITES LANCEOLATUS (L. & H.) F. Braun.

Zamia lanceolata L. & H., Foss. Fl. vol. 3, *pl. 193*, 1836.

Zamites lanceolatus F. Braun., Verzeich. Kreis.-Nat.-Samml. Bayreuth Petrefact., 100, 1840.

Podozamites lanceolatus F. Braun in Münster, Beitr. Petrefactenkunde, vol. 2, pt. 6: 33, 1843.

Schimper, Pal. Végét., vol. 2: 160, 1870.

Velenovsky, Gymn. Böhm. Kreidef., 11, *pl. 2, f. 11–19, 24*, 1885.

Dawson, Trans. Roy. Soc. Can., vol. 3, sec. 4: 6, *pl. 1, f. 3*, 1886.

Lesq. Fl. Dakota Group, 28, *pl. 1, f. 5, 6*, 1892.

Penhallow, Summary Geol. Surv. Can., 1904: 9, 1905.

Fontaine in Ward, Mon. U. S. Geol. Surv., vol. 48: 110, *pl. 24, f. 17–20*, 1906.

Knowlton, Smith. Misc. Coll., vol. 4, pt. 1: 120, *pl. 14, f. 4*, 1907.

Hollick, Mon. U. S. Geol. Surv., vol. 50: 35, *pl. 2, f. 1*, 1907.

Podozamites proximans Conrad, Amer. Jour. Sci., (II) vol. 47: 361, tf. 1869.

Podozamites angustifolius Newb., Fl. Amboy Clays, 44, *pl. 13, f. 2*, 1896 (non f. 1, 3, 4).

Hollick, Bull. N. Y. Bot. Garden, vol. 3: 410, *pl. 71, f. 8*, 1904.

Description.—"Pinnis distantibus, alternis oppositisve, elongatis, basi sensim angustatis, inferioribus lanceolato-linearibus, superioribus elongato-ellipticis; nervis crebris." Schimper, 1870.

This is a species of great vertical range, being recorded from the Jurassic upward to the Upper Cretaceous. The lateral range is equally great, embracing two continents, North America and

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Europe. It is quite probable that it is composite, but no certain grounds for segregation are apparent.

While some students may doubt the wisdom of correlating these Upper Cretaceous forms with a species which is essentially a Jurassic type, specific differention founded merely upon stratigraphy has gone astray so often that in cases like the present synthesis may well precede analysis, and it might be added that this was the view taken by Hollick[1] with reference to material from Glen Cove, Long Island, and by Velenovsky[2] in studying the Cenomanian flora of Bohemia.

This was the first fossil plant from the Raritan which received a specific name, having been described and figured by Conrad in 1869, who, however, failed to perceive its identity with the *Podozamites lanceolatus* of European authors.

As found in the Raritan the leaflets are detached, lanceolate in outline, pointed at both ends and widest near the base. Length about 7 cm., and width about 8 mm.

Occurrence.—Woodbridge, along South River (Conrad).

Collections.—N. Y. Botanical Garden.

PODOZAMITES ACUMINATUS Hollick.

Podozamites acuminatus Hollick in Newb., Fl. Amboy Clays, 45, *pl. 13, f. 7*, 1896.

Description.—Leaflets long, about 16 cm. to 18 cm. in length, 1.1 cm. in width, with a long slender acuminate tip. Venation open. Veins eleven in number, about 1 mm. apart.

This imperfectly characterized species was based upon a single fragmentary specimen collected at the Woodbridge horizon, and as no additional specimens have come to light, its status remains doubtful. It is hardly worthy of a place in the literature, but since it is already established it has to be considered. It is clearly different from the other remains of *Podozamites* hitherto dis-

[1] Hollick, Mon. U. S. Geol. Surv., vol. L, 1907, p. 35.

[2] Velenovsky, Gymn. Böhm. Kreidef., 11 pl. 2, f. 11-19, 24, 1885.

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covered in the Raritan formation, and these differences may well be of specific value. It is to be hoped that additional and more representative material may eventually be collected.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Genus MICROZAMIA Corda.

(In Reuss. Verst. Böhm, Kreidef., ab. II, 1846, p. 85.)

MICROZAMIA GIBBA (Reuss) Corda.

Conites gibbus Reuss, Geognostische Skizzen, vol. 2: 169.
Zamiostrobus gibbus Schimp. Pal. Végét, vol. 2: 202, 1870.
Microzamia gibba Corda in Reuss. Verst. Böhm, Kreidef. ab. 2: 85, 1846.
Velen., Gym. Böhm, Kreidef., 6, *pl. 3, f. 5–16; pl. 4, f. 6; pl. 5, f. 8,* 1885.
Newb., Fl. Amboy Clays, 45, *pl. 12, f. 6, 7,* 1896.

Description.—Judging from Corda's original drawing, which is preserved in the library of the N. Y. Botanical Garden, and from the numerous figures published by Velenovsky, the European specimens, which come from several Cretaceous localities in Bohemia (Lann, Vyserovic, Weissenberg, etc.), are correctly identified as cycadaceous fructifications. With regard to Newberry's specimens no such certainty can be entertained. The type material cannot be found at the N. Y. Botanical Garden, and what specimens of this species are in the collections of that institution are in a very poor state of preservation. Newberry's figures are only remotely like those of the European material, and his determination must be considered very doubtful, although there are no apriori reasons why this form should not occur in the Raritan, since cycad foliage is rather common, and the New Jersey and Bohemian Cretaceous have quite a number of identical species.

A fact tending to throw still more doubt on Newberry's idenfication was observed some years ago while collecting from the Magothy formation at Cliffwood bluff, New Jersey. At this point the clays are full of pyritized cones which are identical

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with those described from Quedlinburg, Saxony, by Heer as *Geinitzia formosa* and by Newberry and the writer as *Sequoia gracillima*. These cones are not always pyritized, but are sometimes simply lignified and flattened in the clays, and in the latter state they are distinguishable with difficulty from the specimens labelled *Microzamia gibba* in the collections of the N. Y. Botanical Garden. Foliage seemingly correctly identified as that of *Geinitzia formosa* has been recorded from Woodbridge by Newberry and from Cliffwood Bluff by the writer, so that the presumption is strong that Newberry's *Microzamia gibba* really is *Geinitzia formosa*. Because I have been unable to find Newberry's types or to settle the question beyond reasonable doubt, and influenced somewhat by the fact that the cones called *Geinitzia formosa* or *Sequoia gracillima* are so very abundant in, and characteristic of, the overlying Magothy formation, I have not thought it wise to make any change in name at the present time.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Genus CYCADINOCARPUS Schimper.

(Pal. Végét., vol. II, 1870, p. 208.)

CYCADINOCARPUS CIRCULARIS Newb.

Cycadinocarpus circularis Newb., Fl. Amboy Clays, 46, *pl. 46, f. 1–4*, 1896.
Smith, Geol. Coastal Plain in Ala., 348, 1894.

Description.—Discoid fruits almost circular in outline from 6 mm. to 12 mm. in diameter, sometimes slightly emarginate on one side at the point which Professor Newberry believed to be the point of attachment, but which is probably the distal micropylar extremity. As usually preserved the impression shows two concentric circles 1 to 2 mm. apart, the inner representing the outline of the inner seed coat and the outer layer the slightly fleshy external coat.

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These fruits always occur detached and are present in considerable abundance at Woodbridge, but have not been detected from other localities in the Raritan. Similar remains are recorded from the Tuscaloosa formation of Alabama, and they are also present in the Bladen formation of North Carolina. As their name indicates they are assumed to represent the fruit of some contemporaneous species of cycad.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Order CONIFERALES.

Family PINACEÆ.

Subfamily ARAUCARIEÆ.

Genus DAMMARA Lam.

(Encyc. II, 1786, p. 259.)

DAMMARA BOREALIS Heer.

Dammara borealis Heer, Fl. Foss. Arct., vol. 6, ab. 2: 54, *pl. 37, f. 5*, 1882.

Velen, Květena ceského cenomanu., 7, *pl. 1, f. 28, 29*, 1889.

Hollick, Trans. N. Y. Acad. Sci., vol. 12: 31, *pl. 1, f. 17*, 1892; Bull. N. Y. Bot. Garden, vol. 2: 402, *pl. 41, f. 6*, 1902; U. S. Geol. Survey, Mon. 50: 37, *pl 2, f. 2–11* (pars), *12–26* (pars), *27a*, 1907.

Newb., Fl. Amboy Clays, 46, *pl. 10, f. 8*, 1896.

—— Hitchcock, Final Rept. Geol. Mass., vol 2: 430, *pl. 19, f. 4, 5*, 1841.

Description.—"D. strobilorum squamis coriaceis, radiatim sulcatis, 22 mm. latis, apice obtuse rotundatis, apiculatis, basi attenuatis." Heer, 1882.

Scale-like organisms from 1 cm. to 2 cm. or possibly more in length, rounded distally and showing in some specimens a but slightly emphasized apiculate point. Greatly expanded laterally in the upper part to a breadth reaching 2.5 cm., abruptly contracted at about the middle to a cuneate or straight-margined

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flat stalk about 5 mm. in width, with numerous resin-canals approximately parallel with the lateral margins and dying out proximad, filled with an amber-like substance.

Remains of this species were described and figured by Hitchcock in his account of the organic remains found at Gay Head, Marthas Vineyard, as long ago as 1841. He did not name them, but remarks: "It seems to me very obvious that these remains must be the seed vessels of some coniferous plants." In 1882 Professor Heer found similar forms in the material from the west coast of Greenland and named and described them, as well as two other very similar forms, and definitely recognized their relation to *Dammara*. Subsequently they have been recorded from the European Cenomanian by Velenovsky, Krasser and Beyer, from the Raritan formation by Professor Newberry, from Long Island and Staten Island by Hollick. Unpublished work of the writer will extend their range southward to North Carolina and Alabama. They are abundant in the Raritan formation at Woodbridge and occur at the South Amboy horizon immediately across the Arthur Kill on Staten Island.

Similar remains have been considered by Heer, White, Krasser and others as representing the fruits of *Eucalyptus*, but it seems obvious that their relations are definitely with the Araucarian conifers.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Genus BRACHYPHYLLUM Brogn.

(Prodrome, 1828, p. 109.)

BRACHYPHYLLUM MACROCARPUM Newb.

Plate VII.

Thuites crassus Lesq., Cret. & Tert. Fl., 32, 1884.

Brachyphyllum crassum Lesq., Proc. U. S. Nat. Mus., vol. 10: 34, 1887; Fl. Dakota Group, 32, *pl. 2, f. 5*, 1892 (non Tenison-Woods, 1883).

Newb., Fl. Amboy Clays, 51, *pl. 7, f. 1–7*; 1896.

Brachyphyllum sp., Knowlton, Bull. Geol. Soc., Am. vol. 8: 137, 140, 1897.

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Brachyphyllum macrocarpum, Newb., MSS name mentioned in footnote, p. 51, Fl. Amboy Clays, 1896.

Knowlton, Bull. U. S. Geol. Surv., No. 163: 29, *pl. 4, f. 5, 6*, 1900.

Hollick, Bull. N. Y. Bot. Garden, vol. 3: 406, *pl. 70, f. 4, 5*, 1904; U. S. Geol. Surv. Mon. 50: 44, *pl. 3, f. 9, 10*, 1907.

Berry, Ann. Rept. State Geol. (N. J.) for 1905; 139, 1906; Bull. Torrey Club, vol. 32: 44, *pl. 2, f. 9*, 1905; Ibid., vol. 33: 168, *pl. 9*, 1906.

Hollick and Jeffrey, Amer. Nat., vol. 40: 200, 1906.

? Moriconia cyclotoxon Deb. & Ett., Heer, Fl. Foss. Arct., vol. 7, *pl. 54, f. 1c*, 1883 (non Heer's other figures).

Description.—Stout twigs, pinnately branched, covered with large, thick, rhomboidal, squamate, densely crowded, appressed leaves attached by practically their whole ventral surface. Phyllotaxy spiral. Leaf-surface striated, the striæ converging toward the obtuse apex. Cones not positively determined.

Brachyphyllum is chiefly an older Mesozoic type, but it remains abundant through the Lower Cretaceous, two species having been described from the Potomac Group of Maryland and Virginia. It is a waning type in the Upper Cretaceous, represented by but a single species, the one under discussion, which persists as high as the Senonian. It is widely distributed, and is recorded from Long Island, Staten Island, New Jersey and Delaware, in the east, and from the Dakota Group, of Kansas, and the Montana Group of Wyoming, in the west.[1] It is probably represented in the Patoot beds of Greenland, by the material which Heer erroneously refers (loc. cit.) to *Moriconia*. While it is not recorded from Europe, Velenovsky has described remains from the Cenomanian of Bohemia, which appear to be identical with the American representatives, referring them to the Jurassic genus *Echinostrobus* of Schimper.[2] Hollick and Jeffrey have recently

[1] It has also been collected by the writer in North Carolina, South Carolina, Georgia and Alabama.

[2] Velen., Gym. Böhm. Kreidef. 1885, p. 16, pl. vi, figs. 3, 6–8; Kvetena ceskeho cenomanu, 1889, p. 9, pl. i, figs. 11–19; pl. ii, figs. 1, 2.

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shown, with the aid of specimens from Staten Island, with structure preserved (loc. cit.), that this species is referable to the Araucarieæ.

This species is extremely common in the upper Raritan beds at South Amboy and their eastward extension on Staten Island, but has not been collected from any of the plant-bearing horizons of the lower Raritan. Prof. Newberry describes (loc. cit.) large cones which he found associated with these twigs and which he thought were related to them, although this seems improbable. The cones are poorly preserved and their affinities cannot be made out. They are very different from previously described cones of *Brachyphyllum*, and the work of Hollick and Jeffrey (loc. cit.) would seem to indicate that the present species had small cones. The cones described by Prof. Newberry, while they are here retained in the synonym of this species, are comparable to the abundant cones from the older Potomac of Maryland, which are referred to the form genus *Abietites*.

Occurrence.—South Amboy.

Collections.—N. Y. Botanical Garden.

Sub-Family CUPRESSEÆ.

Genus THUJA Linné.

(Sp. Pl., 1753, p. 1002.)

THUJA CRETACEA (Heer) Newb.

Libocedrus cretacea Heer, Fl. Foss. Arct., vol. 6, ab. 2: 49, *pl. 29, f. 1–3; pl. 43, f. 1d*, 1882.

Thuja cretacea Newb., Fl. Amboy Clays, 53, *pl. 10, f. 1, 1a*, 1896.

Knowlton, Bull. U. S. Geol. Surv., No. 257: 133, *pl. 16, f. 3a*, 1905.

Berry, Bull. Torrey Club, vol. 33: 169, 1906.

Description.—"L. ramulis gracilibus, oppositis, compressis, foliis quadrifariam imbricatis, lateralibus basi connatis, appressis

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breviter subacuminatis, facialibus rhombeis, minutis, dorso argute carinatis." Heer, 1882.

This species was described originally from the Atane beds of Greenland, as a species of *Libocedrus*. When Prof. Newberry came to study the abundant remains from the upper Raritan he changed the generic reference to *Thuja* on what appears to be good evidence. Similar remains have been identified by Knowlton, from the Judith River beds of Montana, and the writer has noted identical remains in considerable abundance in the Magothy formation of Delaware and Maryland.

This is another one of those species from the upper Raritan whose affinities are entirely with those of somewhat later formations, and which serve to emphasize the Cenomanian age of the formation as a whole.

The twigs are strap-shaped, with nearly parallel sides 2 mm., or slightly less in width, and with four rows of short, appressed leaves.

Occurrence.—South Amboy.

Collections.—N. Y. Botanical Garden.

Genus THUITES Sternberg.

(Fl. d. Vorw., vol. 1, 1823, p. 39.)

Thuites Meriani Heer.

Thuites Meriani Heer, Fl. Foss. Arct., vol. 3, ab. 2:73, *pl. 16, f. 17, 18,* 1873; Ibid., vol. 6, ab. 2:48, *pl. 8, f. 9–11; pl. 29, f. 20, b,* 1882.

Newb., Fl. Amboy Clays, 54, *pl. 10, f. 5,* 1896.

Description.—"Th. ramulis alternis, foliis quadrifariam imbricatis, laterlibus incurvis, acuminatis, facialibus subovatis, dorso, evidenter costatis." Heer, 1873.

Twigs with four-ranked, imbricated, somewhat incurved and appressed, ovate, pointed leaves, dorsally costate. This species was described by Heer in 1873 from the Kome beds of Greenland, although it is doubtfully distinct from *Inolepis imbricata*

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genus and species novum which he describes on the previous page of Die Kreide Flora der Artischen Zone. The later specimens from the much younger Atane beds are not surely identical with the older remains, although they are much the same in general appearance. They appear to depart somewhat from a cyclic phyllotaxy toward a spiral arrangement and the leaves are more spreading and less appressed. The Raritan occurrence of this species is based upon a single specimen from an unknown New Jersey locality and no additional remains have ever been discovered either in New Jersey or in more or less synchronous horizons elsewhere. While this specimen presents no evident differences when compared with Heer's figures of this species, it is very doubtfully related to the original material from the Kome beds.

Occurrence.—Locality unknown.

Collections.—N. Y. Botanical Garden.

Genus JUNIPERUS Linné.

(Sp. Pl., 1753, p. 1038.)

JUNIPERUS HYPNOIDES Heer.

Juniperus hypnoides Heer, Fl. Foss. Arct., vol. 6, ab. *2*: 47, *pl. 44, f. 3; pl. 46, f. 18*, 1882.

Hollick, Trans. N. Y. Acad. Sci., vol. 12: 22, *pl. 1, f. 1*, 1892; Bull. N. Y. Bot. Garden, vol. 2: 403, *pl. 41, f. 7, 7a*, 1902; U. S. Geol. Surv. Mon. 50: 46, *pl. 2, f. 26* (pars), *27b, 28; pl. 3, f. 12–13a*, 1907.

Berry, Bull. Torrey Club, vol. 33: 168, 1906; Ann. Rept. State Geol. (N. J.) for 1905: 139, 1906.

Juniperus macilenta Heer, Newb., Fl. Amboy Clays, 54, *pl. 10, f. 7*, 1896.

Description.—"J. multiramosa, ramulis tenuissimis, congestis, foliis oppositis, falcatis, apice acuminatis, uninerviis, 1 mm. longis." Heer, 1882.

This conifer, which is a common one in the Raritan, was referred by Professor Newberry to *Juniperis macilenta* Heer,

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although if the two species are to be kept separate, a not altogether certain proposition, it is clearly more closely allied to *Juniperus hypnoides* under which Hollick has already placed it (loc. cit., 1907). Professor Newberry describes its association at Woodbridge with *Dammara* scales and was evidently of the opinion that the one was the fruit of the other. Material in the New York Botanical Garden shows this association, which is probably, however, purely a mechanical one. The type material came from the Atane beds of Greenland, and additional remains are also abundant in the Raritan of Kreischerville, Staten Island, and in the Magothy formation of Martha's Vineyard, New Jersey and Delaware.

Occurrence.—Perth Amboy, Woodbridge.

Collections.—N. Y. Botanical Garden.

Genus MORICONIA Deb. and Ett.

MORICONIA CYCLOTOXON Deb. and Ett.

(Urwelt. Acrobry. v. Aachen, 1859, p. 59.)

Plate VIII, Figs. 3–6.

Moriconia cyclotoxon Deb. & Ett., Urwelt. Acrobry. v. Aachen, 59, *pl. 7, f. 23–27,* 1859.

Heer, Fl. Foss. Arct., vol. 6, ab. 2: 49, *pl. 33, f. 1–9b,* 1882; Ibid. vol. 7: 11, *pl. 53, f. 10; pl. 54,* 1883.

Newb., Fl. Amboy Clays, 55, *pl. 10, f. 11–21,* 1896.

Hollick, Ann. N. Y. Acad. Sci., vol. 11: 57, *pl. 3, f. 10,* 1898; Ibid., 418, *pl. 37, f. 8.* U. S. Geol. Surv. Mon., 50: 46, *pl. 3, f. 16, 17,* 1907.

Pecopteris kudlisetensis Heer, loc. cit., vol. 3, ab. 2: 97, *pl. 26, f. 18,* 1874.

Description.—"M. fronde pinnata, pinnis longe petiolatis, pinnatifidis v. pinnatipartitis laciniis ovato-oblongis, integerrimis, apice obtusis, infinis in petiolum late decurrentibus, terminali cæteris parum longiore stricta, margine undulata, lateralibus oppositis patentibus v. arrecto patentibus; rhachi mediana crassa." Deb. and Ett., 1859.

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Twigs, evidently deciduous, thin and flat, spreading in one plane, with pinnately arranged, symmetrical, opposite branches which are covered with thin closely appressed semicircular cyclic leaves, the outlines of which give to the fossil specimens that peculiar geometrical pattern, which once seen is thereafter unmistakable. Professor Heer placed it among the Cupressieæ because of its resemblance to *Libocedrus*, and while the fruit remains unknown, even in the very abundant material from South Carolina, there seems to be no valid ground for questioning this relationship. When only the outlines of the twigs are preserved the fossils have a very fern-like appearance, which served to mislead the original describers.

This exceedingly graceful and interesting conifer was originally described as a fern from the Prussian Senonian. Abundant and better material subsequently collected from Greenland enabled Professor Heer to determine its true nature. It is abundant in the upper Raritan at South Amboy, but does not occur elsewhere in that formation.

Occurrence.—South Amboy.

Collections.—N. Y. Botanical Garden.

Genus WIDDRINGTONITES Endl.

(Synop. Conif., 1847, p. 271.)

WIDDRINGTONITES REICHII (Ettings.) Heer.

Plate VIII, Figs. 1, 2.

Frenelites Reichii Ett., Kreidefl. v. Niedersch, 12, *pl. 1, f. 10 a–c*, 1867.

Widdringtonites Reichii Heer, Fl. Foss. Arct., Vol. 6, ab. 2: 51, *pl. 28, f. 5*, 1882, Ibid., vol. 7: 13, *pl. 52, f. 4, 5*, 1883.

Smith, Geol. Coastal Plain in Ala., 348, 1894.

Newb., Fl. Amboy Clays, 57, *pl. 8, f. 1, 5*, 1896.

Berry, Bull. Torrey Club, Vol. 33: 169, 1906; Ann. Rept. State Geol. (N. J.) for 1905; 138, 1906.

Hollick, U. S. Geol. Surv. Mon. 50: 44, *pl. 4, f. 6–8*, 1907.

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Widdringtonia Reichii (Ettings.) Velen. Gym. Böhm. Kreidef., 27, *pl. 8, f. 4–6; pl. 10, f. 1, 11, 12,* 1885; Sitzs. k. Böhm. Gesell. Wiss. 1886; 639 (6) *pl. 1, f. 14–16,* 1887.

Krasser, Beitr. Paläont. Ost-Ung. und Orients, Bd. 10: 126 (14) *pl. 14 (4), f. 6; pl. 17 (7), f. 4, 7, 8,* 1896.

Description.—"F. ramis suberectis fastigiatis, ramulis filiformibus confertis, foliis adpressis e basi ovata subulatis, strobilis axillaribus duplo longioribus quam latis." Ettings. 1867.

Medium-sized branches with more or less crowded, slender, elongated, fastigiate twigs, bearing reduced ovate-subulate leaves, spirally arranged. The cones are small oval bodies 5 mm. to 12 mm. long, by 3 mm. to 7 mm. in diameter, usually poorly preserved, said by Ettingshausen to be axillary in position, but evidently often terminal as evinced by some of the Raritan material as well as by some of the better preserved cones from the Cenomanion of Bohemia and Moravia. The latter material clearly shows that the cones consisted of four scales. This would ally it with either the subgenus *Widdringtonia* of the genus *Callitris* Vent., to which Eichler in his treatment of the living species in Engler and Prantl (1887) refers Endlicher's genus, or to the subgenus *Eucallitris* Brongn., which also is characterized by four cone-scales. The latter has a single living species of northern Africa and the former has three or four species of southern Africa and Madagascar. The propriety of Eichler's classification may well be questioned, and in any event paleobotanists must necessarily prefer the older segregation of *Frenela* and *Widdringtonia* and their respective form-genera.

There seems to be but little doubt that the present species should be referred to *Widdringtonia,* as Velenovsky and Krasser have done, but as the term *Widdringtonites* is equally indicative of its true affinity, little is to be gained by making the proposed change.

This species, which is probably the most common conifer of the Raritan formation, was described originally by Ettingshausen from the Cenomanian of Niederschœna, in Saxony, as a

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species of *Frenelites*. When Heer discovered it in the Greenland material, where it has been collected from both the Atane and the Patoot beds, he transferred it to the present genus. It has subsequently been reported from the Cenomanian of Bohemia and Moravia, from the Magothy formation at numerous localities and from the southern New England islands. It has also been reported from the Tuscaloosa formation of Alabama, where it is abundant at a number of localities. Heer made *Glyptostrobus gracillinus* Lesq., of the Dakota Group, a synonym of this species, and he has been followed by many subsequent authors. As this relation is not definitely established I have not included Lesquereux's form in the foregoing synonomy, although I think they may eventually prove to be identical.

Widdringtonites Reichii is closely allied, if not identical, with a common conifer of the Patapsco formation of Maryland and Virginia, which is to be described shortly as *Widdringtonites ramosus*, being based upon *Taxodium ramosum* and various other species of Professor Fontaine's Flora of the Potomac Group. Staminate cones of the former are well shown in the Raritan specimen figured by Newberry on pl. 8, fig. 3 (loc. cit.), and similar specimens are common in the Bohemian material.

Occurrence.—Milltown, Sayreville, Woodbridge, Hylton Pits, South Amboy.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

Widdringtonites subtilis Heer.

Widdringtonites subtilis Heer, Fl. Foss. Arct., vol. 3, ab. 2: 101, *pl. 28, f. 1, b,* 1874; Ibid., vol. 6, ab. 2, *pl. 7, f. 13, 14; pl. 28, f. 4, b,* 1882.

Newb., Fl. Amboy Clays, 57, *pl. 10, f. 2–4,* 1896.

Hollick, U. S. Geol. Surv., Mon. 50: 45, *pl. 4, f. 2–5,* 1907.

Widdringtonites Reichii Hollick, Ann. N. Y. Acad. Sci., vol. 11: 58, *pl. 3, f. 8,* 1898.

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Description.—"W. ramis tenuissimis, gracilibus, fastigiatis, foliis imbricatis, appressis, omnino tectis, foliis inferioribus falcatis, superioribus rectis." Heer, 1874.

This species was described from the Atane beds of Greenland by Prof. Heer in 1874. His material was, however, extremely limited. Subsequently it was found in considerable abundance in the Raritan formation, and still more recently Hollick has recorded it from Marthas Vineyard and Block Island. It may be questioned if some of the coniferous material described by Velenovsky from the Bohemian Cretaceous under other names should not be compared with the present form. It is even more slender than the preceding species, with much shorter twigs, which have the appearance of having been somewhat lax in habit; the leaves are more close-set and appressed, narrowly lanceolate, straight and scale-like; they are said by Heer to be somewhat spread and falcate proximad, but this feature has not been observed in any of the Raritan material.

Newberry mentions a vague cone about 1 cm. in diameter as included in the Raritan material. The writer has not seen this specimen, but has found a number of poorly preserved cones among the abundant remains of this species in the Cretaceous beds of South Carolina. Attached cones are common in the lower part of the Tuscaloosa formation of Alabama.

Occurrence.—Woodbridge, South Amboy.

Collections.—N. Y. Botanical Garden.

Genus FRENELOPSIS Schenk.

(Palaeont., vol. XIX, 1869, p. 13.)

FRENELOPSIS HOHENEGGERI (Ett.) Schenk.

Thuites Hoheneggeri Ett., Abh. kk. geol. Reichs. 1 ab. 3, No. 2:26, *pl. 1, f. 6, 7*, 1852.

Frenelopsis Hoheneggeri Schenk, Palæont., vol. 19, hft. 1:13, *pl. 4, f. 5–7; pl. 5, f. 1, 2; pl. 6, f. 1–6; pl. 7, f. 1*, 1869.

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Heer, Fl. Foss. Arct., vol. 3, ab. 2:73, *pl. 18, f. 5–8*, 1874; Ibid., vol. 6, ab. 1:7, *pl. 2, f. 1–3*, 1880; Ibid., ab. 2:16, 1882.

Font., Proc. U. S. Nat. Museum, vol. 16:275, *pl. 42, f. 4 a*, 1893.

Newb., Fl. Amboy Clays, 58, *pl. 12, f. 4, 5*, 1896.

Berry, Bull. Torrey Club, vol. 31:71, *pl. 4, f. 9, 10*, 1904.

Hollick, Bull. N. Y. Bot. Garden, vol. 3:410, *pl. 72, f. 1*, 1904; U. S. Geol. Surv. Mon. *50*:45, *pl. 4, f. 9, 10*, 1907.

Description.—"Th. ramis articulatis, ramulis strictis compressis, ristichis, articulatis, foliis brevissimis, ato-squamæformibus, truncatis vel obtusis, quadrifarian imbricatis, arcte adpressis, dorso carinatis." Ettings., 1852.

This genus was founded by Schenck in 1869 with *Thuites Heheneggeri* Ettings. as the type. The latter received very elaborate treatment at the hands of the former author, and this was rounded out by Zeiller's description of the epidermal and stomatal characters in 1882[1]. It has been recorded from a large number of localities, although the bulk of the remains are rather unsatisfactory, and it is very doubtful if the Raritan or Magothy material as described by Newberry, Hollick, and the writer is correctly identified; at least it is not above suspicion. Characteristic remains of this species do occur, however, in the Kome beds of Greenland and the Trinity of Texas, in addition to the Barremian occurrences in Europe, while *Frenelopsis parceramosa* Font. from the older Potomac of Maryland and Virginia is extremely close to this species, and somewhat similar, but poorly preserved, remains are described from the English Wealden by Seward as *Becklesia anomala*.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

[1] Zeiller, Ann. Sci., Nat., 6e sèr., Bot., t. xiii, p. 231.

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Genus RARITANIA Hollick and Jeffrey.

(Mem. N. Y. Bot. Garden, vol. III, 1909, p. 26.)

RARITANIA GRACILIS (Newb.) Hollick and Jeffrey.

Frenelopsis gracilis Newb., Fl. Amboy Clays, 59, *pl. 12, f. 1–3a*, 1896.

Berry, Bull. Torrey Club, vol. 33: 167, 1906.

Raritania gracilis Hollick and Jeffrey, Mem. N. Y. Bot. Garden, vol. III: 26, *pl. 6, f. 4–7; pl. 9, f. 1–4; pl. 10, f. 14–17; pl. 19, f. 3–6; pl. 20, f. 1*, 1909.

Description.—Twigs of a conifer, represented in clays by crowded cylindrical branches of graceful aspect and slender forking habit. The leaves are reduced almost to the vanishing point, in fact most specimens fail to show any traces of leaves whatever, and it is possible that these spirally-arranged scale-like leaves of Newberry's description may have been founded upon deceptive material.

These twigs are unjointed, an objection against their former reference to the genus *Frenelopsis*. It has been suggested that they represent decorticated specimens of *Widdringtonites Reichii* (Ettings.) Heer, which is so common in the Raritan and overlying Magothy formation. The present species is recorded from both Delaware and Maryland.

Hollick and Jeffrey have shown (loc. cit.), since the foregoing was written, that the present species is not related to Frenelopsis, but constitutes a distinct genus.

Occurrence.—Woodbridge, South Amboy.

Collections.—N. Y. Botanical Garden.

Sub-Family ABIETEÆ.

Genus PINUS Linné.

(Sp. Pl., 1753, p. 1000.)

PINUS RARITANENSIS Berry.

Pinus sp., Newb., Fl. Amboy Clays, 47, *pl. 9, f. 5, 6; f. 7, 8 (?), f. 17, 18 (?)*, 1896.

Pinus raritanensis Berry, Bull. Torrey Club, vol. 36: 247, 1909.

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Description.—It seems very desirable that at least the leaves which are included under Newberry's *Pinus sp.* should have a specific names since pine leaves of this type in fascicles of three occur to the southward in the Coastal Plain, and a definite name is therefore a necessity for purposes of intelligent citation. Whether the poorly-preserved cones and winged seeds, which occur in the same beds, are referable to the same species it is impossible to determine, and since in the overlying Magothy formation there are two types of leaves of *Pinus,* as well as quite different seeds, I have placed a query after Newberry's figures of cones and seeds in the above citation. *Pinus* seems to be confined to the upper part of the Raritan, although leaves, cones and seeds are common in much older deposits elsewhere, going back as far as the Jurassic. Leaves are recorded from the Kome, Kootanie, Trinity and Lakota formation, the Patapsco formation of Maryland and the Albian of Europe is remarkable for the large number of Pinus-like cones which it contains, and Heer has recorded five species from the Atane beds.

Occurrence.—South Amboy.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

Sub-Family TAXODIEÆ.

Genus SEQUOIA Endl.

(Synop. Conif., 1847, p. 197.)

SEQUOIA REICHENBACHI (Gein) Heer.[1]

Araucarites Reichenbachi Gein., Charakteristik, hft. 3: 98, *pl. 24, f. 4,* 1842.

Cryptomeria primaeva Corda in Reuss, Verst. Böhm. Kreidef. ab. 2: 89, *pl. 48, f. 1–11,* 1846.

Sequoia Reichenbachi Heer, Fl. Foss. Arct., vol. 1: 83, *pl. 43, f. 1d, 2b, 5a,* 1868; Ibid., vol. 3, ab. 2: 77, 101, 126, *pl. 12, f. 7c, d; pl. 20, f. 1–8; pl. 28, f. 2; pl. 34, f. 1; pl. 36, f. 1–8; pl. 37, f. 1, 2,* 1874; Ibid., vol. 6, ab. 2: 52, *pl. 28, f. 7,* 1882.

[1] Only representative citations, chiefly American, of this widespread and persistent species are given.

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Fontaine, Potomac Fl., 243, *pl. 118, f. 1, 4; pl. 119, f. 1–5,* etc., 1889.

Lesq., Cret. Fl., 51, *pl. 1, f, 10–10b,* 1874; Fl. Dakota Group, 35, *pl. 2, f. 4,* 1892.

Hollick, Trans. N. Y. Acad. Sci., Vol. 12: 30, *pl. 1, f. 18,* 1892; U. S. Geol. Surv. Mon. 50: 42, *pl. 2, f. 40; pl. 3, f. 4, 5,* 1907.

Nath, in Felix & Lenk, Beitr. Geol. u. Pal. Mexico, 2 Th. 1 hft., 1893..

Newberry, Fl. Amboy Clays, 49, *pl. 9, f. 19,* 1896.

Berry, Bull. N. Y. Bot. Garden, vol. 3: 59, *pl. 48, f. 15–18, 20,* 1903; Bull. Torrey Club, vol. 31: 69, *pl. 4, f. 8,* 1904; Ibid., vol. 32: 44, *pl. 1, f. 3,* 1905; Ibid. 33: 165, 1906.

Knowlton, Smith. Misc. Coll. vol. 4, pt. 1: 126, *pl. 12, f. 7, 8,* 1907; U. S. Geol. Surv. Mon. 32: 657, 1899; Bull. U. S. Geol. Surv. No. 257: 131, *pl. 14, f. 3–5,* 1905.

Sequoia Couttsiae Hollick, Trans. N. Y. Acad. Sci., vol. 12: 30, *pl. 1, f. 5* (non Heer).

Description.—"S. ramis elongatis, foliis decurrentibus, patentibus, falcato-incurvis, rigidis, acuminatis." Heer, 1868.

This widespread Mesozoic species is not abundant in the Raritan formation, being only recorded from the single locality of Woodbridge, where it is not common. This relative rarity is probably to be explained by local climatic conditions due to altitude or to the character of the soil and its water content and their effect upon relative humidity. Of course, such an explanation is largely speculative. We do know, however, that Sequoia twigs are about the last fragments in floating vegetable debris to disintegrate, and that their remains are found in deposits in which the associated vegetation is reduced to an unrecognizable mass, so that it is safe to predicate that *Sequoia Reichenbachi* did not grow near the place where the Raritan sediments were being laid down and that such specimens as are preserved were floated into the Raritan basin by streams, perhaps from the uplands where they grew. In the succeeding

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Magothy formation, this species and other conifers were excessively abundant in this general region, and this species occurs in great abundance in beds of approximately this latter age in every State from New York to Alabama.

Sequoia Reichenbachi has a recorded range on this continent from the Neocomian of Mexico to the Livingston formation of Montana, and it seems to have been equally at home during the greater part of the Cretaceous in Europe and the Arctic region. It is possible that these remains may represent more than a single species, but of this it is impossible to judge. The Tertiary *Sequoia Langsdorfii* has an almost equally wide range, both vertical and horizontal.

In the original description, Geinitz refers this species to the genus *Araucarites*, and several students since his day have pointed out its resemblance to the Eutacta section of the genus *Araucaria*. If this be the true affinity, then this Cretaceous *Araucaria* bore *Sequoia* cones, for the latter have been found attached to the twigs in a number of instances.

Occurence—Woodbridge.

Collections—N. Y. Botanical Garden.

SEQUOIA HETEROPHYLLA Velen.

Plate VI.

Sequoia heterophylla Velen., Gymnos. böhm. Kreidef., *22, pl. 12, f. 12; pl. 13, f. 2–4, 6–9*, 1885; Sitz. K. böhm. Gesel. Wiss., Prag, 1888; 593. *f. 7, 8.*

Hollick, Trans. N. Y. Acad. Sci., vol. 12: 3, *pl. 1, f. 18*, 1892; U. S. Geol. Survey, Mon. 50: 41, *pl. 3, f, 2, 3*. 1907.

Smith, Geol. Coastal Plain in Ala., 348, 1894.

Ward, 15th Ann. Rept. U. S. Geol. Survey, 378, 380, 382, 392, 1895.

Newb., Fl. Amboy Clays, 49, *pl. 6, f. 1–13*, 1896.

Knowlton, Bull. U. S. Geol. Survey, No. 257: 132, *pl. 16, f. 5*, 1905.

NEW JERSEY GEOLOGICAL SURVEY

Berry, Bull. Torrey Club, vol. 33:165, 1906; Ibid., vol. 34: 189, 1907; Ann. Rept. State Geol. (N. J.) for 1905; 139, 1906.

Description.—"Zweige ruthenförmig unter spitzen Winkeln getheilt, ziemlich dünn und schlank. Blätter zweierlei: die schuppenförmigen sehr verlängert, mit stumpfen, nicht abstehenden Spitzen, locker dem Zweige aufsitzend; die der jüngeren Sprosse blattartig, zweireihig am Zweige geordnet, lineal, breit, dick, lederartig, vorne stumpf abgerundet, am Grunde merklich verschmälert, von mehreren Längsstreifen durchzogen. Der Zapfen unbekannt." Velenovsky 1885.

This characteristic species described originally from the Cenomanian and Senonian of Bohemia may be readily recognized by the form of the foliage—the flat lanceolate decurrent leaves above and the short and appressed leaves below. As yet no cones have been correlated with the leafy twigs in the American material. Newberry says of this species that it is one of the most common conifers of the Amboy clays, but mentions no localities. The writer has only found it in the upper Raritan at South Amboy, where it is very common, and at the Hylton Pits, and it has been collected by Hollick from a probably equivalent horizon at Kreischerville, Staten Island.

In the overlying Magothy formation it is a common species, with a recorded range from Marthas Vineyard to Maryland and in the allied Bladen formation of North Carolina. In the west it occurs in the Judith River beds of Montana. It is a distinctly younger element in the Raritan, allying that flora with the higher Upper Cretaceous beds.

Occurrences.—South Amboy, Hylton Pits.

Collections.—N. Y. Botanical Garden, U. S. National Museum.

Sequoia concinna Heer.

Sequoia concinna Heer, Fl. Foss. Arct., vol. 7: 13, *pl. 49, f. 8b, c; pl. 50, f. 1b; pl. 51, f. 2–10; pl. 52, f. 1–3; pl. 53, f. 1b,* 1883.

NEW JERSEY GEOLOGICAL SURVEY

Hollick, U. S. Geol. Surv., Mon. 50: 43, *pl. 2, f. 41*, 1907.

Cones of Sequoia sp., Hollick in Newb., Fl. Amboy Clays, note, p. 49, *pl. 9, f. 4, 4a*, 1896.

Description.—"S. ramis alternis, ramulis congestis, junioribus elongatis, foliis basi valde decurrentibus, lineari-subulatis, apice acuminatis, rectis vel leviter curvatis, dorso carinatus; strobilo breviter ovali, 23 mm. longo, 20 mm. lato, squamis 5–6 angularibus, medio unbonatis, margine striatis." Heer, 1883.

This is doubtfully a member of the Raritan flora and probably came from Newberry's locality "near Keyport," *i. e.*, Cliffwood bluff, which is in the overlying Magothy formation, as I have found cones of this species at that place. Since, however, there is no reason why this species should not occur in the Raritan, and the present uncertainty as to the locality from which Newberry's specimens were collected cannot be cleared up, it is retained as a member of the Raritan flora.

Occurrence.—Locality unknown.

Collections.—N. Y. Botanical Garden, Johns Hopkins University.

Genus GEINITZIA Endl.

(Synop. Conif., 1847, p. 280.)

GEINITZIA FORMOSA Heer.

Geinitzia formosa Heer, Neue Denks. Schweiz Gesell., vol. 24: 6, *pl. 1, f. 9; pl. 2*, 1871.

Newb., Fl. Amboy Clays, 51, *pl. 9, f. 9*, 1896.

Hollick, Trans. N. Y. Acad. Sci., vol. 16: 129, *pl. 12, f. 1, 2*, 1897.

Knowlton, Bull. U. S. Geol. Survey, No. 163: 28, *pl. 5, f. 1, 2*, 1900.

Berry, Bull. N. Y. Bot. Garden, vol. 3: 57, 1903; Bull Torrey Club, vol. 31: 68, *pl. 4, f. 2, 3*, 1904.

Geinitzia sp., Newb., Proc. N. Y. Lyc. Nat. Hist., 2nd ser.: 10, 1873.

NEW JERSEY GEOLOGICAL SURVEY

Description—"ramulis elongatis, virgatis, foliis omnino tectis, foliis, subfalcatis, angustis, apice valde attenuatis, uninerviis, ramis adultis pulvinis rhombeis obtectis." Heer, 1871.

This species, like *Sequoia Reichenbachi*, occurs sparingly at the Woodbridge horizon, and like the latter is more abundant in the overlying Magothy formation at Cliffwood bluff. It resembles this species considerably, but may be distinguished by the thicker twigs with decurrent pointed leaves, which are more curved and less rigid than in the *Sequoia* and with smaller intermediate scale-like leaves, which are altogether wanting in the latter. *Geinitzia formosa* was described originally from the Senonian of Saxony, and it also ranges upwards into the Montana formation of Wyoming. It is another species which serves to ally the Raritan with younger deposits elsewhere.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Family TAXACEÆ.

Sub-Family TAXEÆ.

Genus PROTOPHYLLOCLADUS Berry.

(Bull. Torrey Club, vol. XXX, 1903, p. 440.)

PROTOPHYLLOCLADUS SUBINTEGRIFOLIUS (Lesq.) Berry.

Plate IX.

Phyllocladus subintegrifolius Lesq., Amer. Jour. Sci., vol. 46: 92, 1868; Cret. Fl. 54, *pl. 1, f. 12*, 1874; Fl. Dakota Group, *34, pl. 2, f. 1–3*, 1892.

Thinnfeldia Lesquereuxiana Heer, Fl. Foss. Arct., vol. 6, ab. 2: *37, pl. 44, f. 9, 10; pl. 46, f. 11, 12a, b*, 1882.

Hollick, Trans. N. Y. Acad. Sci., vol. 11: 99, *pl. 3, f. 6*, 1892.

Newb., Fl. Amboy Clays, 59, *pl. 11, f. 1–17*, 1896.

Thinnfeldia subintegrifolia Knowlton, Bull. U. S. Geol. Surv., No. 152: 228, 1898.

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Hollick, Ann. N. Y. Acad. Sci., vol. 11: 58, 419, *pl. 3, f. 4, 5, pl. 36, f. 6,* 1898; Bull. N. Y. Bot. Garden, vol. 2; 403, *pl. 41, f. 13, 14,* 1892.

Protophyllocladus subintegrifolius Berry, Bull. Torrey Club, vol. 30: 440, 1903; Ibid., vol. 31: 69, *pl. 1, f. 5,* 1904; Ann. Rept. State Geol. (N. J.) for 1905; 139, 1906; Johns Hopkins Univ. Circ. new ser., 1907, No. 7: 89–91, *f. 6.* Hollick, U. S. Geol. Surv. Mon. 50: 36, *pl. 5, f. 1–6,* 1907.

Description.—Leaves oblong to linear in outline and coriaceous in texture, from 3 cm. to 17 cm. in length by 0.6 cm. to 3 cm. in width. Apex usually obtuse, rarely pointed. Base decidedly and narrowly cuneate to the short petiole. Margins entire below, above obtusely dentate or undulate, with occasionally teeth which are acute. Midrib stout below becoming attenuated above and frequently disappearing some distance below the apex. Laterals numerous, close, immersed; they branch at an angle of about 20°, running nearly straight and approximately parallel to the margin, sometimes forking. Stomata scattered on both surfaces, with typical guard cells.

This is a widespread species ranging in considerable abundance from Greenland to New Jersey and west to Kansas and Nebraska. Originally referred to *Phyllocladus* by Lesquereux, his type is almost identical with certain phylloclads of modern members of this genus. Subsequently discovered remains from Kansas are considerably larger than the type, as are also a number of the Greenland specimens. Some of the Raritan forms have a somewhat different aspect, being long and narrow; sometimes the margins are entire, often they are more or less sharply toothed.

Much controversy has centered around these forms and especially around the older Mesozoic forms referred to the genus *Thinnfeldia* Ettings., to which these later forms were once referred. The latter genus has been referred successively to the conifers, ferns and cycads. There has never been much doubt that the later forms were gymnospermous. The writer can positively affirm this conclusion, and also that they are true phylloclads and not leaves in the strict morpholigical sense.

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Whether or not they are closely related to the modern genus *Phyllocladus* is still in doubt, although there are some excellent arguments for such a relationship. While fossil remains of undoubted relationship to this genus are extremely rare, Gothan describes wood of similar type from the Jurassic of the east coast of Greenland, under the name of *Phyllocladoxylon*.[1]

Occurrence.—Newberry states that he had some hundreds of specimens from the Amboy Clays, but gives no localities. The writer has collected it from Florida Grove and vicinity.

Collections.—Johns Hopkins University, N. Y. Botanical Garden.

Order GINKGOALES.

Genus BAIERA Braun.

(Flora, 1841, p. 33.)

BAIERA INCURVATA Heer.

Baiera incurvata Heer, Fl. Foss. Arct. vol. 6, ab. 2:45. *pl. 13, f. 6,* 1882.
Newb., Fl. Amboy Clays, 60, *pl. 10, f. 6,* 1896.

Description.—"B. foliis dichotome laciniatis, segmentis angustis, 2-3 mm. latis, linearibus, apice obtusis, incurvatis, nervis longitudinalibus, 3-4, obsoletis." Heer, 1882.

A single incomplete specimen from Woodbridge is identified by Prof. Newberry with this poorly characterized species of Heer, which is based on very incomplete remains. It seems almost certain that the apical curvature which the latter makes as one of the characteristics of this species is simply accidental. The generic relationship seems to be correct and it is probable that *Baiera leptopoda,* Heer, from the same horizon in Greenland belong to the same species.

The genus is an old one, appearing late in the Paleozoic and becoming widespread and very important in the Triassic and

[1] Kungl. Svenska Vetensk. Akad. Handl., Bd. 42, No. 10, 1907.

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Jurassic. It continued into the Cretaceous, but is much reduced in numbers and importance, a single form occuring in the Lower Cretaceous.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Genus CZEKANOWSKIA Heer.

(Fl. Foss. Arct., vol. IV, ab. ii, 1876, p. 70.)

Czekanowskia capillaris Newb.

Czekanowskia capillaris Newb., Fl. Amboy Clays, 61, *pl. 9, f. 14–16*, 1896.

Smith, Geol. Coastal Plain in Ala., 348, 1894 (Nomen nudum.)

Description.—Leaves linear or capillary, long and slender, undivided (?) or dichtomously forked. Length 8 cm. to 10 cm. Judging by the extremely poor material at our command they grew in bundles and were apparently caducous.

The genus was established by Heer in 1876, and its relations have caused considerable discussion, some authors comparing it with *Isoetes*. Both Schenk and Seward, from the stomatal character, place the genus among the Gymnosperms. Among the latter it falls most naturally in the order Ginkgoales, although this relationship is disputed in some quarters. It is essentially a Jurassic type, appearing, however, in the Rhaetic and surviving as late as the Upper Cretaceous, apparently becoming extinct in the Cenomanian, the European *Czekanowskia nervosa* Heer, which is recorded by Fontaine[1] from the Lower Cretaceous of the Black Hills, ranging from the Aptian through the Albian into the Cenomanian of Portugal.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

[1] Fontaine, Ann, Rept. U. S. Geol. Surv. 19th, pt. 2, 1899, p. 685, *pl. 169, f. 1, 2.*

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Class ANGIOSPERMAE.

Sub-Class MONOCOTYLEDONAE.

Order LILIALES.

Family SMILACACEÆ.

Genus SMILAX Linné.

(Sp. Pl., 1753, p. 1028.)

SMILAX RARITANENSIS Berry.

Plate XXIII, Fig. 3.

Paliurus ovalis Dawson, Newb., Fl. Amboy Clays, 107, *pl. 23, f. 8, 9*, 1896 (non Daws.)
Smilax raritanensis Berry, Bull. Torrey Club, vol. 36: 248, 1909.

Description.—Leaves of small size, ovate elliptical in outline, with entire margins, obtusely pointed apex and slightly cuneate base, 3.5 cm. to 4 cm. in length by 1.5 cm. to 2 cm. in breadth. Primaries 3, of medium size, diverging at acute angles from the extreme base, the laterals regularly curving upward and joining the midvein at the summit. Secondaries not visible except 1 or 2 transverse internal ones, and a few curved camptodrome external ones.

This species was identified by Prof. Newberry with *Paliurus ovalis* Dawson[1] which it somewhat resembles and this latter species has been reported by Lesquereux[2] from the Dakota Group and by Hollick[3] from Marthas Vineyard. These occurences may represent Dawson's species, but the Raritan leaves are obviously different, being relatively shorter and broader and of an altogether different aspect.

[1] Dawson, Trans. Roy. Soc. Can., vol. 3, sec. 4: 14, pl. 4, f. 4, 8, 1886.
[2] Lesquereux, Fl. Dakota Group, 166, pl. 35, f. 7, 1892.
[3] Hollick, Mon. U. S. Geol. Surv., vol. 50: 91, pl. 34, f. 14, 1907.

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Prof. Newberry remarks of the difficulty of correlating these and other fossil species with the modern species of *Paliurus* which usually has serrate or crenate leaves, and while no new material has been obtained, it seems desirable to place these leaves in the genus *Smilax* which contains many very similar modern leaves. Lesquereux describes two handsome species of *Smilax* from the Dakota Group, both of which are much larger leaves and differ in other respects from the Raritan species.

Occurence.—Locality unknown.

Collections.—New York Botanical Garden.

Sub-Class DICOTYLEDONAE.

Order MYRICALES.

Family MYRICACEÆ.

Genus MYRICA Linné.

(Sp. Pl., 1753, p. 1024.)

MYRICA HOLLICKI Ward.

Plate X, Fig. 6.

Myrica Hollicki Ward, Amer. Jour. Sci., vol. 45: 437, 1893.
Hollick, Mon. U. S. Geol. Surv. vol. 50: 53, *pl. 7, f. 24*, 1907.
Berry, Bull. Torrey Club, vol. 36: 249, *pl. 18, f. 2*, 1909.
Myrica grandifolia Hollick, Trans. N. Y. Acad. Sci., vol. 12: 5, *pl. 3, f. 1*, 1892. (non Schimper, 1872).

Description.—Leaves of large size, 18 cm. to 22 cm. in length by 4 cm. to 6 cm. in width, broadly lanceolate in outline, widest near the middle and tapering equally to the acuminate apex and the cuneate base. Margins entire for a short distance above the base, elsewhere sharply serrate. Petiole long and stout. Midrib also stout. Secondaries slender, very numerous, being not more than 2 mm. to 3 mm. apart, branching from the midrib at

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angles of 45° or slightly more, subdividing and inosculating near the margin and sending branches into the marginal teeth.

The type of this exceedingly handsome species is a single incomplete specimen, collected at Tottenville, Staten Island, sixteen or more years ago, and now preserved in the Museum of the Staten Island Association of Arts and Sciences. A single specimen was collected from the lower Raritan at Milltown. It is a larger, slightly broader leaf with slightly less prominent teeth, but is obviously identical with the type.

Occurence.—Milltown.

Collections.—U. S. National Museum.

Myrica emarginata Heer.

Plate X, Fig. 5.

Myrica emarginata Heer, Fl. Foss. Arct. vol. 6, ab. 2: 66, *pl. 41, f. 2,* 1882.
Lesq., Fl. Dakota Group, 67, *pl. 12, f. 1,* 1892.
Newb., Fl. Amboy Clays, 62, *pl. 41, f. 10, 11,* 1896.

Description—"M. foliis oblongis, integerrimis, apice emarginatis, basi attenuatis, nervis secundariis subtilissimis." Heer 1882.

The Raritan leaves referred to this species by Prof. Newberry are not quite typical of this species, being somewhat more elongate and lacking the strictly obovate outline shown in the Atane leaves and those from the Dakota group. Recent collections of this species from the southern Coastal Plain also depart from the Raritan leaves in the direction of the type.

The Raritan leaves are 5.5 cm. to 7 cm. in length and 1.8 cm. to 2.5 cm. in breadth, oblong lanceolate in outline and entire, with a strongly emarginate apex and cuneate, narrowly descending base. Secondaries thin, 8 to 10 pairs, branching from the midrib at an angle of about 45°, curving upward, camptodrome.

Occurrence—Locality unknown.

Collections—N. Y. Botanical Garden.

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MYRICA NEWBERRYANA Hollick.

Plate X, Fig. 2.

Myrica Newberryana Hollick in Newb., Fl. Amboy Clays, 63, *pl. 42, f. 5,* 1896.

Description.—Leaves small, lanceolate in outline, about 2.5 cm. long by 0.8 cm. in greatest width. Apex obtusely pointed. Base apparently acute. Margin entire for one-third of the distance above the base, the remainder with somewhat irregular, rounded, dentate teeth. Venation fine but distinct. Secondaries numerous, 7 or 8 pairs, sub-opposite, camptodrome.

This species is based on a few fragmentary specimens from the upper Raritan, of which the leaf figured is the most complete. It is apparently quite distinct from the other members of the Raritan flora.

Occurrence.—South Amboy, Milltown.

Collections.—N. Y. Botanical Garden.

MYRICA FENESTRATA Newb.

Plate X, Fig. 3.

Myrica fenestrata Newb., Fl. Amboy Clays, 63, *pl. 42, f. 32,* 1896.

Description.—Leaf lanceolate in outline, equally pointed at both ends, 5 cm. to 6 cm. in length by 1.4 cm. in greatest width. Margin slightly undulate. Midrib strong. Secondaries stout, numerous, regularly alternate, branching from the midrib at a wide angle, nearly 90°, and running straight almost to the margin where their ends are joined by flat arches, somewhat suggestive of a *Ficus* or a *Eucalyptus.*

This species was based on a single incomplete specimen, and only two additional fragments have been found in the later collections. While its inclusion in the genus *Myrica* is not above question, it seems closer to this type than to any other which has sug-

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gested itself, and as a distinct type of Raritan plant it deserves a place in any enumeration of the Raritan flora.

Occurrence.—Sayreville, Milltown.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

Myrica cinnamomifolia Newb.

Plate X, Fig. 7.

Myrica cinnamomifolia Newb., Fl. Amboy Clays, 64, *pl. 22, f. 9–14*, 1896.

Description.—Leaves of medium size, elliptical in outline, pinnately lobate or panduriform. Lobes obtusely rounded, separated by shallow rounded sinuses of variable width or the margin may be strongly undulate with two or three broad scallops, or one margin may be lobate and the other scalloped. Apex obtusely pointed. Base pointed, slightly decurrent. Petiole stout, 2.5 cm. in length. Leaves very variable in size and outline, ranging from 4.5 cm. to 7.5 cm. in length by 2 cm. to 4 cm. in breadth. Basal half or one-third of the leaf entire, this feature with the ascending opposite basal secondaries giving fragmentary specimens the appearance of a *Cinnamomum* or a *Sassafras*. Midrib mediumly stout. Secondaries few, not more than 2 or 3 pairs, branching from the midrib at an acute angle, curved, indifferently camptodrome and craspedodrome; the basal pair are subopposite branching from the midrib a short distance above the base and curving upward; they traverse ⅓ or ½ the distance to the apex ending in the tip of the lowest lobe or camptodrome, this variability in their course is well shown in the specimen figured; the other secondaries may be alternate or sub-opposite, and they may end in a lobe or not; the second one is a considerable distance above the basal pair, as much as 2.5 cm. in one specimen, and it subtends a somewhat wider angle with the midrib.

These curious leaves are not uncommon, but are mostly incomplete. Professor Newberry has figured several, which clearly show their variable nature. The latter author was not at all

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certain of their relation with *Myrica* and was inclined to associate them with the triple-veined leaves of some Lauraceous genus such as *Cinnamomum,* although the latter are entire as a rule. *Cinnamomum membranaceum* (Lesq.) Hollick has a lateral sinus on each side, but is obviously a triple-veined leaf, while the present species, despite its appearance, is pinnately veined, as is well shown in a number of the specimens.

Occurrence.—Woodbridge, South Amboy.

Collections.—N. Y. Botanical Garden.

MYRICA ACUTA Hollick.

Plate X, Fig. 1.

Myrica acuta Hollick in Newb., Fl. Amboy Clays, 65, *pl. 42, f. 35,* 1896.

Description.—Leaves small, lanceolate in outline, about 3 cm. in length by 1 cm. in width. Apex and base about equally and acutely pointed. Margin entire in the basal half of the leaf, above with somewhat remote and irregularly placed, sharp, denticulate teeth. Secondaries about six pairs, alternate, branching from the midrib at a wide angle and running nearly straight to within a short distance of the margin, where they bend sharply upward and arch to join the secondary next above. These arches are approximately parallel with the margin and give the appearance of a continuous marginal vein. Branches from these arches enter the marginal teeth.

This species, while based upon fragmentary material, is well marked and quite distinct from any other member of the Raritan flora. Prof. Newberry failed to leave any memorandum of the locality from which it was collected, and no subsequent specimens have been discovered.

Occurrence.—Locality unknown.

Collections.—N. Y. Botanical Garden.

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MYRICA RARITANENSIS Hollick.

Plate X, Fig. 4.

Myrica raritanensis Hollick in Newb., Fl. Amboy Clays, 65, *pl. 42, f. 34,* 1896.

?*Phyllites obscura* Hollick in Newb., Ibid., 131, *pl. 42, f. 33,* 1896.

Description.—Leaves small, ovate in outline, about 3 cm. long by 1.3 cm. wide, broadest near the middle and tapering equally in both directions. Apex presumably acute. Base cuneate, acute. Margin entire in the lower half of the leaf, coarsely dentate above. Venation obscure, only a few pairs of thin secondaries being visible.

The form described by Hollick as *Phyllites obscura* is probably an abnormal leaf of this species, and is here included under it with a query. Species based on single specimens from unknown localities and with affinities undeterminable are of little value unless they serve as horizon markers, which this *Phyllites* does not, so that it is desirable from every point of view to make the foregoing disposition of it.

Occurrence.—Locality unknown.

Collections.—N. Y. Botanical Garden.

Genus COMPTONIA Banks.

(Gaertn. Fr. & Sem., vol. II, 1791, p. 58, pl. xc.)

COMPTONIA MICROPHYLLA (Heer) Berry.

Rhus microphylla Heer, Fl. Foss. Arct., vol. 3, ab. 2: 117, *pl. 32, f. 18,* 1874.

Myrica (Comptonia) parvifolia Heer, Ibid., vol. 7: 77, *pl. 71,* f. *12,* 1883.

Myrica (Comptonia) parvula Heer, Ibid., 20, *pl. 55, f. 1–3.* Newb., Fl. Amboy Clays, 63, *pl. 19, f. 6,* 1896.

Comptonia microphylla Berry, Amer. Nat., vol. 40: 508, *pl. 4, f. 1, 3, 4,* 1906.

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Description.—Leaves variable in size, 1.1. cm. to 5 cm. in length by 0.4 cm. to 2 cm. in breadth, ovate lanceolate in outline with an obtusely pointed apex and a cuneate, slightly decurrent base. Margin divided into from 2 to 4 slightly aquiline, rounded, obtusely pointed lobes, the intervening rounded sinuses cut about half way to the midrib. Secondaries craspedodrome, one to each lobe. In the larger leaf there is a second secondary some distance below the one which traverses one of the lobes, and, while this is not visible throughout its length, it was probably camptodrome as in the leaves of the modern *Comptonia*.

It is difficult to understand on what ground Prof. Heer founded his two species *parvula* and *parvifolia* unless it was because they were supposed to have come from different geological horizons. He compares both to the European *Comptonia œningensis* Al. Br., although their resemblance to that species, as a matter of fact, is not very close. The two are exactly similar, as is the *Rhus* included in the foregoing synonymy, except as to size. The Raritan specimen which Newberry identified as *parvula* is closer to *parvifolia,* which fact is noted by the latter author, who presumably hesitated to refer a Cretaceous leaf to a species of the Miocene, as these Arctic deposits were thought to be at that time. The writer has elsewhere (loc. cit.) called attention to the probability of Heer's specimens having come from practically the same horizons, so that there are no valid reasons for maintaining their fancied distinctness.

The earliest leaves of the modern *Comptonia peregrina* (Linné) Coulter usually are very similar to this fossil species. These latter might be considered as the abbreviated leaves, so common in seedling plants and hence without phylogenetic meaning, or they may be considered as representing the normal leaves of these ancient Comptonia plants. The first assumption seems doubtful, not only because of the perishable nature of seedling leaves in general, but because it is unusual for them to become detached and fossilized, and it would be a rather singular coincidence for this to have occurred in New Jersey, Greenland, and Europe only once and at the same geological horizon. Furthermore, no other species of *Comptonia* are known from either the Raritan clays, or the Atane and Patoot schists, from which they

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could have been derived. It would seem that the conclusion is reasonable that these are the normal leaves of the earliest known Comptonias, and that the modern seedling leaves are truly atavistic.

The remains of this species are scanty, the Raritan occurrence being based on a single specimen, and all are very similar to the contemporaneous *Comptonia antiqua* Nilsson, described about seventy-five years ago from Sweden.

Occurrence.—Sayreville.

Collections.—N. Y. Botanical Garden.

Order JUGLANDALES.

Family JUGLANDACEÆ.

Genus JUGLANS Linné.

(Sp. Pl., 1753, p. 997.)

JUGLANS ARCTICA Heer.

Juglans arctica Heer, Fl. Foss. Arct., vol. 6, Ab. 2: 71, *pl. 40, f. 2; pl. 41, f. 4c; pl. 42, f. 1–3; pl. 43, f. 3,* 1882.
Lesq., Fl. Dak. Group, 68, *pl. 19, f. 3; pl. 39, f. 5,* 1892.
Newb., Fl. Amboy Clays, 62, *pl. 20, f. 2,* 1896.
Hollick, Ann. N. Y. Acad. Sci., vol. 11: 58, *pl. 3, f. 7,* 1898.
Berry, Ann. Rep. State Geol. (N. J.) for 1905; 139, *pl. 21, f. 1,* 1906; Bull. Torrey Club, vol. 33: 170, 1906.
Hollick, U. S. Geol. Survey. Mon. 50: 54, *pl. 9, f. 6–8,* 1907.
Ficus atavina Hollick, Trans. N. Y. Acad. Sci., vol. 11: 103; *pl. 4, f. 5,* 1902.

Description.—"I nuce ovali, 34 mm. longa, 17 mm. lata; foliis magnis, foliolis ovalibus, basi inæquilateralibus, integerrimis, nervo medio valido, nervis secundariis angulo semirecto egredientibus, curvatis." Heer, 1882.

The leaves of this species vary considerably in size and outline, which might be expected in the present genus. Heer's type ma-

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terial is somewhat imperfect and in some cases it is difficult to distinguish it from some of the forms referred to the same author's *Juglans crassipes*, although the latter is on the whole a much larger form with a narrower base and less oblong in outline.

Juglans arctica is oblong-ovate in outline with an obtusely pointed apex and a rounded, generally inequilateral base. The petiole and midrib are stout. Secondaries numerous, well marked, parallel, camptodrome. Size varying in complete specimens from 9 cm. to 15 cm. in length and from 3 cm. to 6 cm. in width. The single, nearly-perfect leaf found in the Raritan at Woodbridge, which Newberry provisionally refers to this species, is about 15 cm. in length by 5 cm. in breadth, oblong-ovate in outline, with a rounded, somewhat inequilateral base, a stout petiole and midrib, about 13 pairs of subopposite to alternate camptodrome secondaries which branch from the midrib at a wide angle. There seems to be little doubt of the correctness of Prof. Newberry's determination.

A nut and catkins are associated with the leaves at the type locality in the Atane beds of Greenland which confirm their reference to this genus. The species has a wide range, having been recorded from Marthas Vineyard, Block Island, Staten Island, New Jersey, North Carolina, South Carolina and Kansas.

Occurrence—Woodbridge.

Collections.—N. Y. Botanical Garden.

Order SALICALES.

Family SALICACEÆ.

Genus POPULUS Linné.

(Sp. Pl., 1753, p. 1034.)

POPULUS APICULATA Hollick.

Plate XI, Fig. 4.

Populus apiculata Hollick, Trans. N. Y. Acad. Sci., vol. 12:4, *pl. 3, f. 2*, 1892; U. S. Geol. Surv. Mon. 50:49, *pl. 7, f. 28, 29*, 1907 (?)

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Smith, Geol. Coastal Plain in Ala., 348, 1894.
Newb., Fl. Amboy Clays, 65, *pl. 15, f. 3, 4*, 1896.
Berry, Bull. Torrey Club, vol. 33: 172, 1906.

Description.—Leaves ovate to orbicular in general outline, 8 cm. to 10 cm. in length by 5 cm. to 7 cm. in width. Apex somewhat abruptly produced into an acuminate tip. Base cuneate to rounded or almost truncate. Margins entire. Petiole comparatively long and stout. Midrib mediumly stout. Secondaries 5 or 6 pairs, subopposite below, alternate above, slender, branching from the midrib at angles of from 45° to 50° and arching upward, camptodrome.

Prof. Newberry compared this species with *Populus hyperborea* Heer and *Populus Berggreni* Heer, but seemed doubtful of its real relation to *Populus*. It is also recorded from Staten and Long Islands, from the Magothy formation of Delaware and from the Tuscaloosa formation of Alabama. In the latter region it is quite common and well illustrates the variability from the narrow to the almost orbicular forms.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

POPULUS ORBICULARIS (Newb.) Berry.

Plate XI, Figs. 5, 6.

Phyllites orbicularis Newb., Fl. Amboy Clays, 130, *pl. 24, f. 7, 8*, 1896.
Populus orbicularis Berry, Bull. Torrey Club, vol. 36: 250, 1909.

Description.—Leaves orbicular in outline, with a very slight emargination at the apex and with a slight decurrence from the rounded base to the apparently short petiole. Length about 5 cm. and breadth usually 2 or 3 millimeters less than 5 cm. Margin entire. Midrib mediumly stout. Secondaries camptodrome, relatively coarser than in the preceding species, about 6 pairs, subopposite; they branch from the midrib at a wide angle, are less curved than in the preceding and inclined to be somewhat flexuous.

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Newberry calls attention to the resemblance of this species to *Populus hyperborea* Heer, but is quite positive that it is not related to *Populus*. The writer does not share this opinion. Unless we are prepared to discard *Populus* for *Phyllites* in a large number of cases, this species should surely be referred to the former genus. It is a remarkable coincidence referred to in the present connection only because of its general interest that the type of Sternberg's genus *Phyllites* was very likely a true *Populus* and that *Phyllites* as a form genus for undeterminable leaves will probably have to be dropped eventually in favor of some other name.

The present species is based upon scanty but perfect material confined to the Sayreville horizon.

Occurrence.—Sayreville.

Collections.—N. Y. Botanical Garden.

Genus SALIX Linné.

(Sp. Pl., 1753, p. 1015.)

SALIX NEWBERRYANA Hollick.

Plate XI, Fig. 2.

Salix Newberryana Hollick in Newb., Fl. Amboy Clays, 68, *pl. 14, f. 2–7*, 1896.

Description.—Leaves lanceolate in outline, 8 cm. to 12 cm. in length, by 1 cm. to 2.5 in breadth, with an elongated acuminate apex and a cuneate or more or less rounded base, petiolate. Margins finely sharp-serrate to within a short distance of the base. Midrib mediumly stout. Secondaries fine, more or less obsolete on the upper surface of the leaf, but well defined on the under side. They are numerous, parallel, branching from the midrib at an angle somewhat over 40°, and sweeping upward in broad curves, camptodrome. Areolation polygonal, relatively coarse.

This species is frequent in the Raritan, but the specimens are mostly incomplete. To the localities enumerated by Prof. New-

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berry, Milltown is added as a result of recent work, showing that this species is present from the bottom to the top of the Raritan formation. It has also been collected by the writer from the Bladen formation of North Carolina.

Occurrence.—Sayreville, Woodbridge, South Amboy, Milltown.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

SALIX LESQUEREUXII Berry.

Salix proteæfolia Lesq., (non Forbes, 1829). Amer. Jour. Sci., vol. 46:94, 1868; Rept. on Clays, N. J., 29, 1878; Cret. Fl., 60, *pl. 5, f. 1–4*, 1874; Cret. & Tert. Fl., 42, *pl. 1, f. 14–16; pl. 16, f. 3*, 1883; Fl. Dakota Group, 49, 1892.

Newb., Fl. Amboy Clays, 66, *pl. 18, f. 3, 4*, 1896.

Kurtz, Revista Mus. La Plata, 10:51, 1902.

Berry, Bull. Torrey Club, vol. 33:171, *pl. 7, f. 2*, 1906; Ann. Rept. State Geol. (N. J.) for 1905, 139, 1906.

Salix proteæfolia longifolia Lesq., Fl. Dakota Group, 50, *pl. 64, f. 9*, 1892.

Proteoides daphnogenoides Newb., Fl. Amboy Clays, 72 (pars.) *pl. 32, f. 11*, 1896 (non *f. 13, 14*).

Dewalquea groenlandica Newb., 129 (pars.), *pl. 41, f. 12* (non *f. 2, 3*).

Salix Lesquereuxii Berry, Bull. Torrey Club, vol. 36:252, 1909.

Description.—Leaves ovate-lanceolate in outline, somewhat more acuminate above than below, variable in size, ranging from 6 cm. to 12 cm. in length, and from 1.1 cm. to 2. 2. cm. in greatest width, which is usually slightly below the middle. Petiole, stout, much longer than in *Salix flexuosa*, ranging up to 1.2 cm. in length. Midrib stout below, tapering above. Secondaries numerous, sometimes as many as 20 pairs; they branch from the midrib at angles of about 45° and are parallel and camptodrome.

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Unfortunately, the name given this species was used for another by Forbes in 1829, so that it becomes necessary to rename it, and no name can be more appropriate than that of its distinguished describer, Leo Lesquereux, for whom it is here named.

This is an exceedingly variable species, as might be expected in a *Salix*, and Lesquereux established several varieties, of which at least one, *i. e. linearifolia,* is referable to *Salix flexuosa* Newb. Some of Lesquereux's forms are distinguishable with difficulty from the latter, and this is especially shown in the leaves which he figures on Plate 1 of his Cretaceous and Tertiary Flora. They are, however, larger and somewhat more robust, of a thicker texture and broadest near the base, from which they taper upward to an exceedingly acuminate tip. In general, *Salix Lesquereuxii* is a relatively much broader, more ovate form with more numerous and better seen secondaries and a longer petiole. It is a characteristic Cenomanian species in both the east and the west, and has even been reported from the Cretaceous of Argentina, by Kurtz (loc. cit.). It is abundant in the Raritan formation, both in the lower and upper beds.

Occurrence.—Sayreville, Woodbridge, South Amboy.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

Salix flexuosa Newb.

Salix flexuosa Newb., Later Ext. Floras, 21, 1868; Ill. Cret & Tert. Plants, *pl. 1, f. 4,* 1878; U. S. Geol. Surv. Mon. 35: 56, *pl. 2, f. 4; pl. 13, f. 3, 4; pl. 14, f. 1,* 1898.

Berry, Ann. Rept. State Geol. (N. J.) for 1905: 145, 1906; Bull. Torrey Club, vol. 33: 171, 1906.

Salix proteæfolia linearifolia Lesq., Fl. Dakota Group, 49, *pl. 64, f. 1–3,* 1892.

? Hollick, U. S. Geol. Surv. Mon. 50: 52, *pl. 8, f. 12,* 1907.

Salix proteæfolis flexuosa (Newb.) Lesq. loc. cit., 50, *pl. 64, f. 4, 5,* 1892.

Hollick, Bull. Torrey Club, vol. 21: 50, *pl. 174, f. 5,* 1894; Ann. N. Y. Acad. Sci., vol. 11: 59, *pl. 4, f. 5a,* 1898; U. S. Geol. Surv. Mon. 50: 51, *pl. 8, f. 5, 6a; pl. 37, f. 8b,* 1907.

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Berry, Bull. N. Y. Bot. Garden, vol. 3: 67, *pl. 48, f. 12; pl. 52, f. 2,* 1903.

Description.—Leaves narrow, linear-lanceolate in outline, equally pointed at the apex and base, short petioled, ranging from 5 cm. to 10 cm. in length and from 8 mm. to 13 mm. in width. Margins entire. Midrib stout below, tapering above, usually somewhat flexuous. Secondaries more or less remote, about 10 alternate pairs, branching from the midrib at angles varying from 35° to 45°, camptodrome, of fine calibre and often obsolete.

This species was described by Newberry in 1868 from the Dakota Group. Lesquereux in his Flora of the Dakota Group makes it one of the varieties of his *Salix proteæfolia,* but it is obviously entitled to independent specific rank. It has not heretofore been known from the Raritan formation, but is found to be sparingly represented in the Upper beds at South Amboy. It is pre-eminently a species which characterizes the Magothy and allied formations from Marthas Vineyard to Alabama, being especially abundant in New Jersey and Maryland.

Occurrence.—South Amboy.

Collections.—U. S. National Museum.

Salix raritanensis Berry.

Salix membranacea Newb. (non Thuill, 1799) Later Ext. Floras, 19, 1868; Fl. Amboy Clays, 66, *pl. 29, f. 12,* 1896; U. S. Geol. Surv., Mon. 35: 59, *pl. 2, f. 5–8a,* 1898.

Hollick, Mon. U. S. Geol. Surv., vol. 50: 50, *pl. 8, f. 10,* 1907 (f. 23 ?).

Salix raritanensis Berry, Bull. Torrey Club, vol. 36: 250, 1909.

Description.—Leaves broadly lanceolate in outline, often unsymmetrical, large, petiolate. Length about 13 cm. and breadth at the widest part, which is toward the base, about 3 cm. Base rounded and obtuse. Apex narrowed and acute. Texture smooth and thin. Midrib slender, somewhat curved. Secondaries remote, branching from the midrib at an angle of 45° and curving upward in parallel courses, camptodrome.

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This is another species of *Salix* which it is difficult to define with precision. If the emphasis is laid upon the large size, thin texture, and rounded base, we have characters which are easily recognized and which can be made constant by elimination. It is apparently common in the lower Raritan and has been reported by Hollock (loc. cit.) from Marthas Vineyard, the latter horizon probably of Magothy age. I have queried the small leaf figured by Hollick from Kreischerville, Staten Island, as it seems to be different, although it may be only a small leaf of this species. The latter author has tentatively included *Salix mattewanensis* Berry, which comes from the Magothy formation at Cliffwood, N. J., under this species. This is, in the writer's judgment, perfectly distinct and represents a much smaller, less elongated leaf, of a different consistency and venation.

Unfortunately the original name *Salix membranacea* is preoccupied, so that it becomes necessary to propose a new name, *raritanensis* being here suggested.

Occurrence.—Sayreville, Woodbridge, Milltown.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

SALIX INÆQUALIS Newb.

Plate XI, Fig. 3.

Salix inæqualis Newb., Fl. Amboy Clays, 67, *pl. 16, f. 1, 4, 6; pl. 17, f. 2–7,* 1896.

Hollick, Ann. N. Y. Acad. Sci., vol. XI: 419, *pl. 38, f. 4a,* 1898.

Description.—Leaves elongate-lanceolate in outline, 7 cm. to 12 cm. in length by 1 cm. to 2 cm. in breadth, generally broadest near the base and tapering upward to a long, narrow, acuminate tip. Base cuneate. A long curved petiole sometimes present. Midrib slender, flexuous. Secondaries slender, numerous, branching from the midrib at acute angles and curving upward, camptodrome, sometimes invisible.

These leaves are often unsymmetrical, and their reference to *Salix* is not conclusively established. They are common at the

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Woodbridge locality and are very close to *Salix Lesquereuxii* Berry, which is also present in the Raritan formation and widespread in somewhat later deposits of Magothy and Dakota age or their equivalents. It is possible that these two forms should be united, in fact Hollick in a recent publication[1] tentatively places the Staten Island leaf referred to in the above citation under the latter species. However, the writer does not feel justified in making a change at the present time. Furthermore the Arrochar locality is probably Raritan in age, while the Block Island and Marthas Vineyard floras are probably of Magothy age.

The whole question of a classification of all the Raritan Salix-like leaves, which will be proper from a botanical standpoint, is beset with the greatest difficulties, so that in the absence of positive assurance the least possible amount of change is desirable.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Salis pseudo-Hayei Berry.

Plate XI, Fig. 1.

Salix sp., Newb., Fl. Amboy Clays, 68, *pl. 42, f. 6–8*, 1896.
Salix pseudo-Hayei Berry, Bull. Torrey Club, vol. 36: 251, 1909.

Description.—Leaves, small, relatively short and broad, ovate-lanceolate in outline, uniformly about 3 cm. in length, by 1.1 cm. to 1.4 cm. in greatest breadth, which is about half way between the apex and base. Apex acuminate. Base rounded. Margin entire. Petiole short. Midrib slender and slightly curved. Secondaries fine, obscured in some specimens, 5 or 6 pairs, alternate, camptodrome; they branch from the midrib at an angle of about 45° and curve upward.

This species is not uncommon in the Raritan, although Prof. Newberry fails to mention the exact localities from which he collected it. Later, material has come from the lower Raritan, at Milltown. It has been compared with the Dakota group

[1] Hollick, Mon. U. S. Geol. Survey, vol. L., 1907, p. 52.

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species, *Salix Hayei* Lesq., and with the Arctic Tertiary, *Salix Rœana,* Heer, both of which it resembles in general appearance, The Dakota group leaf, however, is coriaceous, with a coarse venation, blunt apex and more narrow pointed base, and is seen to be quite different from the Raritan species when careful comparisons are made.

Occurrence.—Milltown.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

Order FAGALES.

Family FAGACEÆ.

Genus QUERCUS Linné.

(Sp. Pl., 1753, p. 994.)

QUERCUS RARITANENSIS Berry.

Quercus Johnstrupi Newb., Fl. Amboy Clays, 69, *pl. 19, f. 7,* 1896 (Non Heer).

Quercus raritanensis Berry, Bull. Torrey Club, vol. 36: 249, 1909.

Description.—Leaves ovate in outline, subcoriaceous, apparently about 8 cm. or 9 cm. in length, by 4.5 cm. in width, pointed above. Margin with coarse pointed teeth separated by rounded sinuses.

The New Jersey occurrence of this species is based on the single obscure fragment of the terminal half of a leaf figured by Prof. Newberry and correlated with *Quercus Johnstrupi* Heer, a Greenland species.

The New Jersey form is obviously not the same as Heer's, which has pointed instead of rounded sinuses, and is a smaller, more *Myrica*-like leaf, with the marginal teeth dentate rather than serrate.

The present species considerably resembles an undescribed *Quercus* from the Cretaceous of North and South Carolina, but this resemblance cannot be construed as a proof of identity

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because of the incompleteness of the New Jersey material, consequently the present form is here renamed in allusion to the horizon from which it was collected.

Occurrence.—Sayreville.

Collections.—N. Y. Botanical Garden.

Order URTICALES.

Family ULMACEÆ.

Genus PLANERA Gmelin.

(Syst., vol. II, pt. i, 1891, p. 150.)

PLANERA KNOWLTONIANA Hollick.

Planera Knowltoniana Hollick in Newb., Fl. Amboy Clays, 69, *pl. 42, f. 1–4,* 1896.

Description.—Leaves ovate in outline, broadest toward the base, 2.5 cm. to 5 cm. in length, by 1 cm. to 2 cm. in breadth, with an obtusely pointed apex and a rounded, pointed base. Margin entire below for a short distance, elsewhere coarsely serrate. Midrib thin, somewhat flexuous. Secondaries numerous, 6 to 8 pairs, parallel, fine, not much curved; they branch from the midrib at an acute angle, being either opposite or alternate, and terminate in the marginal teeth. Lateral branches from toward the tips of some of the secondaries terminate in the intervening teeth.

This species is frequent at the Woodbridge locality, but is rather poorly preserved, as is so often the case with the more delicate leaves of the smaller Ulmaceæ. It is very typical of the leaves of this family in general outline, marginal and venation characters, and could be compared with a number of later species of *Planera.* It is quite distinct, however, from the species of *Planera* recently described by the writer from the Bladen formation of North Carolina.[1]

[1] Berry, Bull. Torrey Club, vol. 34, 1907, p. 193, pl. 11, f. 7, 8.

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Occurrence.—Woodbridge.
Collections.—N. Y. Botanical Garden.

Family MORACEÆ.

Genus FICUS Linné.

(Sp. Pl., 1753, p. 1059.)

FICUS MYRICOIDES Hollick.

Ficus myricoides Hollick in Newb., Fl. Amboy Clays, 71, *pl. 32, f. 18; pl. 41, f. 8, 9,* 1896; U. S. Geol. Surv., Mon. 50: 57, *pl. 11, f. 8, 9,* 1907 (?) (non-Ward, 1906).

Description.—Leaves narrowly lanceolate in outline, with the maximum dimensions of 2 cm. in width by 10 cm. in length, but sometimes considerably smaller. Margin entire. Apex bluntly rounded. Midrib mediumly stout, straight. Secondaries numerous, about 2 mm. apart, straight and parallel, diverging from the midrib at angles of about 45°, or slightly more, branching to form polygonal areoles near the margin.

This species is not conclusively allied to *Ficus,* nor is it especially well known since the specimens are all fragmentary. It is also recorded by Hollick from Glen Cove, Long Island, and Gay Head, Marthas Vineyard, and by Fontaine and Ward from the Patapsco formation of Maryland. It is probable, however, that some of the remains that have been referred to this species are not related to the type material. This is especially true of the Long Island and Marthas Vineyard leaves which are larger and which suggest to the writer some of the many species of *Magnolia* identified by Dr. Hollick in the insular deposits. The supposed Patapsco occurrence is based on leaf fragments of *Sapindopsis.*

Occurrence.—Milltown.
Collections.—N. Y. Botanical Garden.

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FICUS DAPHNOGENOIDES (Heer) Berry.

Plate XII, Fig. 4.

Protoides daphnogenoides Heer, Phyll. Crét. d. Nebr. 17, *pl. 4, f. 9, 10,* 1866.

Lesq., Cret. Fl., 85, *pl. 15, f. 1, 2,* 1874; Fl. Dakota Group, 90, 1892.

Hollick, Trans. N. Y. Acad. Sci., vol. 11:98, *pl. 3, f. 1, 2,* 1892; Ibid., vol. 12:36, *pl. 2, f. 4, 9, 13,* 1893; Bull. Torrey Club, vol. 21:52, *pl. 177, f. 1,* 1894; U. S. Geol. Surv., Mon. 50:59, *pl. 12, f. 1–5,* 1907.

Smith, Geol. Coastal Plain in Ala., 348, 1894 (determined by Ward).

Newberry, Fl. Amboy Clays, 72, *pl. 17, f. 8, 9; pl. 32, f. 11, 13, 14; pl. 33, f. 3; pl. 41, f. 15,* 1896.

Gould, Am. Jour. Sci. (IV), vol. 5, 175, 1898 (determined by Ward).

Berry, Bull. N. Y. Bot. Garden, vol. 3:74, *pl. 51, f. 6–9,* 1903.

Ficus proteoides Lesq., Fl. Dakota Group, 77, *pl. 12, f. 2,* 1892.

Ficus daphnogenoides Berry, Bull. Torrey Club, vol. 32:327, *pl. 21,* 1905; Ibid., vol. 33:173, *pl. 7, f. 5,* 1906; Ibid., *vol.* 34:194, *pl. 11, f. 10, 11,* 1907.

Eucalyptus ? attenuata Newb., Fl. Amboy Clays, *pl. 16, f. 5* (non *f. 2, 3*) 1896.

Description.—"Les feuilles sont coriaces, à la base atténuées, entières; la nervure médiane est forte; elle porte deux nervures secondaires faibles, acrodromes, qui sont presque paralléles au limbe; mais elles ne sont pas opposées, comme chez les Daphnogene et Cinnamomum." Heer, 1866.

This species was described by Heer from the Dakota group of Nebraska and was based upon very incomplete material. His specimens have some long ascending secondaries, but Lesquereux's more complete specimens from the same horizon and region show that these secondaries were not acrodrome, but camptrodone. The species in this feature and also in other

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respects differs from *Protea* and its allies, which are more coriaceous, with the secondaries branching at acute angles and massed toward the often-apetiolate base. Compared with the genus *Ficus*, it is found to closely resemble a number of different species from such widely separated localities as Central and South America and the Celebes. Especially among the Mexican and Central American forms are very similar leaves seen, e. g., *Ficus fasciculata* Watson, *Ficus lancifolia* Hook and Arn., *Ficus ligustrina* Kunth and Bouché and *Ficus sapida* Miq., especially the latter, which has much the same outline and consistency, the same prominent midrib and the same venation. Placed in the genus *Ficus* where these fossil forms properly belong, they find their affinity in the group which includes, among others, such species as *Ficus elongata* Hosius, *Ficus Berthoudi* Lesq., *Ficus suspecta* Velen., *Ficus Krausiana* Heer, etc.

This species has been found to be quite variable in size, ranging in length from 11 cm. to 22 cm. and in breadth from 1.9 cm. to 3.7 cm. It is usually widest in the lower half of the leaf, although sometimes the base is quite narrow and the widest part is toward the middle. In all unequivocal material the upper half of the leaf is narrow and is produced as a long, slender, often recurved tip, which is one of the characteristic features of the species.

It is a widespread and common form ranging from Marthas Vineyard to Alabama in Eastern North America, and from Northwest Territory to Kansas and Nebraska in the west, and serves to ally the Raritan formation with somewhat later beds elsewhere.

Occurrence.—Sayreville, Woodbridge, Milltown, South Amboy.

Collections.—U. S. National Museum, N.Y. Botanical Garden.

FICUS OVATIFOLIA Berry.

Pate XII, Fig. 3.

Ficus ovata Newb., Fl. Amboy Clays, 70, *pl. 24, f. 1–3*, 1896.
Ficus Woolsoni Berry, Bull. Torrey Club, vol. 34: 194, *pl. 12, f. 1*, 1907.
Ficus ovatifolia Berry, Bull. Torrey Club, vol. 36: 253, 1909.

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Description.—Leaves ovate in outline, 8 cm. to 13 cm. in length by 4 cm. to 7 cm. in breadth, petiolate. Apex extended, acute. Base rounded or somewhat descending. Margins entire. Principal veins 3, from the base, the midrib being the stoutest and slightly flexuous. The lateral veins diverge at angles of about 45° and curve upward, traversing somewhat more than the basal half of the leaf and connecting with branches from the lowest pair of camptodrome secondaries of which there are several alternating pairs which branch from the midrib at a wider angle. The laterals give off on the outside 8 to 10 camptodrone veins. Quadrangular areoles formed by nearly straight transverse nervilles fill all of the intervening space.

This species is very close to the same author's *Ficus Woolsoni*, which is a much less elongated comparatively broader leaf, often with a cordate base in consequence.

The very appropriate name *ovata* is antedated by *Ficus ovata* Don (1802–03), so that it becomes necessary to rename the Raritan species.

Occurrence.—Woodbridge, Milltown.

Collections.—N. Y. Botanical Garden.

FICUS WOOLSONI Hollick.

Plate XII, Figs. 1, 2.

Ficus Woolsoni Hollick, Trans. N. Y. Acad. Sci., vol. 12: 33, *pl. 2, f. 1, 2c,* 1892; Ann. N. Y. Acad. Sci., vol. 11: 419, *pl. 37, f. 9,* 1898; U. S. Geol. Surv., Mon. 50: 59, *pl. 11, f. 5, 6,* 1907.

Smith, Geol. Coastal Plain in Ala., 348, 1894.

Newb., Fl. Amboy Clays, 70, *pl. 20, f. 3; pl. 23, f. 1–6,* 1896.

Berry, Bull. N. Y. Bot. Garden, vol. 3: 74, *pl. 47, f. 7,* 1903; Bull. Torrey Club, vol. 33: 172, 1906; Ann. Rept. State Geol. (N. J.) for 1905; 139, 1906.

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Description.—Leaves broadly ovate to cordate in outline, 7 cm. to 10 cm. in length by 6 cm. to 10 cm. in breadth, with an acute apex and a cordate to a rounded slightly decurrent base. Margin entire. Principal veins 3, the midrib being the stoutest. The laterals branch at a wide angle from the top of the petiole, traversing considerably more than the basal half of the leaf and joining the camptodrome secondaries above; they give off on the outside numerous camptodrome branches, the lowest of which sometimes branch from their extreme base, giving basal fragments of these leaves the appearance of *Hedera primordialis* Sap.

As previously pointed out, this species has many points of resemblance to the preceding one, but is decidedly shorter and broader, with a more orbicular outline and a marked tendency toward a cordate base. It was evidently of a more coriaceous texture since the finer venation is obsolete.

It is a much more abundant form in the Raritan formation and enjoys a considerable outside distribution, being recorded from Staten Island and from the Tuscaloosa formation in Alabama. It is also present in the Magothy formation. Both this and the preceding represent a type of *Ficus* very abundant in the Upper Cretaceous of the Western Interior region of the United States.

Occurrence.—Sayreville, Woodbridge, Hylton Pits.

Collections.—N. Y. Botanical Garden.

Order PROTEALES.

Family PROTEACEÆ.

Genus PERSOONIA Swartz.

(Trans. Linn. Soc. Lond., vol. IV, 1798, p. 215.)

PERSOONIA SPATULATA Hollick.

Persoonia spatulata Hollick in Newb., Fl. Amboy Clays, 71, *pl. 42, f. 14,* 1896.

Description.—Leaf obovate-spatulate in outline, with an entire margin, 3.4 cm. in length, by about 1 cm. in breadth, widest to-

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ward the broadly rounded apex and tapering downward to the cuneate base. Midrib slender. Secondaries numerous, close, fine, branching from the midrib at an acute angle which is very narrow in the basal part of the leaf, nearly straight and comparatively long, apparently camptodrome.

This species was based on the single specimen figured by its author and no additional material has since come to light. It seems to be generically identical with *Persoonia Lesquereuxii* Knowlton, a much commoner form which is relatively shorter and broader and of a less delicate texture and habit. Its relation to the genus *Persoonia* is entirely problematical.

Occurrence.—South Amboy.

Collections.—N. Y. Botanical Garden.

PERSOONIA LESQUEREUXII Knowlton.

Plate XX, Fig. 6.

Persoonia Lesquereuxii Knowlton in Lesq., Fl. Dakota Group, 89, *pl. 20, f. 10–12,* 1892.
Newb., Fl. Amboy Clays, 71, *pl. 42, f. 16,* 1896.
Berry, Bull. Torrey Club, vol. 33: 173, 1906.
Andromeda latifolia Newb., Fl. Amboy Clays, 120 (pars.), *pl. 33, f. 9,* 1896 (non *f. 6–8, 10*).

Description.—Leaves obovate in outline, with a broadly rounded apex, sub-emarginate in one of the Dakota group specimens, gradually narrowing to the decurrent base. Varying from 1.7 cm. to 5 cm. in length by 1.2 cm. to 2.5 cm. in greatest width, which is toward the apex. Petiole stout. Texture subcoriaceous. Secondaries sparse, 3 or 4 pairs, thin, alternate, branching from the stout midrib at an acute angle, about 25°, camptodrome.

This species, which was described originally from the Dakota group, of Kansas, is somewhat variable in appearance. Hollick referred a small almost orbicular leaf from the New Jersey Raritan to it, presumably on the basis of its resemblance to Knowl-

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ton's fig. 12. For the same reason the writer is inclined to think that Newberry's pl. 33, fig. 9, which he calls an *Andromeda,* is also referable to this species. Similar obovate leaves are also present in the overlying Magothy formation.

Professor Newberry left no indication of the locality in the Raritan from which this species was collected. It is, however, present in subsequent collections from South Amboy.

Occurrence.—South Amboy.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

Order RANALES.

Family RANUNCULACEÆ (?).

Genus DEWALQUEA Sap. and Mar.

(Essai Végét Marnes Heersiennes de Gelinden, 1874, p. 55.)

DEWALQUEA GROENLANDICA Heer.

Dewalquea groenlandica Heer, Fl. Foss. Arct., vol. 6, Ab. 2: 87, *pl. 29, f. 18, 19; pl. 42, f. 5, 6; pl. 44, f. 11,* 1882; Ibid., vol. 7: 37, *pl. 62, f. 5, 6,* 1883.

Smith, Geol. Coastal Plain in Ala., 348, 1894.

Newb., Fl. Amboy Clays, 129, *pl. 41, f. 2, 3,* (non *f. 12*), 1896.

Hollick, Ann. N. Y. Acad. Sci., vol. 11: 423, *pl. 36, f. 7,* 1898; U. S. Geol. Survey, Mon. 50: 106, *pl. 8, f. 25,* 1907.

Berry, Bull. N. Y. Bot. Garden, vol. 3: 98, *pl. 57, f. 3,* 1903; Bull. Torrey Club, vol. 34: 194, 1907.

Description.—"D. foliis digitato-trifoliolatis, foliolis lanceolatis, integerrimis, basim versus sensim attenuatis; nervo medio valido, nervis secundariis angulo perecuto egredientibus, valde curvatis." Heer, 1882.

The two type figures from Kardlok, Greenland, have very much elongated attenuated bases and the leaflets reach a width of

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2.2 cm. While their distal portions are broken off they were apparently 12 cm. or 13 cm. in length. Subsequently, remains of a similar nature from elsewhere in Greenland were referred by Heer to this species, among them, the only complete leaf (loc. cit. pl. lxii, fig. 6) which shows a blunt apex. It is with this latter specimen that the Raritan leaves show the most marked affinity. The latter are found detached, but are unsymmetrical, as is the case with the leaflets of many trifoliate forms. They have a rather slender midrib and 6 or 8 pairs of very thin ascending camptodrome secondaries, the apex is blunt and the base is attenuated. They are about 7 cm. in length by 1.4 cm. to 1.7 cm. in greatest width. There seems to be little room for doubt but that they are correctly identified.

This species has a wide range, if reliance can be placed on the published records, which include Staten Island, North Carolina and Alabama.

Occurrence.—Locality unknown.

Collections.—N. Y. Botanical Garden.

Dewalquea trifoliata Newb.

Dewalquea trifoliata Newb., Fl. Amboy Clays, 129, *pl. 22, f. 4–7*, 1896.

Description.—Leaves trifoliate. Leaflets linear lanceolate. While the tips are missing on all of the specimens the apex was apparently acuminate. Base cuneate and decurrent, in some instances continued downward and joining that of its fellow leaflets, inequilateral in the lateral leaflets. Size variable, ranging from about 8 cm. to 12 cm. in length and 1.2 cm. to 2 cm. in breadth. Margins entire throughout. Midrib medium, slightly flexuous. Secondaries numerous, thin, more or less obsolete, apparently camptodrome.

A number of specimens, all incomplete, have been collected from the Woodbridge clays and several are figured in Prof. Newberry's monograph. The genus is characteristic of the Upper Cretaceous and Lower Eocene and its botanical affinities are still considered doubtful, although it is usually classed with

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the Ranunculaceæ following the views of Saporta and Marion, who handled a large amount of fine material from the Heersian of Belgium.

The present species has not been recognized outside of the Raritan formation and is perfectly distinct from the wide ranging *Dewalquea groenlandica* Heer.

Occurence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Family MAGNOLIACEÆ.

Genus MAGNOLIA Linné.

(Sp. Pl., 1753, p. 535.)

MAGNOLIA SPECIOSA Heer.

Plate XIV, Fig. 3.

Magnolia speciosa Heer, Neue Denks. Schw. Gesell, vol. 23: 20, *pl. 6, f. 1; pl. 9, f. 2; pl. 10, f. 1*, 1869.

Lesq., Cret. & Tert. Fl., 72, 1874; Fl. Dakota Group, 202, *pl. 60, f. 3, 4*, 1892.

Hollick, Trans. N. Y. Acad. Sci., vol. 12: 234, *pl. 7, f. 4*, 1893; Bull. Torrey Club, vol. 21: 60, *pl. 178, f. 5*, 1894; Bull. Geol. Soc. Amer., vol. 7: 13, 1895; U. S. Geol. Surv., Mon. 50: 64, *pl. 19, f. 1–4*, 1907.

Smith, Geol. Coastal Plain in Ala., 348, 1894.

Knowlton, 21 Ann. Rept. U. S. Geol. Surv., pt. 7, 318, 1901.

Berry, Bull. Torrey Club, vol. 31: 76, *pl. 3, f. 10*, 1904; Ibid., vol. 32: 46, *pl. 2, f. 4, 5*, 1905.

Magnolia auriculata Newb., Fl. Amboy Clays, 75 (pars.), *pl. 41, f. 13; pl. 58, f. 10*, 1896.

Description.—"M. foliis maximis, coriaceis, ovato-ellipticis, apice longe attenuatis, valde acuminatis, basi in petiolum validum attenuatis, nervo primario crasso, nervis secundariis valde curvatis, camptodromis." Heer, 1869.

This species is somewhat variable in size, the American material which is somewhat smaller than the type material from

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Moletein, Moravia, ranging in length from 8.5 cm. to 19 cm., and in width from 4 cm. to 7.5 cm. It is ovate-elliptical in outline with the apex more or less produced and the base decurrent. The midrib and petiole are stout. The secondaries are well marked, camptodrome; they number 7 to 9 pairs, and are subopposite, branching from the midrib at an angle of about 45° and curving upward. The texture is coriaceous.

This species, which was described originally from the Cenomanian of Moravia, has been found to have a wide range in America. Typical leaves occur in the Dakota Group which range southward to Texas. It is present on Marthas Vineyard and Long Island, and in the Magothy formation of New Jersey. While not heretofore reported from the Raritan it would seem as if some of the leaves which Prof. Newberry described as *Magnolia auriculata* should be referred to this species. They range down in size, but this is also true of some of the western leaves of this species. *Magnolia auriculata* was reported by Prof. Ward from the Tuscaloosa formation of Alabama, but all of the specimens so labelled, which have come into the writer's hands for study, are closer to *Magnolia speciosa*, and not one shows any tendency toward an auriculate base which is the main characteristic of the former species. This may, of course, have been a variable feature, as it is to a certain extent in the existing *Magnolia Fraseri* Walt., and *Magnolia macrophylla* Michx., but if it is worth anything at all in the fossils it is worth emphasizing. This is another species which tends to correlate the Raritan with the Cenomanian of Europe.

Occurrence.—Woodbrige.

Collections.—N. Y. Botanical Garden.

Magnolia alternans Heer.

Plate XV Fig. 1.

Magnolia alternans Heer, Phyll. Crét. d. Nebr., 20, *pl. 3, f. 2–4; pl. 4, f. 1, 2,* 1866; Fl. Foss. Arct., vol. 3, ab. 2: 116, *pl. 33, f. 5, 6; pl. 34, f. 4,* 1874; Ibid., vol. 6, ab. 2: 91, *pl. 21, f. 2; pl. 46, f. 21,* 1882.

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Lesq., Cret. Fl., 92, *pl. 18, f. 4,* 1874; Fl. Dakota Group, 201, *pl. 34, f. 11,* 1892.

Velen., Fl. Böhm. Kreidef. Pt. 2: 19; *pl. 6, f. 5; pl. 7, f. 6,* 1883.

Smith, Geol. Coastal Plain in Ala., 348, 1894.

Newb., Fl. Amboy Clays, 73, *pl. 55, f. 1, 2, 4, 6,* 1896.

Hollick, U. S., Geol. Surv., Mon. 50: 67, 1907.

Pollard, Trans. N. Y. Acad. Sci., vol. 13: 181, 1894.

Description.—"M. foliis coriaceis, petiolatis, ellipticis, integerrimis, basi in petiolum attenuatis, nervis secundariis angulo acuto egredientibus, valde curvatis, camptodromis, alternis tenuioribus." Heer, 1866.

This is a rather poorly defined species whose wide range is based for the most part upon very fragmentary material. It is oblong elliptical in outline, 9 cm. to 15 cm. in length by 3 cm. to 7 cm. in breadth, with a stout petiole 5 cm. to 7 cm. in length. Apex pointed. Base cuneate to rounded. Midrib stout. Secondaries stout, separated by tertiaries, camptodrome.

This species was described originally from the Atane beds of Greenland, and it has since been reported outside of the New Jersey area from the Cenomanian of Bohemia, the Dakota Group in Nebraska, Kansas and Minnesota, the Tuscaloosa formation of Alabama and the Raritan (?) of Long Island. As previously mentioned, all of the references in the foregoing synonymy cannot be vouched for as regards correctness of identification.

Occurrence.—Sayreville, Woodbridge.

Collections.—N. Y. Botanical Garden.

Magnolia Boulayana Lesq.

Plate XIV, Fig. 2.

Magnolia Boulayana Lesq., Fl., Dakota Group, 202, *pl. 60, f. 2,* 1892.

Knowlton, 21 Ann. Rept. U. S. Geol. Surv., pt. 7: 318, 1901.

Berry, Bull. Torrey Club, vol. 36: 254, 1909.

Magnolia glaucoides Hollick, Bull. Torrey Club, vol. 21: 60, *pl. 175, f. 1, 7,* 1894; U. S. Geol. Surv., Mon. 50: 67, *pl. 19, f. 6; pl. 20, f. 6,* 1907.

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Smith, Geol. Coastal Plain in Ala., 348, 1894.
Newb., Fl. Amboy Clays, 74, *pl. 57, f. 1–4*, 1896.

Description.—Leaves narrowly elliptical in outline, remarkably uniform in size and shape, 8.5 cm. to 13 cm. in length and 3.5 cm. to 4.5 cm. in breadth. Apex usually bluntly rounded, sometimes acute. Base matching the apex. Petiole mediumly stout, 3 cm. to 4 cm. in length. Midrib mediumly stout. Secondaries slender, often obsolete, about 11 pairs, equidistant, parallel, camptodrome, branching from the midrib at an angle of about 40°. Tertiaries when seen transverse. Texture coriaceous.

This species was described originally from the Dakota Group of Kansas. Professor Newberry described the Raritan remains, which are abundant at the Woodbridge locality, as a new species, and it has been kept distinct by Hollick, who recognized, however, its practical identity with the Dakota Group plant.

There can be no question but that they belong to the same species which is also recorded from Marthas Vineyard and Long Island, and from the Woodbine formation of Texas and the Tuscaloosa formation of Alabama.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Magnolia Isbergiana Heer (?).

Magnolia Isbergiana Heer, Fl. Foss. Arct., vol. 6, abth. 2:91, pl. 36, fig. 3, 1882.
Hollick, Bull. Torrey Club, vol. 21:60, 1894. Mon. U. S. Geol. Surv., vol. 50:66, pl. 20, fig. 4, 1907.

Description.—"M. foliis late ovatis, basi rotundatis; nervis secundariis approximatis, angulo acuto egredientibus, curvatis." Heer, 1882.

This species was described by Professor Heer from the Atane beds of western Greenland and compared with that author's *Magnolia Capellinii*, from which it differs in its thinner and more numerous secondaries and its truncated base. It has also been

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recorded by Hollick from the Cretaceous at Glen Cove, Long Island.

The material from Milltown is fragmentary, as is the type from Greenland and the single specimen from Long Island, so that it is difficult to determine all of its specific characters. In general the leaf is broadly ovate or subelliptical in outline, with a rounded or bluntly pointed apex and a widely truncated base, rounded laterally. Length, 9 cm. to 12 cm. Greatest width, which is at or near the base, 6 cm. to 10 cm. Midrib comparatively slender. Secondaries, 9 or 10 alternate pairs, very thin, branching from the midrib at an acute angle, camptodrome.

This species remotely resembles *Magnolia Capellinii* as has been pointed out by Heer. It also suggests in its general outline and venation characters *Magnolia Lacoeana* of Lesquereux, differing merely in the character of its base.

Occurrence.—Milltown.

Collections.—U. S. National Museum.

Magnolia Newberryi Berry.

Plate XIII.

Magnolia longifolia Hollick, Trans. N. Y. Acad. Sci., vol. 12: 36, *pl. 3, f. 9*, 1892; Ann. N. Y. Acad. Sci., vol. 11: 422, *pl. 37, f. 3*, 1898; U. S. Geol. Surv. Mon. 50: 66, *pl. 20, f. 2, 3*, 1907 (non Sweet, 1826).

Smith, Geol. Coastal Plain in Ala., 348, 1894.

Newb., Fl. Amboy Clays, 76, *pl. 55, f. 3, 5; pl. 56, f. 1–4*, 1896.

Magnolia Newberryi Berry, Bull. Torrey Club, vol. 34: 195, *pl. 13, f. 6*, 1907.

Description.—Leaves mostly of large size, ovate to oblong in outline, about 20 cm. in length by 9 cm. to 10 cm. in breadth, broadest toward the base. Apex sub-acute or obtuse. Base varying from obtusely rounded, almost truncate, to somewhat cuneate. Petiole and midrib stout. Secondaries comparatively thin and open, about 12 pairs, camptodrome. Tertiaries

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forming 4, 5, or 6 sided areoles, quite prominent in some specimens.

This is the largest *Magnolia* of the Raritan, the leaves of which are said by Prof. Newberry to reach a length of 30 cm. or more. It is frequent at the Woodbridge locality and has also been reported from Staten Island and Marthas Vineyard, from the Tuscaloosa formation in Alabama and from the Bladen formation in North Carolina.

In a general way it resembles an immense leaf of *Magnolia woodbridgensis,* and it also approaches somewhat *Magnolia longipes,* but the petiole is only about one-third the length that it is in the latter species.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Magnolia Lacoeana Lesq.

Plate XVI, Fig. 2.

Magnolia Lacoeana Lesq., Fl. Dakota Group, 201, *pl. 60, f. 1,* 1892.
Newb., Fl. Amboy Clays, 73, *pl. 55, f. 1, 2,* 1896.
Hollick, U. S. Geol. Surv. Mon. 50:65, *pl. 17, f. 2,* 1907.

Description.—Leaves broadly oval to almost orbicular in outline, obtuse or abruptly pointed above and rounded to a somewhat cuneate below, 10 cm. to 12 cm. in length, by 8.5 cm. to 9.5 cm. in width. Midrib stout, somewhat flexuous. Secondaries numerous, camptodrome, mediumly stout, 10 to 12 pairs; they branch from the midrib at an acute angle, immediately curving outward, forming festoons near the margin, which is somewhat undulate in one specimen which Prof. Newberry referred to this species.

This species differs from its contemporaries, especially in its nearly round outline; Prof. Lesquereux finds a resemblance to *Magnolia Inglefieldi* Heer from Greenland, and it also suggests some of the Arctic forms which have been referred to *Magnolia Capellini* Heer.

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While this species is reported from such widely separated points as Marthas Vineyard and Kansas, it is nowhere abundant, and is usually poorly preserved, suggesting that the leaves were readily macerated. It also occurs in unreported collections from the Magothy formation in Maryland.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

MAGNOLIA LONGIPES Hollick.

Plate XIV, Fig. 1.

Magnolia longipes Hollick, Bull. Torrey Club, vol. 21: 60, *pl 178, f. 3,* 1894; U. S. Geol. Surv. Mon. 50: 64, *pl. 21, f. 5, 6,* 1907.

Newb., Fl. Amboy Clays, 76, *pl. 54, f. 1–3,* 1896.

Description.—Leaves oblong-ovate in outline, apparently about 18 cm. in length, by 6 cm. or 7 cm. in breadth, which was below the middle. Apex obtusely rounded. Base usually cuneate. Midrib and petiole very stout, the latter unusually long, reaching 12 cm. or 13 cm. in some specimens. Secondaries camptodrome, relatively thin and remote, 10 to 12 pairs, branching from the midrib at an angle of about 45° and soon curving upward to join a branch from the secondary next above. This forms a series of large arches which approximately parallel the margin and constitute one of the distinctive characters of this species, another being the long petiole and the oblong, almost straight-sided, shape.

This was a very striking Magnolia and is frequent in the Raritan at Woodbridge. Fragmentary specimens which have been correlated with these remains are reported from Long Island. It is apparently quite different in appearance from any of the other Cretaceous species of Magnolia, although it suggests somewhat a gigantic form of *Magnolia woodbridgensis.*

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

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MAGNOLIA WOODBRIDGENSIS Hollick.

Plate XV, Fig. 2.

Magnolia woodbridgensis Hollick in Newb., Fl. Amboy Clays, 74, *pl. 36, f. 11; pl. 57, f. 5–7,* 1896; Ann. N. Y. Acad. Sci., vol. 11:60, *pl. 3, f. 2,* 1898. U. S. Geol. Surv. Mon. 50:66, *pl. 20, f. 7,* 1907.

Berry, Bull. N. Y. Bot. Garden, vol. 3:77, *pl. 53, f. 5; pl. 57, f. 2,* 1903.

Description.—Leaves elongate-ovate in outline, 10 cm. to 15 cm. in length by 4 cm. to 6 cm. in greatest breadth, which is toward the base. Apex obtuse. Base rounded. Midrib stout. Secondaries slender, numerous, about 12 pairs, camptodrome, branching from the midrib at a wide angle in some instances approaching 90°. The original description says that the texture is thin, although, according to the writer's observations, it is subcoriaceous, and the venation is often obsolete.

This species is common in the Raritan at the Woodbridge locality, and it has also been recorded from Block Island and from the Magothy formation at Cliffwood bluff.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

MAGNOLIA HOLLICKI Berry.

Plate XV, Fig. 3.

Magnolia Hollicki Berry, Bull. Torrey Club, vol. 36:253, 1909.

Magnolia auriculata Hollick, Bull. Torrey Club, vol. 21:61, *pl. 179, f. 6, 7,* 1894; U. S. Geol. Surv. Mon. 50:67, *pl. 19, f. 5; pl. 20, f. 5, 8,* 1907 (non Lam., 1783).

Smith, Geol. Coastal Plain in Ala., 348, 1894.

Newb., Fl. Amboy Clays, 75, *pl. 58, f. 1–9, 11,* 1896 (non *f. 10*).

Berry, Bull. Torrey Club, vol. 33:174, 1906.

Dicotyledonous leaf impression Hitchcock, Geol. Mass., vol. 2:430, *pl. 19, f. 1* (pars), 1841.

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Description.—Leaves orbicular-ovate in outline, 4 cm. to 10 cm. in length by 2 cm. to 5.5 cm. in width, petiolate. Apex acute, slightly extended in one or two specimens. Base rounded occasionally, usually pronouncedly auriculate. Petiole and midrib stout. Secondaries few, 6 or 7 pairs, sub-opposite, camptodrome. Texture smooth and subcoriaceous.

This magnificent species is abundant and well preserved at the Woodbridge locality and Marthas Vineyard and in the Magothy formation of Maryland. Prof. Newberry was somewhat uncertain as to its relationship with Magnolia and compared it with *Aristolochia, Polygonum* and *Toxylon.* The latter is the only genus which is at all suggestive, and it furnishes no instances of auriculate bases, while this character of a base prevails in more than one modern species of Magnolia. The outline, consistency and venation, are all in accord in pointing to Magnolia as the proper generic reference. This is one of those forms mentioned from Marthas Vineyard by Prof. Hitchcock in his Geology of Massachusetts published in 1841.

Unfortunately the specific name had been previously used by both Lamarck and Desvaux in 1783 and 1789, so that the fossil species may well be renamed in honor of Dr. Hollick, who has done so much in the elucidation of the Cretaceous floras in the vicinity of New York.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Genus LIRIODENDRON Linné.

(Sp. Pl., 1753, p. 535.)

LIRIODENDRON OBLONGIFOLIUM Newb.

Liriodendron oblongifolium Newb., Bull. Torrey Club, vol. 14: 5, *pl. 61, f. 1,* 1887; Fl. Amboy Clays, 81, *pl. 52, f. 1–5,* 1896.

Hollick, Bull. Torrey Club, vol. 21: 62, *pl. 179, f. 3,* 1894; U. S. Geol. Surv. Mon. 50: 68, *pl. 21, f. 8,* 1907.

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Description.—A considerable variety of forms are referred by Professor Newberry to this species; most of these are fragmentary and depart somewhat from the usual form; for example, his fig. 2 shows the terminal portion of the lobes with several acute marginal teeth. This author's fig. 1 is here taken as the typical form, and it may be described as follows: Leaves oblong in outline, of large size, 11 cm. in length along the midrib by about the same distance in greatest width. Apex emarginate. Base truncate. Laterally there are three or four incipient lobes or points separated by wide, shallow, rounded sinuses, the lowest pair being almost half the distance from the base to the end of the midrib. Petiole long and stout. Midrib stout. Secondaries slender but well marked, numerous, about 12 pairs, sub-opposite, mostly camptodrome, usually sending branches to the marginal points, occasionally one runs direct to a marginal point; they branch from the midrib at a wide angle, about 65°, and are comparatively straight in their courses and consequently approximately parallel.

The remains of this species are rather infrequent and fragmentary, on the whole they indicate a leaf surprisingly like that of the modern tree and almost identical with those modern leaves which are more or less quadrangular in outline, with shallow rounded sinuses and from 2 to 5 marginal lobes on each side.

This species is confined to the Woodbridge locality, with the exception of a single extremely doubtful fragment from Glen Cove, Long Island, which Hollick tentatively identifies with it.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

LIRIODENDRON QUERCIFOLIUM Newb.

Plate XVII, Fig. 1.

Liriodendron quercifolium Newb., Bull. Torrey Club, vol. 14: 6, *pl. 62, f. 1,* 1887; Fl. Amboy Clays, 81, *pl. 51, f. 1–6,* 1896.

Description.—Leaves oblong in general outline, of large size, pinnately divided by narrow sinuses into from 2 to 4 lateral

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lobes. Apex emarginato. Base truncate to somewhat cordate. Length along the midrib varying from 7 cm. to 9 cm. and probably considerably greater in some specimens since one fragment measures 12 cm. in width. Width in perfect specimens about 9 cm. Lateral lobes ovate in outline with very acute tips, sometimes narrowed proximad giving them an almost obovate outline; intervening lateral sinuses narrow and deeply cut, in some instances reaching nearly to the midrib, rounded. In some specimens only 2 main lobes are developed on each side, which are then quite similar to the typical modern leaf. In these cases, however, the upper lobes are divided by a shallow sinus into 2 sharp lobules. Other specimens show 3 lobes of equal magnitude on each side, while one of the best specimens has 4 nearly equal lobes on each side, the basal and apical pairs being somewhat shorter than the medial pairs. This form of leaf is very suggestive of some species of *Quercus*, but its variations, as well as its venation, show that it is related to *Liriodendron*. The petiole is preserved for a considerable length and is very stout, as is the midrib. There is one main secondary traversing each lobe and running directly to its apical point. In addition there are one or more camptodrome secondaries in each lobe which anastomose with branches from the main secondary, their number being dependent upon the relative width of the lobe; they branch from the midrib at angles of about 60°.

At first sight this species appears to differ considerably from *Liriodendron oblongifolium* and from the modern form, but this difference is not nearly as great as it seems, and it is probable that *Liriodendron quercifolium* is simply a variation from the common ancestor of the two species in the direction of *Liriodendron pinnatifidum* Lesq. Numerous leaves of the modern tree can be found with an incipient lobation suggesting *Liriodendron quercifolium*. In these, however, the sinus is comparatively shallow and rounded, so that the general appearance of the two is not markedly similar.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

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Family LAURACEÆ.

Genus SASSAFRAS Nees.

(Handb. Bot., vol. ii, 1831, p. 418.)

SASSAFRAS ACUTILOBUM Lesq.

Plate XVIII, Fig. 2.

Sassafras acutilobum Lesq., Cret. Fl., 79, *pl. 14, f. 1, 2,* 1874; Cret. and Tert. Fl., 56, *pl. 5, f. 1, 5,* 1883; Fl. Dakota Group, 100, 1892.

Hollick, Trans. N. Y. Acad. Sci., vol. 12: 236, *pl. 7, f. 1,* 1893; U. S. Geol. Surv. Mon. 50: 77, *pl. 30, f. 8, 9,* 1907.

Newb., Fl. Amboy Clays, 87, *pl. 25, f. 1–10; pl. 26, f. 2–6,* 1896.

Kurtz, Revista Mus. La Plata, vol. 10: 53, 1902.

Berry, Bot. Gazette, vol. 34: 438, 1902; Bull. N. Y. Bot. Garden, vol. 3: 81, *pl. 45, f. 1, 2,* 1903; Bull. Torrey Club, vol. 31: *pl. 1, f. 6,* 1904; Ann. Rept. State Geol. (N. J.) for 1905, 139: *pl. 22, f. 4, 5,* 1906.

Description.—Trilobate leaves, variable in size and outline. Length 2.5 cm. (in the young leaves which are preserved at the Woodbridge locality) up to 14 cm., averaging 10 cm. to 12 cm. Width from the tips of the lateral lobes likewise ranging from 1 cm. to 15 cm. averaging about 10 cm. Lobes mostly conical and acute, the middle being usually slightly the broadest and longest. Lateral lobes directed more or less laterally. Base decurrent. The sinuses between the lobes are usually open and rounded, the margins forming an angle of approximately 90°. There is considerable variation, however, in this respect, some of the leaves having comparatively narrow sinuses with the lobes directed upward, as in *Sassafras progentor* Hollick, while others at the opposite extreme of the series, have extremely shallow sinuses, so shallow that the leaf has the appearance of a triangularly pointed, entire leaf. The lateral primaries may branch

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from the midrib at or near the base, as they do in a majority of the Raritan forms, or their point of divergence may be a considerable distance above the base, as in modern Sassafras leaves. Their angle of divergence from the midrib varies from about 30° to 40°. The secondaries are usually numerous, regular, camptodrome, and connected by transverse tertiaries, although in the Raritan leaves this uniformity is often lacking. Petiole, stout and long. The marginal vein along the sinus, a marked feature in modern leaves of this genus, is generally wanting in this species, although present in occasional specimens.

This species is apparently widely distributed and almost as variable as the modern Sassafras. Described originally from the Dakota Group as a variety of *Sassafras mudgei*, it occurs, also, on Marthas Vineyard and Long Island and in the Magothy formation of New Jersey and Delaware. It has been recorded from Cerro Guido, Argentina, and Velenovsky identifies somewhat doubtful remains from the Cenomanian of Bohemia as this species. Probable Sassafras fruit has been found in the same strata with *S. acutilobum*[1], tending to show that it is a true Sassafras, notwithstanding its dissimilarities; however, this is not certain, as the leaves and fruit were not found associated. Lesquereux's smallest figure of *S. acutilobum* is considerably smaller, with the lobes directed upward, and is probably a young leaf of his larger form. His other figure approaches some of the leaves which Newberry refers to this species, but has narrower and more produced lobes.

There is considerable doubt as to whether or not the Coastal Plain leaves are generically related to Sassafras. Whether the Dakota group forms are those of Sassafras it is not easy to decide. No modern Sassafras leaves have the primaries and the lateral lobes so nearly horizontal; the secondaries are not so uniformily regular, nor do they curve upward to join the next above at a point. In the modern leaf an outwardly and downwardly directed branch from the latter is emphasized. There is never such an open sinus, amounting as it does to

[1] Lesquereux, Fl. Dakota Group, p. 230.

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nearly 90°, and the lobes in the modern leaf have their margins inflated and not straight. In these ancient leaves the sinus seldom has a marginal vein, the secondary in this region usually forking and striding it, or curving to join its neighbor. The secondary system seems to be uniform throughout the leaf, while in the modern leaf there is always evidence of changed conditions in that region around the sinus; the secondaries or their representatives from both the primaries and midrib are changed in size and direction, and usually belong to the tertiary system. None of the Dakota leaves of this species show the characteristic basal venation of the modern leaf. While we should not, necessarily, expect Cretaceous species to conform to the modern type, still the character of the secondary system in the former is so different from what would obtain in a leaf descended from a simple ancestor, such as Sassafras is thought to have done, that we are inclined to associate these leaves with those trilobed forms which have been referred to, *Aralia* or *Sterculia*, laying aside, for the present, any consideration as to whether or no they are true species of *Aralia* and *Sterculia*.

However, in view of the present uncertainty, and because of the havoc to the stratigraphic value of these leaves which would be wrought by any change of name, they are retained in the genus *Sassafras* pending more positive evidence of their affinity.

Occurrence.—Woodbridge, Milltown.

Collections.—N. Y. Botanical Garden.

SASSAFRAS PROGENITOR Hollick.

Plate XVIII, Fig. 1.

Sassafras progenitor Hollick, Bull. Torrey Club, vol. 21: 53, *pl. 174, f. 1*, 1894; Bull. Geol. Soc. Amer., vol. 7: 13, 1895; U. S. Geol. Surv. Mon. 50: 78, *pl. 30, f. 11*, 1907.

Newb., Fl. Amboy Clays, 88, *pl. 27, f. 1–3*, 1896.

Berry, Bot. Gazette, vol. 34: 443, 1902; Bull. Torrey Club, vol. 31: 78, *pl. 1, f. 3*, 1904.

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Description.—Trilobate leaves of variable size, 5 cm. to 20 cm. in length, by 3.5 cm. to 13 cm. in breadth. Lobes pointed or obtuse, the middle one considerably the larger. Petiole short and stout. Primaries branching from the cuneate base at an acute angle. Secondaries remote, camptodrome with the exception of the pair, of which one runs to the sinus on each side.

Prof. Newberry is very positive that this leaf is a true *Sassafras*, with which view I entirely agree. The small leaf is the exact counterpart of the modern Sassafras leaf in outline and venation, with the exception that the primaries are basal. While no marginal veins are visible at the sinuses, the first secondaries leave the midrib and curve upward, running directly to the sinuses as in the existing Sassafras leaves. Hollick's specimen from Long Island, while fragmentary, has a short branch running to the sinus in the half of the leaf-blade which is preserved. Newberry's other figures each lack the basal portion of the blade and one of the lateral lobes; the lobes are more obtuse than in his smaller specimen. While the sinus appears to lack a marginal vein, the disposition of the secondaries and tertiaries in this region is Sassafras-like.

This species is common but fragmentary in the Raritan at Woodbridge, and has also been reported from Long Island and from the Magothy formation of New Jersey. It suggests somewhat *Sassafras Mudgei* Lesq. from the Dakota Group.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

SASSAFRAS HASTATUM Newb.

Plate XVII, Fig. 2.

Sassafras hastatum Newb., Fl. Amboy Clays, 88, *pl. 27, f. 4–6; pl. 28, f. 1, 2; pl. 40, f. 4*, 1896.

Berry, Bot. Gazette, vol. 34: 448, 1902.

Hollick, Bull. N. Y. Bot. Garden, vol. 3: 414, *pl. 79, f. 4*, 1904; U. S. Geol. Surv. Mon. 50: 78, *pl. 29, f. 4; pl. 30, f. 12*, 1907.

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Description.—Trilobate leaves more or less hastate in outline. Lobes conical, obtusely pointed, the middle one the larger. The lateral lobes are generally directed horizontally, thus the base is truncate in extreme forms, in others it is broadly rounded, while still other fragments indicate that it was cuneate in some specimens. These leaves vary considerably in size and appearance, some of them approaching *Sassafras progenitor* Hollick in appearance. They are about 10 cm. to 12 cm. in length, by about the same distance from tip to tip of the lateral lobes. Primaries 3, somewhat flexuous, diverging a considerable distance above the base, the short and stout petiole continuing upward in the base of the leaf in undiminished size to this point of divergence. Angle between the lateral primaries and the midrib varying from 32° to 70°, being usually nearer the latter than the former figure. In one specimen there are 2 pairs of laterals below the point of divergence of the primaries.

This species shows considerable diversity of characters. It is quite common at the Woodbridge horizon and is also reported from Long Island and Marthas Vineyard. Its relation to the modern Sassafras is very doubtful and it seems to be allied to some of the Raritan forms which Newberry identifies with *Aralia*.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Genus LAURUS Linné.

(Sp. Pl., 1753, p. 369.)

LAURUS PLUTONIA Heer.

Laurus plutonia Heer, Fl. Foss. Arct., vol. vi, ab. 2: 75, *pl. 19, f. 1d, 2–4; pl. 20, f. 3a, 4–6; pl. 24, f. 6b; pl. 28, f. 10, 11; pl. 42, f. 4b,* 1882; Ibid., vol. vii: 30, *pl. 58, f. 2; pl. 62, f. 1a,* 1883.

Velen., Fl. Böhm, Kreidef., Theil 3, p. 1, *pl. 4, f. 2–4,* 1884.

Lesq., Fl. Dakota Group, 91, *pl. 13, f. 5, 6; pl. 22, f. 5,* 1892; Geol. and Nat. Hist. Surv., Minn., vol. 3, pt. 1, p. 14, *pl. A, f. 6; pl. B, f. 5,* 1895.

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Newb., Fl. Amboy Clays, 85, *pl. 16, f. 10, 11*, 1896.

Hollick, Ann. N. Y. Acad. Sci., vol. ii: 60, *pl. 4, f. 6, 7*, 1898; U. S. Geol. Surv., Mon. 50: 80, *pl. 27, f. 9, 11; pl. 28, f. 1, 2*, 1907.

?Gould, Amer. Jour. Sci., vol. 5: 175, 1898.

Berry, Bull. N. Y. Bot. Gard., vol. 3: 79, *pl. 50, f. 9–11*, 1903; Bull. Torrey Club, vol. 31: 77, *pl. 3, f. 1*, 1904; Ibid., vol. 33: 178, 1906; Ann. Rept. State Geol. (N. J.) for 1905: 138, 139, 1906.

Description.—"L. foliis subcoriaceis, lanceolatis, utrinque attenuatis, acuminatis, integerrimis; nervo primario validiusculo, nervis secundariis numerosis, tenuibus, sub-angulo acuto egredientibus, arcuatis, interstitiis reticulatis." Heer, 1882.

Leaves lanceolate in outline, usually tapering in both directions, but sometimes less acute at the base. Length 7 cm. to 11 cm.; greatest width 1.5 cm. to 2.5 cm. Midrib mediumly stout. Petiole short and stout, 6 mm. to 15 mm. in length. Secondaries slender, eight or more alternate pairs, camptodrome.

This species was described by Heer from the Atane beds of Greenland, and a large number of somewhat variable and fragmentary specimens were figured. Professor Newberry records specimens from the Raritan formation without giving any specific localities. Those figured show leaves which are relatively wider than the usual leaves of this species, but these are comparable with some of the Greenland material, as, for example, Heer's pl. 20, fig. 5 and pl. 28, fig. 11. Entirely typical leaves occur in the top layers of the Raritan at the Hylton Pits.

Subsequent to its description by Professor Heer this species was recorded from a very large number of Cretaceous plant beds, so that its present range, both geographical and geological, is rather extensive. A number of these records are not entirely above question, and this appears to be especially true of the forms from the Cenomanian of Bohemia, which Velenovsky so identifies.

It is evidently a rare plant in the Raritan, but becomes abundant in the immediately succeeding floras, being common in that of the Dakota Group and in the Magothy formation at a number of localities in New Jersey and Maryland. It is a common form

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in the insular Cretaceous floras and also occurs in the South Atlantic Coastal Plain. Supposed fruits are figured by Heer (loc. cit. pl. 42, f. 4b).

Occurrence.—Hylton Pits, Milltown.

Collections.—N. Y. Botanical Garden.

Genus LAUROPHYLLUM Goeppert.

(Tertiärfl. Java, 1854, p. 45.)

LAUROPHYLLUM NERVILLOSUM Hollick.

Laurophyllum nervillosum Hollick, Mon. U. S. Geol. Surv., vol. 50: 82, *pl. 27, f. 6, 7*, 1907.

Berry, Bull. Torrey Club, vol. 36: 255, 1909.

Proteoides daphnogenoides Hollick, Ann N. Y. Acad. Sci., vol. 11: 420, *pl. 36, f. 1, 3*, 1898.

Description.—Leaves of comparatively large size, oblong lanceolate in outline, about 15 cm. in length by about 2.6 cm. in greatest breadth, which is about midway between the apex and base. Apex acuminate. Base pointed, narrowly cuneate. Midrib stout. Secondaries thin, close, parallel, branching from the midrib at angles not exceeding and usually somewhat less than 45°, ascending, nearly straight or somewhat flexuous, connected by transverse nervilles, branching and inosculating near the margin where they merge in the tertiary venation.

This species was described originally from the terminal moraine at Tottenville, Staten Island, and undoubtedly represents transported Raritan materials. Three specimens are contained in the Milltown collection, and the writer has also collected it from somewhat higher horizons south of New Jersey. It is somewhat like *Laurophyllum lanceolatium* Newberry, but has a markedly different venation and a less lanceolate outline. It is also quite close to *Laurophyllum elegans* Hollick, which is, however, a more slender lanceolate leaf, with narrowly produced apex and base and a somewhat coarser venation, with less close and more curved camptodrome secondaries.

Occurrence.—Milltown.

Collections.—U. S. National Museum.

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LAUROPHYLLUM ELEGANS Hollick.

Laurophyllum elegans Hollick, Mon. U. S. Geol. Surv., vol. 50: 81, *pl. 27, f. 1–5*, 1907.
Berry, Bull. Torrey Club, vol. 36: 255, 1909.
Laurus plutonia Hollick, Trans. N. Y. Acad. Sci., vol. 11: 99, *pl. 3, f. 3, 4*, 1892; Ibid., vol. 12: 236, *pl. 6, f. 1*, 1893.
Proteoides daphnogenoides Hollick, Ann. N. Y. Acad. Sci., vol. 11: 420, *pl. 36, f. 2*, 1898.

Description.—Leaves elongate-lanceolate in outline, somewhat flexuous, about 12 cm. to 13 cm. in length, by about 2 cm. in greatest width, which is about midway between the apex and the base. From this point narrowing gradually distad into an antennuated, acuminate, usually curved tip and basally into a long, narrowly cuneate base. Midrib stout, stouter than in *Laurophyllum nervillosum* Hollick. Secondaries numerous, usually less close and somewhat coarser than in the latter species; they branch from the midrib at an acute angle below, which becomes more open above the base of the leaf. They are usually more curved than in *L. nervillosum* and more distinctly camptodrome. Tertiaries, transverse throughout.

These leaves were recorded originally by Hollick as *Laurus plutonia*, Heer, and are later compared by the former author with *Laurus angusta* Heer, which latter species they resemble more than they do the former. In outline they are not unlike *Laurophyllum angustifolium*, Newb., from Woodbridge, N. J., but differ decidedly in venation. They are also similar, but quite distinct from *Laurophyllum nervillosum*, Hollick, and *Laurophyllum reticulatum*, Lesq., of the Dakota Group.

The specimens outside of those recorded in the present contribution from New Jersey and those which are as yet unpublished from the region south of New Jersey, are from transported materials associated with the terminal moraine, from which numerous specimens have been collected. Those from Tottenville, Staten Island, are undoubtedly of Raritan age, while

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those from Glen Cove may have been originally from the Magothy formation, although they are probably Raritan.

Occurrence.—South Amboy.

Collections.—U. S. National Museum.

Laurophyllum lanceolatum Newb.

Laurophyllum lanceolatum Newb., Fl. Amboy Clays, 87, *pl. 17, f. 1, 12,* 1896.

Description.—Leaves broadly lanceolate in outline and coriaceous in texture. Nine cm. to 15 cm. in length, by 1.8 cm. to 3 cm. in width, the minimum rather than the maximum being the usual dimensions. Apex more extended than the base, obtusely pointed. Base cuneate, acute. Midrib stout, as is the short petiole. Secondaries fine, usually obsolete, 12 to 15 pairs, subequal, alternate, branching from the midrib at an angle of about 45° and curving upward, camptodrome. Leaf surface noticeably smooth.

This species, which came originally from the Woodbridge locality, where it is common, is equally common at Milltown. It appears to be confined to the New Jersey Raritan, and suggests somewhat the leaves which have been referred to *Laurus plutonia* Heer, from which it may be distinguished in the absence of venation by its texture.

Occurrence.—Woodbridge, Milltown.

Collections.—N. Y. Botanical Garden.

Laurophyllum angustifolium Newb.

Laurophyllum angustifolium Newb., Fl. Amboy Clays, 86, *pl. 17, f. 10, 11,* 1896.

Berry, Bull. N. Y. Bot. Garden, vol. 3:80, *pl. 47, f. 1, 5, 8; pl. 49, f. 1–5,* 1903; Bull. Torrey Club, vol. 33:178, 1906.

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Description.—Leaves elongate-lanceolate, very symmetrical in outline, 10 cm. to 15 cm. in length by 1.5 cm. to 2 cm. in width, widest above the middle, tapering with almost straight sides to the elongate-acute base. Apex narrowed, subacute. Petiole short and stout. Midrib also stout. Secondaries fine, often obsolete, 12 to 15 pairs, branching from the midrib at an angle of about 45° and curving upward, camptodrome. Texture subcoriaceous.

This species which was described from the Woodbridge locality, where it is common, has also been found in the overlying Magothy formation in both New Jersey and Maryland. In the absence of complete and well-marked specimens it is often difficult to differentiate it from contemporaneous species of other genera with similar lanceolate leaves.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Laurophyllum minus Newb.

Laurophyllum minus Newb., Fl. Amboy Clays, 86, *pl. 16, f. 7–9*, 1896.

Description.—Leaves elongate-lanceolate, 8.5 cm. to 13 cm. in length by 1.6 cm. to 2.3 cm. in width, with an obtuse summit and a cuneate or somewhat obtuse base, occasionally decurrent. Substance very thick and coriaceous. Petiole and midrib very stout, the former longer than in most species referred to this genus. Secondaries invariably obsolete.

This is the least well-defined species of *Laurophyllum* in the Raritan formation and may represent leaf variations of some of the other species. It also suggests the leaves which Heer describes from Greenland as *Myrica longa*.

It was said to be "not uncommon" by Prof. Newberry, although he failed to enumerate any specific localities. Later collections from South Amboy contain several specimens.

Occurrence.—South Amboy.

Collections.—N. Y. Botanical Garden.

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Genus CINNAMOMUM Blume.

CINNAMOMUM NEWBERRYI Berry.

Plate XVI, Fig. 3.

Cinnamomum intermedium Newb., Fl. Amboy Clays, 89, *pl. 29, f. 1–8, 10*, 1896 (non Ettingshausen).

Smith, Geol. Coastal Plain in Ala., 348, 1894 (nomen nudum).

Berry, Ann. Rept. State Geol. (N. J.) for 1905: 139, *pl. 20, f. 2–6*, 1906; Bull. Torrey Club, vol. 33: 179, *pl. 7, f. 3, 4*, 1906.

Hollick, U. S. Geol. Surv. Mon. 50: 74, *pl. 29, f. 7; pl. 30, f. 1, 2*, 1907.

Cinnamomum sezannense Wat., Hollick, Bull. Torrey Club, vol. 21: 53, *pl. 180, f. 5, 7*, 1894; Ann. Rept. N. Y. State Mus., 55th: A 50 (1901) 1903.

Description.—Leaves ovate-lanceolate in outline, 7 cm. to 12 cm. in length by 2.3 cm. to 4 cm. in width. Apex usually obtusely pointed, sometimes acute. Below narrowed to an acute base. Petiole stout. Venation stout. Primaries 3, the laterals diverging at an acute angle usually some distance above the base and traversing at least more than half the distance to the tip. Secondaries in the upper half of the leaf, 3 or 4 pairs, alternate, camptodrome. The laterals give off numerous camptodrome branches on the outside.

This species is quite common in the Raritan formation at nearly all of the fossiliferous localities and it also has a considerable outside range extending eastward on Long Island and southward in Delaware, Maryland and Alabama. A very similar leaf which is widely distributed in the Cenomanian of Bohemia is identified by Velenovsky[1] as *Aralia daphnophyllum*.

Cinnamomum Heeri was reported from the Raritan at South Amboy by Professor Lesquereux in the 1878 clay report, but it seems probable that this determination was based on specimens

[1] Velenovsky, Fl. Böhm. Kreidef. 1: 30, pl. 7, f. 5–8, 10; pl. 8, f. 1–5, 1882.

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of *Cinnamomum Newberryi* since the former species has never been encountered in Raritan deposits either during the progress of Professor Newberry's or the writer's investigations. This species is present, however, in the succeeding Magothy formation. It is a broader leaf with a more rounded base and more prominent primaries. The two species are closely allied, but seem to be abundantly distinct.

The well known name for the present species proposed by Professor Newberry was already in use for a different fossil species described some years earlier by Baron Ettingshausen, hence it becomes necessary to rename the New Jersey species, and the foregoing name is suggested in honor of Professor Newberry.

Occurrence.—Sayreville, Woodbridge, South Amboy, Hylton Pits.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

Family MENISPERMACEÆ.

Genus MENISPERMITES Lesquereux.

(Cret. Fl., 1874, p. 94.)

MENISPERMITES BOREALIS Heer.

Plate XVIII, Fig. 4.

Menispermites borealis Heer, Fl. Foss. Arct., vol. 6, ab. 2: 91, *pl. 39, f. 2,* 1882.
Newb., Fl. Amboy Clays, 84, *pl. 50, f. 1–6,* 1896.

Description.—"M. foliis magnis, ovato-ellipticis, integerrimis, quinque-nerviis." Heer, 1882.

The type of this species is a single large fragment of an unsymmetrical leaf from the Atane beds of Greenland. Professor Newberry's material from New Jersey is more abundant, but not complete enough for a proper diagnosis. It may be described as follows: Leaves markedly unsymmetrical, ovate-elliptical in outline, about 10 cm. to 15 cm. in length by 6 cm. to

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8 cm. in greatest breadth, which is toward the base. Apex obtusely pointed, seldom preserved. Base varying from cuneate to truncate or somewhat cordate. Venation palmate, principal veins said by Heer to be five in number, although only a midrib and two laterals on one side are shown in his figure. The Raritan leaves usually have four veins, two laterals on the convex side and one on the straight side; they diverge from the base and are not so stout as the midrib. Margins entire. Venation camptodrome, more or less obsolete.

This species is somewhat suggestive of *Menispermites obtusiloba* Lesq. of the Dakota Group, with which Professor Heer compared it. The latter is, however, a much more symmetrical leaf, larger in size, with undulate margins and a tendency toward a trilobate form. The fact that the laterals in the New Jersey material are camptodrome might prevent its inclusion in this genus were it not for the fact that the author of the genus also included *camptodrome* forms in it, as, for example, *Menispermites grandis* Lesq., *Menispermites ovalis* Lesq., and *Menispermites cyclophyllum* Lesq.

Occurrence—Woodbridge.

Collections.—N. Y. Botanical Garden.

MENISPERMITES WARDIANUS Hollick.

Plate XVIII, Fig. 3.

Menispermites Wardianus Hollick, in Newb., Fl. Amboy Clays, 85, *pl. 29, f. 9, 11*, 1896.

Description.—Leaves ovate in outline, unsymmetrical, with an acute apex and a cuneate base, 8 cm. to 9 cm. in length by about 4 cm. in greatest breadth, which is about midway between the base and the apex. Margin entire. Midrib mediumly stout, curved nearer the shortest margin. Two lateral primaries diverge at an acute angle from its base and a fourth vein of lesser calibre diverges at the same point and approximately parallels the more convex of the two margins. Tertiary venation obsolete.

These leaves were referred to *Menispermites* by their describer because of their unsymmetrical outline in accordance with Prof.

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Newberry's views, although many students will be disposed to question this relationship. The exact locality from which they were collected was not recorded, and no additional specimens have been discovered in subsequent collections, so that our knowledge of the species must remain incomplete, especially as the available material is imperfect.

Occurrence.—Locality unknown.

Collections.—N. Y. Botanical Garden.

Order ROSALES.

Family LEGUMINOSÆ.

Genus LEGUMINOSITES Bowerbank.

(Foss. Fr. & Seeds London Clay, 1840, p. 124.)

LEGUMINOSITES CORONILLOIDES Heer.

Leguminosites coronilloides Heer, Fl. Foss. Arct., vol. 3, ab. 2: 119, *pl. 34, f. 14,* 1874.
Lesq., Fl. Dakota Group, 149, *pl. 13, f. 10,* 1892.
Newb., Fl. Amboy Clays, 97, *pl. 42, f. 48,* 1896.
Hollick, U. S. Geol. Surv. Mon. 50: 86, *pl. 32, f. 16, 17,* 1907.

Leguminosites frigidus Hollick, Trans. N. Y. Acad. Sci., vol. 12: 34, *pl. 2, f. 11,* 1892.

Colutea coronilloides Heer, Fl. Foss. Arct., vol. 6, ab. 2: 100, 1882.

Description.—"L. foliolis parvulis, ovalibus, breviter petiolatis, nervis secundariis distantibus, curvatis, subtilissimus." Heer, 1874.

Leaflets small, oval in outline, unsymmetrical, 1.5 cm. to 2.8 cm. in length by 8.5 mm. to 12 mm. in breadth, entire, short petioled. Midrib stout. Secondaries thin, remote, 3 to 5 pairs, alternate, camptodrome, often obsolete.

Leguminous leaflets from a number of widely removed localities have been referred to this species, and while all of these are very similar in general characters, their positive identity cannot be affirmed with any great confidence. Described originally from

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the Atane beds, they have been detected by Lesquereux in the Dakota Group, by Newberry in the Raritan, by Hollick at Marthas Vineyard and Staten Island and by the writer from Maryland. They are very similar to other species of Leguminosites, as, for example, *Leguminosites frigidus* Heer[1] described from the Patoot beds.

Prof. Heer in his last report (loc. cit.) refers this form to the genus *Colutea,* but it does not seem wise to follow him in this reference with no more evidence than is available. Prof. Newberry unfortunately neglected to record the exact locality for the Raritan material and no additional specimens have been obtained.

Occurrence.—Locality unknown.

Collections.—N. Y. Botanical Garden.

LEGUMINOSITES ATANENSIS Heer.

Leguminosites atanensis Heer, Fl. Foss. Arct., vol. 3, ab. 2: 119, *pl. 34, f. 6,* 1874.
Newb., Fl. Amboy Clays, 97, *pl. 42, f. 40,* 1896.

Description.—"L. foliolis firmis, oblongis, crassinerviis." Heer, 1874.

Leaflets, elliptical in outline, 3 cm. to 4 cm. in length, by 1.5 cm. to 1.9 cm. in breadth. Margins entire. Apex evenly rounded. Base cuneate. Petiole present, 3 to 5 mm. in length, stout. Midrib stout. Secondaries, 6 or 7 pairs, subopposite, branching at angles varying from 50° to 60°, camptodrome.

This well-marked leaflet, if it is a leaflet, was described from the Atane beds of Greenland, by Prof. Heer, and is represented in the Raritan by a single complete specimen, which is somewhat smaller than the type, but otherwise identical with it, except that the secondaries are straighter and do not clearly show camptodrome characters. There is some resemblance to *Myrsine oblongata* Hollick, from the same beds. Prof. Newberry failed

[1] Heer, Fl. Foss. Arct., 7: 44, pl. 55, f. 21, 22; pl. 65, f. 13, 1883.

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to indicate any specific locality and no additional specimens have since been obtained in the New Jersey area.

Occurrence.—Locality unknown.

Collections.—N. Y. Botanical Garden.

LEGUMINOSITES OMPHALOBIOIDES Lesq.

Leguminosites omphalobioides Lesq., Fl. Dakota Group, 149, *pl. 38, f. 4*, 1892.
Newb., Fl. Amboy Clays, 97, *pl. 42, f. 39*, 1896.

Description.—Leaflets, elliptical in outline, 3.2 cm. to 4 cm. in length, by 1.5 cm. to 1.7 cm. in greatest breadth, which is about half way between the apex and the base. Texture subcoriaceous. Apex rather broadly rounded. Base slightly narrowed and decurrent to the point of attachment. Lesquereux speaks of a short petiole, but this is lacking in his type figure and in all the specimens examined by the writer. The midrib is not especially wide, but is quite prominent. The secondaries are thin and alternate; they number about six pairs, and branch from the midrib at angles of 50° or somewhat less, curving upward close to the margins, camptodrome.

This species was described originally from the Dakota Group of Kansas. The Raritan leaf is very close to the type, differing merely in that the outline is more nearly elliptical than it is in the western form. Prof. Newberry failed to record the locality from which his specimens were obtained and no subsequent material has come to light from the New Jersey clays.

Occurrence.—Locality unknown.

Collections.—N. Y. Botanical Garden.

LEGUMINOSITES RARITANENSIS Berry.

Plate XX, Fig. 5.

Leguminosites raritanensis Berry, Bull. Torrey Club, vol. 36: 257, *pl. 18, fig. 4*, 1909.

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Description.—Leaflets large, 7.5 cm. by 5.1 cm., almost a perfect ellipse in outline, slightly emarginate at the apex; midrib thin and straight; secondaries numerous, nearly straight, ascending at an angle of about 45°, camptodrome, of delicate calibre and scarcely discernable.

This species is based upon a single individual and seems properly referable to this genus. In outline it suggests some of the forms which have been referred to *Populus,* but its venation is quite different. It also resembles some of the specimens referred to *Liriodendropsis,* which is simply another way of emphasizing the fact that it is a leguminous leaflet of unknown generic affinities.

Occurrence.—South Amboy.

Collections.—U. S. National Museum.

Genus COLUTEA Linné.

(Sp. Pl., 1753, p. 723.)

COLUTEA PRIMORDIALIS Heer.

Plate XX, Fig. 4.

Colutea primordialis Heer, Fl. Foss. Arct., vol. 6, ab. 2 : 99, pl. *27, f. 7–11; pl. 43, f. 78,* 1882.

Lesq., Fl. Dakota Group, 148, *pl. 13, f. 8, 9,* 1892.

Hollick, Bull. Torrey Club, vol. *21* : 56, *pl. 174, f. 2,* 1894; U. S. Geol. Surv., Mon. 50 : 84, *pl. 32, f. 14, 15,* 1907.

Newb., Fl. Amboy Clays, 97, *pl. 19, f. 4, 5,* 1896.

Description.—"C. foliolis membranaceis, breviter petiolatis, pollicaribus, ovalibus, integerrimis, basi attenuatis, apice profunde emarginatis; nervis secundariis subtilissimis, camptodromis." Heer 1882.

Newberry's specimens from Woodbridge, if they are referable to this species at all, are abnormal or possibly incomplete since the base is much unlike the usual leaves of this species. A typical specimen, however, has been found at South Amboy (Allen pit).

Occurrence.—Woodbridge, South Amboy.

Collections.—N. Y. Botanical Garden.

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Genus LIRIODENDROPSIS Newberry.

(Fl. Amboy Clays, 1896, p. 82.)

LIRIODENDROPSIS RETUSA (Heer) Hollick.

Plate XIX, Fig. 1.

Sapotacites retusa Heer, Fl. Foss. Arct., vol. 7: 32, *pl. 61, f. 10*, 1883.

Newb., Fl. Amboy Clays, 123, *pl. 53, f. 5, 6*, 1896.

Liriodendron simplex Hollick, Trans. N. Y. Acad. Sci., vol. 12: 235, *pl. 5, f. 5*, 1893.

Liriodendropsis retusa Hollick, U. S. Geol. Surv. Mon. 50: 72, *pl. 25, f. 8, 9*, 1907.

Description.—"S. foliis oblongo-ovatis, basi attenuatis, apice leviter emarginatis, integerrimis, nervo medio debili, secundariis subtilissimis." Heer 1883.

These leaves are oblong-ovate in outline, with a decidedly emarginate rather than a retuse apex. They are 6 cm. to 8.2 cm. in length by 2.8 cm. to 3.3 cm. in greatest breadth, which is toward the full, cuneate base. Petiole short and reasonably stout. Secondaries mostly obsolete, apparently numerous, slightly curved, parallel.

Prof. Newberry was quite positive that these leaves were different from those which he referred to *Lirodendropsis*, although he compared them to *Liriodendropsis simplex* as well as to *Liriodendron Meekii* Heer and various forms of *Leguminosites* He thought that the angular apical points served to distinguish *Liriodendropsis simplex*, but this character is far from constant in the abundant Long Island material.

The type material came from the Patoot beds of Greenland, and this species is also recorded from Glen Cove, Long Island, as well as Woodbridge, N. J.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

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LIRIODENDROPSIS SIMPLEX (Newb.) Newb.

Plate XIX, Fig. 2.

Liriodendron simplex Newb., Bull. Torrey Club, vol. 14:6, *pl. 62, f. 2, 3,* 1887 (pars).

White, Am. Jour. Sci., vol. 39:98, *pl. 2, f. 6, 7,* 1890.

Uhler, Trans. Md. Acad. Sci., vol. 1:207 (1892) 1901.

Hollick, Trans. N. Y. Acad. Sci., vol. 11:99, *pl. 2, f. 2, 4, 5, 7, 9,* 1892; Ibid., vol. 12:235, *pl. 5, f. 1, 2, 4; pl. 7, f. 2,* 1893; 55th Ann. Rept. N. Y. State Mus. 150, 1903.

Pollard, Trans. N. Y. Acad. Sci., vol. 13:180, 1894.

Liriodendropsis simplex Newb., Fl. Amboy Clays, 83, *pl. 19, f. 2, 3; pl. 53, f. 1–4, 7,* 1896.

Smith, Geol. Coastal Plain in Ala., 348, 1894. (nomen nudum.)

Hollick, U. S. Geol. Surv. Mon. 50:72, *pl. 23, f. 1–7; pl. 24, f. 1–9; pl. 25, f. 1, 4, 5, 7, 10–12; pl. 26, f. 1b, c, d,* 1907.

Description.—Leaves or leaflets ovate to ovate-lanceolate in outline, with entire margins, emarginate apex and cuneate base, varying from 5 cm. to 10 cm. in length, and from 3 cm. to 5 cm. in breadth. Midrib, stout. Secondaries stout, numerous, camptodrome; their intervals filled by more or less parallel, reticulating fine tertiaries. The angles of divergence are variable even in the same leaf, and the exigencies of preservation obscure the finer venation in some specimens, which give them a strikingly different appearance from others in which the preservation is more complete.

These leaves are very variable in size and outline. The apex is often angular at the corners of the leaf-blade and at the sinus, at other times it is rounded. The sinus may be shallow or moderately deep. The leaflets are much wider than in the following species, and the width is usually greatest in the upper part, although this feature is far from constant.

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This species is very common at a number of localities in the New Jersey Raritan and also on Marthas Vineyard, Long Island and Staten Island. It is equally common in the Tuscaloosa formation of Alabama. None of the American specimens, abundant as they are, shows definitely its trifoliate nature, but this is indicated by the relative position of the leaflets in some of the specimens figured by Hollick (loc. cit).

These leaves were segregated from *Liriodendron* by Newberry, on the basis of their simple nature, emarginate apex, crowded and fine venation and relatively small size, although their describer says that they are evidently related to *Liriodendron*. Since 1896, much new material has been collected, especially from Long Island. Holm,[1] as long ago as 1890, suggested that these leaves were not related to *Liriodendron*, but were comparable to those of a number of leguminous genera. Somewhat similar leaves were described from Bohemia as *Myrsinophyllum varians*, by Velenovsky,[2] and more closely allied forms as *Bignonia pulcherrima*, by Bayer,[3] the latter sufficiently well preserved to show their trifoliate nature.

Ward[4] refers a species described by Saporta as a *Chondrophyton*, from the Cenomanian of Portugal to *Liriodendropsis*, to which it is obviously not related, as the writer pointed out some years ago.[5] Recently, Hollick[6] has given a resumé of the genus, together with descriptions of new species and a large number of illustrations. The probabilities are all in favor of their reference to the Leguminosæ, to which family they are referred in the present contribution.

Occurrence.—Woodbridge, Milltown, Hylton Pits.

Collections.—N. Y. Botanical Garden.

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[1] Holm, Proc. U. S.Nat. Mus., 13: 15–35, 1890; Bot. Gaz. 20: 312–316, 1895.

[2] Velen., Kvetena ceského cenomanu, 25, pl. 4, f. 8, 9; pl. 5, f. 12; pl. 6, f. 10, 11, 1889.

[3] Studien Gebiete Böhm. Kreidef. (Perucer Schichten) 1900 (1901), p. 156, f. 126a, b.

[4] Ward, 16th Ann. Rept. U. S. Geol. Survey, pt. 1: 540, pl. 107, f. 6–8, 1896.

[5] Berry, Bull Torrey Club, vol. 31: 77, 1904.

[6] Hollick, Mon. U. S. Geol. Survey, vol. L: 69–73, 1907.

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LIRIODENDROPSIS ANGUSTIFOLIA Newb.

Liriodendron simplex Newb., Bull. Torrey Club, vol. 14:6, *pl. 62, f. 4*, 1887, (pars).

Liriodendropsis angustifolia Newb., Fl. Amboy Clays, 84, *pl. 53, f. 8*, 1896.

Smith, Geol. Coastal Plain in Ala., 348, 1894 (nomen nudum).

Hollick, U. S. Geol. Survey, Mon. 50:71, *pl. 26, f. 1a, 2–5*, 1907.

Description.—Leaves or leaflets lanceolate to linear-lanceolate in outline, relatively long and narrow, with an emarginate, usually angular apex and a cuneate base. Size variable, from 6 cm. to 9 cm. in length by 1.9 cm. to 3 cm. in greatest breadth, which is never in the upper part of the leaf, the margins usually being straight and almost parallel from the angular apical corners, bowing outward slightly in the lower half of the leaf and curving downward to the rather long petiole. Midrib stout. Secondaries numerous, camptodrome. Tertiaries as in the preceding species.

It may be doubted if this is anything more than a variant of the preceding, but as the remains are so abundant it may represent a closely allied, although specifically distinct type. Hollick has described two additional species in the abundant material of this type contained in the insular Cretaceous flora, i. e., *Liriodendropsis constricta* and *L. spectabilis*, making the latter one extreme of a series of which *L. angustifolia* Newb. is the other. The relations are obviously as pointed out, but it seems questionable, in view of the individual variation even of these segregates, whether it would not have been better to have considered all of these forms as variations of a single species.

The present species is abundant in the Raritan at Woodbridge, and also on Marthas Vineyard and at Glen Cove, Long Island. It is recorded on the identification of Prof. Ward from the Tuscaloosa formation of Alabama, but the writer is unable to verify the latter record.

Occurrence.—Woodbridge, Florida Grove.

Collections.—N. Y. Botanical Garden.

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Genus CAESALPINIA Linné.

(Sp. Pl., 1753, p. 380.)

CAESALPINIA COOKIANA Hollick.

Cæsalpinia Cookiana Hollick in Newb., Fl. Amboy Clays, 94, *pl. 42, f. 49, 50*, 1896.

Description.—Leaflets of small size, elliptical in outline, entire, 1 cm. to 1.4 cm. in length by 8 mm. or 9 mm. in breadth across the middle. Apex and base about equally rounded. Texture delicate. Midrib slender. Secondaries few, distant, about 3 subopposite pairs; they branch from the midrib at a wide angle, about 80°, and are, with the exception of the lower pair, straight two-thirds of the distance to the margin, where they turn upward in broadly rounded arches parallel with the margin to join the secondaries next above.

The generic affinity of these fossils is doubtful. They almost certainly represent the leaflets of some compound leguminous leaf, and as nothing is to be gained by an attempt to redefine their generic relations, they are left where they were placed by their describer. The exact locality in the Raritan from which they were collected remains unknown.

Occurrence.—Locality unknown.

Collections.—N. Y. Botanical Garden.

CAESALPINIA RARITANENSIS Berry.

Plate XX, Fig. 3.

Caesalpinia raritanensis Berry, Bull. Torrey Club, vol. 36: 251, 1909.

Description.—Elliptical leaflets about 3 cm. long and 2.2 cm. broad, with markedly emarginate apex; midrib missing; secondaries branching at a wide angle, almost 90° and but slightly curved, anastomosing by broad, evenly rounded loops, about two-thirds of the distance to the margin.

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This is possibly only an extraordinary large leaflet of *Caesalpinia Cookiana* Hollick, somewhat more elongated in outline and strictly congeneric with that species. It is, unfortunately, based upon the single imperfect specimen figured.

Occurrence.—South Amboy.

Collections.—U. S. National Museum.

Genus BAUHINIA Linné.

(Sp. Pl., 1753, p. 374.)

BAUHINIA CRETACEA Newb.

Plate XIX, Fig. 3.

Bauhinia cretacea Newb., Bull. Torrey Club, vol. 13:77, *pl. 56*, 1896; Fl. Amboy Clays, 91, *pl. 43, f. 1–4; pl. 44, f. 1–3*, 1896.

Description.—This handsome species is common at the Woodbridge horizon and is characterized by Professor Newberry as follows: "Leaves large, from 10 cm. to 18 cm. in diameter, general outline circular, deeply two-lobed, sinus reaching below the middle, margin entire, base rounded, lobes oblong or broadly spatulate; nervation strong, radiate or bilateral, midrib slender, from 1 cm. to 4 cm. in length, running to bottom of medial sinus, there forking equally, each slender branch running parallel with the margin of the sinus; lateral nerves strong, usually two, rarely one on each side, springing from a common base, the interior lateral nerve strongest, forking several times and giving off fine branches, which inosculate to form a graceful festoon near the upper margin; the exterior lateral nerves throwing off numerous branches which anastomose in loops near the margin, producing a camptodrome nervation. In those which have but a single lateral nerve the lobes are narrower, and each is covered with the ramifications of the branches, which spring chiefly from the outer side of the single main nerve."

"The form and nervation of these leaves are so precisely those of some of the Bauhinias of the present flora that there can be

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no reasonable doubt that we here have the remains of a well-marked species of this genus, which grew near the mouth of the Hudson river in the middle of the Cretaceous age, and was the associate of the magnolias, tulip trees, aralias, etc., which composed the angiosperm forest of eastern North America. In size some of these leaves exceed those of any living Bauhinia, and the outline and nervation indicate that the genus was as perfectly defined and highly specialized in the Cretaceous age as now."

"The living Bauhinias inhabit the tropical and subtropical regions of the Old and New Worlds, India, Mauritius, Surinam, Cuba, Mexico, etc. The genus is closely related to Cercis, and most of the species have a similar habit. In a few the leaves are orbicular or slightly emarginate, but they are generally bilobed, the sinus reaching the middle of the leaf, sometimes extending to the base, as is the case with the only species inhabiting the United States, *B. lunariodes* Gray of Texas and Mexico."

"In most of the East India species the nervation is more crowded than in the fossil leaves before us, each having three and sometimes four lateral nerves, the medial nerve, however, being quite the same. In several oriental species, and all those of the New World, the nervation is simpler and especially like that of the fossil."

A fossil species of Bauhinia from the Tortonian deposits of Oeningen, Baden, was described by Heer as long ago as 1859.[1] Soon afterward Unger described two additional species,[2] both based on pods, from Croatia. Five years later the same author described another species from the Aquitanian of Kumi, Greece.[3] In 1885 Velenovsky described another species from the Cenomanian of Bohemia[4] without, however, recognizing its true relationship. The next year Professor Newberry described the foregoing species, and the following species was added to the Raritan flora when his monograph came out in 1896. In 1908 the writer described a small but striking new species[5] from the

[1] Heer, Fl. Tert. Helv., vol. 3: 109, pl. 134, f. 21, 1859.
[2] Unger, Sylloge, vol. 2: 31, pl. 11, f. 2, 3, 1862.
[3] Unger, Foss, Fl. v. Kumi, 61, pl. 15, f. 36, 1867.
[4] Velenovsky, Fl. Böhm. Kreidef. Th. 4: 12, pl. 6, f. 4, 1885.
[5] Berry, Torreya, vol. 8: 218, f. 3, 1908.

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Magothy formation of Maryland and a new and ornate species, as yet undescribed, has been collected from the upper beds of the Tuscaloosa formation in Alabama.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Bauhinia gigantea Newb.

Bauhinia ? gigantea Newb., Fl. Amboy Clays, 93, *pl. 20, f. 1*, 1896.

Description.—Leaves of immense size for this genus, apparently very similar to the preceding in general appearance, but about 20 cm. in diameter. Lobes deeply cleft, more so than in *Bauhinia cretacea*, and possibly reaching quite to the base. The single nearly complete lobe collected is oblong, unsymmetrical in outline, 20 cm. long by 7 cm. to 8 cm. in width, with an almost straight inner margin. Apex obtuse. The venation is stout, the principal vein starting at the basal inner margin runs almost straight to the apex, dividing the lobe in the ratio of about 1 to 5, it gives off three camptodrome secondaries internally, the lowest of which branches slightly below the middle of the lobe. Externally there are six approximately equidistant and parallel camptodrome secondaries decreasing regularly in size from the base upward.

Only two specimens of this species have been discovered, the more complete one being the single lobe which Prof. Newberry figured. However, there can be no question as to its generic relations. It is very similar to the preceding species, but may be distinguished by its much larger size, more deeply cut lobes, undulate outer margin and by the details of venation, one feature of which is the marked unsymmetrical position of the principal vein.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

NEW JERSEY GEOLOGICAL SURVEY

Genus DALBERGIA Linné f.

(Suppl., 1781, p. 52.)

DALBERGIA APICULATA Newb.

Dalbergia apiculata Newb., Fl., Amboy Clays, 90, *pl. 42, f. 17–19*, 1896.

Description.—Leaflets obovate in outline, unsymmetrical, 2 cm. to 5 cm. in length by about 1.5 cm. to 2 cm. in greatest breadth, which is in the upper half of the lamina. Apex broadly rounded, tipped with an apiculate point. Base narrowly elongated. Margin entire. Midrib thin, generally curved. Secondaries 6 or 7 pairs, slender, branching from the midrib at an angle of about 45° or slightly more and curving upward, camptodrome.

These leaves undoubtedly belong to some leguminous plant and are of the same general characters as the leaves usually referred to *Dalbergia*. They are frequent at the Woodbridge locality in the lower Raritan beds.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Genus HYMENAEA Linné.

(Sp. Pl., 1753, p. 1192.)

HYMENAEA DAKOTANA Lesq.

Hymenaea dakotana Lesq., Fl. Dakota Group, 145, *pl. 55, f. 2, 3; pl. 56, f. 1, 2; pl. 62, f. 2*, 1892.

Hollick, Bull. Torrey Club, vol. 21: 56, *pl. 176, f. 4*, 1894; U. S. Geol. Surv., Mon. 50: 83, *pl. 32, f. 5–7*, 1907.

Newb., Fl. Amboy Clays, 90, *pl. 41, f. 14*, 1896.

Berry, Ann. Rept. State Geol. (N. J.) for 1905; 138, 139, *pl. 22, f. 1, 2*, 1906; Bull. Torrey Club, vol. 33: 176, 1906.

Dalbergia Rinkiana Hollick, Trans. N. Y. Acad. Sci., vol. 12: 236, *pl. 6, f. 5*, 1893.

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Description.—Leaves compound, generally of 2, rarely 3, elliptical or oblong-lanceolate, unsymmetrical, entire, petiolate leaflets. Leaflets variable in size and outline, usually considerably curved and unsymmetrical, broadest on the outside, ranging from 3 cm. to 8 cm. in length and from 1.2 cm. to 3 cm. in breadth. Apex obtusely pointed to acute, sometimes somewhat recurved. Base cuneate. Midrib narrow, curved. Secondaries slender, often seen with difficulty, 6 to 8 pairs, oblique, parallel, camptodrome, the lower long curved and approximately parallel with the margins.

This species was described by Lesquereux from rather abundant remains preserved in the Dakota sandstones of Kansas, and it has since been recorded from the Raritan or the Magothy formations of Marthas Vineyard, Long Island and New Jersey. The Raritan form is of the smaller, more obtuse type, but is almost an exact counterpart of Lesquereux's *pl. 41, fig. 14.* The Magothy forms are also smaller than most of the Dakota Group forms. Some of these latter are especially interesting in that they show the entire leaves, which are of the following character: The common petiole is stout for a distance of from 5 mm. to 15 mm., where it forks into two stout branches 10 mm. to 15 mm. long, each subtended by a single leaflet. Occasionally there are three leaflets instead of the normal two.

A species of *Hymenaea* was described by Saporta from the Cenomanian of Bohemia[1] which shows considerable resemblance to the American form. Later collections described by Velenovsky[2] contain many leaves which he identifies with Soparta's species, *Hymenaea primigenia,* which he finds is rarely entire and usually with a crenate-dentate margin. Hollick records[3] forms similar to the latter from the Marthas Vineyard Cretaceous, which is probably more recent than the New Jersey Raritan.

The forms from the Atane beds of Greenland which Prof. Heer described as *Dalbergia Rinkiana*[4], are very similar to the

[1] Le Monde des Plantes, p. 199, f. 2, 1879.
[2] Fl. Böhm. Kreidef. theil 3: 9, pl. 5, f. 4; pl. 6, f. 1–4, 1884.
[3] Mon. U. S. Geol. Surv., vol. 50: 84, pl. 32, f. 8, 9, 1907.
[4] Fl. Foss, Arct., vol. VI, ab. 2: 102, pl. 26, f. 1–3, 1882.

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larger leaves of *Hymenaea*. They are described as being pinnate, but whether this character is based upon specimens seen or merely upon the fact that the two figured specimens each show two leaves similarly oriented, as if they had once formed part of a pinnate leaf, cannot be determined.

Prof. Newberry failed to record the exact locality for the Raritan plant and it is not contained in any recent collections.

Occurrence.—Locality unknown.

Collections.—N. Y. Botanical Garden.

Genus PHASEOLITES Unger.

(Synop. Pl. Foss., 1845, p. 244.)

PHASEOLITES MANHASSETTENSIS Hollick.

Plate XXII, Fig. 2.

Phaseolites manhassettensis Hollick, Bull. N. Y. Botanical Garden, vol. 3: 414, *pl. 78, f. 1, 2,* 1904; U. S. Geol. Surv., Mon. 50:86, *pl. 32, f. 2, 3,* 1907.

Berry, Bull. Torrey Club, vol. 36: 256, *pl. 18, f. 3,* 1909.

Description.—Leaves ovate-falcate in outline, markedly unsymmetrical, 6 cm. to 7.5 cm. in length by 2.4 cm. to 2.8 cm in greatest breadth, which is below the middle of the leaf. Margins entire. Apex acute. Base cuneate. Petiole short and stout. Midrib stout and curved. Secondaries fine, about 9 pairs, often obsolete, diverging from the midrib at an acute angle.

This species was described from Manhassett Neck, Long Island, a locality which should probably be included within the Raritan formation. The species is scarcely distinguishable from *Phaseolites elegans* described by the same author from Brooklyn, and both are very close to the Dakota Group *Phaseolites formus* Lesq., in fact, it is scarcely conceivable that these extremely limited variations are not all of a single species. However, they should be allowed to stand until more abundant and complete material is at hand for comparison. Another comparison which is suggested is with *Hymenaea dakotana* Lesq.

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The Milltown leaf, of which two specimens have been found, is more suggestive of *Phaseolites elegans* in general appearance than it is of the species with which it is identified. This is due to its more slender apical portion. On the other hand, it shows the very full convex base on one side, and the more acutely branching secondaries which are considered specific characters of *Phaseolites manhassettensis.*

Occurrence.—Milltown.

Collections.—U. S. National Museum.

Genus PRUNUS Linné.

(Sp. Pl., 1753, p. 473.)

PRUNUS ? ACUTIFOLIA Newb.

Plate XXII, Fig. 1.

Prunus ? acutifolia Newb., Fl. Amboy Clays, 90, *pl. 14, f. 1,* 1896.

Description.—Leaves ovate in outline, about 4.5 cm. in length by 2.5 cm. in breadth. Apex acute. Base rounded or slightly cuneate. Margins regularly and finely serrate except for a few millimeters at the base. Secondaries indistinct, evidently numerous and parallel, branching from the midrib at an acute angle, about 45°.

This species was based upon a single imperfect specimen from Woodbridge. An additional specimen, lacking the tip, and two other fragments were subsequently collected at South Amboy. A very similar leaf from Gay Head, Marthas Vineyard, is described by Hollick[1] as an *Amelanchier,* and Lesquereux describes leaves and fruit from the Dakota Group as a species of *Prunus* of the Amygdalus section.

Occurrence.—Woodbridge, South Amboy.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

[1] Hollick, Mon. U. S. Geol. Surv., vol. L, 1907, p. 83, pl. 32, f. 1.

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Order GERANIALES.

Family RUTACEÆ.

Genus CITROPHYLLUM Berry.

(Bull. Torrey Club, vol. 36, 1909 p. 258.)

CITROPHYLLUM ALIGERA (Lesq.) Berry.

Plate XXI, Figs. 1–8.

Ficus aligera Lesq., Fl. Dakota Group, 84, *pl. 10, f. 3–6*, 1892.
Berry, Rept. State Geologist (N. J.) for 1905, 139: 1906.
Bull. Torrey Club, vol. 33: 172, 1906.
Citrophyllum aligera Berry, Bull. Torrey Club, vol. 36: 258, *pl. 18a, figs. 1–8*, 1909.

Description.—Leaves, small, elliptical to ovate or ovate-lanceolate in outline, coriaceous in texture, varying from 2.5 cm. to 6 cm. in length by 1.8 cm. to 3.2 cm. in breadth. Margins entire, occasionally slightly undulate. Apex rounded or obtusely acuminate. Base rounded, sub-truncate or cuneate. Petiole stout, from .7 cm. to 2 cm. in length, conspicuously alate. The petiolar wings may be oblong-lanceolate in outline or obovate, together they are from 2.5 mm. to 5 mm. in width, averaging about 3.5 mm. Midrib stout. Secondaries fine, more or less obscured by the coriaceous leaf substance, about 9 alternate pairs, branching from the midrib at angles of from 45° to 50°, parallel, camptodrome.

These curious leaves were described by Lesquereux from the Dakota Group as a species of *Ficus* and compared with *Ficus bumelioides* Ettings., and *Ficus mudgei* Lesq., neither of which has alate petioles, while the first has an emarginate apex. Subsequently the same leaves were found in the Magothy formation of New Jersey, and only recently a single small leaf was found in the upper Raritan beds at South Amboy. They exhibit considerable variability in outline, but all have exactly the same aspect and conspicuous alate petiole. They appear to be related to the leaves of the modern genus *Citrus*. The latter have ex-

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actly the same texture and venation, the same variability in outline and marginal undulations, the same stout midrib and conspicuously alate petioles. In examining a suite of specimens of the latter and comparing them with the fossils the conclusion seems to be irresistible that they are related, and the writer has consequently referred the fossils to a new genus which emphasizes this relationship to the modern genus. All of the fossil specimens which are at all complete are figured on Plate xxi, and two modern leaves are introduced for comparison. Possible arguments against the present view may be based on the theory that the modern alate petioles are derived from ancestors with compound leaves; in fact, some modern species still have trifoliate leaves, and if this were true of the fossils as well, it would require considerable rapidity of evolution in this genus previous to the mid-Cretaceous. The modern leaves abscis from the top of the petiole, and would be unlikely to occur as fossils with the petiole attached, neither can any indication of such an abscission line be made out in the fossils. This is the most difficult argument to combat. However, modern leaves are sometimes shed in their entirety, and we are justified in predicating the occasional fall of leaves before maturity when the abscission layer of cells had not yet become weakened. The agency might be violent winds, the passage of large animals like some of the Cretaceous dinosaurs, or weakened conditions due to insect or fungous diseases.

Occurrence.—South Amboy.

Collections.—U. S. National Museum.

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Order SAPINDALES.

Family ILICACEÆ.

Genus ILEX *Linné.*

(Sp. Pl., 1753, p. 125.)

ILEX ? ELONGATA Newb.

Ilex ? elongata Newb., Fl. Amboy Clays, 98, *pl. 18, f. 1, 5,* 1896.

Description.—Leaves of relative large size for this genus, lanceolate in outline, 10 cm. to 13 cm. in length, by 3 cm. in greatest breadth. Apex and base acute. Margin with remote spiny teeth. Midrib, stout. Secondaries thin, apparently craspedodrome, branching from the midrib at an acute angle in the middle of the leaf, but at a much wider angle toward the apex.

This species is based upon the two incomplete specimens figured by Prof. Newberry (loc. cit.), which are the only specimens that have ever been collected. Consequently, the diagnosis is somewhat incomplete, the generic relationship is uncertain and the reference to *Ilex* can only be provisional.

Occurrence.—Sayreville.

Collections.—N. Y. Botanical Garden.

ILEX AMBOYENSIS *Berry.*

Ilex ? ovata Newb., Fl. Amboy Clays, 98, *pl. 18, f. 2,* 1896 (non Gœpp. 1852).

Ilex amboyensis Berry, Bull. Torrey Club, vol. 36:259, 1909.

Description.—Leaves small, broadly lanceolate in outline, about 4 cm. in length, by 2 cm. in breadth. Apex obtuse. Base narrowed and apparently acute. Margin beset with small and large subacute teeth. Midrib mediumly stout and curved. Only a few secondaries are visible, these branch from the midrib at

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angles of about 45° and with but slight curving run directly to the marginal teeth.

This species was based on the single specimen figured by Prof. Newberry (loc. cit.), and no additional specimens have come to light. Although associated with the preceding, it is abundantly distinct. Like the former, however, its botanical affinity is uncertain. Prof. Newberry's name was a preoccupied one and the present name is given in allusion to the general locality.

Occurrence.—Sayreville.

Collections.—N. Y. Botanical Garden.

Family CELASTRACEÆ.

Genus CELASTRUS Linné.

(Sp. Pl., 1753, p. 196.)

CELASTRUS ARCTICA Heer.

Plate XXV, Figs 1–5.

Celastrus arctica Heer, Fl. Foss. Arct., vol. 7:40, *pl. 61, f. 5d, e*, 1883.

Newb., Fl. Amboy Clays, 98, *pl. 13, f. 8–18*, 1896.

Hollick, Ann. N. Y. Acad. Sci., vol. 11:60, *pl. 4, f. 8*, 1898; Bull. N. Y. Bot. Garden, vol. 3:408, *pl. 70, f. 12, 13*, 1904; U. S. Geol. Surv. Mon., 50:88, *pl. 33, f. 9–11*, 1907.

Description.—"C. foliis parvulis, lineari-lanceolatis, apice longe attenuatis, basi angustatis, denticulatis, nervis secundariis angulo acuto egredientibus." Heer, 1883.

Leaves elongated and narrow, linear-lanceolate in outline, with an equally acuminate apex and base and a short, stout petiole, ranging from 4 cm. to 13 cm. in length, by from 0.5 cm. to 1.5 cm. in breadth. Midrib stout. Secondaries numerous, parallel, nearly straight, branching from the midrib at acute angles ranging from 12° to 37°, inosculating near the margin, short branches from this marginal hem entering the teeth. Margin regularly

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and somewhat remotely dentate, with shallow, rounded sinuses between the teeth, the cuneate base entire margined.

This species, which is excessively abundant in the upper Raritan beds at South Amboy, but which has not been found elsewhere in the New Jersey Raritan, was described originally from the Patoot beds of Greenland, which are usually correlated with the Senonian of Europe. The Greenland material was limited and the specimens were small in size compared with the usual Raritan forms. There is no question of their identity, however. Professor Heer compared them with *Celastrus Ettingshauseni*, of the European Tertiary, which resembles a number of modern species of *Celastrus* of the East Indian region. The present fossils exhibit considerable resemblance to the leaflets of the palmately compound Dewalqueas of the European Upper Cretaceous and Lower Eocene, but no evidence of a similar habit is indicated among the large number of specimens collected from South Amboy.

This species is recorded by Hollick from Block Island and Long Island, and is also present in the Kreischerville beds of Staten Island.

Occurrence.—South Amboy.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

Genus CELASTROPHYLLUM Goeppert.

(Tertiarfl. Insel Java, 1854, p. 52.)

CELASTROPHYLLUM MINUS Hollick.

Plate XXII, Fig. 3.

Celastrophyllum minus Hollick in Newb., Fl. Amboy Clays, 105, *pl. 42, f. 51, 52*, 1896.

Description.—Leaves small, 12 mm. to 13 mm. in length by about 8 mm. in greatest breadth, broadly spatulate in outline. Margin entire or somewhat irregularly and feebly crenate in the upper half of the leaf. Apex broadly rounded. Base narrow,

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cuneate, decurrent on the relatively long petiole. Venation obsolete.

This small species was based on a limited amount of material in Prof. Newberry's collection, which lacked information as to the exact locality. It has not since been collected and is to be regarded as obscure in its affinities, although it resembles the forms which Newbeery called *Celastrophyllum robustum* and *C. spatulatum,* and may possibly represent small leaves of either of these species.

Occurrence.—Milltown.

Collections.—N. Y. Botanical Garden.

CELASTROPHYLLUM NEWBERRYANUM Hollick.

Plate XXII, Figs. 5–7.

Celastrophyllum Newberryanum Hollick in Newb., Fl. Amboy Clays, 101, *pl. 49, f. 1–27,* 1896; Trans. N. Y. Acad. Sci., vol. 16: 133, *pl. 14, f. 1,* 1897.

Knowlton in White & Schuchert, Bull. Geol. Soc. Amer., vol. 9: 353, 1898.

Berry, Bull. N. Y. Bot. Garden, vol. 3: 85, 1903; Bull. Torrey Club, vol. 31: 78, 1904.

Description.—Leaves of medium size, 2.5 cm. to 6 cm. in length by 1 cm. to 2.5 cm. in breadth, ranging in outline from narrowly to broadly ovate or obovate. Apex somewhat rounded, although it may be acute or apiculate in the narrower forms. Base somewhat cuneate and slightly decurrent. Margin entire in the basal half or third of the leaf, sometimes so throughout, elsewhere with mostly small, closely set, appressed denticles. Midrib mediumly stout. Secondaries 5 or 6 pairs, branching from the midrib at angles of about 45°, curved, camptodrome.

In size, outline and venation this species, which is exceedingly abundant, is very close to various modern members of the family Celastraceae, and may be compared with our existing *Celastrus scadens* Linné, which it closely resembles.

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It is probably present in the Atane beds of Greenland in some of the leaves which Heer includes under his *Celastrophyllum crenatum*, and it has been reported by Hollick from the Magothy formation at Cliffwood bluff, where it is apparently rare. It would seem as if such an abundant element in the late Raritan would be present in allied floras to the southward, although as yet its presence has not been detected. A new species which occurs in the Magothy formation at Grove Point, Maryland, approaches *Celastrophyllum Newberryanum* and is probably a direct descendant from it.

Forms from the Bohemian Cretaceous, which are practically identical with the smaller and more pointed leaves of this species, are referred by Velenovsky[1] to the genus *Phillyrea* of the Oleaceæ and compared with the living *Phillyrea latifolia* Linné of southern Europe.

Occurrence.—Sayreville, South Amboy.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

CELASTROPHYLLUM UNDULATUM Newb.

Celastrophyllum undulatum Newb., Fl. Amboy Clays, 102, *pl. 38, f. 1–3*, 1896.

Smith, Geol. Coastal Plain in Ala., 348, 1894 (nomen nudum).

Description.—Leaves of large size, 10 cm. to 15 cm. in length by 4 cm. to 8 cm. in breadth, ovate oblong or ovate in outline, with an obtuse or bluntly pointed apex and somewhat narrowed base. Margin strongly undulate or broadly and coarsely crenate, somewhat variable in the character of its teeth. Midrib stout. Secondaries numerous, a dozen or more sub-opposite pairs, which branch from the midrib at a wide angle and fork near the margins to form festoons which coincide approximately with the marginal teeth.

[1] *Phillyrea Englehardti* Velen., Fl. Böhm. Kreidef., Theil. IV., 1885, p. 7, *pl. iv., figs. 2–5.*

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This very large species resembles the larger leaves which are referred to *Celastrophyllum crenatum* Heer, but is much larger and more elongate in outline. Its size has apparently rendered perfect specimens rare and the recovered remains are usually fragmentary. Velenovsky hints at its identity with the leaves named by him *Myrica Zenkeri* from the Bohemian Cretaceous, although this resemblance is obviously slight, the present species more nearly resembling the Bohemian leaves which this author identifies as a species of *Ternstroemia*.

It has been reported from the Tuscaloosa formation of Alabama, and the writer has obtained material even larger than the largest New Jersey specimens from the Bladen formation of North Carolina.

Occurrence.—Sayreville, Woodbridge.

Collections.—N. Y. Botanical Garden.

CELASTROPHYLLUM DECURRENS Lesq.

Plate XXII, Fig. 8.

Celastrophyllum decurrens Lesq., Fl. Dakota Group, 172, *pl. 36, f. 1*, 1892.

Celastrophyllum angustifolium Newb., Fl. Amboy Clays, 100, *pl. 14, f. 8–17*, 1896.

Description.—Leaves of variable size, 5 cm. to 15 cm. in length by 1.5 cm. to 4 cm. in breadth, lanceolate, tapering almost equally in both directions. Apex usually acuminate, rarely subacute. Base narrowed and decurrent. Margins entire toward the base, above serrulate, or finely crenate-dentate. Midrib stout. Secondaries fine and very numerous, usually about 2 mm. apart, parallel, diverging from the midrib at an angle of 40° to 45°, finally branching and forming an intricate network along the margin, the ultimate branches running directly to the margin.

The single specimen from the Dakota Group of Kansas, upon which Lesquereux founded this species is not specifically distinct from the more abundant leaves from the Raritan, which Newberry called *Celastrophyllum angustifolium*, the latter serving simply to show the limits of variation of the former. Les-

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quereux compared his leaf to *Celastrophyllum lanceolatum* Ettings. and Newberry in discussing Velenovsky's treatment of *Myrica Zenkeri,* is quite positive that the present species is a *Celastrophyllum.* The evidence for this is by no means as conclusive as Newberry thought it was, and it will probably be demonstrated in the future that the present species is a *Myrica* and not a *Celastrophyllum,* another alternative being to regard it as a species of *Dryandroides,* the genus to which Ettingshausen originally referred *Myrica Zenkeri.*

This species apparently ranges throughout the Raritan, the writer being able to add Milltown and South Amboy to the recorded localities.

Occurrence.—Woodbridge, South Amboy, Milltown.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

CELASTROPHYLLUM CRETACEUM Lesq.

Celastrophyllum cretaceum Lesq., Fl. Dakota Group, 173, *pl. 38, f. 12–14,* 1892.
Newb., Fl. Amboy Clays, 100, *pl. 42, f. 13,* 1896.

Description.—Leaves small, 2 cm. to 4 cm. in length by 0.9 cm. to 1.2 cm. in breadth, elliptical or oblong in outline. Apex obtusely rounded. Base narrowed, giving some of the leaves an almost spatulate outline. Texture thick, subcoriaceous. Margin entire throughout. Midrib comparatively stout. Secondaries slender, branching from the midrib at an angle of 30° to 40°, slightly curved, distant, parallel, often obsolete, camptodrome.

These leaves, which occur in some abundance in the Dakota Group of Kansas and reappearing in the Raritan, are by no means satisfactorily correlated with the genus *Celastrophyllum* and suggest some Ericaceous genus.

This species is not contained in any recent collections from New Jersey, and Newberry again failed to record the localities from which his material was obtained.

Occurrence.—Locality unknown.

Collections.—N. Y. Botanical Garden.

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CELASTROPHYLLUM CRENATUM Heer.

Plate XXII, Fig. 9; Plate XXIII, Fig. 2.

Celastrophyllum crenatum Heer, Fl. Foss. Arct., vol. 7: 41, *pl. 62, f. 21*, 1883.
Smith, Geol. Coastal Plain in Ala., 348, 1894.
Newberry, Fl. Amboy Clays, 99, *pl. 48, f. 1–19*, 1896.
Berry, Bull. Torrey Club, vol. 34: 197, *pl. 13, f. 5*, 1907.

Description.—"C. foliis parvulis, membranaceis, ellipticis, crenatis, nervis secundariis numerosis, valde camptodromis, reticulato venosis." Heer, 1883.

Leaves very variable in size, 2 cm. to 8 cm. in length by 1 cm. to 5 cm. in breadth, ovate or elliptical in outline, broadly rounded above, narrowed and inequilateral below. Margins entire below, coarsely toothed above with somewhat variable rounded, crenate or crenate-dentate teeth. Occasional specimens are entire throughout and some have a markedly inequilateral base. Midrib mediumly stout. Secondaries numerous, 9 to 10 pairs, subopposite, branching from the midrib at an angle somewhat in excess of 45°, slightly curved upward and parallel, branching near the margin to form festoons from which branches enter the marginal teeth.

This species was described by Heer from the Patoot beds of Greenland, and unfortunately only a single small leaf was figured. The Raritan leaves, which are abundant, grade into much larger forms, which are also present in the Bladen formation of North Carolina and the Tuscaloosa formation of Alabama.

Occurrence.—Sayreville, South Amboy.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

CELASTROPHYLLUM SPATULATUM Newb.

Plate XXII, Fig. 4.

Celastrophyllum spatulatum Newb., Fl. Amboy Clays, 103, *pl. 42, f. 43–45*, 1896.
Celastrophyllum robustum, Newb., Ibid., *f. 41, 42.*

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Description.—Leaves small, 3 cm. to 4 cm. in length by 1.4 cm. to 3 cm. in breadth, ovate to broadly spatulate in outline. Apex rounded more or less broadly. Base narrowed and decurrent. Margins entire below, dentate above, the teeth usually confined to the apical third of the leaf. Midrib usually somewhat curved, giving the leaves an unsymmetrical appearance. Secondaries 6 to 8 pairs, branching from the midrib at an acute angle, curving slightly upward, camptodrome.

The more narrow forms were separated from the broader forms by Prof. Newberry, both being given specific rank, although it seems obvious that they are the variable extremes of a single species, and that not an especially variable one. They approach rather closely to *Celastrophyllum Brittonianum* Hollick, but are readily distinguishable by their less symmetrical shape and narrower base, their coarser and less numerous teeth, and their usually more numerous, more ascending, and straighter secondaries.

No localities for this species are given in Prof. Newberry's Monograph. Later collections show it to be abundant in the upper Raritan at South Amboy.

Occurrence.—South Amboy.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

CELASTROPHYLLUM GRANDIFOLIUM Newb.

Plate XXIII, Fig. 1.

Celastrophyllum grandifolium Newb., Fl. Amboy Clays, 104, *pl. 19, f. 8; pl. 21, f. 1–4,* 1896.

? Hollick, Mon. U. S. Geol. Surv., vol. 50: 88, *pl. 33, f. 8,* 1907.

Description.—Leaves large, 12 cm. to 25 cm. in length, by 4 cm. to 7 cm. in breadth, ovate-lanceolate in outline. Apex rounded or subacute. Base varying from rounded to cuneate. Margins entire below, above somewhat irregularly undulate or closely serrate, or with coarse, rounded teeth. Petiole long (up to 4.5 cm.), very stout. Midrib stout. Secondaries numerous

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and slender for such large leaves, 12 to 15 pairs, branching from the midrib at angles of 45° or slightly more, somewhat flexuous and iregular in their course, camptodrome. Tertiaries generally transverse, forming a coarsely quadrangular areolation.

This species is quite variable, not only in size, but especially in marginal characters, which show every gradation from nearly entire forms to closely serrate forms; this is, however, a character which is more or less variable in all of the Raritan species of this genus. This is a very distinct species, however, its nearest ally apparently being *Celastrophyllum lanceolatum*, described by Ettingshausen from the Cretaceous of Saxony,[1] and which Heer apparently recognized in his Greenland material.[2]

Numerous specimens from New Jersey are in Newberry's collection, but none have the locality labels preserved. Two specimens were obtained in recent collections from Milltown.

Occurrence.—Milltown.

Collections.—N. Y. Botanical Garden.

CELASTROPHYLLUM BRITTONIANUM Hollick.

Celastrophyllum Brittonianum Hollick in Newb., Fl. Amboy Clays, 105, *pl. 42, f. 37, 38, 46, 47*, 1896.

Ward, 15th Ann. Rept. U. S. Geol. Surv., 349, 358, 377, 378, 379, 1895 (nomen nudum).

Mon. U. S. Geol. Surv. vol. 48: 493, *pl. 107, f. 7*, 1906.

Description.—Leaves small, 4 cm. to 5 cm. in length, by 1.2 cm. to 1.5 cm. in breadth, lanceolate, or in some specimens somewhat spatulate in outline. Apex subacute. Base somewhat decurrent and straight sided. Margins entire below, denticulate above. Midrib stout. Secondaries numerous, somewhat irregular, of fine calibre but prominent, camptodrome.

This species is clearly distinct from *Celastrophyllum spatulatum* Newb., although it stands nearer the latter than to any

[1] Ettingshausen, Kreidfl. von Niederschoena, 1867, p. 260, pl. iii, fig. 9.

[2] Heer, Fl. Foss. Arct., vol. VII, 1883, p. 40, *pl. lxiv, fig. 9a; pl. lxv, figs. 7, 8.*

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other known form. It seems to be a somewhat older type, since it has been recognized in the considerably older deposits of the Patapsco formation in Virginia. It would be interesting to know from what horizon or horizons in the Raritan it had been collected, but Prof. Newberry failed to indicate the locality in connection with any of his several specimens, and it has not been collected since his day.

Occurrence.—Locality unknown.

Collections.—N. Y. Botanical Garden.

Family ACERACEÆ.

Genus ACER Linné.

(Sp. Pl., 1753. p. 1055.)

ACER AMBOYENSE Newb.

Acer amboyense Newb., Fl. Amboy Clays, 106, *pl. 46, f. 5–8,* 1896.

Acer sp., Hollick, Mon. U. S. Geol. Surv., vol. 50: 89, *pl. 33, f. 12, 13,* 1907.

Description.—Leaves unknown. Species based on fruits (samara) which resemble greatly those of the modern red maple of this latitude. They are somewhat variable in appearance, in the size of the carpel and in the outline of the wing, but these are interpreted as examples of variability such as may readily be seen in examining a series of fruits of the modern species.

The carpel proper varies in diameter from 3 mm. by 2 mm., to 7 mm. by 3 mm., the latter probably being nearer the normal form. The wing varies in length from 1 cm. to 1.7 cm., probably averaging about 1.5 cm. and in breadth from 5 mm. to 9 mm. The lower margin is thickened and curved (straight in one specimen) with the characteristic parallel, curving, occasionally forked veins.

Although these remains are fairly common and seem clearly allied to *Acer,* no leaves of this genus have been discovered in

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the Raritan and a single, poorly defined leaf is referred to *Acer* from the insular Cretaceous flora. This absence of foliar remains suggests that these remains are more properly comparable with the winged seeds of conifers like those of *Pinus*, leaves of which are common in the Raritan formation. Judged by the modern representatives they are much more like *Acer* than *Pinus* or other conifers, and they are therefore retained in the genus where they were placed by Prof. Newberry.

In addition to specimens from Woodbridge and South Amboy, undoubtedly similar specimens are recorded from Marthas Vineyard.

Occurrence.—Woodbridge, South Amboy.

Collections.—N. Y. Botanical Garden.

Order RHAMNALES.

Family RHAMNACEÆ.

Genus RHAMNITES Forbes.

(Quart. Jour. Geol. Soc. Lond., vol. VII, 1851, p. 103.)

RHAMNITES MINOR Hollick.

Rhamnites minor Hollick, in Newb., Fl. Amboy Clays, 106, *pl. 42, f. 36*, 1896.

Description.—Leaves small, ovate in outline, 1.9 cm. or 2 cm. in length and 1.1 cm. or 1.2 cm. in greatest breadth, which is at the middle of the leaf. Apex rounded. Base cuneate, slightly decurrent to the extremely short and stout petiole. Venation fine. Secondaries, few, 4 or 5 pairs, subopposite; the lower diverge at an acute angle and run parallel with the margin; the upper are much shorter and more oblique; all camptodrome.

This species is based on the single specimen figured in Prof. Newberry's monograph (loc. cit) and no additional examples have come to light. In general appearance and venation it is con-

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generic and closely resembles *Rhamnites apiculatus* Lesq.,[1] but is of smaller size and has a less acute tip and a shorter petiole The original locality in the Raritan from which the specimen was collected is not recorded.

Occurrence.—Locality unknown.

Collections.—N. Y. Botanical Garden.

Family VITACEÆ.

Genus HEDERA Linné.

(Sp. Pl., 1753, p. 202.)

HEDERA OBLIQUA, Newb.

Hedera obliqua Newb., Fl. Amboy Clays, 113, *pl. 37, f. 8; pl. 38, f. 5*, 1896.

Description.—Leaves large, obliquely elliptical in outline, markedly unsymmetrical, 9 cm. to 15 cm. in length by 8 cm. to 11 cm. in width. Margins somewhat undulate, especially distad. Petiole stout, 2.3 cm. or more in length. Apex broadly rounded or emarginate. Base rounded or truncate. Primaries 5 or more, palmate, diverging at acute angles from the top of the thickened petiole, the midrib the stoutest; the balance fork or soon curve to join branches from the midrib, forming a somewhat irregular and open network of camptodrome arches.

This species may be nothing more than a variant of *Hedera primordialis* Saporta, which it greatly resembles, since it is much less abundant. It is, however, generally larger in size, strikingly unsymmetrical and lacks the cordate base of that species. It is confined to the Woodbridge locality.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

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[1] Lesq., Fl. Dakota Group, 171, pl. 37, f. 8–13, 1892.

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HEDERA PRIMORDIALIS Saporta.

Hedera primordialis Sap., Le Monde des Pl., 200, *f. 29, 1, 2,* 1879.

Velen., Fl. Böhm Kreidef. Theil 1 : 19 *pl. 8, f. 7; pl. 9, f. 4, 5; pl. 10, f. 3, 4,* 1882.

Heer, Fl. Foss. Arct., vol. 6, ab. 2 : 82, *pl. 15, f. 9, 10; pl. 24, f. 6, 7a; pl. 28, f. 13, 14,* 1882.

Newb., Fl. Amboy Clays, 113, *pl. 19, f. 1, 9; pl. 37, f. 1–7,* 1896.

Berry, Bull. Torrey Club, vol. 34 : 201, *pl. 16,* 1907.

Description.—Leaves elliptical, reniform, or cordate in outline, very variable in size and shape. Length 3 cm. to 12 cm., breadth 3.2 cm. to 12 cm., usually broader than long. Apex rounded or obtusely pointed, sometimes slightly emarginate. Margin somewhat irregular but entire. Base varying from truncate to deeply cordate. Petiole long and stout, usually not preserved. Venation palmate from top of the petiole. Primaries varying in number from 3 to 7, usually 5 to 7, of which the midrib is the stoutest, especially in the smaller leaves. The lowest pair of primaries, which are approximately parallel with the basal margins of the leaf, are smaller in size than the others, and should, perhaps, be regarded as secondaries. If this is done the primaries are normally 5 in number, curved and camptodrome.

This species was figured by Saporta in 1879 from the Cenomanian of Bohemia and described three years later by Velenovsky from the same horizon. Heer identifies rather fragmentary remains from the Atane beds of Greenland with this species, which is also abundant in the Woodbridge Raritan and in the Bladen formation of North Carolina. It varies greatly in size and appearance, some of the smaller specimens from abroad suggesting the genus *Cercis,* while the smaller Raritan leaves suggest somewhat the genus *Ficus.* Of these variable specimens we are disposed to consider as typical Velenovsky's *Pl. X, fig. 4,* and Saporta's *fig. 2,* as well as various Woodbridge specimens, which are, however, mostly incomplete.

This is a remarkably widespread species and better characterized where it does occur than is usually the case in such cosmo-

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politan types. It is an important horizon marker and by itself is almost sufficient to fix the age of the Raritan as Cenomanian. Although the modern representation of this genus is reduced to two species in Europe and northern Africa and a third in Japan, it seems to have been a more or less prominent type in the Cretaceous and Tertiary floras of the globe. In addition to the present species, which has the wide range previously mentioned, eight or ten additional Cretaceous species, mostly American, are known. The Eocene, both of America and Europe, furnishes six or eight species; the Oligocene, of Europe and the Arctic regions, one or two species, and the Miocene and Pliocene two or three additional. The modern Old World *Hedera Helix* Linné is recorded from the Pleistocene (Interglacial) of England, Italy and the Paris basin, and one of the Upper Miocene species appears also to have survided into the Italian Pleistocene. While so abundant an element in our Cretaceous floras, it is not a native plant in the existing flora of North America.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Genus CISSITES Heer.

(Phyll. Crét. Nebr., 1866, p. 19.)

CISSITES FORMOSUS Heer.

Cissites formosus Heer, Fl. Foss. Arct., vol. 6, ab. 2:85, *pl. 21, f. 5–8*, 1882.

Lesq., Fl. Dakota Group, 161, *pl. 21, f. 5*, 1892.

? Hollick, Bull. Torrey Club, vol. 21:57, *pl. 174, f. 6*, 1894; U. S. Geol. Surv. Mon. 50:94, *pl. 37, f. 7*, 1907.

Newb., Fl. Amboy Clays, 107, *pl. 47, f. 1–8*, 1896.

Description.—"C. foliis palmatis, profunde trilobatis, lobo medio basi contracto, trilobato, lobis obtusis." Heer, 1882.

The foregoing description was based upon very fragmentary material from the Atane beds of Greenland, from which, nevertheless, Prof. Heer reconstructed the supposed outline of the perfect leaf. Judging by the specimens referred to this species

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by Lesquereux and Newberry, it was an exceedingly variable form. In plan it was trilobate, but the subsidiary lobes developed upon both the median and the lateral lobes obscures this trilobate character and suggests *Cissites parvifolius* Berry[1] of the Albian of America and Europe, *Cissites dentato-lobatus* Lesq., of the Dakota Group or *Cissus vitifolia* Velen. of the Cenomanian of Bohemia.

The primaries are stout and 3 in number; they may diverge from the top of the stout petiole or be supra-basilar; very often the branches of the laterals approach so near the base that the leaves have the appearance of being palmately 5-veined.

This species is common but fragmentary in the Raritan beds; it ranges in size from 7 cm. to 10 cm. in length and from 6 cm. to 12 cm. between the tips of the main lateral lobes. The sinuses are all rounded, and the main ones may be deep or shallow. The fragment from Long Island referred to this species by Hollick is, as that writer remarks, exceedingly unsatisfactory and doubtful.

The genus *Cissites* was instituted by Heer in 1866 for the species *Cissites insignis* from the Dakota Group of Nebraska, which presented various points of affinity with the genus *Cissus* of Linné. It is a largely developed type in the upper half of the Cretaceous period, but is replaced after the Eocene by forms which are definitely referable to the modern allied genera such as *Cissus, Vitis,* etc.

Occurrence.—Sayreville, Woodbridge, South Amboy.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

Cissites crispus Velen. ?

Cissites crispus Velen., Fl. Böhm. Kreidef., Th. 4: 12, *pl. 4, f. 6,* 1885.

? Newb., Fl. Amboy Clays, 108, *pl. 42, f. 20–23,* 1896.

? Berry, Bull. Torrey Club, vol. 33: 177, 1906.

Description.—"Das abgebildete Fragment gehört einem kleinen Blättchen von rundlicher Form und handförmiger Nerva-

[1] Founded on the species of *Vitiphyllum* of Fontaine and *Cissites obtusilobus* Saporta.

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tion. Es ist am Rande geschnitten gezähnt. Die Haupt-und Secondärnerven sind scharf hervortretend Die Blattfläche zwischen den stärkeren Nerven ist faltig gewölbt. Velenovsky, 1885.

This species is characterized by Velenovsky as quoted above. The American remains of small deeply toothed or incised leaves, while they resemble the Bohemian form and are probably related to it, are doubtfully identical with it. This is especially true of the Magothy leaves contained in carbonate of iron nodules, which the writer has identified as this species from New Jersey and Delaware; both this and the Raritan determinations are, therefore, questioned in the foregoing synonomy.

Occurrence.—Woodbridge, South Amboy.

Collections.—N. Y. Botanical Garden.

Order MALVALES.

Family STERCULIACEÆ.

Genus PTEROSPERMITES Heer.

(Fl. Tert. Helv. vol. III, 1859, p. 37.)

PTEROSPERMITES OBOVATUS (Newb.) Berry.

Protophyllum obovatum Newb., Fl. Amboy Clays, 128, *pl. 38, f. 4*, 1896.

Pterospermites obovatus Berry, Bull. Torrey Club, vol. 36: 259, 1909.

Description.—Leaf elliptical in outline, about 12 cm. in length by 7.5 cm. in greatest breadth, which is near the middle. Margins entire. Midrib stout. Secondaries about 10 pairs, sub-opposite to alternate, comparatively slender and somewhat flexuous, camptodrome. Apex apparently rounded. Base contracted and then prominently auriculate, the three or four secondaries involved radiating from the base of the midrib.

This species is based upon a single specimen from Woodridge, which Professor Newberry suggested might be related to the modern species of *Coccoloba*.

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Very little can be said in favor of the reference of this leaf to Lesquereux's genus *Protophyllum*, all of the species of which differ from it in outline and marginal characters. Professor Newberry places great reliance upon the character of the base, but in the Raritan specimen this is decidedly auriculate and not subpeltate and the veins in this part of the leaf are radiate and not more or less parallel. Finally, the venation is distinctly camptodrome and not craspedodrome, as it is in Lesquereux's definition of the genus and in all other species which have subsequently been referred to it. For these reasons it is here placed in the genus *Pterospermites*, which seems to be a more natural arrangement. It may be compared with *Pterospermites auriculatus* Heer[1] of the Atane beds of Greenland, which, while somewhat different in outline, is a leaf of the same general facies and is undoubtedly congeneric.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Order PARIETALES.

Family PASSIFLORACEÆ Linné.

Genus PASSIFLORA Linné.

(Sp. Pl., 1753, p. 955.)

PASSIFLORA ANTIQUA Newb.

Plate XXIII, Fig. 5.

Passiflora antiqua Newb., Fl. Amboy Clays, 109, *pl. 23, f. 7*, 1896.

Description.—Leaves of medium size, narrowly bilobate, the lobes widely diverging at an angle of about 45°, rounded apically. Sinus open, rounded. Base broadly cuneate. Petiole stout. Margins entire. Primaries 3 palmate from top of

[1] Heer, Fl. Foss. Arct. vol. 6, Ab. 2: 95, *pl. 27, f. 4*, 1882.

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the petiole, diverging at acute angles, the midrib running straight to the base of the sinus, the laterals but slightly curved in passing to the tips of the lobes. Secondaries remote, fine, camptodrome.

Passiflora is entirely a warm temperate or tropical type, and while it is found in both Asia and Australia it is primarily American and makes its greatest display in the tropics of Central and South America. Perhaps 250 species in all have been described.

Fossil representatives of this genus are rare. In addition to the present species two characteristic species are described by Friedrich[1] from the much more recent Ligurian deposits of Saxony.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Order MYRTALES.

Family MYRTACEÆ.

Genus EUCALYPTUS L'Heritier.

(Sert. Angl., 1788, p. 18.)

EUCALYPTUS GEINITZI (Heer) Heer.

Myrtophyllum Geinitzi Heer, Fl. v. Moletein, *22, pl. 11, f. 3, 4,* 1872; Fl. Foss. Arct., vol. 3, ab. 2: 116, *pl. 32, f. 14–17; pl. 33, f. 6b,* 1874.

Eucalyptus Geinitzi Heer, Fl. Foss. Arct., vol. 6, ab. 2: 93, *pl. 19, f. 1c; pl. 45, f. 4–9; pl. 46, f. 12c, d, 13;* 1882.

Velen., Fl. Böhm. Kreidef. Theil 4: 1, *pl. 1, 2, 3, fig. 1; pl. 4, f. 1, 13,* 1885.

Lesq., Fl. Dakota Group, 138, *pl. 37, f. 20,* 1892.

Newb., Fl. Amboy Clays, 110, *pl. 32, f. 2, 12* (non *f. 15, 16*) 1896.

[1] Friedrich, Beitr. Tertfl. Sachsen, 195, 234, *pl. 25, f. 20; pl. 31, f. 1, 2,* 1883.

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Hollick, Ann. N. Y. Acad. Sci., vol. 11:60, *pl. 4, f. 1–3*, 1898; Mon. U. S. Geol. Surv., vol. 50:96, *pl. 35, f. 1–8, 10–12*, 1907.

Berry, Bull. N. Y. Bot. Garden, vol. 3:87, *pl. 53, f. 3*, 1903; Bull. Torrey Club, vol. 31:78, *pl. 4, f. 5*, 1904; Ibid., vol. 33:180, 1906; Ibid., vol. 34:201, *pl. 15, f. 4*, 1907.

Myrtophyllum Warderi Lesq., Fl. Dakota Group, 136, *pl. 53, f. 10*, 1892.

Hollick, Mon. U. S. Geol. Surv., vol. 50:97, *pl. 35, f. 13*, 1907.

Eucalyptus ? angustifolia Newb., (non Desv. 1822) Fl. Amboy Clays, 111, *pl. 32, f. 1, 6, 7*, 1896.

Hollick, Bull. N. Y. Bot. Garden, vol. 3:408, *pl. 70, f. 8, 9*, 1904; Mon. U. S. Geol. Surv., vol. 50:95, *pl. 35, f. 9, 14, 15*, 1907.

Description.—"M. foliis petiolatis, coriaceis, anguste lanceolatis, nervis secundariis sub-angulo acuto egredientibus." Heer, 1872.

A very large number of somewhat variable leaves have been referred to this species since it was described by Heer in 1869 as the type of the genus *Myrtophyllum* and based upon material from the Cenomanian of Moravia. In 1882 the same author definitely referred this form to the genus *Eucalyptus*.

These diverse appearing leaves are, as a rule, of the same general type, and differ merely in size or in the closeness or remoteness of their secondaries, and it seems doubtful if the species as at present understood is composite, as has been claimed by some authors.

In general these leaves are lanceolate in outline (ovate-lanceolate in some Bohemian specimens), broadest near the middle and almost equally tapering in both directions to the acute apex and base. The petioles are very stout, as is the prominently raised midrib. Secondaries numerous, thin, branching from the midrib at acute angles, about 45°, and running with but slight curvature to the marginal hem, which is either almost straight where the secondaries are close-set or more or less bowed where the sec-

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ondaries are some little distance apart, as in the Raritan specimens. The larger leaves from New Jersey, which Prof. Newberry referred to this species, are not related to the smaller ones from South Amboy, which appear to be correctly identified.

This species is wide-ranging and has been recorded from a number of Cenomanian localities in Europe and from the Atane beds of Greenland, the Dakota Group of Kansas, the Magothy formation of New Jersey and Delaware, the Bladen formation of North Carolina, from Marthas Vineyard, Block Island, Long Island and Staten Island.

The specimens from South Amboy described by Prof. Newberry as *Eucalyptus angustifolia* are here referred to *Eucalyptus Geinitzi*, to which species the Marthas Vineyard forms certainly belong. The Raritan leaves are segregated by Newberry on the ground of their more attenuated base and apex. This is shown to some extent in his Figure 1, but not in his other two figures, Figure 7 showing a leaf with a rounded base. My experience has been that the observed variation in undoubted leaves of *Eucalyptus Geinitzi* is sufficiently wide to include leaves like those referred to *E. angustifolia*. There is no advantage in maintaining on paper a species based on fragmentary material which it is impossible to differentiate with certainty. The name *E. angustifolia* is antedated by the living species so-called by Desvaux in 1822, and rather than rename the Raritan plant it is referred to the present species.

Under his discussion of *Eucalyptus angustifolia* Prof. Newberry goes into a somewhat lengthy discussion of the objects which Prof. Heer regarded as *Eucalyptus* fruits, and records it as his opinion that they are unrelated to *Eucalyptus* and congeneric with the so-called scales of *Dammara* extensively distributed in mid-Cretaceous deposits. The lapse of time has fully sustained the latter view, and no paleobotanist at the present time would think of supporting the former view.[1]. Not only is this the case, but in one species of *Dammara*, at least, it has been shown by structural specimens that it and presumably all the other species are referable to the Araucarieæ.

[1] Some of the Bohemian remains are not included in this statement.

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Occurrence.—Sayreville, Milltown, Woodbridge, South Amboy.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

EUCALYPTUS LINEARIFOLIA Berry.

Plate XXVIII, Fig. 8.

Eucalyptus ? nervosa Hollick, Bull. Torrey Club, vol. 21: 56, *pl. 174 f. 10,* 1894; Ann. N. Y. Acad Sci., vol. 11: 61, *pl. 4, f. 5b,* 1898; Mon. U. S. Geol. Surv., vol. 50: 95, *pl. 8, f. 6b; pl. 35, f. 16,* 1907 (non. F. Muell.)

Smith, Geol. Coastal Plain in Ala., 348, 1894.

Newb., Fl. Amboy Clays, 112, *pl. 32, f. 3–5, 8,* 1896.

Eucalyptus linearifolia Berry, Bull. Torrey Club, vol. 34: 203, 1907.

Description.—Leaves elongate-linear in outline, 10cm. to 15 cm. in length by 1 cm. or less in width, with entire margins, a narrow cuneate base and a rounded obtuse apex. Midrib stout. Secondaries very numerous, parallel, crowded, 1 mm. to 2 mm. apart; they branch from the midrib at angles of 45° or somewhat less and run in a straight course to the marginal vein, which connects their distal ends in a straight line parallel, and close to, the margin.

This species is very similar to the contemporaneous leaves which have been referred to this genus, and especially to *Eucalyptus Wardiana* Berry[1] described from the overlying Magothy formation; in fact it is quite possible that the leaves from Block Island, Long Island and North Carolina, which have been identified as *Eucalyptus linearifolia,* may really be examples of *Eucalyptus Wardiana.* The former is also recorded from the Tuscaloosa formation of Alabama.

Occurrence.—South Amboy.

Collections.—N. Y. Botanical Garden.

[1] Berry, Bull. Torrey Club, 32: 47. 1905.

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EUCALYPTUS ? PARVIFOLIA Newb.

Eucalyptus ? parvifolia Newb., Fl., Amboy Clays, 112, *pl. 32, f. 9–10*, 1896.

Description.—Leaves small, lanceolate in outline, 5 cm. to 6 cm. in length by 1.1 cm. to 1.3 cm. in greatest width, which is about midway between the apex and the base, both of which are equally acute. Margins entire. Petiole apparently short. Midrib stout. Secondaries rather fine and remote, camptodrome somewhat angular; there are 9 or 10 subopposite to alternate pairs which branch from the midrib at angles of about 45° or less and inosculate at a considerable distance from the margin, there being no marginal vein present as in the usual leaves of this genus.

While it seems probable that this species is not referable to the genus *Eucalyptus*, nor related to the other leaves from the Raritan formation which are here referred to that genus, the material is so scanty and time-worn that it has seemed wisest to retain it as identified by Prof. Newberry rather than to attempt a reidentification which could not be made with any degree of conclusiveness.

This species has been recorded from the Tuscaloosa formation of Alabama, but like many other specimens from different localities in the Coastal Plain, so identified by Ward, it is not identical with Newberry's leaves, but is referable to *Salix* or *Laurus*.

This restricts the occurrence of the present species to the upper Raritan beds at South Amboy and emphasizes the singular variety and abundance of these supposed *Eucalyptus* leaves at this single horizon in the late Raritan.

Occurrence.—South Amboy.

Collections.—N. Y. Botanical Garden.

EUCALYPTUS ANGUSTA Velen.

Plate XXVIII, Figs. 1–4.

Eucalyptus angusta Velen., Fl. Böhm. Kreidef., Theil 4: 3, *pl. 3, f. 2–12*, 1885; Kvetena ceskeho cenomanu, 21, *pl. 6, f. 1*, 1889.

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Sap., Fl. Foss. Portugal, *207, pl. 36, f. 12,* 1894.
Berry, Bull. Torrey Club, vol. 36: 260, 1909.

Description.—"Blätter lineal, schmal lineallanzettlich, in der Mitte oder in der unteren Hälfte am breitesten, ganzrandig, vorne in eine sehr lange Spitze vorgezogen und mit einem harten Dorn beendet, Der Primärnerv gerade, ziemlich stark, zur Spitz hin verdünnt. Die Secundärnerven zahlreich, unter spitzen Winkeln entspringend, am Rande durch einen Saumnerv untereinander verbunden. Der Blattstiel gerade, etwa 1 cm. lang, stark." Velenovsky, 1885.

The foregoing is Velenovsky's description of this interesting species which is exceedingly common at a number of localities in the Perucer schichten of Bohemia (Cenomanian), where this author subsequently found fruit-bearing twigs which he described and figured in 1889 and which, it would seem, conclusively establish the botanical relations of these leaves.

Subsequently Saporta (loc. cit.) recorded this species from the Albian beds of Portugal; the latter material is, however, rather incomplete and open to question. Recent collections in our own Coastal Plain show that this species was present in considerable abundance on this side of the Atlantic at the same time that it flourished in Europe. It has been collected from the upper Raritan at South Amboy, where it is common; from the Bladen formation of South Carolina, and from the Upper Cretaceous of Georgia, and may be somewhat more fully characterized as follows:

Leaves alternate or scattered, mostly elongated, linear-lanceolate in outline, often falcate, 4.5 cm. to 15 cm. in length, by 5 mm. to 13.5 mm. in width, with an attenuated acute tip and a narrowly cuneate base declining to the short and stout petiole. Midrib mediumly stout below, becoming attenuated above. Secondaries very numerous, fine, and close-set, about 1 mm. apart, parallel, rather straight; they branch from the midrib at acute angles of about 30° or slightly less and run with but slight curvature to join the well-marked but fine marginal hem which shows in all the American material and in most of

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the illustrations of the foreign material. In all respects this is one of the most characteristically *Eucalyptus*-like species of the many which have been so identified, and its totality of characters, combined with the presence of attached fruits in the Bohemian material, which are not unlike some of those of modern forms, renders the identification very satisfactory.

Occurrence.—South Amboy.

Collections.—U. S. National Museum.

EUCALYPTUS ? ATTENUATA Newb.

Plate XXVIII, Fig. 6.

Eucalyptus ? attenuata Newb., Fl. Amboy Clays, iii, *pl. 16, f. 2, 3,* (non. *f. 5*) 1896.

Smith, Geol. Coastal Plain in Ala., 348, 1894 (nomen nudum).

Ward, Ann. Rept. U. S. Geol. Surv., 15th: 371, 1895 (nomen nudum).

Berry, Rept. State Geol. (N. J.) for 1905: 138, 1906; Bull. Torrey Club, vol. 33:180, 1906; Ibid., vol. 34; 203, 1907.

Description.—Leaves lanceolate in outline, 9 cm. to 12 cm. in length by 1.5 cm. to 2 cm. in greatest width, which is in the basal half of the leaf. Margin entire, somewhat undulate in some specimens. Apex narrow and produced, acutely pointed. Base cuneate. Petiole stout, 1 cm. to 2 cm. in length. Midrib stout, especially in its lower part. Secondaries numerous, branching from the midrib at an acute angle, reticulate-camptodrome.

This species has little in common with the leaves usually referred to this genus, except its outline, which is also that of a great many unallied genera. It is somewhat suggestive of some of the leaves referred to *Laurophyllum,* in fact many possible relationships could be suggested, all of which possess equal elements of uncertainty, so that it seems wisest to permit Prof. Newberry's identification to stand after pointing out its inconclusive nature.

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This species is common in the upper Raritan and has a recorded range of considerable extent in somewhat later formations. It is recorded from the Magothy formation of New Jersey and Maryland, the Bladen formation of North Carolina and the Tuscaloosa formation of Alabama.

Occurrence.—South Amboy, Hylton Pits.

Collections.—N. Y. Botanical Garden.

Order UMBELLALES.

Family CORNACEÆ.

Genus CORNOPHYLLUM Newb.

(Fl. Amboy Clays, 1896, p. 119.)

CORNOPHYLLUM VETUSTUM Newb.

Cornophyllum vetustum Newb., Fl. Amboy Clays, 119, *pl. 19, f. 10,* 1896.

Description.—Leaves elliptical in outline, 7–8 cm. long by about 4 cm. wide, with acute apex and base, the latter slightly decurrent and inequilateral. Margin entire, very slightly undulate. Midrib slender and straight. Secondaries slender, about 7 pairs, opposite or alternate, branching from the midrib at an angle of about 45°, and strongly curved upward, approximately parallel and camptodrome; they increase in length from the apex to the base, the lower ones sweeping upward in strong arches parallel with the margin and all drawn inward toward the apex.

With the exception of the delicate and somewhat flexuous character of the venation, these leaves are strictly comparable with those of *Cornus,* good species of which, very similar to the Raritan leaf, occur in the Dakota Group, in Greenland and in the Magothy formation of Maryland. Doubtless the Raritan species will eventually be referred to that genus, meanwhile the present generic appellation is a sufficient index of its relationship.

This species is rather rare, and as indicated above, serves to ally the Raritan with somewhat younger formations.

Occurrence.—Woodbridge, Milltown.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

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Family ARALIACEÆ.

Genus ARALIA Linné.

(Sp. Pl., 1753, p. 273.)

ARALIA NEWBERRYI Berry.

Aralia palmata Newb., Fl. Amboy Clays, 117, *pl. 39, f. 6, 7; pl. 40, f. 3,* 1896 (non Lamarck).

(?) Berry, Bull. N. Y. Botanical Garden, vol. 3:93, *pl. 44,* 1903; Bull. Torrey Club, vol. 31:79, *pl. 4, f. 12,* 1904. Hollick, U. S. Geol. Surv. Mon. 50:98, *pl. 38, f. 4,* 1907.

Aralia rotundiloba Hollick, Ann. N. Y. Acad. Sci., vol. 11:421, *pl. 38, f. 2,* 1898.

Aarlia sp., Hollick, Ann. Rept. N. Y. State Mus., vol. 55:150 1903.

Aralia polymorpha Newb., Fl. Amboy Clays, 118, *pl. 39, f. 1–5,* 1896.

Aralia Newberryi Berry, Bull. Torrey Club, vol. 34:201, *pl. 15, f. 1,* 1907.

Description.—Leaves very variable in size and outline, palmately 3 to 5 lobed. Lobes conical, obtusely rounded. Sinuses open, shallow, rounded. Margin entire except basally, where incipient lobations cause undulations. Petiole long and stout. Midrib stout, more or less curved or flexuous. Primaries 3 to 5 from the base, prominent, running to the tips of the lobes. Secondary branches very slender, camptodrome. The middle lobe is usually longest and broadest, and the basal lateral lobes may be reduced to subordinate and but slightly marked divisions of the main lateral lobes.

As can be readily seen, the relative development of the apical or basal lobes and the depths of the intervening sinuses greatly alters the appearance of these leaves. Some are quite symmetrical, while others are very unsymmetrical; some are pre-eminently 3-lobed and sublobate, others are 5-lobed with additional incipient lobes. The variations are almost exactly com-

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parable with the similar variations in the leaves of the modern *Sassafras* due to position and age.

There seems to be no basis for maintaining the distinction between *Aralia palmata* and *A. polymorpha* Newb. The species is abundant in the Raritan, and survives in the overlying Magothy formation in a slightly modified form, which may prove eventually to be a distinct species.

The genus *Aralia,* to which this and the several following species are referred, is an important element in the Cretaceous floras of the globe, with many species especially in the Dakota Group and the Bohemian Cenomanian. The large number of species, seven in all, in the Raritan furnishes corroborative evidence of its Cenomanian age.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Aralia quinquepartita Lesq.

Plate XX, Fig. 8; Plate XXIV, Fig. 5.

Aralia quinquepartita Lesq., Ann. Rept. U. S. Geol. and Geog. Surv. Terr., 1871; 302, 1872; Bull. U. S. Geol. Surv. Terr., vol. 1: 394, 1876; Cret. Fl. 90, *pl. 15, f. 6,* 1874; Fl. Dakota Group, 136, 1892.

Newb., Fl. Amboy Clays, 115, *pl. 40, f. 1, 2,* 1896; Mon. U. S. Geol. Surv., vol. XXXV.: 123, *pl. 9, f. 1,* 1898.

Description.—Leaves generally of large size and coriaceous texture, from 5 cm. to 17 cm. in length by from 9 cm. to 17 cm. or possibly more in greatest breadth between the tips of the lateral lobes, petiolate. Palmately 5-lobed. Lobes long, linear or lanceolate in outline, obtusely pointed. Terminal lobe of the same size as the principal lateral lobes from which it is separated by narrow but rounded sinuses extending three-quarters of the distance to the base. The ground plan of the leaf is trilobate, with each of the lateral lobes more or less deeply divided into two almost equal divisions, the basal one of which is more or less subordinate. Primaries stout, 3 in number

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from the cuneate base or a slight distance above, running from thence to the tips of the lobes. From 1.5 cm. to 4 cm. above their origin the lateral primaries send off stout, lateral, more or less subordinate branches which run to the tips of the subordinate lobes. These latter may nearly equal the principal lobes as they do in the complete specimen figured by Newberry in 1898, or they may be more or less reduced as they are in the large specimen figured by the same author from Woodbridge, in which the one on the right side is apparently but slightly developed. These lobes are also subordinate in the dainty little leaf of this species figured in the present report from the Hylton Pits. The secondaries are numerous and camptodrome as a rule, although a single one in the last-mentioned specimen runs directly to a prominent serrate point on the lower side of the subordinate lobe, a short distance below its apex.

Although fragmentary remains of this handsome species were discovered during the work of the Hayden Survey in Kansas, and were described by Lesquereux in 1876, the subsequently-collected, more complete material has never been adequately described.

Occurrence.—Woodbridge, Hylton Pits.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

ARALIA GROENLANDICA Heer.

Aralia groenlandica Heer, Fl. Foss. Arct., vol. 6, ab. 2: 84, *pl. 38, f. 3; pl. 39, f. 1; pl. 46, f. 16, 17*, 1882.
Lesq., Fl. Dakota Group, 134, *pl. 54, f. 1–3*, 1892.
Newb., Fl. Amboy Clays, 116, *pl. 28, f. 4*, 1896.
Berry, Bull. N. Y. Bot. Garden, vol. 3: 94, *pl. 45, f. 4*, 1903.
Hollick, U. S. Geol. Surv. Mon. 50: 98, *pl. 37, f. 3–6*, 1907.

Description.—"A foliis magnis, coriaceis, lævigatis, basi rotundatis, trilobatis, lobis subæqualibus, lobo medio simulato, rotundato separato." Heer, 1882.

This species is very poorly defined, both Heer and Lesquereux including it in leaves showing a quite considerable range of

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variability. They are all coriaceous, trilobate leaves of considerable size with long and stout petioles. Length 6 cm. to 10 cm. Width 7 cm to 12 cm. Lobes ovate, pointed or rounded,[1] with open rounded sinuses, the lateral lobes showing a tendency to become sublobate below. Primaries slender, camptodrome. Lesquereux makes "five nerved from the top of the petiole," a character of this species as it is in all the specimens which he figures and in one or two of Heer's figures. These extra laterals are much more slender than are the regular primaries and are not constant unless the species be considered composite.

The Coastal Plain leaves referred to this species by Newberry, Hollick and the writer are as a rule somewhat smaller in size, with narrower lobes. This species is infrequent in the Raritan, and the leaves referred to it are suggestive of what Newberry called *Aralia patens*. The species is more abundant in the somewhat later Cretaceous deposits of Marthas Vineyard and Cliffwood bluff. It was described originally from the Atane beds of Greenland and is also present in considerable abundance in the Dakota Group of Kansas.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Gardens.

ARALIA ROTUNDILOBA Newb.

Aralia rotundiloba Newb., Fl. Amboy Clays, 118, *pl. 28, f. 5; pl. 36, f. 9*, 1896.

Description.—Leaves elliptical in outline, palmately five-lobed, about 8 cm. in length, by 10 cm. in greatest breadth. Lobes all stout and rounded or slightly retuse distad, separated by shallow, rounded, open sinuses. Margins entire. Base truncate. Petiole long and very stout. Primaries comparatively slender, 3 in number, with a pair of subordinate laterals usually present. Secondaries slender, camptodrome.

As this species is based upon infrequent specimens it may possibly represent a variety of *Aralia Newberryi*, some forms

[1] Retuse in one specimen which Lesquereux refers to this species.

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of which it resembles quite considerably. It is not an especially well marked species in any event, and the two forms which Prof. Newberry figures show considerable variability. Fragmentary specimens of what the writer believes to be this species are present in the collections from the Hylton Pits.

Occurrence.—Woodbridge, Hylton Pits.

Collections.—N. Y. Botanical Garden.

ARALIA PATENS Hollick.

Aralia patens Hollick, Bull. Torrey Club, vol. 21: 54, *pl. 174, f. 4*, 1894; Mon. U. S. Geol. Surv., vol. 50: 98, *pl. 38, f. 3*, 1907.

Newb., Fl. Amboy Clays, 117, *p. 37, f. 6*, 1896.

Description.—Leaves palmately trilobate, the lobes subequal, linear in outline, subacute, divergent, the lateral lobes directed transversely to the median lobe, the intervening sinuses being deep and open and forming an angle of nearly forty-five degrees. Margins entire. Base truncate. Petiole long and stout. Midrib stout. Lateral primaries, which diverge from the top of the petiole, also stout, but somewhat less so than the midrib. A subsidiary lateral of finer calibre branches from the outside point of origin of each lateral primary. Secondaries irregular, rather straight, diverging from the primaries at usually a wide angle, their ends joined by a marginal vein.

This is a rather ill-defined and infrequent species and suggests the leaf which Prof. Newberry figured as *Aralia groenlandica* Heer. A fragment has been reported by Hollick from Glen Cove, Long Island, and an equally poor fragment is contained in the present collections from South Amboy.

Occurrence.—Woodbridge, South Amboy.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

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ARALIA FORMOSA Heer.

Aralia formosa Heer, Kreidefl. v. Moletein, 18, *pl. 8, f. 3,* 1869.
Lesq.,Cret. & Tert. Fl., 60, *pl. 11, f. 3, 4,* 1883; Fl. Dakota Group, 131, 1892.
Velen., Fl. Böhm. Kreidef., Th. 2:21, *pl. 5, f. 2; pl. 6, f. 7; pl. 7, f. 2–4,* 1882.
Newb., Fl. Amboy Clays, 116, *pl. 22, f. 8,* 1896.

Description.—"A. foliis petiolatis, triplinerviis, trilobatis, lobis apice dentatis, obtusiusculis." Heer, 1869.

The occurrence of this species in the Raritan formation is based upon a single fragmentary specimen, figured by Prof. Newberry from South Amboy. The species was described, originally, from the Cenomanian of Moravia, and was subsequently recorded in considerable abundance from the Cenomanian of Bohemia and the Dakota Group of the west. The New Jersey material, as far as it goes, agrees very well with the more typical material from elsewhere, especially that from Bohemia. It may be distinguished from *Aralia wellingtoniana* Lesq., the only other Raritan *Aralia* which is not entire margined by the obtusely pointed lobes, always three in number, the decurrent base, and by the coarse undulate-dentate teeth.

Occurrence.—South Amboy.

Collections.—N. Y. Botanical Garden.

ARALIA WELLINGTONIANA Lesq.

Plate XXV, Fig. 7.

Aralia wellingtoniana Lesq., Fl. Dakota Group, 131, *pl. 21, f. 1; pl. 22, f. 2, 3,* 1892.
Smith, Geol. Coastal Plain in Ala., 348, 1894.
Newb., Fl. Amboy Clays, 114, *pl. 26, f. 1,* 1896.
Aralia concinna Newb., Ibid., footnote, p. 114.

Description.—"Leaves large, coriaceous, palmately three or five lobed, narrowed in an inward curve to a prolonged base,

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decurring to the petiole; lobes long, oblong-lanceolate, abruptly pointed, sharply equally dentate from above the base, the teeth turned outside or slightly upward, separated by shallow sinuses; primary nerves broad and flat; secondaries more or less oblique, slightly curving or nearly straight in passing to the borders, entering the teeth, craspedodrome, mostly simple; areolation distinctly reticulate, in irregularly quadrate or polygonal meshes."

"The leaves, which are 15 cm. to 16 cm. long, excluding the petiole, vary, of course, in width according to the number of lobes and their divergence from the median nerve, which, in most of the specimens that I have seen averages thirty-five degrees. The lobes are a little broader in the middle, slightly narrowing to the sinusus, 7 cm. to 10 cm. long, and from 2 cm. to 3 cm. broad at the middle. The separate lobe has the teeth much larger, more turned upward, appearing also of a thicker texture."

"The species is so remarkably similar to *A. Saportanea* Lesq., that at first sight it appears identical. It differs, however, by the coriaceous texture of the leaves, the reticulate areolation, the larger teeth, the more or less upwardly-turned secondaries, which are not curved or camptodrome, but run straight to the teeth and enter them; the base of the leaf is longer, decurrent, and the lobes more abruptly or obtusely pointed." Lesquereux, 1892.

This species is so well described by Prof. Lesquereux that his description is introduced *in toto* above. It is an extremely handsome species and quite different from any other form in the Raritan flora. The Raritan leaves are all trilobate, and it would seem as if the 5-lobed form was only an occasional variant, as the same species in its occurrence in the Tuscaloosa formation of Alabama is also trilobate.

There is considerable resemblance to *Aralia decurrens,* Velenovsky,[1] of the Bohemian Cenomanian, in which, however, the lobes are relatively narrower and longer, with coarser teeth and deeper sinuses.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

[1] Velenovsky, Fl. Böhm. Kreidef., Theil 3, 1884, p. 11, pl. 4, f. 5–7.

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Order ERICALES.

Family ERICACEÆ.

Genus ANDROMEDA Linné.

(Sp. Pl., 1753, p. 393.)

ANDROMEDA NOVÆ-CÆSAREÆ Hollick.

Andromeda novæ-cæsareæ Hollick in Newb., Fl. Amboy Clays, 121, *pl. 42, f. 9–12, 28–31*, 1896.

Smith, Geol. Coastal Plain in Ala., 348, 1894 (misspelled *calcareæ*).

Berry, Bull. Torrey Club, vol. 33: 181, 1906; Ibid., vol. 34: 204, 1907.

Description.—Thick entire leaves of small size, with stout petiole and midrib and obscure secondary venation, which is for the most part immersed in the thick substance of the leafblade. Length ranging from 2.5 cm. to 5 cm. and width varying from 0.9 cm. to 1.3 cm. Venation when visible shows numerous parallel, camptodrome secondaries which branch from the midrib at an acute angle, curving upward and relatively long. While the majority of these leaves are equally acuminate at both ends, there is considerable variation in this respect, and a well-marked tendency is shown in a considerable number of specimens which are relatively broader, especially in the upper half of the leaf, toward an obtusely rounded apex, the termination of the midrib showing as a faint mucronate point. The base in these forms gradually narrows to the stout petiole, the term oblanceolate or lanceospatulate perhaps describing them better than any other. The variations in outline of this species are well shown in the figures reproduced in Prof. Newberry's monograph. A large number of the leaves which the writer has identified as this species from the Coastal Plain, south of New Jersey, have this obtusely rounded apex.

Within the Raritan formation this species is only known with certainty from the upper beds at South Amboy. It becomes

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more abundant in the overlying Magothy formation and is present from New Jersey and Maryland, as well as from the Bladen formation of North Carolina, the Middendorf formation of South Carolina and the Tuscaloosa formation of Alabama. It does not appear to be especially close to either *Andromeda Snowii* Lesq. or *Andromeda linifolia* Lesq. of the Dakota Group with which Dr. Hollick has instituted comparisons. Material from North Carolina definitely proves its Ericaceous affinities.

Occurrence.—South Amboy.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

ANDROMEDA GRANDIFOLIA Berry.

Andromeda latifolia Newb., Fl. Amboy Clays, 120, *pl. 33, f. 6–8, 10* (non *f. 9*); *pl. 34, f. 6–11; pl. 36, f. 10,* 1896 (non Wright).

Smith, Geol. Coastal Plain in Ala., 348, 1894 (nomen nudum).

Hollick, Bull. N. Y. Bot. Garden, vol. 3: 416, *pl. 79, f. 3,* 1904; Mon. U. S. Geol. Surv., vol. 50: 100, *pl. 39, f. 1,* 1907.

Andromeda grandifolia Berry, Bull. Torrey Club, vol. 34: 204, *pl. 15, f. 3,* 1907.

Description.—Leaves thick and coriaceous, varying considerably in size and shape. From 4 cm. to 20 cm. in length by 1.5 cm. to 7 cm. in width, ovate-lanceolate in outline, with an entire, usually somewhat undulate or unsymmetrical margin. Apex obtusely pointed or sometimes rounded. Base somewhat wedge-shaped. Midrib and petiole very stout. Secondaries relatively few, 6 to 8 eight pairs, stout and flexuous, branching from the midrib at an acute angle and sweeping upward in long curves and eventually inosculating to complete the strictly camptodrome venation.

This species occurs throughout the lower Raritan in New Jersey and at somewhat higher horizons in the Cretaceous of the Southern States. It is larger, relatively broader and less regular than *Andromeda Parlatorii* Heer, the two leaves figured on plate

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23 showing the average shape with a length of about 10 cm. and a width of about 5 cm.

Occurrence.—Sayreville, Woodbridge, Milltown.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

ANDROMEDA COOKII Berry.

Andromeda flexuosa Newb., (non Moon, 1849) Fl. Amboy Clays, *121, pl. 34, f. 1–5,* 1896.

Hollick, Bull. N. Y. Bot. Garden, vol. 3:416, *pl. 79, f. 2,* 1904; Mon. U. S. Geol. Surv., vol. 50: 101, *pl. 39, f. 6,* 1907.

Andromeda Cookii Berry, Bull. Torrey Club, vol. 36: 261, 1909.

Description.—Leaves coriaceous, variable in size, lanceolate in outline, 6 cm. to 12 cm. in length by 1.5 cm. to 3 cm. in width, with an acuminate apex and a somewhat cuneate base. Midrib stout and flexuous. Secondaries strong, somewhat flexuous, branching from the midrib at an acute angle and arching upward in long curves, camptodrome. Tertiaries mostly simple, transverse, forming oblong areoles.

This species is of the same general character as the other Raritan species of *Andromeda* with which it is strictly congeneric. It is a common form in the lower Raritan, although most of the specimens are imperfect. Elsewhere it is recorded from Glen Cove, Long Island, but the material from the latter locality is not very conclusive. The name given to this species by Newberry was unfortunately preoccupied, and the name here used is given in honor of the late George H. Cook, whose work on the Raritan and allied formations has furnished the basis for all subsequent studies.

Occurrence.—Sayreville, Woodbridge, Milltown.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

ANDROMEDA PARLATORII Heer.

Andromeda Parlatorii Heer, Phyll. Crét. d. Nebr., 18, *pl. 1, f. 5,* 1866; Fl. Foss. Arct., vol. 3, ab. 2: 112, *pl. 32, f. 1, 2,* 1874; Ibid., vol. 6, ab. 2: 79, *pl. 21, f. 1b, 11; pl. 42, f. 4c,* 1882.

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Lesq., Cret. Fl. 88, *pl. 23, f. 6, 7; pl. 28, f. 15*, 1874; Fl. Dakota Group, 115, *pl. 19, f. 1; pl. 52, f. 6*, 1892.
Smith, Geol. Coastal Plain in Ala., 348, 1894.
Newb., Fl. Amboy Clays, 120, *pl. 31, f. 1–7; pl. 33, f. 1, 2, 4, 5*, 1896.
Hollick, Ann. N. Y. Acad. Sci., vol. XI., 420, *pl. 37, f. 1–4*, 1898; U. S. Geol. Surv., Mon. 50: 101, *pl. 39, f. 2–5*, 1907.
Berry, Bull. N. Y. Bot. Garden, vol. 3: 97, *pl. 50, f. 1–4*, 1903; Bull. Torrey Club, vol. 31: 79, *pl. 1, f. 1, 2*, 1904; Ibid., vol. 33: 181, 1906; Ibid., vol. 34: 203, *pl. 15, f. 2*, 1907.

Prunus ? Parlatorii Lesq., Amer. Jour. Sci., vol. 46: 102, 1868.
Leucothoe Parlatorii Schimp., Pal. Végét., vol. 3: 11, 1874.

Description.—"A foliis lanceolatis, basi attenuatis, integerrimis, nervo medio valido, transversium striato, secundariis subtilissimis, angulo acuto egredientibus, camptodromis." Heer, 1866.

This species was first described by Prof. Heer, in one of the earliest published accounts of the Dakota Group flora, and it has since been found to have a wide geological and geographical range.

It is one of the commonest Cenomanian species occurring in Minnesota, Kansas, Nebraska, in the west, and from Greenland to Alabama, in the east. It is as common in the overlying Magothy formation as it is in the Raritan, being recorded from Marthas Vineyard, New Jersey, Delaware and Maryland. It is also present in the Bladen formation of North Carolina.

The genus *Andromeda* of Linné has been much segregated by subsequent botanists, and this is reflected in Schimper's proposal to refer this species to *Leucothoe*. However, the more general term has obvious advantages for the paleobotanist in cases like the present, where it is well-nigh impossible to segregate these various Ericaceous genera with any degree of accuracy.

Occurrence.—Newberry mentions no specific localities, but says: "Found at nearly every locality opened." I have very

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good specimens from Milltown, six in all, one of which is a replica of Newberry's specimen shown on pl. 31, fig. 3. Also found at the Hylton Pits.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

Order PRIMULALES.

Family MYRSINACEÆ.

Genus MYRSINE Linné.

(Sp. Pl., 1753, p. 196.)

MYRSINE BOREALIS Heer.

Myrsine borealis Heer, Fl. Foss. Arct., vol. 3, ab. 2: 113, *pl. 32, f. 23,* 1874; Ibid., vol. 6, ab. 2: 81, *pl. 24, f. 7b, 8, pl. 27, f. 1b; pl. 44, f. 5a; pl. 46, f. 19, 20,* 1882.

White, Amer. Jour. Sci., vol., 39:98, *pl. 2, f. 5,* 1890.

Smith, Geol. Coastal Plain in Ala., 348, 1894.

Newb., Fl. Amboy Clays, 122, *pl. 24, f. 4–6,* 1896.

Hollick, Bull. Geol. Soc. Amer., vol., 7: 13, 1895; Mon. U. S. Geol. Surv., vol. 50: 102, *pl. 39, f. 10, 11,* 1907.

Diospyros rotundifolia Hollick, Bull. Torrey Club, vol. 21: 53, *pl. 179, f. 2,* 1894.

Description.—"M. foliis ovatis (?), integerrimis, nervis secundariis numerosis, approximatis, ramosis, camptodromis." Heer, 1874.

Leaves ovate-elliptical in outline, obtusely rounded above and slightly cuneate below, 2:5 cm. to 5 cm. in length, by 1.2 cm. to 3 cm. in width, with a stout petiole about 1 cm. in length. Margins entire. Texture coriaceous, more or less obscuring the venation. Midrib stout. Secondaries mediumly stout, 5 to 8 alternate pairs, parallel, branching from the midrib at an acute angle, camptodrome. Tertiaries fine, forming an inosculating series of elongated meshes more or less parallel with the secondaries. In specimens in which the tertiary venation is visible the appearance is very

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different from that shown in Prof. Newberry's figures, where only the secondaries are seen. These latter may be compared with the similarly preserved leaves from Greenland figured by Heer (*pl. 24, f. 8; pl. 44, f. 5a*).

This species was described, originally, from the Atane beds of Greenland, and was subsequently collected in considerable abundance from the Raritan formation. It has also been recorded from Marthas Vineyard and Long Island; from the Tuscaloosa formation of Alabama, and from the Bladen formation of North Carolina. It is another form which establishes the relation of the Raritan flora to the Cenomanian.

Occurrence.—South Amboy, Milltown.

Collections.—N. Y. Botanical Garden.

Myrsine oblongata Hollick.

Plate XXIV, Fig. 1.

Myrsine oblongata Hollick in Newb., Fl. Amboy Clays, 122, *pl. 42, f. 15*, 1896.

Description.—Leaves of small size, elliptical in outline, 2.6 cm. in length by 1.3 cm. in breadth. Apex broadly rounded; base almost equally so. Margins entire. Venation fine and indistinct. Secondaries 5 or 6 pairs, camptodrome.

This species was based upon a single specimen regarding which Professor Newberry failed to record the exact locality, and no additional specimens have since come to light. It is very doubtfully related to *Myrsine*, which usually has a much closer venation, and suggests a number of leaflets which have been referred to genus *Leguminosites*. As no positive light can be shed on its real affinities, it is left in the genus where it was placed by its describer.

Occurrence.—South Amboy (?).

Collections.—N. Y. Botanical Garden.

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MYRSINE GAUDINI (Lesq.) Berry.

Plate XXIV, Figs 3, 4.

Myrsinites ? Gaudini Lesq., Fl. Dakota Group, 115, *pl. 52, f. 4,* 1892.

Myrsine elongata Hollick, Bull. Torrey Club, vol. 21 : 54, *pl. 177, f. 2,* 1894; Ann. N. Y. Acad. Sci., vol. 11 : 420, *pl 38, f. 3, 4 b, c,* 1898; Mon. U. S. Geol. Survey, vol. 50 : 102, *pl. 8, f. 1b; pl. 39, f. 13, 14,* 1907.

Newb., Fl. Amboy Clays, 122, *pl. 22, f. 1–3,* 1896.

Myrsine Gaudini Berry, Bull. Torrey Club, vol. 36 : 262, 1909.

Description.—Leaves oblanceolate or elongate-obovate in outline, 5.5 cm. to 7 cm. in length by 1.9 cm. to 2.5 cm. in greatest width. Margins entire. Apex obtusely rounded. Base somewhat elongated, narrowly cuneate. Petiole present, stout. Midrib stout below, rapidly diminishing in calibre. Secondaries numerous, 8 to 10 pairs, alternate, branching from the midrib at angles of from 40° to 45°, camptodrome. When tertiary venation is distinctly preserved the venation is more typical than when only the secondaries are partially visible.

This species is well distributed in the Raritan and has also been recorded from Long Island and Staten Island. The identification of *Myrsinites ? Gaudini* Lesq., with the eastern forms with which it is obviously identical extends the range eastward from the Dakota Group of Kansas. It may be readily distinguished from the other Rartain species by its relatively narrow elongated form. It is also present in undescribed collections of the writer from North Carolina and Alabama.

Occurrence.—South Amboy, Milltown.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

NEW JERSEY GEOLOGICAL SURVEY

Order EBENALES.

Family EBENACEÆ.

Genus DIOSPYROS Linné.

(Sp. Pl., 1753, p. 1057.)

DISOPYROS PRIMÆVA Heer.

Diospyros primæva Heer, Phyll. Crét. d. Nebr., 19, *pl. 1, f. 6, 7*, 1866; Fl. Foss. Arct., vol. 6, ab. 2:80, *pl. 18, f. 11*, 1882; Ibid., vol. 7:31, *pl. 61, f. 5a, b, c*, 1883.
Lesq., Fl. Dakota Group, 109, *pl. 20, f. 1–3*, 1892.
Smith, Geol. Coastal Plain in Ala., 348, 1894.
Newb., Fl. Amboy Clays, 124, *pl. 30, f. 1–5*, 1896.
Knowlton, 21st Ann. Rept. U. S. Geol. Surv., pt. 7:317, *pl. 39, f. 3*, 1901.
Berry, Bull. Torrey Club, vol. 32:46, *pl. 2*, 1905; Ibid., vol. 34:204, 1907.
Hollick, Mon. U. S. Geol. Surv., vol. 50:103, *pl. 40, f. 2, 11*, 1907.

Description.—"D. foliis oblongo-ovalibus, integerrimis, apice obtusiusculis, nervis secundariis serpentinis, ramosis, camptodromis." Heer, 1866.

Leaves oblong-ovate in outline, variable according to age, ranging from 3 cm. to 15 cm. in length, by 1.3 cm. to 5 cm. in greatest breadth, which is in the middle part. Apex subacute or obtuse. Base cuneate. Margins entire. Petioles rather long and very stout. Midrib also stout. Secondaries branching from the midrib at usually acute angles, subopposite or alternate, parallel, camptodrome. Tertiaries forming polygonal areoles, whose relative prominence is one of the features of this species.

This species, which is quite suggestive of the modern *Diospyros virginiana* Linné, was described by Heer from the Dakota Group of Nebraska nearly half a century ago. It has proved to be a most wide-ranging form, having been identified at both the Atane

NEW JERSEY GEOLOGICAL SURVEY

and Patoot horizons in Greenland; from various localities within the Dakota Group, including the Woodbine formation of Texas; and with the exception of the fragments from Marthas Vineyard and Long Island, which are of questionable identity, it is common in either the Raritan or Magothy or homotaxial formations from New Jersey to Alabama.

Its most marked character is the prominence of its tertiary areolation. It is abundant in the Raritan, occurring both in the older and younger beds, and is one of the species which points very strongly to the Cenomanian age of these deposits.

Occurrence.—South Amboy, Milltown.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

Diospyros amboyensis Berry.

Phyllites ellipticus Newb., Fl. Amboy Clays, 130, *pl. 24, f. 9*, 1896.

Diospyros amboyensis Berry, Bull. Torrey Club, vol. 36: 262, 1909.

Description.—Leaves elliptical in outline, large, 8 cm. long by 4.6 cm. broad; margin undulate; apex rounded, almost retuse; base broadly rounded, thus differing from the wedge-shaped base of *Diospyros primæva;* midrib strong, although not so strong as in the latter species; secondaries numerous, 8-10 pairs, regular, leaving the midrib at an angle of about 45°, camptodrome; tertiary venation of large polygonal meshes, finer in calibre than in *Diospyros primæva.*

Unfortunately no specimens other than Newberry's original type have been found, and it is possible that it was an aberrant leaf of the common *Diospyros primæva,* some undoubted leaves of which suggest it in their sum of characters. One of the leaves which Heer identifies from the Atane schists of Greenland as *Populus hyperborea,*[1] while the apex is partially destroyed and the tertiaries are not shown, is very similar to the species under

[1] Heer, Fl. Foss. Arct., vol. 3, ab. 2; *pl. 29, f. 6, 18.*

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discussion. This similarity does not extend, however, to the other leaves identified as this species.

A species of Diospyros has already been described as *Diospyros elliptica* by Knowlton, so that it becomes necessary to rename the Raritan leaf.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Calycites diospyriformis Newb.

Plate XXIX, Figs. 2–4.

Calycites diospyriformis Newb., Fl. Amboy Clays, 132, *pl. 46, f. 39–41*, 1896.

Description.—Calyx-like organism, 10 mm. to 12 mm. in width, consisting of a central portion 4 mm. or 5 mm. in diameter, marked at its center by a small circle about 1 mm. across, which is the abscission scar where the calyx became detached from the peduncle. From the central portion there radiates marginally five subequal, rapidly narrowing, sepal-like, pointed lobes.

In every aspect these objects suggest the persistent calyx of modern species of *Diospyros* as well as various similar fossil specimens which have been referred to this genus, and they may well represent the calyx of a contemporary species of that genus, possibly the abundant *Diospyros primæva* Heer.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

NEW JERSEY GEOLOGICAL SURVEY

Order GENTLANALES.

Family ASCLEPIADACEÆ.

Genus ACERATES Elliott.

(Bot. S. C. & Ga., vol. 1 : 316, 1817.)

ACERATES AMBOYENSIS Berry.

Acerates sp., Hollick in Newb., Fl. Amboy Clays, 124, *pl. 32, f. 17; pl. 41, f. 4, 5,* 1896.

Berry, Bull. Torrey Club, vol. 34:205, 1907.

Acerates amboyensis Berry, Ibid., vol. 36:263, 1909.

Description.—Leaves narrow and elongated, somewhat falcate, lanceolate or linear-lanceolate in outline, 5 cm. to 7.5 cm. in length by 5 mm. to 8 mm. in breadth, gradually narrowed above and cuneate below. Margin entire, somewhat undulate. Petiole apparently wanting. Texture thick. Secondaries numerous, rather angular, branching from the midrib at acute angles, camptodrome.

There is no reason why this species should not have a specific name, if only for purposes of intelligent citation. It is, moreover, perfectly distinct from the other members of the Raritan flora and is easily recognized. It is confined to the Upper Raritan in New Jersey, but occurs in the Bladen formation of North Carolina. Several species of *Acerates* are described by Heer from the Greenland Cretaceous.

Occurrence.—South Amboy.

Collections.—N. Y. Botanical Garden.

INCERTÆ SEDIS.

Genus CALYCITES Massalongo.[1]

(Schizzo Geog., 1850, p. 72.)

CALYCITES PARVUS Newb.

Calcyites parvus Newb., Fl. Amboy Clays, 131, *pl. 46, f. 28, 29,* 1896.

[1] A single Raritan species of *Calycites* is placed in its proper botanical position under *Diospyros.*

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Description.—Calyx-like organisms of small size, with 5 radiating, short and rounded sepals (?) from the disk-like central portion, the whole 6 mm. to 7 mm. in diameter.

The botanical affinity of these calyx-like organisms is entirely a matter of speculation. That they are the remains of flowers of some member of the Raritan flora seems quite probable. They are so small and rare that they are often likely to escape observation altogether.

A number of supposed floral remains have been grouped under this genus, but it would be profitless to discuss any of them in this place.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Genus CARPOLITHUS Allioni.

(Oryct. Pedemont, Sp., 1757, p. 6.)

CARPOLITHUS PRUNIFORMIS Newb.

Carpolithus pruniformis Newb., Fl. Amboy Clays, 133, *pl. 46, f. 42*, 1896.

Description.—Organisms of small size, somewhat irregular in shape, ovoid, pointed at both ends, longitudinally striated. Found either singly or united in pairs at their ends by a comparatively long narrow neck. Length about 1.5 cm. Breadth 7 mm.

These objects, which evidently represent the fruits of some Raritan plant, are of unknown affinity. They are not rare at the Woodbridge locality, and suggest the pods of some leguminous plant, numbers of which normally bear such pods, while similar pods occur in other genera, as, for example, in *Robinia*, where the normal pods are of the ordinary canoe-shape. They are also remotely suggestive of the tubers of *Equisetum*, which are so often found in the fossil state.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

NEW JERSEY GEOLOGICAL SURVEY

CARPOLITHUS FLORIBUNDUS Newb.

Carpolithus floribundus Newb., Fl. Amboy Clays, 133, *pl. 46, f. 17–21*, 1896.

Hollick, Mon. U. S. Geol. Surv., vol. 50: 110, *pl. 7, f. 20, 21*, 1907.

Description.—Capsules broadly ovate in outline and elliptical in cross-section, 5 mm. to 8 mm. in length, by 3 mm. to 6 mm. in breadth, apparently 5-chambered and dehiscing at the apex. Before dehiscence the apex appears sharply pointed, afterward the fossils, as preserved, show from 2 to 5 sharp teeth. These capsules occur singly, sometimes attached to a rather stout peduncle, in other instances they are preserved in pairs, and Newberry figures one specimen (loc. cit., *f. 19*) in which the capsule-bearing branches are apparently dichotomously arranged.

These objects occur in considerable abundance at Woodbridge, N. J., and they are also recorded, by Hollick, from Gay Head, Marthas Vineyard. Their botanical affinity is unknown.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

CARPOLITHUS HIRSUTUS Newb.

Carpolithus hirsutus Newb., Fl. Amboy Clays, 134, *pl. 46, f. 14, 14 a*, 1896.

Hollick, Mon. U. S. Geol. Surv., vol. 50: 110, *pl. 7, f. 3–8*, 1907.

Carpolithus spinosus Hollick, Bull. Geol. Soc. Amer., vol. 7: 13, 1895.

Description.—Fruits obovate to elliptical in outline, 1 cm. to 1.5 cm. in length, by 0.6 cm. to 1 cm. in breadth, attached to a stout peduncle, 1 cm. long, in one specimen. Ornamented with a corona of prickle-like spines, in various states of preservation, sometimes complete, tapering and sharply pointed, about 2.5 mm.

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in length; these must have been of considerable consistency to assure their preservation.

These objects, which seem to represent bilocular capsules or twincarpels, are common in the clays at Woodbridge, N. J., and are also recorded in considerable abundance from Gay Head, Marthas Vineyard. Their botanical relations are unknown.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Carpolithus ovæformis Newb.

Carpolithus ovæformis Newb., Fl. Amboy Clays 134, *pl. 46, f. 15, 16*, 1896.

Description.—Fruits ovate or slightly obovate in outline, apparently representing a rather thick-walled capsule, 1.2 cm. to 2 cm. in length by 0.6 cm. to 1 cm. in breadth, with a pointed apex and a rounded base. Peduncle short and stout, curved.

These objects are uncommon at the Woodbridge locality and their botanical relationship is problematical.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Carpolithus woodbridgensis Newb.

Carpolithus woodbridgensis Newb.. Fl. Amboy Clays, 133, *pl. 46, f. 22*, 1896.

Description.—Fruits or seeds, 9 mm. to 10 mm. in length by 3 mm. to 4 mm. in diameter, elliptical in shape and with fine longitudinal striations.

These forms are of somewhat infrequent occurrence at the Woodbridge locality and of unknown botanical relationship.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

NEW JERSEY GEOLOGICAL SURVEY

Genus CHONDROPHYLLUM Necker.

(Elem. Bot., vol. II., 1790, p. 347.)

CHONDROPHYLLUM OBOVATUM Newb.

Chondrophyllum obovatum Newb., Fl. Amboy Clays, 118, *pl. 42, f. 26, 27*, 1896.

Description.—Leaves small, orbicular or obovate in outline, 1.3 cm. to 2.6 cm. in length, by 1 cm. to 2 cm. in greatest breadth, which is the upper half of the leaf. Margins entire. Apex rounded, sometimes slightly emarginate. Base more or less cuneate. Midrib slender, much attenuated. Secondaries slender, about six pairs, branching at acute angles, camptodrome. Areolation polygonal.

These leaves form an inconspicuous element in the Raritan flora and there is very little ground either for or against their reference to *Chondrophyllum*. The genus is poorly defined and its relations are problematical. It seems very probable that it is composite and its relations have been thought to be with the Vitaceæ and the Araliaceæ. One species at least, as the writer will show in his description of the North Carolina Cretaceous flora, is not a dicotyledon at all, but is clearly allied with the modern monocotyledonous genus *Pistia*.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

CHONDROPHYLLUM RETICULATUM Hollick.

Chondrophyllum reticulatum Hollick in Newb., Fl. Amboy Clays, 119, *pl. 41, f. 6, 7*, 1896.

Description.—Leaves delicate, apparently broadly orbicular in outline, 3 cm. to 3.5 cm. in length by 3 cm. to 4 cm. in breadth, with broadly rounded apex and a cuneate base. Petiole present, stout. Midrib slender. Secondaries 4 to 5 alternate pairs, parallel, slender, branching at an acute angle, camptodrome, distally merging in the tertiary reticulations.

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This species was based upon imperfect specimens which somewhat resemble *Chondrophyllum orbiculatum* Heer. No additional material is contained in the recent collections and the original locality for the type remains unknown.

Occurrence.—Locality unknown.

Collections.—N. Y. Botanical Garden.

Genus FONTAINEA Newb.

(Fl. Amboy Clays, 1896, p. 94.)

FONTAINEA GRANDIFOLIA Newb.

Fontainea grandifolia Newb., Fl. Amboy Clays, 96, *pl. 45, f. 1–4*, 1896.

Description.—Leaves may be regarded as bilobate or as dichotomously compound with bilobate leaflets. The latter are markedly unsymmetrical, linear-lanceolate in outline. Distally they are narrowed and obtusely pointed. The base is markedly unsymmetrical, one margin decurring for a distance of from 1 cm. to 2 cm. below the opposite margin. The extremely stout midrib (or common winged petiole of a double leaf) runs straight for a distance of 5 cm. to 6 cm., at which point it forks dichtomously at an acute angle, the two stout branches running to the tips. Internally this fork is naked for a distance of 2 cm. to 3 cm. of each limb, from which point the inner laminæ of the lobes curve out until the lobe becomes equilateral or even broader on its inner lamina. The secondary venation is fine; the secondaries, which are numerous and parallel, branch at a very large angle and become lost in the leaf substance toward the margin, although they seem to be camptodrome in their final course.

In discussing these peculiar fossils, which are not uncommon at the Woodbridge locality, Prof. Newberry compares them with *Haliserites Reichii*[1] reproducing Sternberg's figure on plate xiv., fig. 5. This plant, which came from the greensand of Niederschœna in Saxony (Cenomanian) was discovered by Reich and named *Fucoides dichotomus*. Sternberg referred it to *Haliser-*

[1] Sternberg, Fl. d Vorwelt 2: 34, *pl. 24, f. 7.*

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ites because of its fancied resemblance to a recent alga, *Haliseris polypodoides* Ag. This plant is hardly a seaweed and seems to be congeneric with the Raritan plant. It was, however, much smaller and differed in other particulars.

Another similar form is figured by Bronn[1] as *Haliserites Reichii* and described by Rossmassler and Cotta as a *Chiropteris*. Schimper[2] refers it to the genus *Delesseria* because of its resemblance to the modern *Delesseria ruscifolia* Ag. This plant also is scarcely a seaweed, in fact, Rothpletz has recently proposed calling it *Phyllites Reichii*[3]. It is exceedingly close to *Fontainea* and is probably a dicotyledon. Still another similar plant is the one described from the Cenomanian of Bohemia by Velenovsky as *Aralia furcata*[4]. This undoubtedly belongs to the same genus as the New Jersey plant and is compared by its describer with the genera *Jatropha, Vitex, Cussonia,* etc. It can hardly be regarded as belonging to the genus *Aralia*.

Prof. Newberry states his preference for a relationship with *Hymenaea* and *Bauhinia* and regards the genus *Sapindopsis* from the older Potomac as related to the Raritan plant. The two are entirely distinct, however, and the Raritan plants must remain for the present, at least, in the form genus *Fontainea,* to which Prof. Newberry referred them.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

NEWBERRYANA gen. nov.

NEWBERRYANA RIGIDA (Newb.) Berry.

Hausmannia rigida Newb., Fl. Amboy Clays, 35, *pl. 1, f. 2, 3, 5,* 1896.

Description.—"Frond large, bipinnate or tripinnate, flat; central line of pinnæ and pinnules traversed by a strong, continuous

[1] Lethaea Geognostica, *pl. XXVIII, Fig. 1.*

[2] Pal. Végét, I: 178 and 185, 1869.

[3] Rothpletz, Zeits. deutsch. geol. Gessell., vol. 48: 904, 1896.

[4] Fl. Böhm. Kreidef. Th. 3: 13, *pl. 4, f. 1,* 1884 (*Aralia elegans*).

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midrib, from which are given off many fine flexuous, branching veins. Margins entire, pinnæ and pinnules mostly opposite, pinnules linear, subacute." Newberry, 1896.

The above is Professor Newberry's characterization of this interesting plant, which he refers to the Hepaticæ. It is, obviously, not related to the genus *Hausmannia*, Dunker, which has been definately proven to be a fern genus[1] of the family Dipteriaceæ, so that I have ventured to propose a new generic name, selected in honor of Prof. Newberry. What its real nature is, I am at a loss to say. It is probably a fern, but as its botanical affinity remains uncertain, I have placed it among the Raritan forms of unknown botanical affinities, since there are no grounds for retaining it in the Hepaticæ.

Occurrence.—Woodbridge, South Amboy.

Collections.—N. Y. Botanical Garden.

Genus TRICALYCITES Hollick.

(Bull. Torrey Club, vol. 21, 1894, p. 63.)

TRICALYCITES PAPYRACEUS Hollick.

Tricalycites papyraceus Hollick, Bull. Torrey Club, vol. 21:63, *pl. 180, f. 8,* 1894; Ann. N. Y. Acad. Sci., vol. 11:61, *pl. 3, f. 6,* 1898; Ibid., 423, *pl. 37, f. 1, 2;* Bull. N. Y. Bot. Garden, vol. 2:405, *pl. 41, f. 3,* 1902; Mon. U. S. Geol. Surv., vol. 50:109, *pl. 5, f. 8–12,* 1907; 55th Ann. Rept. N. Y. State Mus., 1901 (1903) p. 151.

Smith, Geol. Coastal Plain in Ala., 348, 1894.

Newb., Fl. Amboy Clays, 132, *pl. 46, f. 30–38,* 1896.

Berry, Bull. Torrey Club, vol. 31:81, *pl. 1, f. 4,* 1904.

Description.—Well defined organisms, apparently dicotyledonous in their affinities and involucral or bracteate in their nature. They consist of a central nucleus which is usually of small size, that is to say, 1 mm. to 3 mm. in diameter, borne at the apex of a stout peduncle or stalk, 2 mm. to 5 mm. in length. To

[1] Richter, Die Gattung Hausmannia Dunker, Liepzig, 1906.

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this nucleus three membraneous wings are usually attached. These wings usually diverge from each other at angles of about 45°; they are broadly linear, obovate or ovate in outline, with broadly rounded, almost truncate tips and narrowed somewhat toward the base, the lateral wings being usually somewhat unsymmetrical; they are marked by fine parallel longitudinal veins converging toward the base and anastomosing at intervals. In size they range from 0.5 cm. to 2.5 cm. in length by 2 mm. to 10 mm. in width. Both Hollick and Newberry call attention to the somewhat greater length of the middle wing, which is, however, far from being a constant character since some specimens fail to show it, all of the wings being of similar size, or the central wing may even be much smaller, as it is in some of the Alabama material, where, along with the normal forms, there occur others with all of the wings directed upward and the central one only about half the size of the laterals.

The botanical relation of these curious objects remains unknown, although they are probably comparable to the bracts so largely developed in some of the Juglandaceæ and Betulaceæ, or to certain of the winged fruits to be found among the modern Sapindaceæ or Dipterocarpaceæ. In the abundant remains from Tottenville, Staten Island; Gay Head and Nashaquitsa, Marthas Vineyard, and Glen Cove, Long Island, Dr. Hollick has described another species, *Tricalycites major*[1] based on forms which are usually two winged and with a larger nucleus, the wings reaching a length of 4 cm. and a width of 1.3 cm. The same author has described similar but smaller remains from Marthas Vineyard as *Calycites obovatus*[2] and still smaller remains from Montauk Point as *Calycites alatus*[3]. While perhaps from the standpoint of the paleobotanist these segregations are permissible or even desirable, it may be doubted if they express real specific distinctions and not merely individual variations. There is certainly a suggestion in the forms from the Tuscaloosa formation of Alabama, which occur with the normal *Tricalycites papyraceous*, that

[1] Hollick, Mon. U. S. Geol. Surv., vol. 50, 1907, p. 108, *pl. V, figs. 13–22.*
[2] Ibid., p. 109, *pl. V, fig. 23.*
[3] Ibid., p. 109, *pl. V, fig. 24.*

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the central wing may be more or less abortive or completely so, in which instance we get some terms of the series leading to *Tricalycites major* or to the almost identical smaller forms which are referred to *Calycites obovatus* and *alatus*.

Tricalycites papyraceous is abundant at Woodbridge, and also occurs in the upper Raritan at South Amboy. It occurs sparingly at Cliffwood bluff, N. J., and is abundant in the insular Cretaceous floras and that of the Tuscaloosa formation of Alabama.

Occurrence.—Woodbridge, South Amboy.

Collections.—U. S. National Museum, N. Y. Botanical Garden.

Genus TRICARPELLITES Bowerbank.

(Hist. Foss. Fr. & Seeds, London Clay, 1840, p. 76.)

TRICARPELLITES STRIATUS Newb.

Tricarpellites striatus Newb., Fl. Amboy Clays, 132, *pl. 46, f. 9–13*, 1896.

Hollick, Mon. U. S. Geol. Surv., vol. 50: 108, *pl. 7, f. 1*, 1907.

Description.—Fruit-like objects, irregularly ovoid in shape, 2.5 cm. to 4 cm. in length, and about 2 cm. in diameter, apparently enclosed in a longitudinally striated husk, pointed above, rounded below, grouped in threes at the summit of a stout stem.

These objects are of characteristic appearance, and are quite common in the Raritan formation at the Woodbridge locality. Their botanical affinity is entirely conjectural, and they are wholly confined to New Jersey, except for a single, very poorly defined specimen, reported by Hollick, from Marthas Vineyard.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

NEW JERSEY GEOLOGICAL SURVEY

Genus VIBURNUM Linné.

(Sp. Pl., 1753, p. 267.)

VIBURNUM INTEGRIFOLIUM Hollick.

Viburnum integrifolium Hollick, Bull. Torrey Club, vol. 21 : 54, *pl. 177, f. 7,* 1894; Mon. U. S. Geol. Surv., vol. 50: 105, *pl. 40, f. 1,* 1907.

Newb., Fl. Amboy Clays, 125, *pl. 41, f. 1,* 1896.

Description.—Leaves of large size, broadly ovate in outline, about 11 cm. or 12 cm. in length, by 7.5 cm. in greatest breadth, which is toward the middle of the leaf. Apex pointed (?). Base rounded (?). Margins entire. Midrib stout. Secondaries also stout, 5 or 6 pairs, subopposite, camptodrome, branching from the midrib at an acute angle and curving upward, connected by numerous straight, transverse tertiaries, which are mostly obsolete.

This species was based on a single, imperfect specimen, which Prof. Newberry referred to the genus *Viburnum,* comparing it with the modern *Viburnum lantanoides,* which it does not resemble in the least degree. An additional fragmentary specimen has been described by Hollick from Glen Cove, Long Island, which is sufficient to show that the base was pointed or rounded and not cordate as suggested by Newberry.

There is absolutely no ground for its reference to *Viburnum,* but rather than attempt a re-identification with such incomplete material as a basis, Prof. Newberry's name is retained and the specimen is placed with those of unknown affinities, instead of in the place where *Viburnum* would come in the natural system.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

Genus WILLIAMSONIA Carruthers.

(Trans. Linn. Soc. Lond., vol. XXVI, 1868, p. 680.)

WILLIAMSONIA SMOCKII Newb.

Williamsonia Smockii Newb., Fl. Amboy Clays, 127, *pl. 36, f. 1–8,* 1896.

NEW JERSEY GEOLOGICAL SURVEY

Description.—Indefinite floral or fruit-remains of variable size, 2.5 cm. to 4 cm. long, by 2.5 cm. to 3 cm. in diameter, cylindrical, apparently cupshaped, and with a simple margin, which may be slightly expanded or contracted; narrowing below to a comparatively slender peduncle. Base and peduncle apparently covered with scales or small bracts, although the preservation is such that this is rather inferential.

Prof. Newberry sees in these objects a not altogether obvious resemblance to *Williamsonia cretacea* Heer. They may be related to the Cycadales, but this supposition is far from positive, and they are retained in the genus to which Prof. Newberry referred them, rather than make a change based upon the slender evidence available. They are said to be common in the Raritan, several specimens having been figured by their describer, who failed, however, to record the exact locality, and no new material is contained in the more recent Raritan collections.

Occurrence.—Locality unknown.

Collections.—N. Y. Botanical Garden.

WILLIAMSONIA PROBLEMATICA (Newb.) Ward.

Palæanthus problematicus Newb., Fl. Amboy Clays, 125, *pl. 35, f. 1–9*, 1896.

Williamsonia problematica Ward, 15th Ann. Rept. U. S. Geol. Surv. 382, 1895.

Hollick, Mon. U. S. Geol. Surv., vol. 50:107, *pl. 5, f. 27–32*, 1907.

Description.—Fructifications consisting of a long and stout peduncle preserved for a length of 2 cm. to 3 cm. and about 7 cm. in diameter, expanding distally into a discoid conical receptacle, the edge of which is surmounted by 10 to 20 lanceolate bracts 1.5 cm. to 3.5 cm. in length and 2 mm. to 10 mm. in diameter, the whole of a very durable consistency.

These objects are present in considerable abundance in the Raritan clays, and Prof. Newberry figures a number of specimens, although he neglects to mention the localities from which they

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were collected. He seems disposed to attach considerable weight to their resemblance to a helianthoid flower, and points out that they differ from the typical Williamsonias in the apparent absence of the internal seed-bearing cone. The nature of the remains does not enable one to form a positive opinion, nevertheless their resemblance to well-preserved Williamsonias which are undoubtedly cycadean, lends more support to a theory of relationship with the latter group of plants than with the essentially modern Compositæ. The increased interest in the Cycadales called forth in recent years, has served to establish the cycadean affinity of a number of species of Williamsonia, and structural material has in a measure cleared up their morphology, so that while this order of plants had commenced its final decline in Raritan time, it must be remembered that it was exceedingly abundant in the older Cretaceous deposits of Maryland and Virginia, and remnants of cycad fronds are by no means uncommon in the Raritan deposits.

Many supposed Williamsonias have been described, most of those from American rocks being founded upon exceedingly imperfect material. Perhaps the form most like the present species is *Williamsonia delawarensis* Berry[1] described from the Magothy formation of Delaware. It may be questioned if the forms from Marthas Vineyard which Hollick (loc. cit.) refers to *Williamsonia problematica* are not more properly referable to *Williamsonia delawarensis*. This is especially true of this author's figures 29 to 32, while figures 27 and 28 may be lateral views of the compressed transverse views of the objects described as *Williamsonia Riesii*. From nearly homotaxial horizons *Williamsonia elocata* has been described by Lesquereux[2] from the Dakota sandstone, and *Williamsonia cretacea* has been described from the Atane beds of Greenland by Heer[3]. The Williamsonias described by Ward from the older Cretaceous are all extremely poor and of doubtful affinities, but *Williamsonia virginiensis* described by Fontaine from the older Potomac of Virginia, is

[1] Johns Hopkins Univ. Circulars, No. 199, 1907, p. 84, *f. 4.*

[2] Lesq., Fl. Dakota Group, 87, *pl. 2, f. 9, 9a*, 1892.

[3] Heer, Fl. Foss. Arct., vol. VI, Abth. 2: 59, *pl. 12, f. 1; pl. 13, f. 9*, 1882.

NEW JERSEY GEOLOGICAL SURVEY

well preserved and characteristic, and can scarcely be anything but the remains of a cycadean fructification.

Occurrence.—Locality unknown.

Collections.—N. Y. Botanical Garden.

Genus PHYLLITES Sternberg.[1]

(Fl. d. Vorw., vol. I, 1823, p. 39.)

PHYLLITES TRAPAFORMIS sp. nov.

Plate XX, Figs. 1, 2.

Description.—Leaf very small, elliptical in outline, 6 mm. in length, by 4 mm. in greatest width, which is about half way between the apex and the base. Petiole missing (if ever present). Base evenly rounded. Margin entire in the lower half of the leaf, but broken to form five relatively large dentate teeth distad, the central one, which is the largest and most prominent, constituting the pointed apex of the leaf. Outside lateral teeth smallest, and separated by a rounded sinus from the inside lateral teeth, which, in turn, are separated from the apical tooth by shallow angular sinuses. Venation delicate, consisting of a thin midrib and craspedodrome secondaries branching from near the base on each side and running to the lateral teeth. From these there branch, from near their point of insertion on the outer side, camptodrome veins of the same calibre. Shorter, inwardly-directed veins branch higher up. There are one or two thinner camptodrome marginal veins deployed along the lower outer margin of the leaf.

This well-characterized little leaf, if it is a leaf, suggests various existing leaflets, such as those of *Spiræa, Thalictrum,* etc., as well as the floating leaves of some Cretaceous species allied with the modern genus *Trapa*. There is the further possibility that the present form may represent either a floral or vegetative bract of some Cretaceous species of unknown botanical affinity.

[1] Since the type of this useful form-genus is probably a species of *Populus*, it is probable that it will eventually have to be abandoned.

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and for this reason it has been placed in the comprehensive form-genus *Phyllites.*

Occurrence.—South Amboy.

Collections.—U. S. National Museum.

PHYLLITES UNDULATUS Newb.

Phyllites undulatus Newb., Fl. Amboy Clays, 131, *pl. 24, f. 10,* 1896.

Description.—Leaf large, broadly elliptical in outline, apparently about 7 cm. in length, by 6 cm. in greatest breadth. Apex broadly rounded. Base destroyed. Margin pronouncedly undulate. Venation fine, but distinct. Midrib slender and flexuous. Secondaries remote, about five pairs, alternate, branching at an acute angle, curved, camptodrome.

This species is unfortunately based upon a single specimen, which lacks the basal portion. It is obviously distinct from the other forms known from the Raritan formation, although it may possibly be an aberrant leaf of *Celastrophyllum undulatum,* Newb. Since, however, this cannot be conclusively proven, it is here retained in the ambiguous genus *Phyllites,* to which it was assigned by Prof. Newberry.

Occurrence.—Woodbridge.

Collections.—N. Y. Botanical Garden.

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INDEX.

Names in italics are *Synonyms.*

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PLATES.

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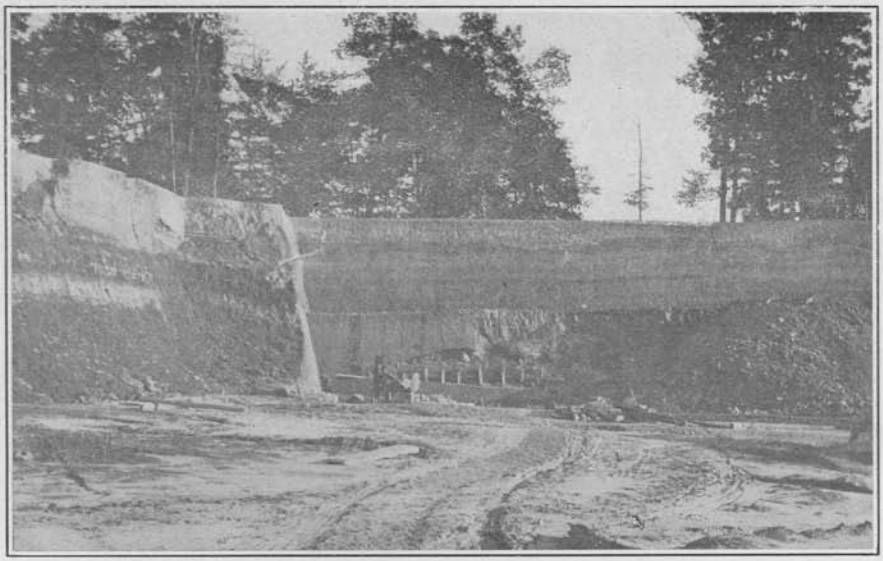

Fig. 1.—The Woodbridge clays, Cutter's Pit, Woodbridge.

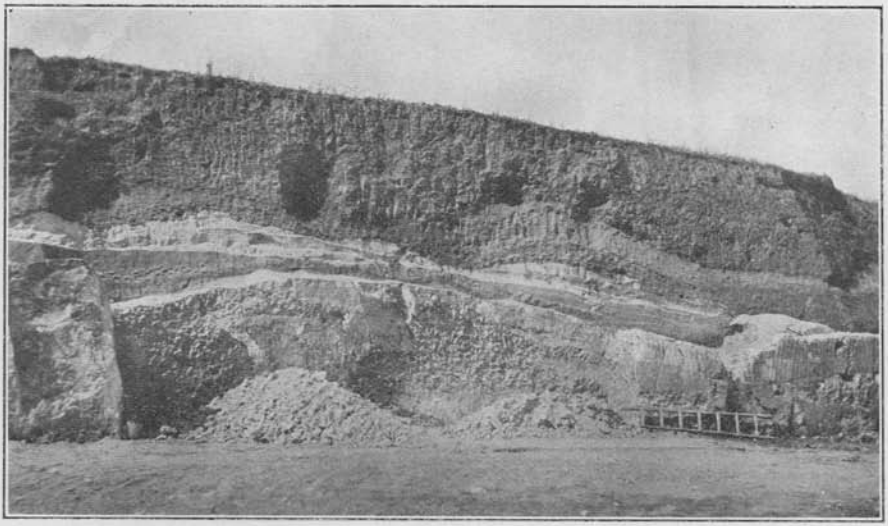

Fig. 2.—Woodbridge clays, showing eroded upper surface.

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Fig. 1—Cross bedded Raritan sand near Florida Grove.

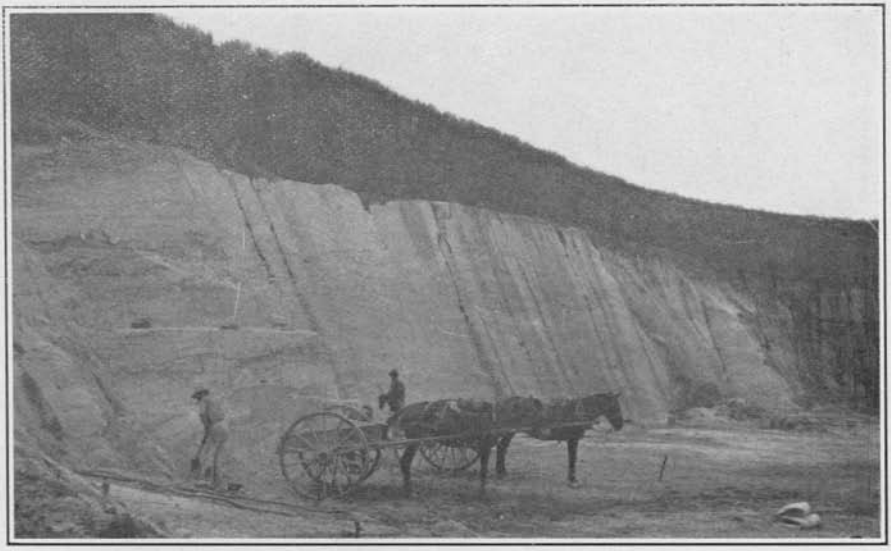

Fig. 2—Raritan Sand ("feldspar") overlying Woodbridge Clay.

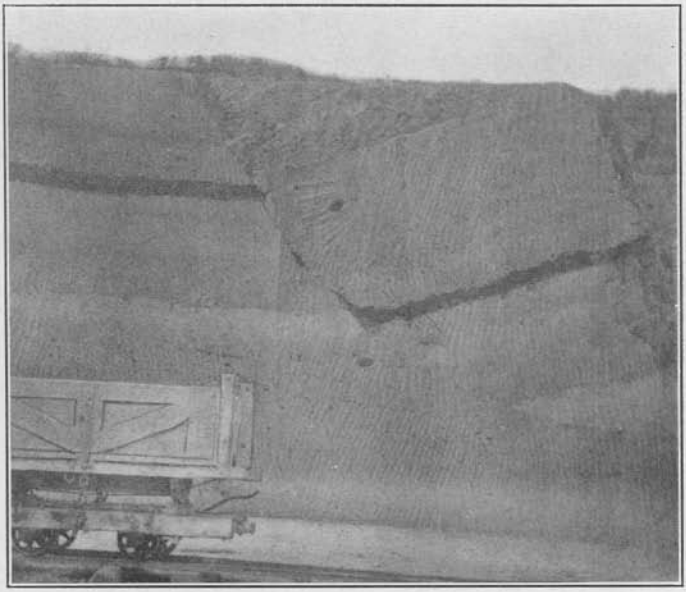

Fig. 1.—Woodbridge clay with seam of lignite, near Florida Grove.

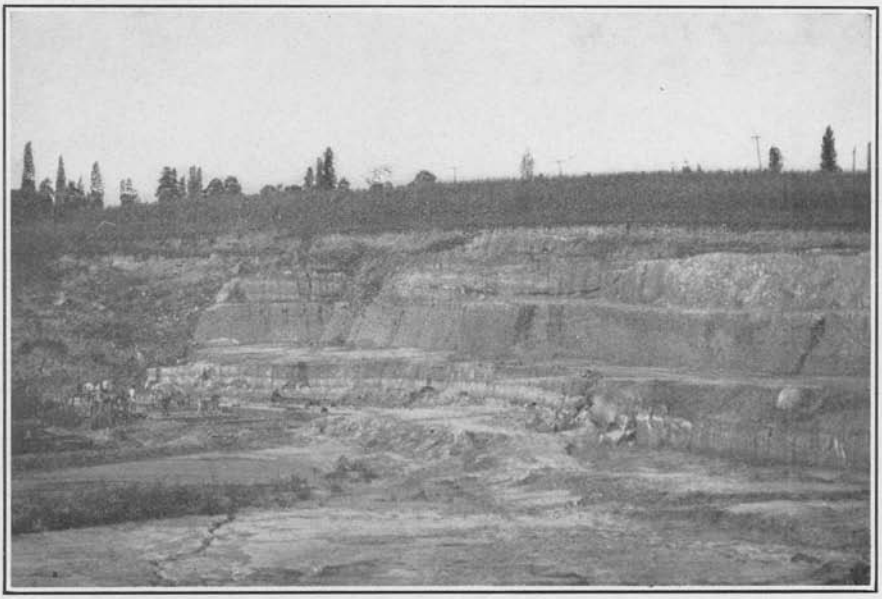

Fig. 2.—Fire clay and fireproofing clay, north of Keasbey.

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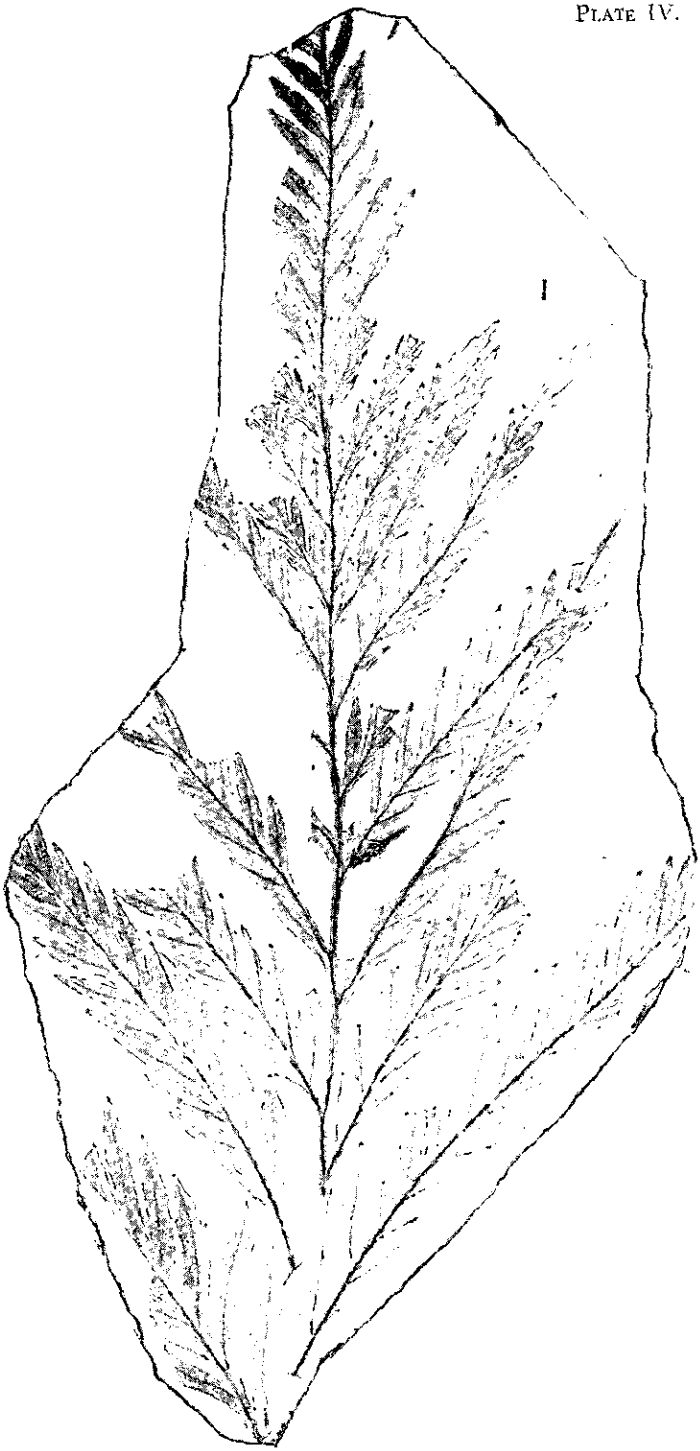

Fig. 1—Dicksonia groenlandica Heer, Woodbridge.

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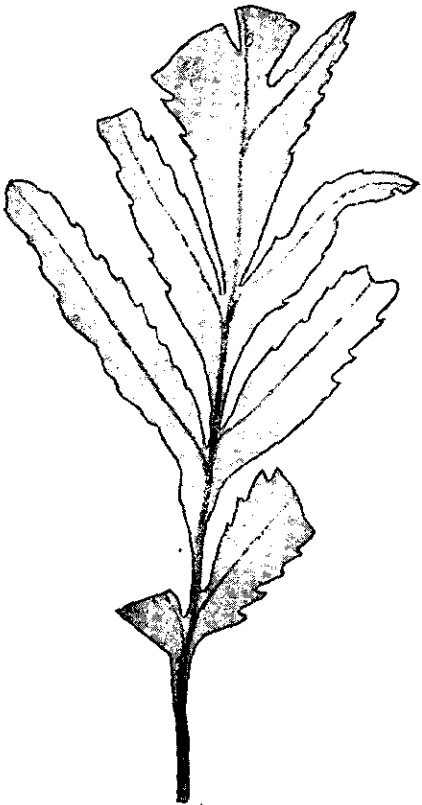

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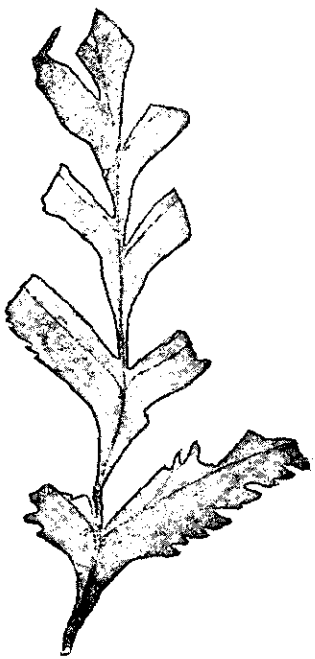

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Figs. 1, 2—Asplenium Foersteri Deb. & Ett., Woodbridge.
Figs. 3, 4—Asplenium Dicksonianum Heer, Woodbridge.

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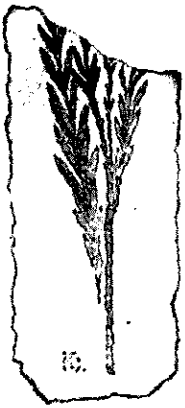

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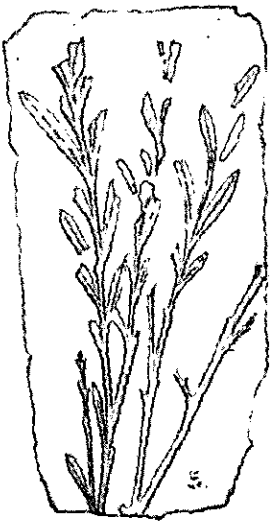

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Figs. 1–5—Sequoia heterophylla Velen., South Amboy.

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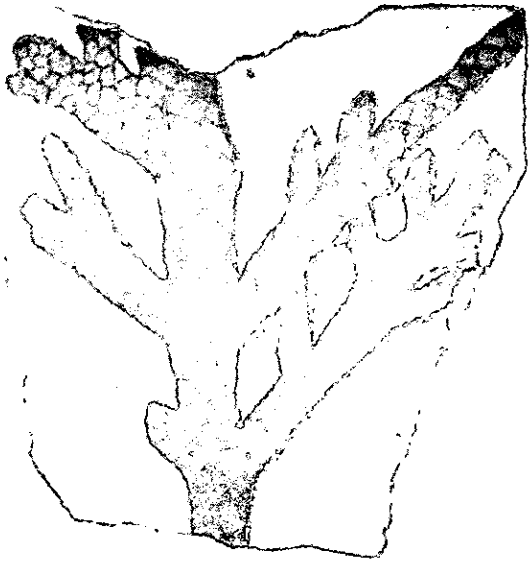

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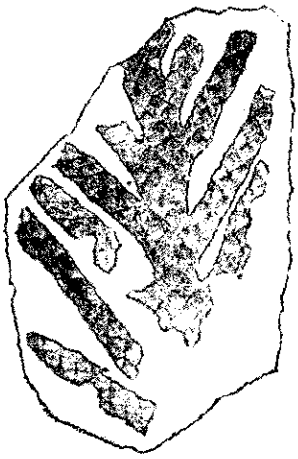

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Figs. 1–4—Brachyphyllum macrocarpum Newb., South Amboy.

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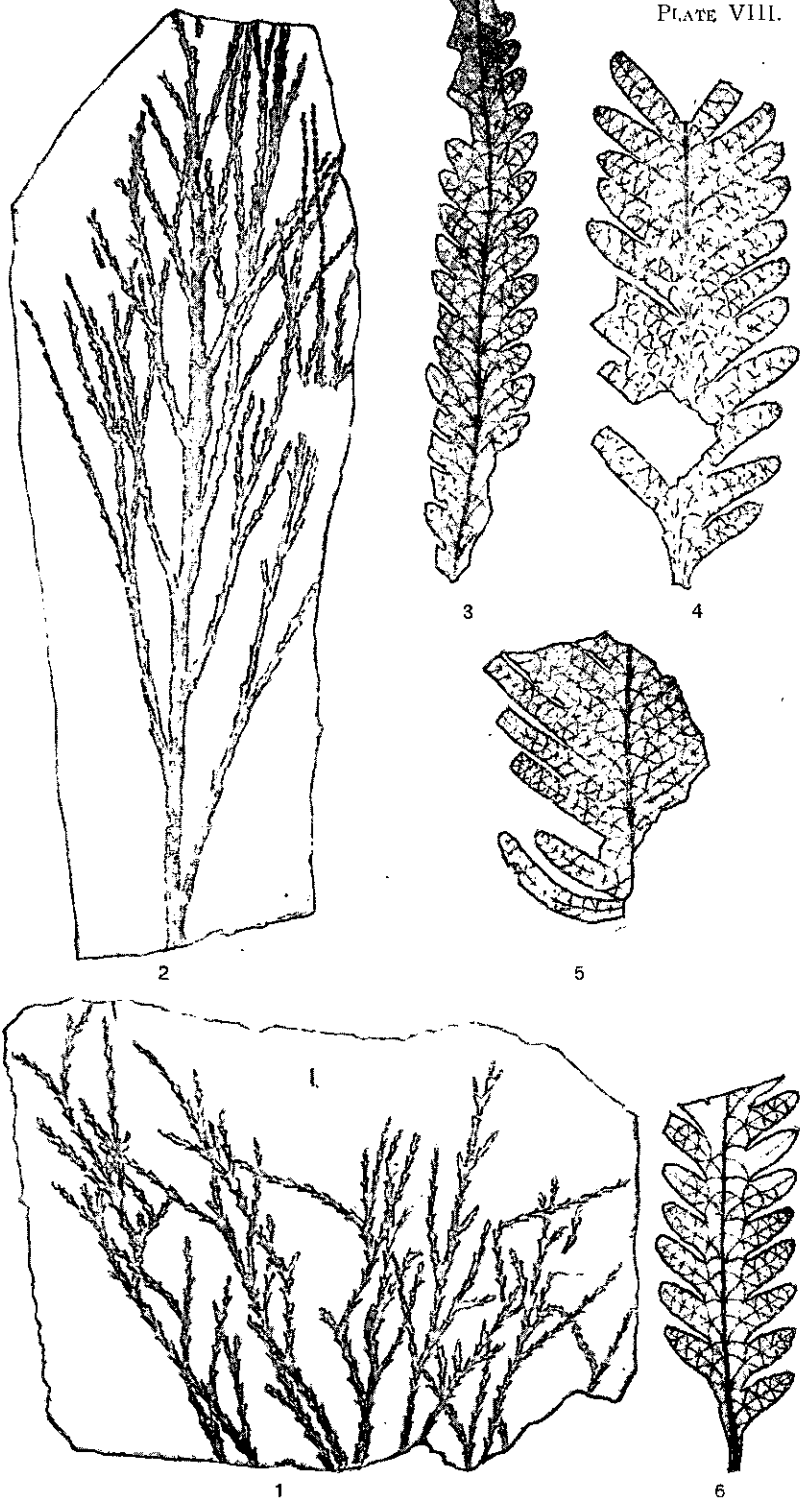
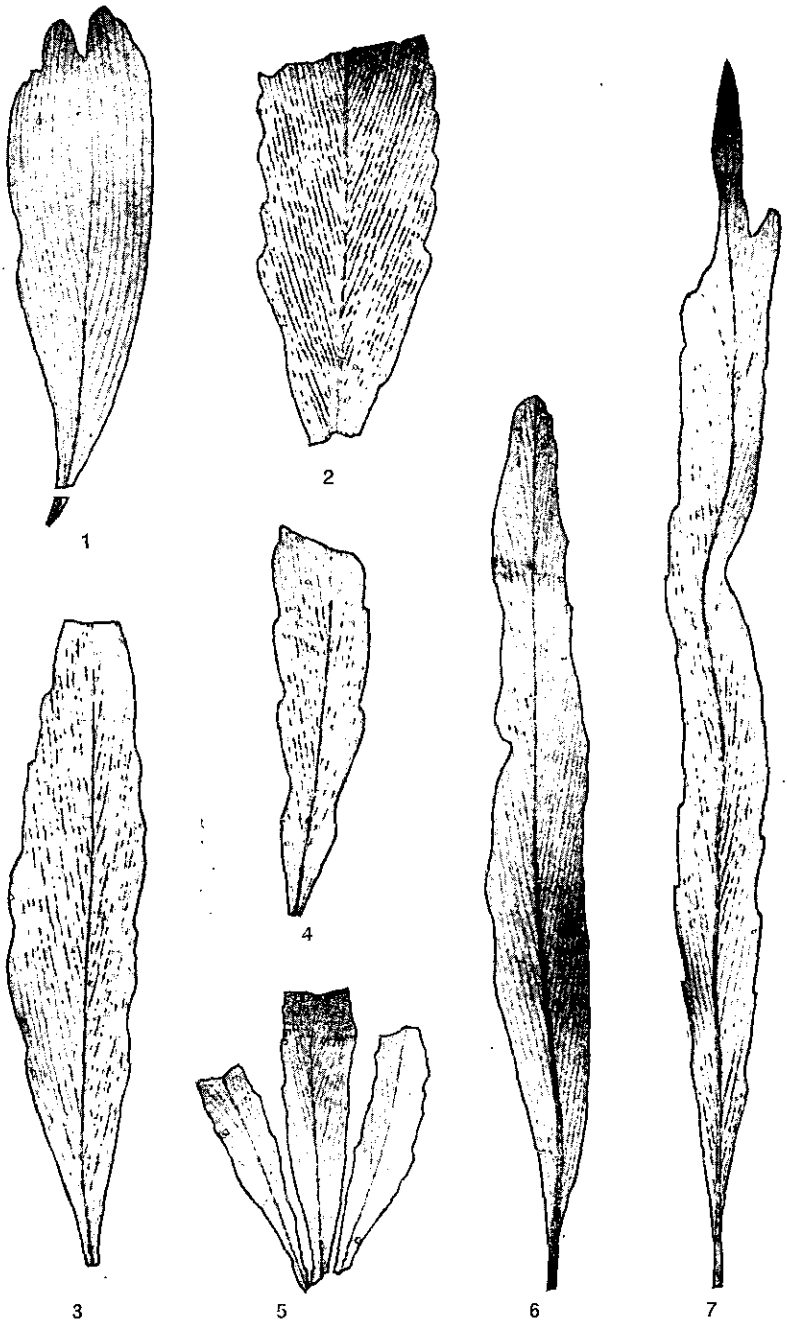


Figs. 1, 2.—Widdringtonites Reichii (Ett.) Heer, South Amboy.
Figs. 3–6.—Moriconia cyclotoxon Deb. & Ett., South Amboy.



Figs. 1–7—Protophyllocladus subintegrifolius (Lesq.) Berry, Woodbridge.

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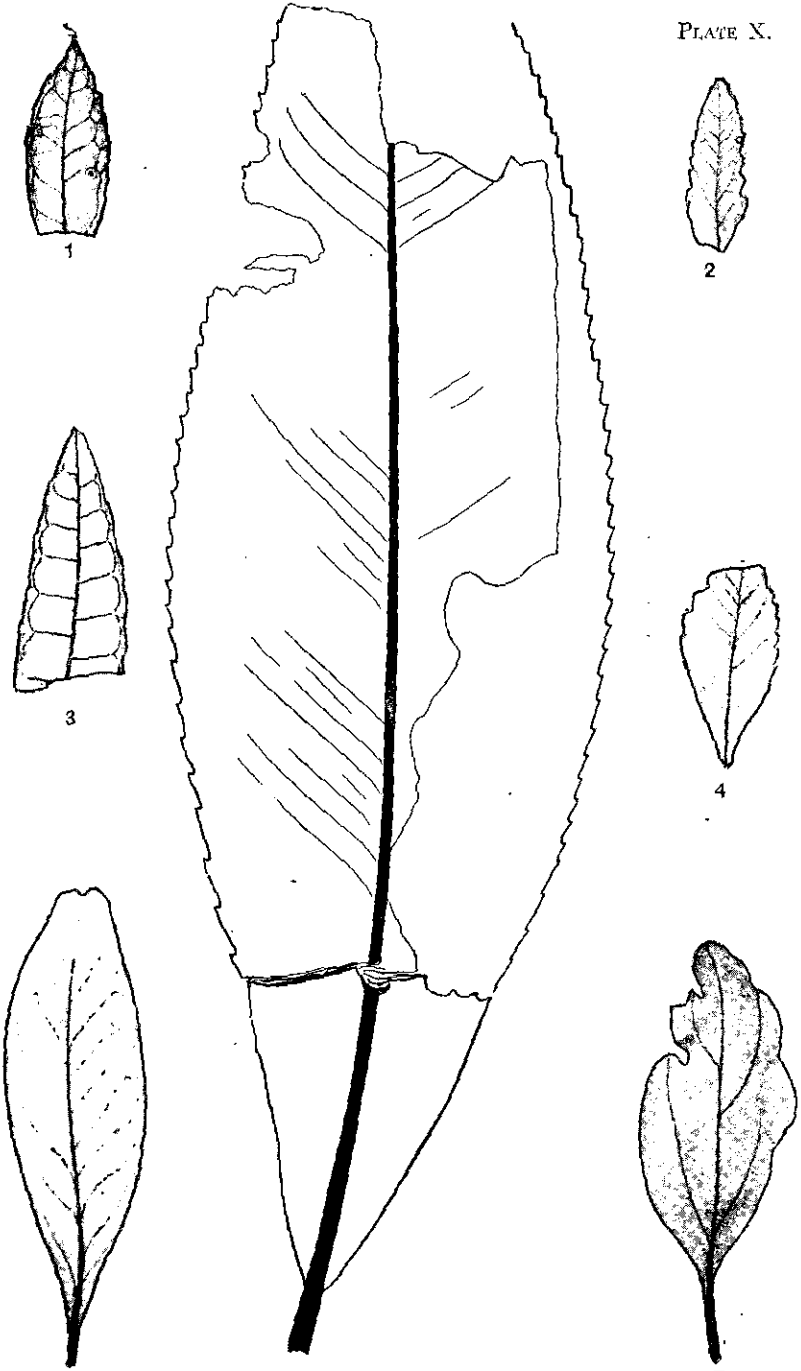

Fig. 1.—Myrica acuta Hollick, locality unknown. *Fig. 2.*—Myrica Newberryana Hollick, South Amboy. *Fig. 3.*—Myrica fenestra Newb., Sayreville. *Fig. 4.*—Myrica raritanensis Hollick, locality unknown. *Fig. 5.*—Myrica emarginata Heer (?), locality unknown. *Fig. 6.*—Myrica Hollicki Ward, Milltown. *Fig. 7.*—Myrica cinnamomifolia Newb., Woodbridge.

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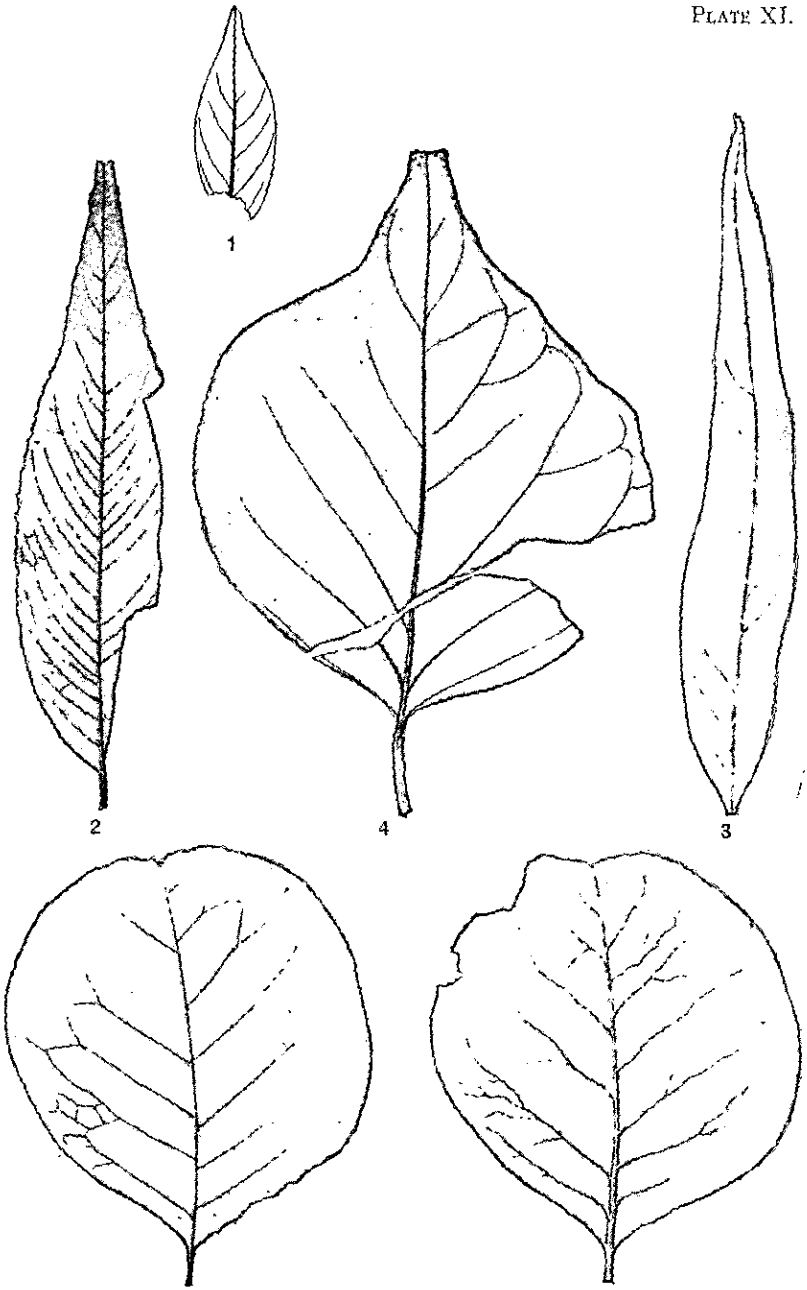

Fig. 1.—Salix pseudo-Hayei Berry, Milltown.
Fig. 2.—Salix Newberryana Hollick, South Amboy.
Fig. 3.—Salix inæqualis Newb., Woodbridge.
Fig. 4.—Populus apiculata Newb., Woodbridge.
Figs. 5, 6.—Populus orbicularis (Newb.) Berry, Sayreville.

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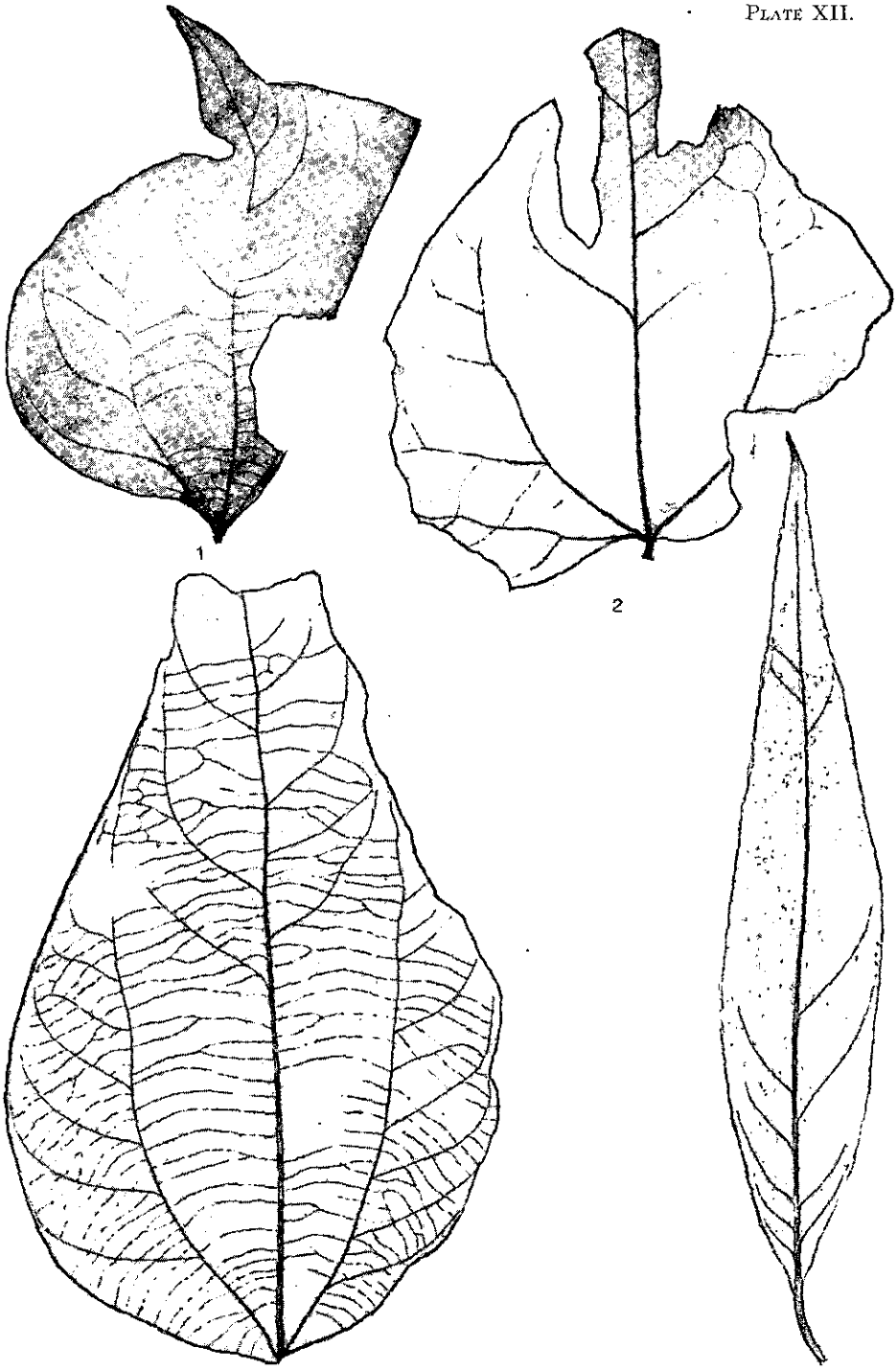

Figs. 1, 2.—Ficus Woolsoni Newb., Woodbridge.
Fig. 3.—Ficus ovatifolia Berry, Woodbridge.
Fig. 4.—Ficus daphnogenoides (Heer) Berry, Woodbridge.

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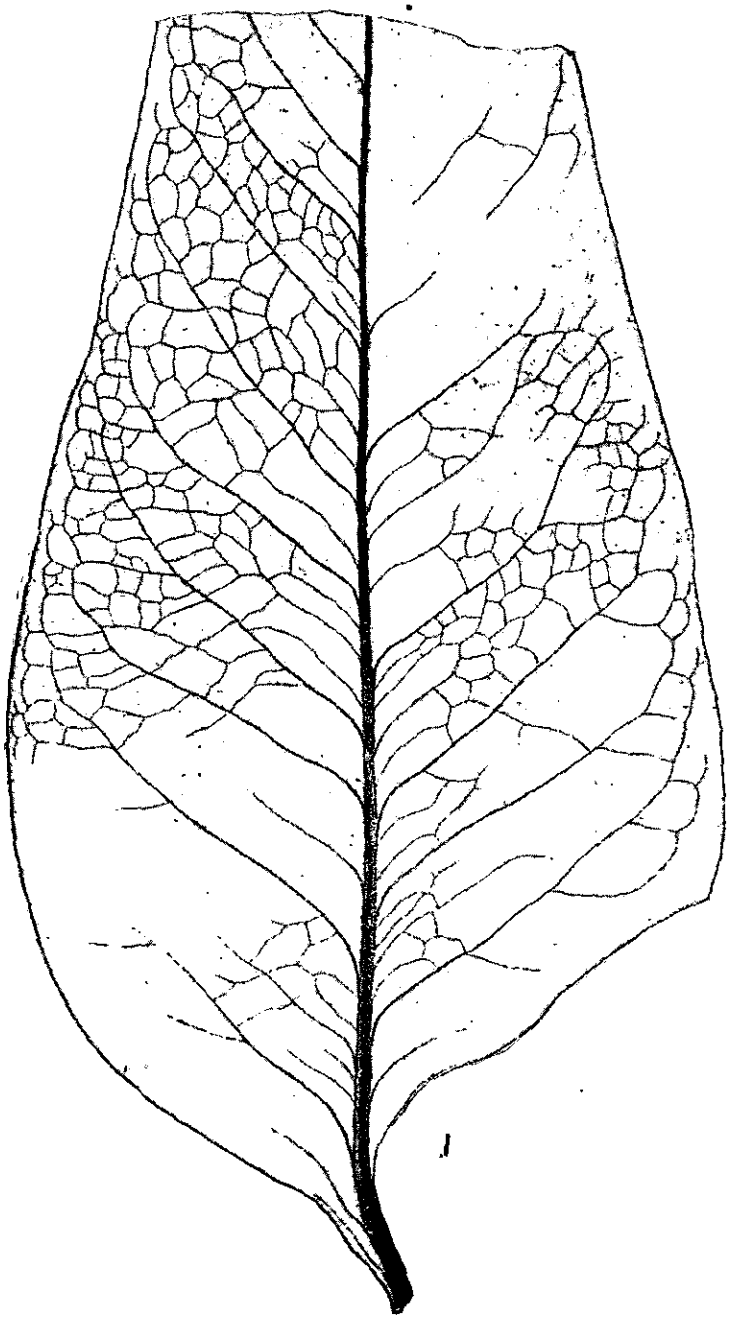

Fig. 1.—Magnolia Newberryi Berry, Woodbridge.

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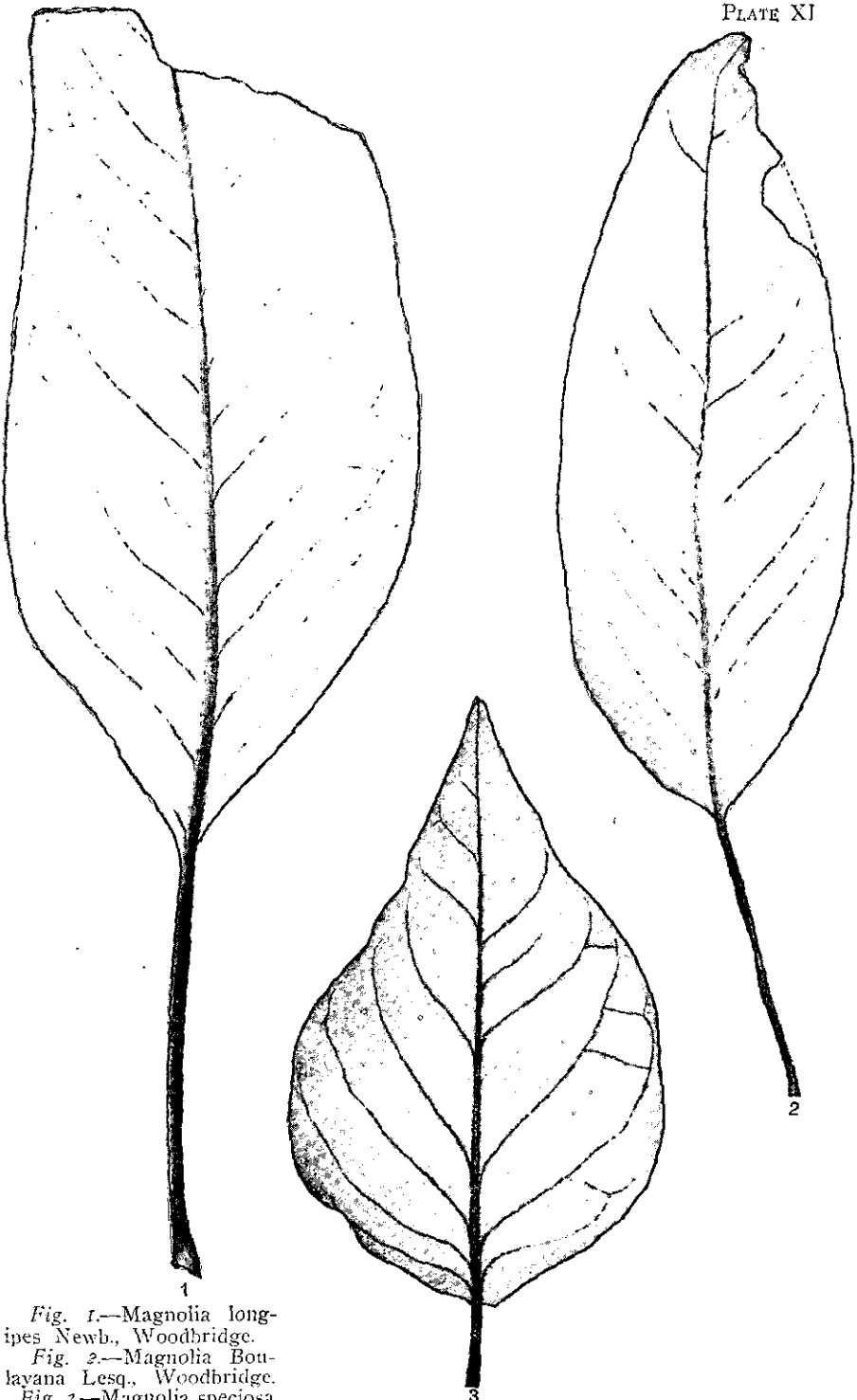

Fig. 1.—Magnolia longipes Newb., Woodbridge.
Fig. 2.—Magnolia Boulayana Lesq., Woodbridge.
Fig. 3.—Magnolia speciosa Heer. Woodbridge.

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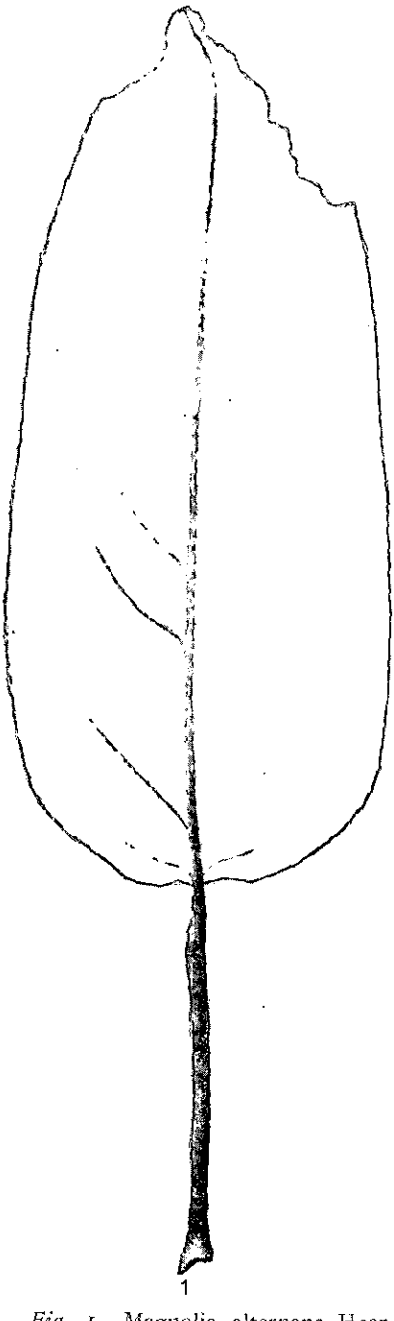

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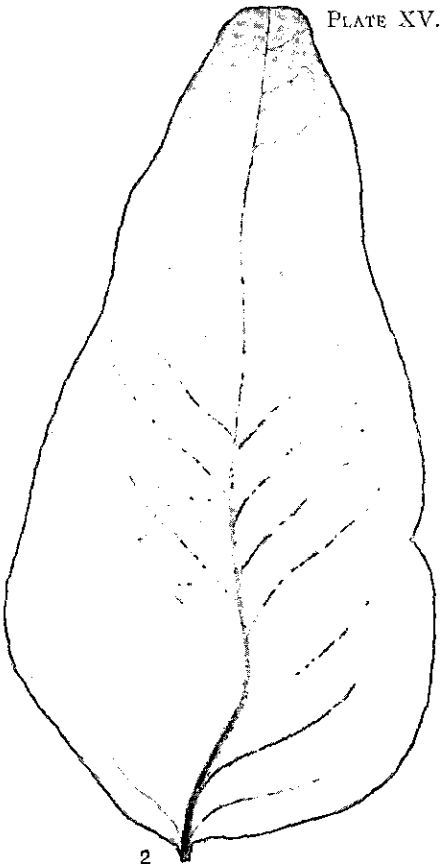

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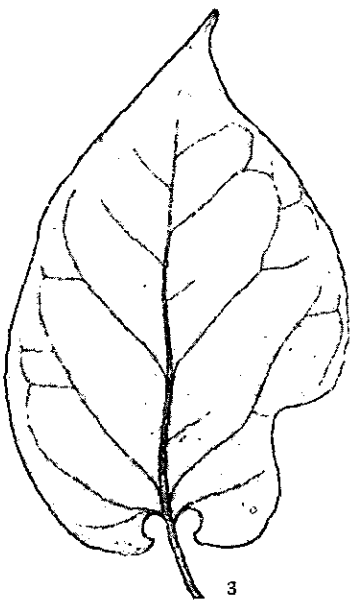

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Fig. 1.—Magnolia alternans Heer (?), Woodbridge.
Fig. 2.—Magnolia woodbridgensis Hollick, Woodbridge.
Fig. 3.—Magnolia Hollicki Berry, Woodbridge.

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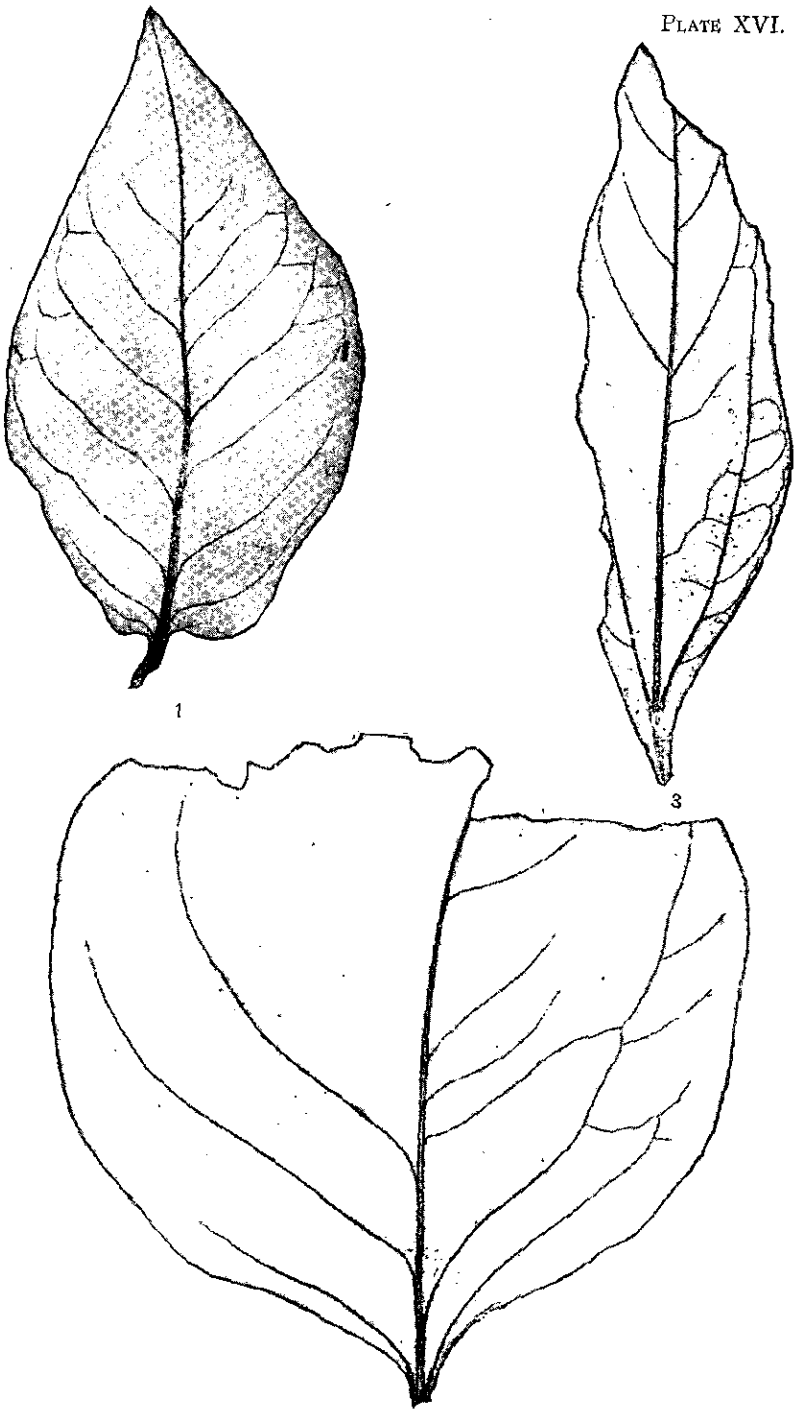

Fig. 1.—Magnolia Hollicki Berry, Woodbridge.
Fig. 2.—Magnolia Lacœana Lesq., Woodbridge.
Fig. 3.—Cinnamomum Newberryi Berry, Woodbridge.

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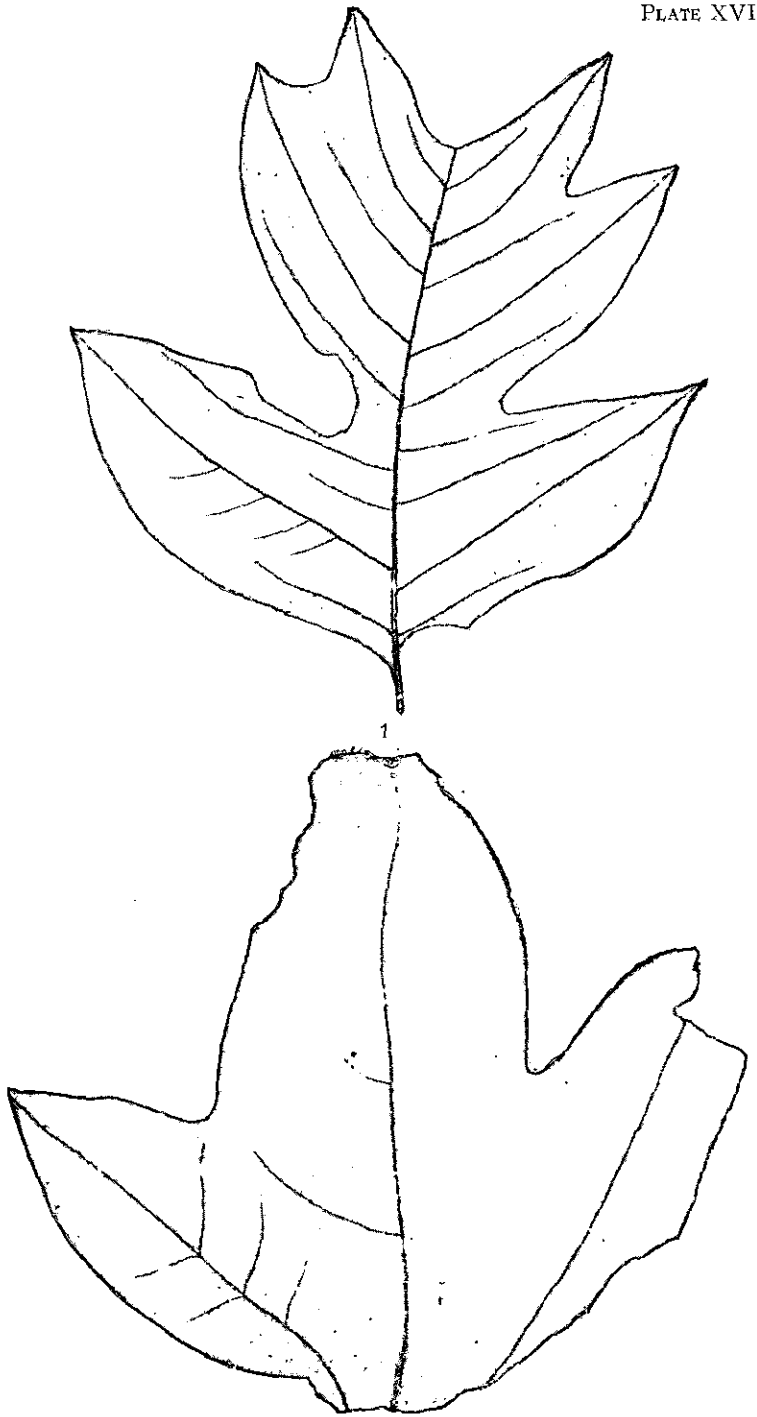

Fig. 1.—Liriodendron quercifolium Newb., Woodbridge.
Fig. 2.—Sassafras hastatum Newb., Woodbridge.

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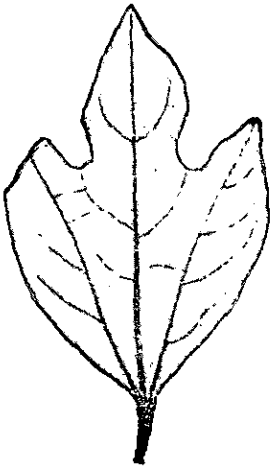

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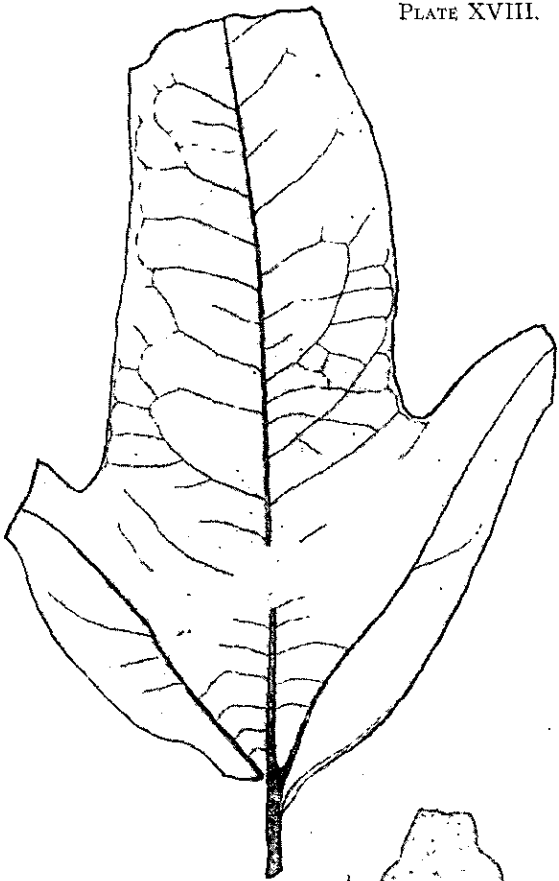

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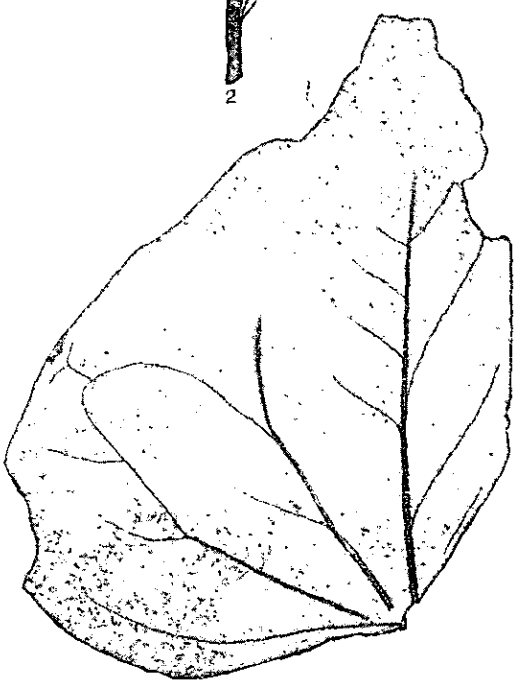

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Fig. 1.—Sassafras progenitor Newb., Woodbridge.

Fig. 2.—Sassafras acutilobum Lesq., Woodbridge.

Fig. 3.—Menispermites Wardianus Hollick, locality unknown.

Fig. 4.—Menispermites borealis Heer (?) Woodbridge.

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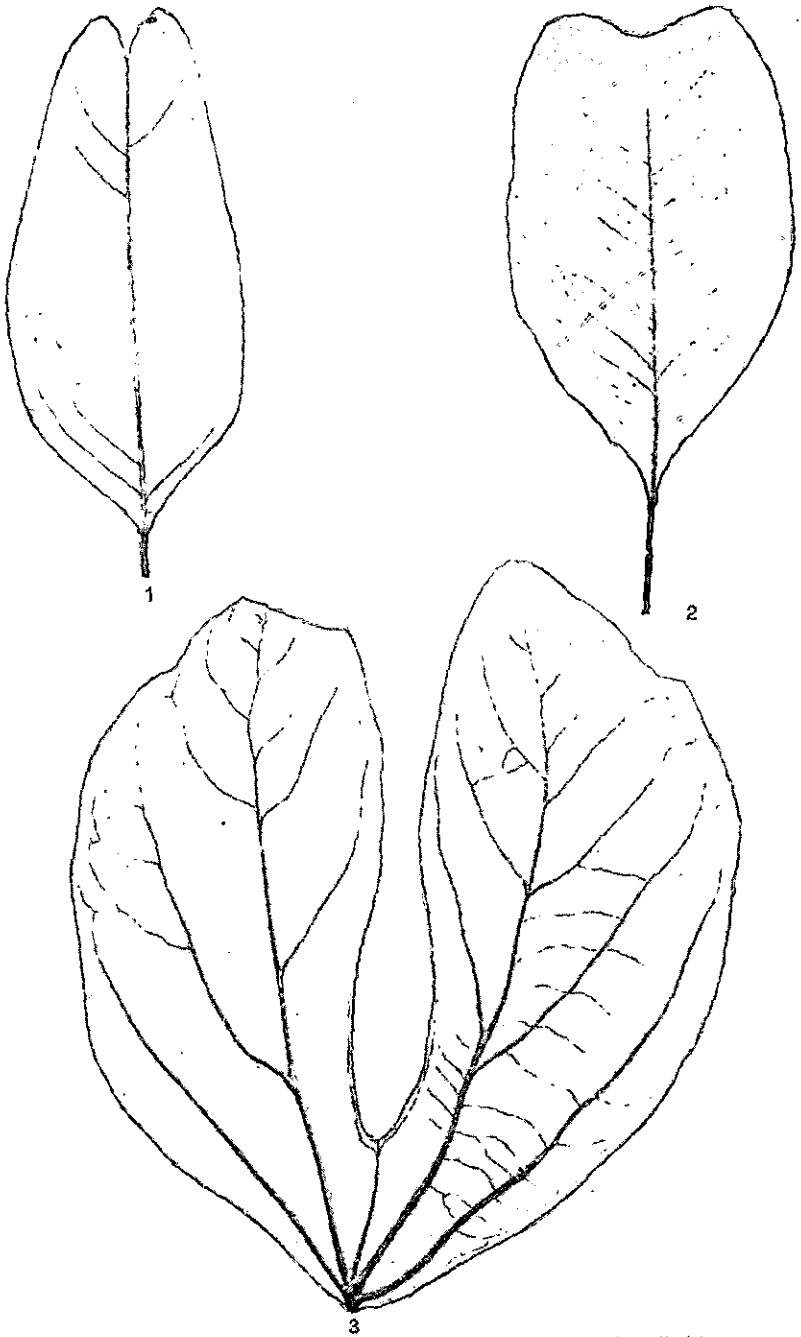

Fig. 1.—Liriodendropsis retusa (Heer) Hollick, Woodbridge.
Fig. 2.—Liriodendropsis simplex (Newb.) Newb., Woodbridge.
Fig. 3.—Bauhinia cretacea Newb., Woodbridge.

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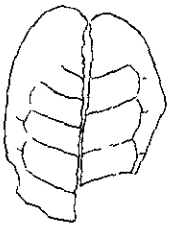

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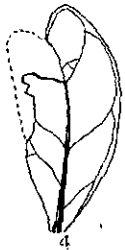

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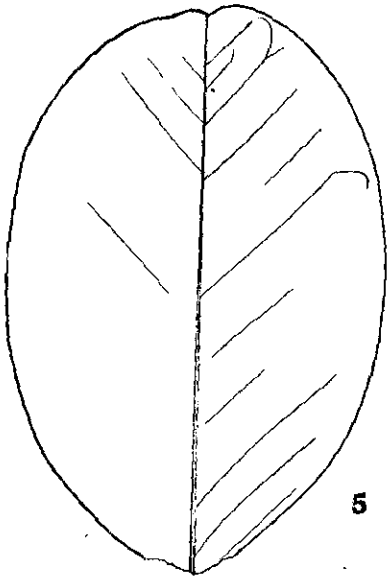

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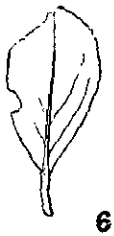

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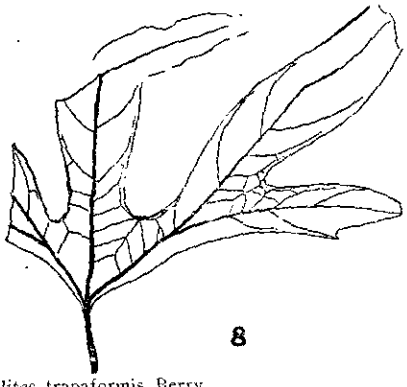

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Figs. 1, 2.—Phyllites trapaformis Berry.
Fig. 1.—Type natural size, South Amboy.
Fig. 2.—Same enlarged four times.
Fig. 3.—Cæsalpinia raritanensis Berry. South Amboy.
Fig. 4.—Colutea primordialis Heer. South Amboy.
Fig. 5.—Leguminosites raritanensis Berry. South Amboy.
Fig. 6.—Persoonia Lesquereuxii Knowlton. South Amboy.
Fig. 7.—Andromeda novæ-cæsareæ Hollick. South Amboy.
Fig. 8.—Aralia quinquepartita Lesq., Hylton Pits.

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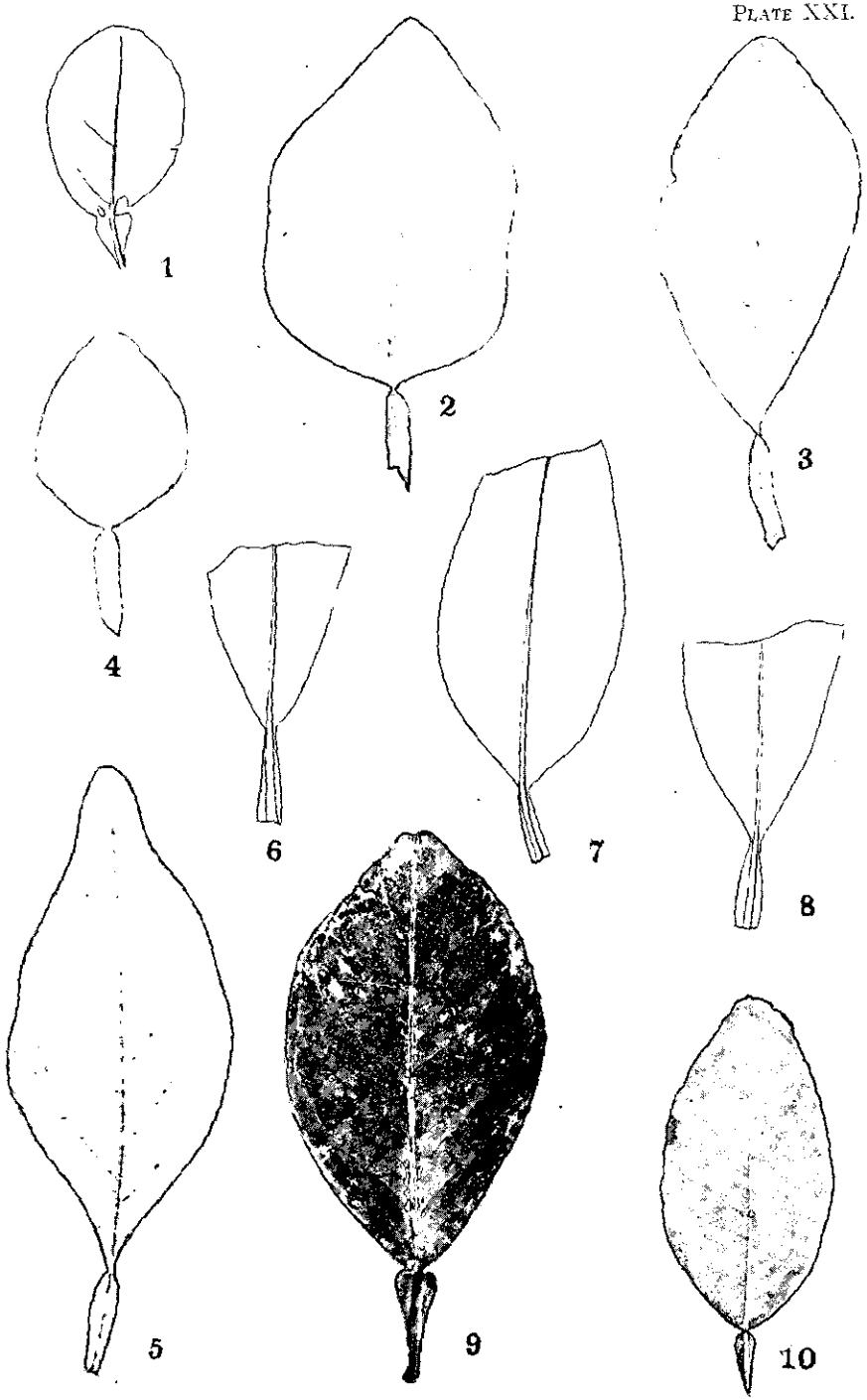

Figs. 1–8.—Citrophyllum aligerum (Lesq.) Berry.
Fig. 1.—Allen Pit, South Amboy.
Figs. 2–5.—Cloud County, Kansas.
Figs. 6–8.—Cliffwood clays, N. J.
Fig. 9.—Citrus vulgaris Risso *from* Florida, for comparison.
Fig. 10.—Citrus Limonum Risso *from* St. Croix, for comparison.

NEW JERSEY GEOLOGICAL SURVEY

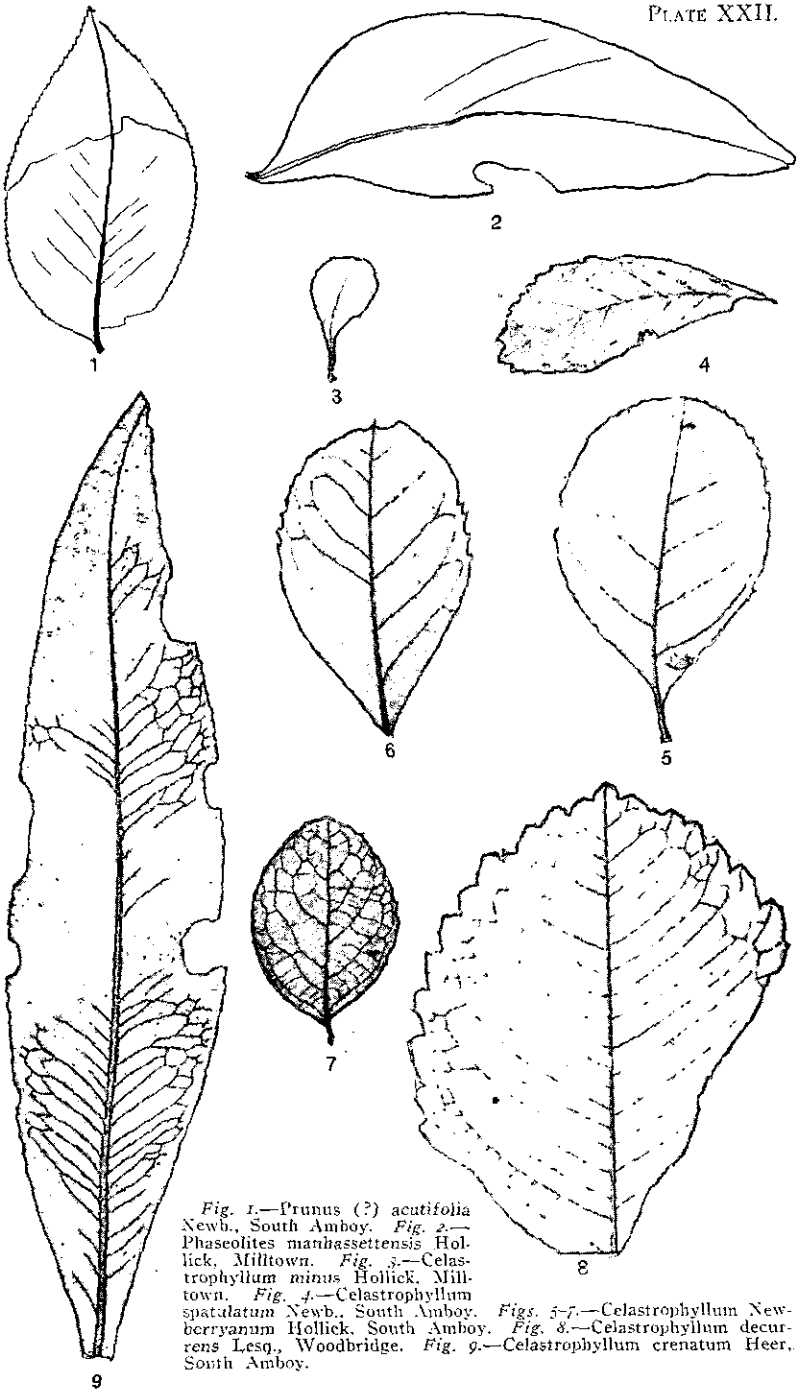

Fig. 1.—Prunus (?) *acutifolia* Newb., South Amboy. *Fig. 2.*—Phaseolites manhassettensis Hollick, Milltown. *Fig. 3.*—Celastrophyllum *minus* Hollick, Milltown. *Fig. 4.*—Celastrophyllum *spatulatum* Newb., South Amboy. *Figs. 5–7.*—Celastrophyllum Newberryanum Hollick, South Amboy. *Fig. 8.*—Celastrophyllum decurrens Lesq., Woodbridge. *Fig. 9.*—Celastrophyllum crenatum Heer, South Amboy.

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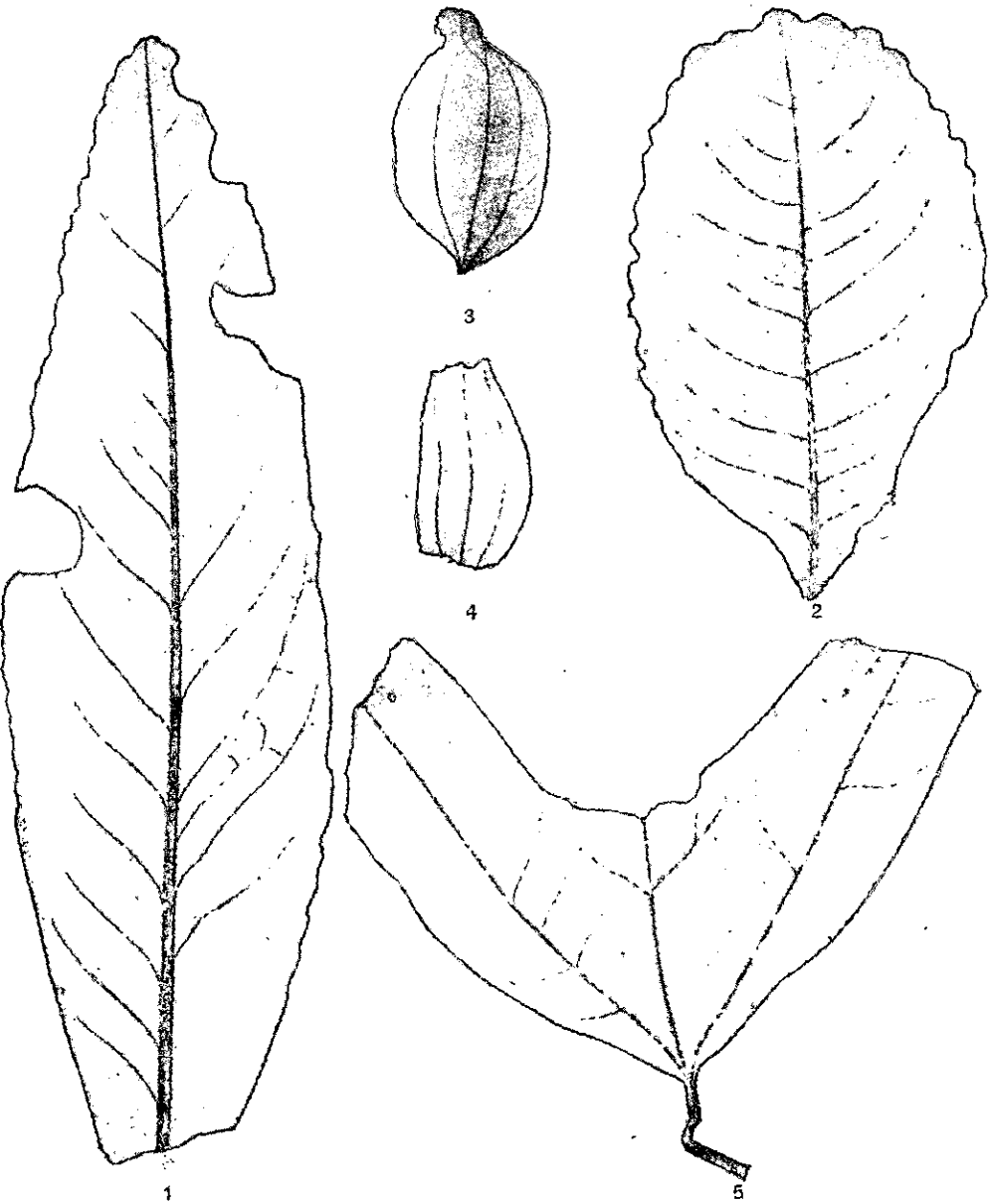

Fig. 1.—Celastrophyllum grandifolium Newb., locality unknown.
Fig. 2.—Celastrophyllum crenatum Heer, South Amboy.
Figs. 3-4.—Smilax raritanensis Berry, locality unknown.
Fig. 5.—Passiflora antiqua Newb., Woodbridge.

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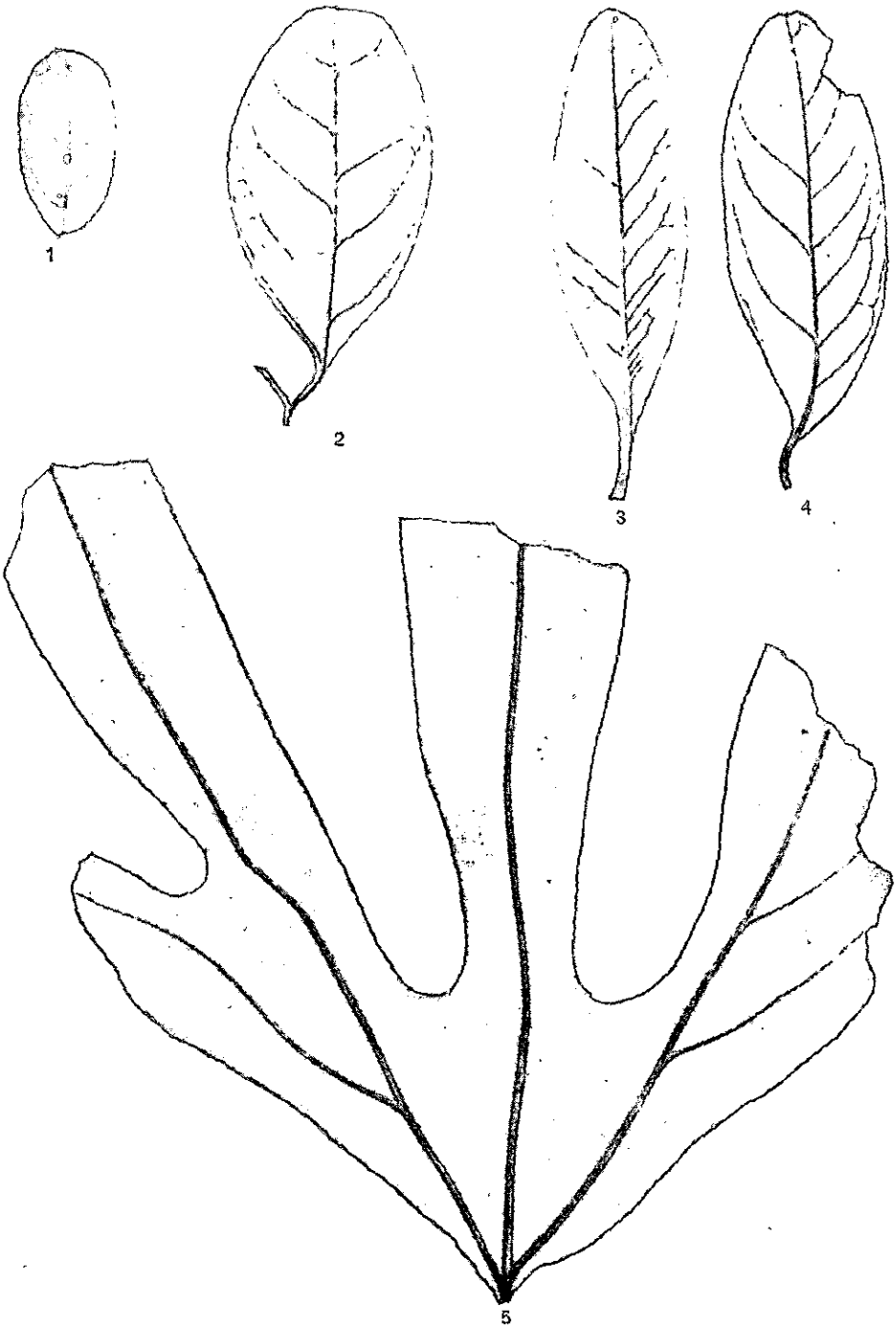

Fig. 1.—Myrsine oblongata Hollick, South Amboy (?).
Fig. 2.—Myrsine borealis Heer, South Amboy.
Figs. 3, 4.—Myrsine Gaudini (Lesq.) Berry, South Amboy.
Fig. 5.—Aralia quinquepartita Lesq., Woodbridge.

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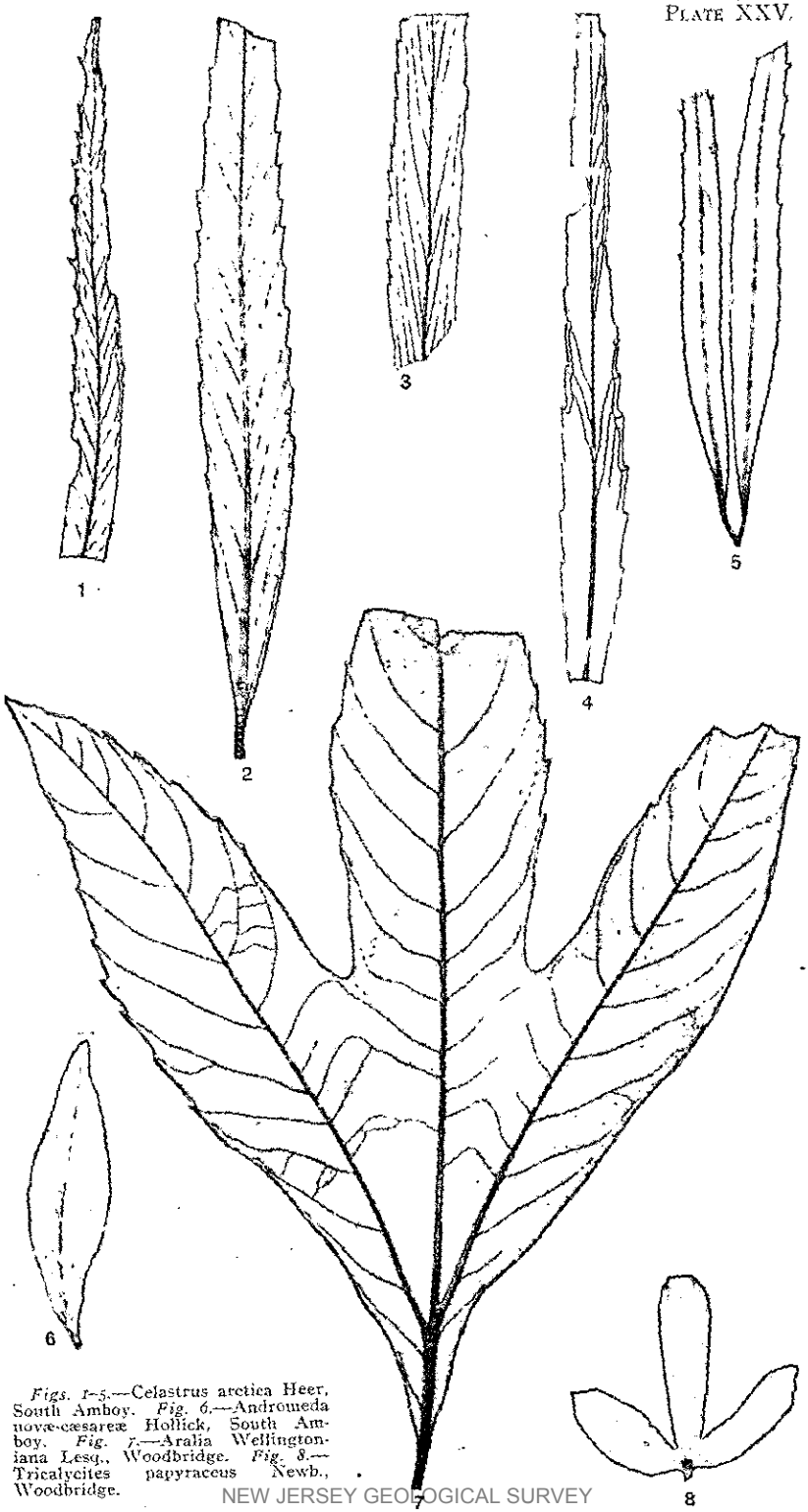

Figs. 1–5.—Celastrus arctica Heer, South Amboy. *Fig. 6.*—Andromeda novæ-cæsareæ Hollick, South Amboy. *Fig. 7.*—Aralia Wellingtoniana Lesq., Woodbridge. *Fig. 8.*—Tricalycites papyraceus Newb., Woodbridge.

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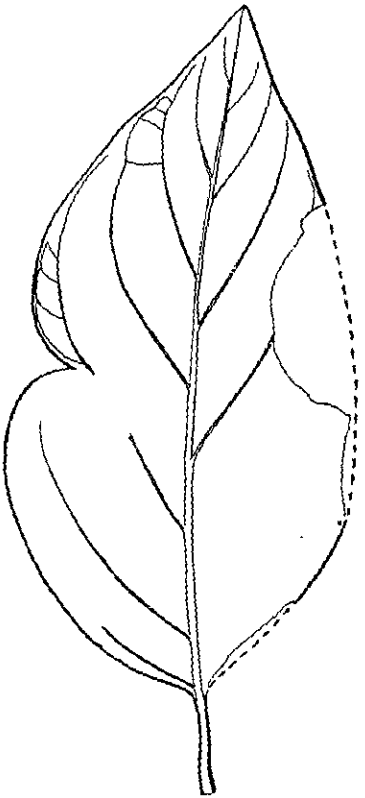

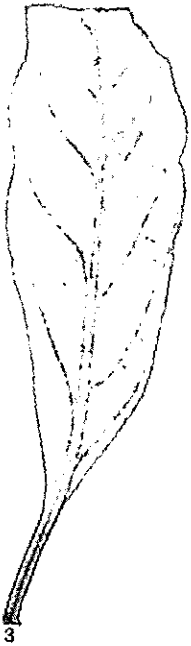

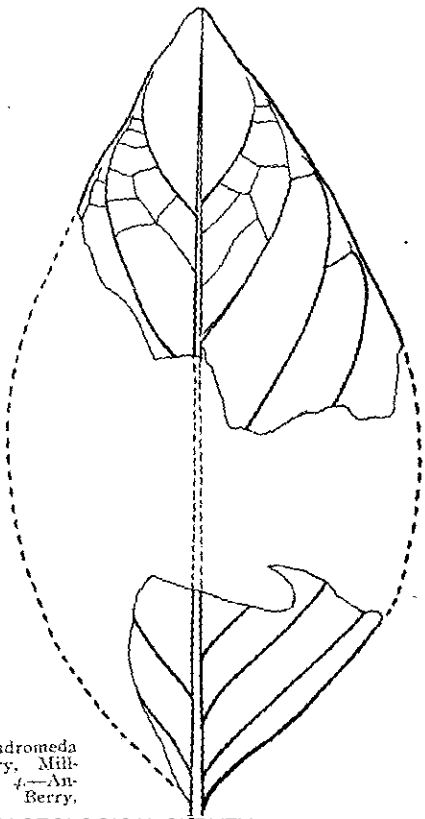

Figs. 1, 2.—Andromeda grandifolia Berry, Milltown. *Figs. 3, 4.*—Andromeda Cookii Berry, Woodbridge.

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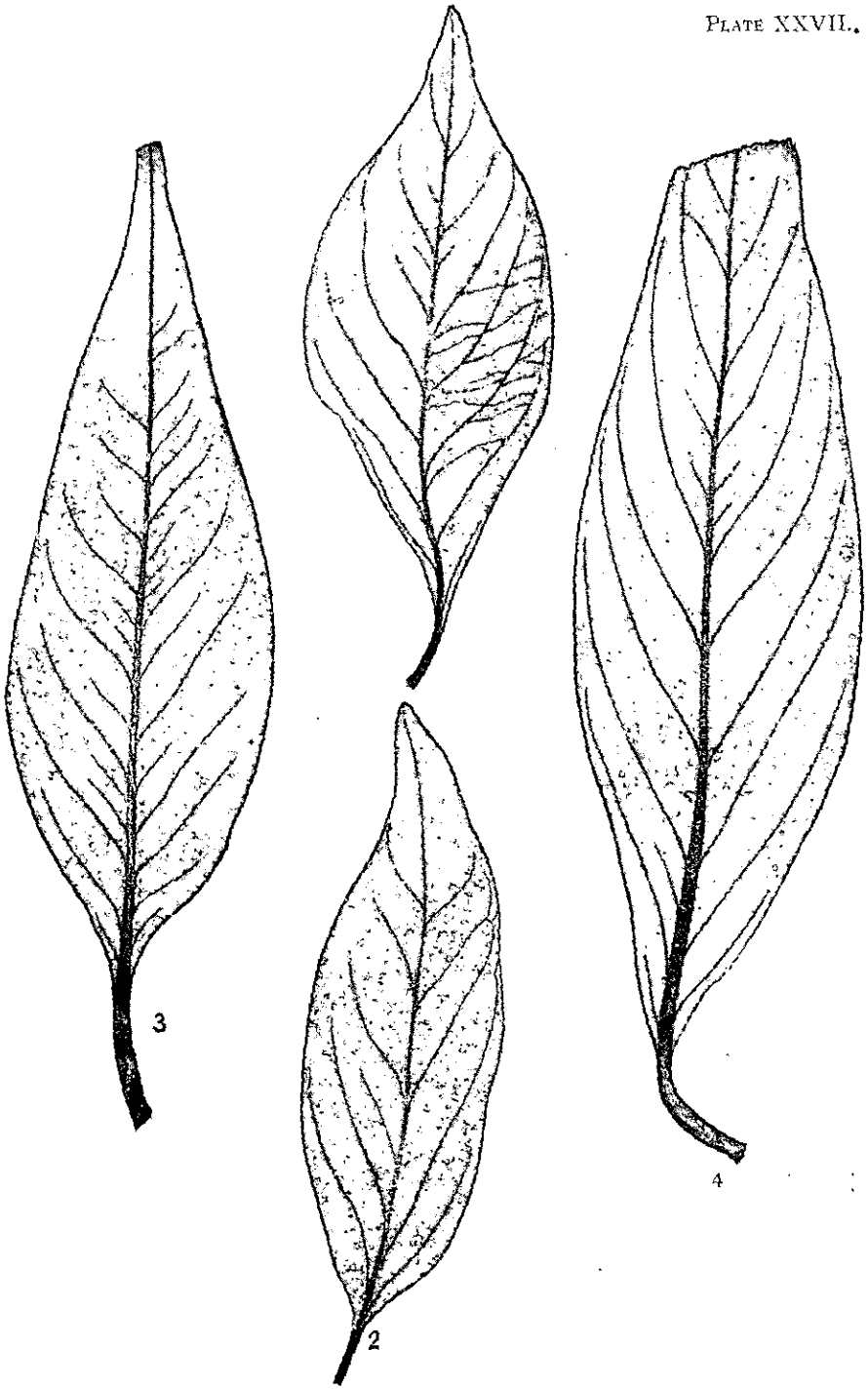

Figs. 1–4.—Andromeda Parlatorii Heer, Woodbridge.

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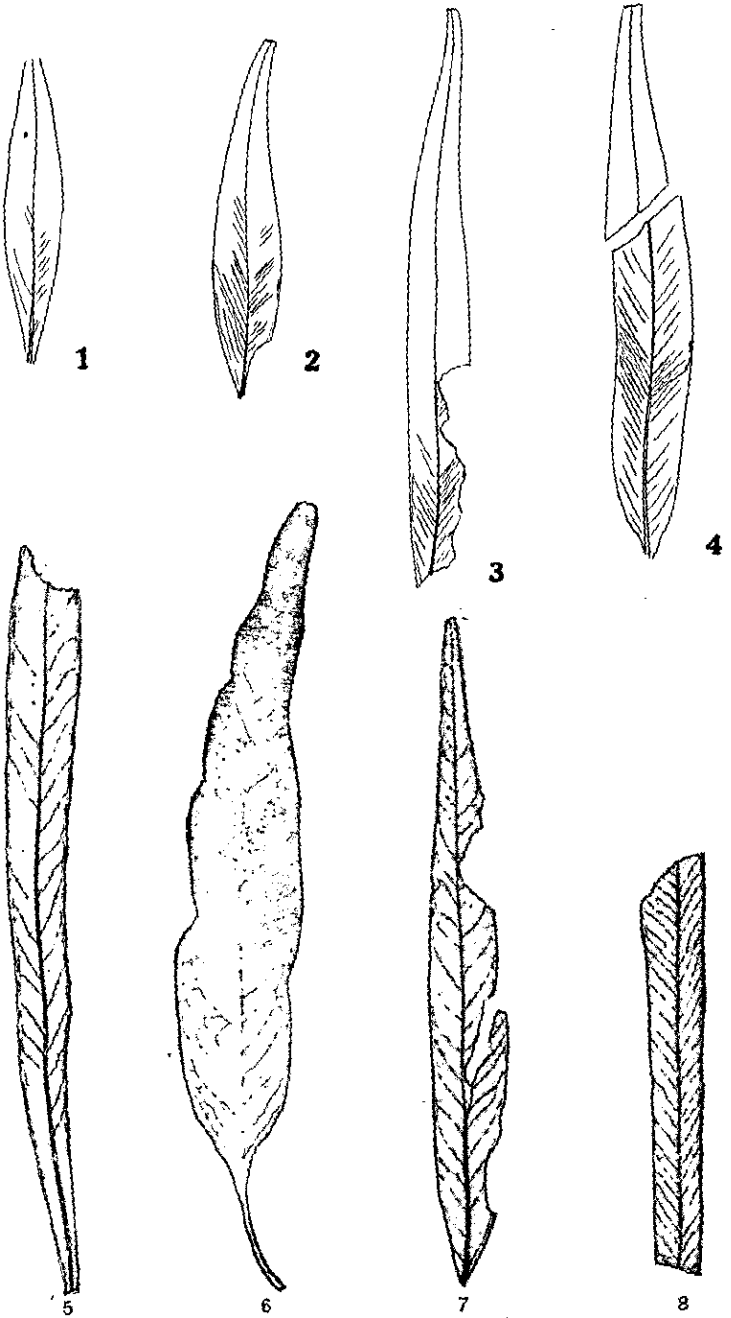

Figs. 1–4.—Eucalyptus angusta Velen., South Amboy.
Fig. 5.—Eucalyptus angustifolia Newb., South Amboy.
Fig. 6.—Eucalyptus attenuata Newb., South Amboy.
Fig. 7.—Eucalyptus Geinitzi (Heer) Heer, Woodbridge.
Fig. 8.—Eucalyptus linearifolia Berry, South Amboy.

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Fig. 1.—Diospyros primæva Heer, South Amboy.
Figs. 2–4.—Calycites diospyriformis Newb., Woodbridge.
Fig. 5.—Diospyros elliptica (Newb.) Berry, Woodbridge.

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