MARYLAND
GEOLOGICAL SURVEY

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LOWER CRETACEOUS

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LETTER OF TRANSMITTAL

To His Excellency Austin L. Crothers,

Governor of Maryland and President of the Geological Survey Commission,

Sir:—I have the honor to present herewith the fourth volume of a series of reports dealing with the systematic geology and paleontology of Maryland. The preceding volumes have dealt with the Tertiary and Quaternary deposits and the remains of animal and plant life which they contain. The present volume treats of the Lower Cretaceous deposits and their contained life, a knowledge of which is very important from an educational and scientific standpoint. I am,

Very respectfully,

WM. BULLOCK CLARK,

State Geologist.

Johns Hopkins University,
Baltimore, *September*, 1911.

CONTENTS

ILLUSTRATIONS

PREFACE

The present volume is the fourth of a series of reports dealing with the systematic geology and paleontology of Maryland, the Eocene, Miocene, and Plio-Pleistocene deposits having already been fully described.

The Lower Cretaceous deposits which form the subject-matter of the present volume are more fully developed in the Maryland-Virginia area than anywhere else in eastern North America and the Maryland section is the type for the whole Atlantic coastal plain. Similarly the faunas and floras of the Lower Cretaceous are much more fully represented than elsewhere in this general region, the flora in particular being the richest known flora of this age.

The vertebrate fauna of the Arundel formation collected by Mr. John B. Hatcher and studied by the late Professor O. C. Marsh of Yale University is of interest, since it is the only Lower Cretaceous vertebrate fauna known east of the Mississippi River, and it was upon these materials that Professor Marsh based his opinion that the Potomac was of late Jurassic age. This fauna has been thoroughly revised and elaborated in the light of additional collections by Professor R. S. Lull of the same institution. His results are in agreement with the evidence of the fossil plants, that these deposits are of Lower Cretaceous age.

The invertebrate faunas, while meagre and poorly preserved, are of great interest, since they constitute the only known representation in eastern North America of the estuarine and fluviatile invertebrate life of the Lower Cretaceous. This fauna has been described by Professor W. B. Clark of the Johns Hopkins University.

The fossil floras have been restudied by Mr. E. W. Berry of the Johns Hopkins University. The difficulties in the way of an adequate study of the Potomac flora are very great. The material, with the exception of silicified wood, lignite, and the silicified trunks of Cycadeoidea, is all in the form of impressions, and these, while abundant and diverse, are with some notable exceptions poorly preserved as well as fragmentary, much more so than the diagrammatic figures built up from various fragments by previous students would lead one to suspect. The silicified wood and lignite, while abundant, has for the most part undergone so much decay before fossilization that the bulk of it is worthless. In addition to the sections made by Dr. F. H. Knowlton and forming the basis of his paper on the Fossil Wood and Lignite of the Potomac, a large number of sections have been studied by Mr. Berry, most of which proved unidentifiable, because of the extreme stage of decay before fossilization. The most perfectly preserved show only the comparatively unimportant features of the secondary wood. The petrified Cycadeoidea trunks were also found to be poorly preserved, constituting in this respect a remarkable contrast with those from the Black Hills area and elsewhere.

The necessity of some sort of systematic treatment of the maze of described forms in the literature of the Potomac which would enable the geologist or the botanist to obtain some idea of the flora has long been felt. The pre-existing multiplicity of species has made it necessary to retain a number of extremely doubtful forms. Many have, however, disappeared by reduction to synonymy, and some basis for the correlation of a number of genera with their living representatives has become apparent during the progress of the work.

Certain important forms known only from the continuation of the Maryland deposits in the Virginia area have been included, while others upon which no new light could be shed have been omitted. These latter will be discussed on a subsequent occasion in a work devoted to the Virginia area and in course of preparation for the Geological Survey of that state. Mr. Berry is indebted to various friends and colleagues both at home and abroad for assistance during the progress of the work. He is under especial obligations to the U. S. National Museum and Dr. F. H. Knowlton for facilities in the study of the large Lower Cretaceous collections of that institution as well as for many other courtesies. The British Museum through Dr. A. Smith Woodward rendered invaluable assistance in contributing a large number of English Wealden plants for comparison, and Professor Yokoyama of Tokio kindly forwarded Japanese material of *Onychiopsis*. Dr. Albert Mann of the Department of Agriculture and Doctors F. H. Blodgett and W. Ralph Jones have contributed photo-micrographs or camera lucida drawings.

The U. S. Geological Survey has cooperated in furnishing a large number of the illustrations and in various other ways.

Finally any student of Lower Cretaceous floras must acknowledge his great indebtedness to previous workers who have contributed to our knowledge of these floras, more especially to Professor Seward in England, the late Marquis Saporta in Portugal, the late Professor Oswald Heer in the Arctic regions, and Professors Ward and Fontaine in this country.

THE LOWER CRETACEOUS DEPOSITS OF MARYLAND

BY

WILLIAM BULLOCK CLARK

ARTHUR B. BIBBINS

AND

EDWARD W. BERRY


MAP
SHOWING THE DISTRIBUTION OF THE
LOWER CRETACEOUS
FORMATIONS
OF
MARYLAND
MARYLAND GEOLOGICAL SURVEY
WM. BULLOCK CLARK, STATE GEOLOGIST
SCALE
One inch equals five miles
1:312,500
1911
LEGEND
Patapsco Formation
Arundel Formation
Patuxent Formation
POTOMAC GROUP
Fossil Localities
Location of Sections
HOWARD
BALTIMORE
HARFORD
CECIL
KENT
QUEEN ANNES
TALBOT
CAROLINE
MONTGOMERY
PRINCE GEORGES
ANNE ARUNDEL
CHARLES
VIRGINIA
CALVERT
BALTIMORE
TOWSON
ANNAPOLIS
WASHINGTON
ALEXANDRIA
ROCKVILLE
ELKTON
BELAIR
CHESTERTOWN
CENTERVILLE
DENTON
EASTON
CAMBRIDGE
PRINCE FREDERICK
LA PLATA
UPPER MARLBORO
POTOMAC RIVER

THE LOWER CRETACEOUS DEPOSITS OF MARYLAND

BY

WM. BULLOCK CLARK, ARTHUR B. BIBBINS,

AND

EDWARD W. BERRY

INTRODUCTION

A knowledge of the Lower Cretaceous deposits of Maryland can only be secured through an understanding of the physiography and geology of the broad province of which the State of Maryland forms a part. The physical features which characterize this area may be traced for varying distances into adjoining regions, some being recognized as far as the New England coast on the north, and others as far as the Gulf Region on the south.

The Physiography

The region here considered forms a portion of the Atlantic slope, which stretches from the crest of the Alleghanies to the sea, and which is divided into three more or less sharply defined regions known as the Coastal Plain, the Piedmont Plateau, and the Appalachian Region. These three districts follow the Atlantic border of the United States in three belts of varying width from New England southward to the Gulf. Maryland is, therefore, closely related in its physiographic features to the States which lie to the north and south of it, while its central location on the Atlantic border renders it perhaps the most characteristic in this broad tract. In crossing the three districts from the ocean border the country rises at first gradually, and then more rapidly, until it culminates in the highlands of the western portion of the State.

The *Coastal Plain* is the name applied to the low and partially submerged surface of varying width extending from Cape Cod southward through Florida, and confined between the Piedmont Plateau on the west and the margin of the continental shelf on the east. The line of demarkation between the Coastal Plain and the Piedmont Plateau is sinuous and ill-defined, for the one passes over into the other oftentimes with insensible topographic gradations, although the origin of the two districts is quite different. A convenient, although somewhat arbitrary boundary between the two regions in the Maryland area is furnished by the Baltimore and Ohio Railroad in its extension from Wilmington southwestward through Baltimore to Washington. The eastern limit of the Coastal Plain is at the edge of the continental shelf. This is located about 100 miles off shore at a depth of 100 fathoms beneath the surface of the Atlantic Ocean. It is in reality the submerged border of the North American continent, which extends seaward with a gently sloping surface to the 100-fathom line. At this point there is a rapid descent to a depth of 3000 fathoms, where the continental rise gives place to the oceanic abyss.

The Coastal Plain, therefore, falls naturally into two divisions, a submerged or *submarine division* and an emerged or *subaërial division.* The seashore is the boundary line which separates them. This line of demarkation, although apparently fixed, is in reality very changeable, for during the past geologic ages it has migrated back and forth across the Coastal Plain, at one time occupying a position well over on the Piedmont Plateau, and at another far out at sea. At the present time there is reason to believe that the sea is encroaching on the land by the slow subsidence of the latter, but a few generations of men is too short a period in which to measure this change.

The subaërial division is itself separable in Maryland into the Eastern Shore and the Western Shore. These terms, although first introduced to designate the land masses on either side of Chesapeake Bay, are in reality expressive of a fundamental contrast in the topography of the Coastal Plain. This difference gives rise to an Eastern Shore and a Western Shore type of topography. Chesapeake Bay and Elk River separate the two. Areas showing the Eastern Shore type are found along the margin of the Western Shore at intervals as far south as Herring Bay, and again from Point Lookout northwestward along the margin of the Potomac River. On the other hand, an outlier of the Western Shore type of topography is found at Grays Hill, in Cecil County, at the northern margin of the Eastern Shore. The Eastern Shore type of topography consists of flat, low, and almost featureless plains, while the Western Shore is a rolling upland, attaining four times the elevation of the former, and resembling the topography of the Piedmont Plateau much more than that of the typical Eastern Shore. It will be seen later that these two topographic types, which at once strike the eye of the physiographer as being distinctive features, are in reality not as simple as they first appear, but are built up of a complex system of terraces dissected by drainage lines.

The Coastal Plain of Maryland, with which most of the State of Delaware is naturally included, is separated from that of New Jersey by the Delaware River and Delaware Bay, and from that of Virginia by the Potomac River, but these drainage ways afford no barriers to the Coastal Plain topography, for the same types with their systems of terraces exist in New Jersey and Virginia as well as in Maryland.

The Chesapeake Bay, which runs the length of the Coastal Plain, drains both shores. From the Western Shore it receives a number of large tributaries which are in the process of developing a dendritic type of drainage, and which have cut far deeper channels than have the rivers of the Eastern Shore. If attention is now turned to the character of the shore-line, it will be seen that along Chesapeake Bay it is extremely broken and sinuous. A straight shore-line is the exception, and in only one place, from Herring Bay southward to Drum Point, does it become a prominent feature. These two classes of shore correspond to two types of coast. Where the shore is sinuous and broken, it is found that the coast is low or marshy, but where the shore-line is straight, as from Herring Bay southward to Drum Point, the coast is high and rugged, as in the famous Calvert Cliffs which rise to a height of 100 feet or more above the Bay. The shore of the Atlantic Ocean is composed of a long line of barrier beaches which have been thrown up by the waves and enclose behind them lagoons flushed by streams which drain the seaward slope of the Eastern Shore.

It was stated in the early part of this chapter that the topography of the Coastal Plain is in reality more complex than at first appears, and that this complexity is due to a system of terraces out of which the region is constructed. The subaërial division of the Coastal Plain contains four distinct terraces and part of another, while the submarine contains one only. This makes for the Coastal Plain, as a whole, a group of five terraces. These terraces, beginning with the highest, are known by the names of Lafayette, Sunderland, Wicomico, Talbot, and Recent. All five of the subaërial terraces are found on the Western Shore, while only three of them occur on the Eastern Shore. These terraces wrap about each other in concentric arrangement, and are developed one above another in order of their age, the oldest standing topographically highest.

THE GEOLOGY

The area of low land and shallow sea floor which borders the Piedmont Plateau on the east and passes with constantly decreasing elevation eastward to the margin of the continental shelf has been described under the name of the Coastal Plain. It is made up of geological formations of late Mesozoic and Cenozoic age. These later formations stand in marked contrast to the older strata to the westward, in that they have been but slightly changed since they were deposited. Laid down one above another upon the eastern flank of the Piedmont Plateau, when the sea occupied the present area of the Coastal Plain, these later beds form a series of thin sheets that are inclined at low angles seaward, so that successively later formations are encountered in passing from the inland border of the region toward the coast. Oscillation of the sea floor, with some variation both in the angle and direction of tilting, went on, however, during the period of Coastal Plain deposition. As a result the stratigraphic relations of these formations, which have generally been held to be of the simplest character, possess in reality much complexity along their western margins, and it is not uncommon to find that intermediate members of the series are lacking, as the result of transgression, so that the discrimination of the different horizons, in the absence of fossils, often requires the utmost care.

The Coastal Plain sediments were laid down after a long break in time following the deposition of the red sandstones and shales (Newark formation) of late Triassic age, which overlie the crystalline rocks of the western division of the Piedmont Plateau, and complete the sequence of geological formations found represented in Maryland and Delaware. From the time deposition opened in the coastal region during early Cretaceous time to the present, constant sedimentation has apparently been going on, notwithstanding the fact that frequent unconformities appear along the landward margins of the different formations.

The formations consist of the following:

Formations of the Coastal Plain.

Cenozoic.		
Quaternary.		
Recent.		
Pleistocene	Talbot	= Columbia Group.
	Wicomico	
	Sunderland	
Tertiary.		
Pliocene (?)	Lafayette.	
Miocene	St. Mary's	= Chesapeake Group.
	Choptank	
	Calvert	
Eocene	Nanjemoy	= Pamunkey Group.
	Aquia	
Mesozoic.		
Cretaceous.		
Upper Cretaceous	Rancocas.	
	Monmouth.	
	Matawan.	
	Magothy.	
	Raritan.	
Lower Cretaceous	Patapsco	= Potomac Group.
	Arundel	
	Patuxent	

CRETACEOUS

Lower Cretaceous

The Lower Cretaceous is represented by the Potomac Group, which consists of the Patuxent, Arundel, and Patapsco formations, deposits laid down under estuarine and fluviatile conditions. The three formations have only been recognized in their full development in Maryland, the lowermost Patuxent formation not being found to the north of Maryland but extending southward as the basal division of the Coastal Plain series through the south Atlantic States to eastern Alabama, while the uppermost Patapsco formation extends northward into Pennsylvania and disappears southward in central Virginia. The Arundel formation has been recognized in Maryland alone.

The three formations are unconformable to each other and the underlying and overlying formations. They consist chiefly of sands and clays, the former frequently arkosic, while gravel beds are found at certain points where the shoreward accumulations are still preserved. The deposits of the Patuxent formation consist mainly of sand, often arkosic, and at times argillaceous, while clay beds at times appear. The Arundel formation consists largely of clays, frequently dark colored, and affording in places large amounts of nodular carbonate of iron. At times the deposits are very carbonaceous. The Patapsco materials consist largely of highly colored and variegated clays which grade over into lighter colored sandy clays and also at times into sands.

The organic remains consist largely of fossil plants although the Arundel formation has afforded representatives of several orders of Reptilia together with a few invertebrate fossils. The fossil plants in the Patuxent and Arundel formations consist chiefly of ferns, cycads, and conifers, while the Patapsco formation contains a considerable representation of dicotyledonous types. Messrs. Berry and Lull, who have studied the plant and animal remains regard them as characteristic of the Lower Cretaceous. The fossil plants of the Patuxent and Arundel are strongly Neocomian-Barremian in character, while those of the Patapsco are distinctly Albian.

The total average thickness of the Lower Cretaceous formations in Maryland is between 600 and 700 feet, and they show an average dip of about 40 feet in the mile to the southeast.

Upper Cretaceous

The deposits referred to the Upper Cretaceous comprise the Raritan, Magothy, Matawan, Monmouth, and Rancocas formations. The two lower formations are estuarine and fluviatile in origin, while the overlying formations are distinctly marine. All of these formations can be traced to the northward into Delaware and New Jersey, where they attain an even larger development than in Maryland. To the southward they are gradually overlapped, one after the other, by the Tertiary formations and are unknown in Virginia. Similar deposits are found in North Carolina and the States which lie to the south of it but are known under other formational names.

The four upper formations form an apparently conformable series resting unconformably upon the Raritan formation, which in turn overlies the Patapsco formation unconformably. A slight unconformity may perhaps exist between the Magothy and the Matawan, although a fuller study of the relation of these formations indicates that they are probably conformable over the greater portion of the area of outcrop. The deposits consist chiefly of sands and clays, with some gravels in the two lower formations, while the three higher formations consist more particularly of clays and sands, the latter often somewhat glauconitic, although much less so than similar deposits in New Jersey. The Raritan formation consists chiefly of thick-bedded and light-colored sands with some gravels. Clays generally light in color occur in the lower portion of the formation. The Magothy formation is made up of sands and clays that change rapidly both horizontally and vertically, finely laminated clays with sand layers and more or less carbonaceous often appearing. The Matawan formation is composed of micaceous, sandy clays somewhat more sandy at times in the upper portion and more argillaceous in the lower portion of the formation. The Monmouth formation consists of reddish and pinkish sands more or less glauconitic in character. The Rancocas formation, which outcrops in Delaware near the Maryland line, consists of greensand marls which are frequently highly calcareous.

The organic remains consist chiefly of fossil plants in the Raritan and Magothy formations, and of fossil invertebrates in the Matawan, Monmouth, and Rancocas formations. The flora consists largely of dicotyledonous types those forms found in the Raritan formation being distinctly Cenomanian in character while those of the Magothy are apparently Turonian in age, which is apparently also the age of the Matawan invertebrates. The Monmouth fauna, corresponding to the Ripley fauna of the Gulf, is universally regarded as of Senonian age, while the overlying Rancocas fauna has been referred to the Danian.

The total average thickness of the Upper Cretaceous formations of Maryland is about 400 feet. They show a dip of from 20 to 35 feet in the mile to the southeast.

TERTIARY

Eocene

The Eocene is represented by the Pamunkey Group, which consists of the Aquia and Nanjemoy formations. The deposits are of marine origin and comprise part of a geologic province embracing Virginia, Maryland, and Delaware.

The two formations constitute a conformable series which overlies the Upper Cretaceous deposits in Maryland unconformably while in Virginia it has transgressed the latter and is found overlying the Lower Cretaceous strata unconformably. The deposits consist chiefly of greensands which are often calcareous in the Aquia formation and argillaceous in the Nanjemoy formation.

The fossils consist mainly of animal remains and comprise an extensive fauna, embracing particularly the group of Mollusca and Anthozoa, which shows a faunal relationship with the Wilcox and probably with the lower Claiborne beds of the Gulf.

The total thickness of the Eocene deposits in Maryland is about 225 feet, and they show an average dip of 12½ feet in the mile to the southeast.

Miocene

The Miocene deposits of Maryland are represented by the Chesapeake Group, which is made up of the Calvert, Choptank, and St. Mary's formations.[1] These formations are of marine origin. They attain a very extensive development in the drainage basin of Chesapeake Bay, both in Maryland and Virginia, from which area they can be traced southward into North Carolina and northward into Delaware and New Jersey. To the south of the Hatteras axis the conditions change materially, and other formations presenting faunal affinities more or less close are found.

The several formations comprising the Miocene are apparently slightly unconformable to each other, although this unconformity is oftentimes not apparent, the Choptank in some areas being apparently conformable to the Calvert, while the St. Mary's seemingly presents the same relations to the Choptank. The deposits of the Chesapeake Group consist largely of sands, clays, and marls. The Calvert is in part sandy and in part clayey, with extensive deposits of diatomaceous earth in the lower or Fairhaven member, and numerous marl beds packed with molluscan shell remains in the upper or Plum Point member. The Choptank formation is essentially sandy, although clays and marls also occur. The St. Mary's formation is decidedly clayey with sands or sandy clays, the latter typically greenish-blue in color and often containing large quantities of fossils.

The organic remains consist largely of fossil invertebrates, by far the most common group being the mollusca. Diatoms are very common, and remains of land plants are not rare in the basal strata, while corals, bryozoans, and echinoderms are not infrequent. Many cetacean forms have been found at some localities.

The thickness of the Miocene deposits is between 450 and 500 feet, and the strata have an average dip of 10 feet in the mile to the southeast.

[1] Another formation, the Yorktown, occurs at the summit of the Chesapeake Group in Virginia and North Carolina.

Pliocene (?)

The supposed Pliocene is represented by the Lafayette formation which has been considered as extending from the Gulf along the Atlantic border region as far northward as Pennsylvania, where the last remnants are found. The Lafayette formation is chiefly developed as a terrace lying irregularly and unconformably on whatever older formation chances to be beneath it whether along the margin of the Piedmont Plateau or the Coastal Plain.

Few fossils have been found in the Lafayette, and those not sufficiently distinctive to determine its age. We simply know that it is younger than the latest Miocene on which it rests and older than the oldest Pleistocene beds found in its immediate vicinity. It may be either Tertiary or early Quaternary in age, although most authors hitherto have regarded it as probably Pliocene in age. Doubtless materials of very different ages have been referred by various students to the Lafayette. The type section in Lafayette County, Mississippi, has recently been shown to be of Eocene age.[1]

The materials comprising the Lafayette formation consist of clay, loam, sand, and gravel which are often highly ferruginous, the iron being often present in the deposits in sufficient amount to act as a cement. These materials are generally very imperfectly sorted. The deposits rarely exceed 50 feet in thickness, while the southeasterly dip is only a few feet in the mile.

QUATERNARY

Pleistocene

The Pleistocene deposits consist of a series of surficial materials known under the name of the Columbia Group, which has been divided in Maryland and adjacent States into the Sunderland, Wicomico, and Talbot formations. They consist mainly of a series of terraces which wrap about the Lafayette and the lower portions of the older formations, and hence extend as fluviatile deposits up the stream courses.

[1] Berry, Journ. Geol., vol. xix, 1911, pp. 249-256.

FIG. 1.—VIEW SHOWING BASAL CONGLOMERATE OF THE PATUXENT OVERLYING THE PIEDMONT CRYSTALLINES AT ROLAND PARK, BALTIMORE CITY.

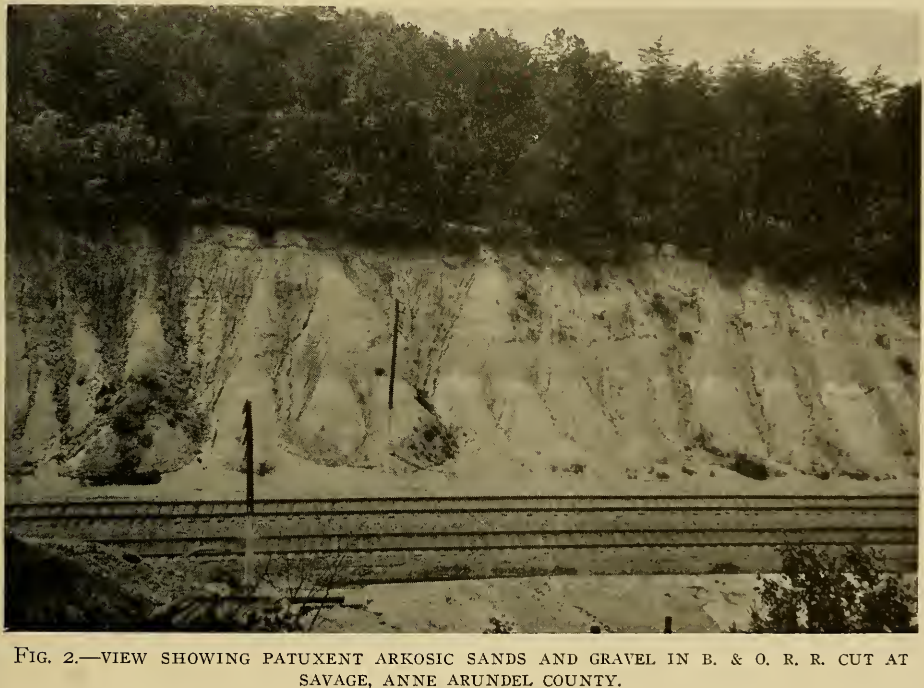

FIG. 2.—VIEW SHOWING PATUXENT ARKOSIC SANDS AND GRAVEL IN B. & O. R. R. CUT AT SAVAGE, ANNE ARUNDEL COUNTY.

Fossils have been found particularly in the latest, or Talbot formation, where extensive shell beds of estuarine and marine origin are known. Fossil plants have been found in all the formations. Their general similarity has made it impossible to establish distinctive floras as a basis for the correlation of the several formations, which has been based mainly on physiographic grounds.

The materials consist of clay, loam, sand, gravel, peat, and ice-borne boulders. These do not as a rule occur in very definite beds, but grade into each other both vertically and horizontally. The coarser materials are often cross-bedded, and are for the most part distinctive over the lower portion of each of the formations, while the finer materials, particularly the loam, are commonly found in the upper part of the formations, although these conditions are by no means universal. Each of the formations rarely exceeds 25 or 30 feet in thickness, although under exceptional conditions a thickness of two or three times that amount occurs.

Recent

The Recent deposits embrace chiefly those being laid down to-day over the submarine portion of the Coastal Plain, and along the various estuaries and streams. To these must also be added such terrestrial deposits as talus, wind-blown sand, and humus. In short, all deposits which are being formed under water or on the land by natural agencies belong to this division of geological time.

The Recent terrace now in process of formation along the ocean shore-line and in the bays and estuaries is the most significant of these deposits, and is the latest of the series of terrace formations which began with the Lafayette, the remnants of which to-day occupy the highest levels of the Coastal Plain, and which has been followed in turn by the Sunderland, Wicomico, and Talbot.

A deposit of almost universal distribution in this climate is the humus or vegetable mold, which being mixed with the weathered surface of the underlying rocks forms our agricultural soils. The intimate relationship therefore of the soils and underlying geological formations is evident.

Other accumulations in water and on land are going on about us all the time, and with those already described represent the formations of Recent time.

HISTORICAL REVIEW

The more detailed and specific discussions of the Potomac Group and its contained fossils, as is usually the case, were preceded by a long period during which the geological and lithological relations chiefly attracted attention, and this in turn was preceded by a still longer period during which the subjects were still more general, and only passing reference was made to the series of strata since designated the Potomac Group.

The earliest definite reference to rocks of this age is contained in two papers by B. H. Latrobe, the first of which dates back to 1799 and refers to the use of "Rappahannoc freestone" in the construction of the lighthouse at Cape Henry. The second paper, published in 1809, describes this rock and its uses, and mentions the presence of the contained wood and lignite from the vicinity of Fredericksburg, Virginia.

The paper by John Finch, read before the Philadelphia Academy in 1823, and so often cited in historical discussions of Coastal Plain geology, mentions the organic remains in the clay underlying the diluvial gravel at Washington, and although not altogether unequivocal probably refers to Potomac strata. Morton's paper of 1829, which was based on the notes of Vanuxem, describes the lignite and charred wood of these rocks, which they include in their "Secondary formation."

The first intimation of the wide extent of the Potomac formations is contained in an early report of Edward Hitchcock, published in 1833, in which he mentions the probable distribution of deposits of this age from Cape Cod to the Gulf of Mexico.

In a paper published by Thomas G. Clemson in 1835 there is a good description of the Potomac material near Fredericksburg with its fossil wood and lignites, and with the first reference to impressions of plants which he says are finely preserved in blue argillaceous fissile beds from six inches to a foot in thickness.

Richard C. Taylor, in a paper immediately following that of Mr. Clemson devotes six pages and a folded plate to the description and illustration of these plants, which he identified as *Lycopodiolithes ?* sp., *Lepidodendron* sp., *Sphenopteris* sp., *Pecopteris ?* sp., and *Thuites ?* sp., and which are the remains of *Frenelopsis, Sphenolepis, Cladophlebis,* etc. These he saw bore no relation to the plants from the Richmond coal field, which were attracting considerable attention at that time and he infers that the containing rocks are of Secondary age, perhaps co-eval with the oolites.

The year 1835 also marks the beginning of the important series of reports on the geology of Virginia by William B. Rogers, State Geologist of that State, the first describing the Potomac sandstones along the "Fall-line" and mentioning the presence of silicified wood, lignite, and plant impressions. In his report for 1839 the same author traces his "Sandstone formation" as far south as Bollings Bridge on the Nottaway River in southern Virginia. In his next report, that for 1840, he designates this formation the "Upper Secondary," and traces its extent northward from Petersburg to the Potomac River. Later reports also frequently refer to these rocks, which he regarded as Upper Oolite in age.

Richard C. Taylor returns to this subject in his work on the Statistics of Coal, published in 1848, and compares the organic remains to those from the Portland of southern England.

With the appointment of Philip T. Tyson to be State Agricultural Chemist of Maryland, the latter State enters the literature. The map accompanying his first report enumerates twenty-four formations, of which the Cretaceous includes two, the first "a thick group of sands and clays of various colors." "In some localities it abounds in lignite derived from coniferous plants." "The bluish-gray varieties derive their color from the carbonaceous remains of plants"; the second, or Iron-ore clays, "a series of beds of fine gray and lead-colored clays containing several courses of carbonate of iron in flattened masses and nodules." "The color of these clays is due to carbonaceous matter."

Tyson early discovered a saurian tooth in the latter beds, which was described under the generic name *Astrodon* by Christopher Johnston in

1859, and more fully described by Professor Joseph Leidy in 1865. From the same bed which yielded the tooth Tyson records "a new genus of Cycas of large dimensions," "silicified coniferous wood," and "lignites (coniferous)." In his next report, published in 1862, Tyson discusses these iron-ore clays and says he is disposed to place them as low as the oolitic, which view is concurred in by Agassiz, to whom he had showed a photograph of the cycad trunk. Tyson found a number of these cycad trunks and sent pictures of them to various geologists. They are mentioned by Professor Dana in the first edition of his Manual, with the comment that P. T. Tyson observes that they may be Upper Jurassic. One trunk was presented to Professor Dawson and is still at Montreal, another was presented to Professor Marsh and is now in the Yale College collection, while a third turned up recently at the South Carolina College at Columbia, probably a gift by Tyson to Professor Le Conte, who at that time was located at Columbia. The others were for a long time in the possession of the Maryland Academy of Sciences, which institution eventually turned them over to the Johns Hopkins University where they are at the present time. Professor Dawson sent one of Tyson's photographs to Carruthers, who refers to it in a postscript to his memoir "On Fossil Cycadean Stems from the Secondary Rocks of Britain," published in 1870.

Professor Cope in a paper read before the Philadelphia Academy in 1868, sketches the geology of the Cretaceous as developed from New Jersey to Virginia, mentioning the cycadaceous plants of Tyson, and also referring to the clays along the Rappahannock from which Professor Uhler has obtained the "remains of some six species of plants, in beautiful preservation, of the order Cycadaceæ ?, Gnetaceæ, and Filices." This was probably the Fredericksburg plant locality which afterward rewarded Professor Fontaine's efforts with such a great variety of specimens. Professor Cope states that it is extremely probable that these Virginia beds are the continuation of those of Maryland and Alexandria, and he proceeds to sketch the conditions of deposition comparing them to the conditions which prevailed to the westward in Triassic times. He says further: "The age is therefore probably truly Wealden or Neocomian."

Among other "Geological Notes" presented to the Boston Society of Natural History in 1875 by W. B. Rogers is a paper "On the Gravel and Cobblestone Deposits of Virginia and the Middle States," in which he clearly distinguishes the surficial gravels of the Lafayette and Columbia from those of the older Potomac. "In the belt partially occupied by the surface deposit here referred to there is exposed another group of strata with which, at first view, the sandy and argillaceous layers of this formation might readily be confounded. These are the silicious, argillaceous, and pebbly beds, which, underlying the Tertiary in Virginia, and the well-marked Cretaceous formation farther north, have, in the latter region, been regarded as belonging to the base of the Cretaceous series of the Atlantic States. In Virginia the formation consists typically of a rather coarse and sometimes pebbly sandstone, in which the grains of quartz and feldspar are feebly cemented by kaolin, derived from the decomposition of the latter, and of argillaceous and silicious clays variously colored and more or less charged with vegetable remains, either silicified or in the condition of lignite. These constitute the group of beds designated in the Virginia geological reports as the Upper Secondary sandstone, and referred by me long since (1842) to the upper part of the Jurassic series, corresponding probably to the Purbeck beds of British geologists. From the Potomac northward this group of deposits, as exposed in the deep railroad cuts between Washington and Baltimore and on to Wilmington, is made up of variegated, soft, argillaceous, and silicious beds, which, from the preponderance of ferruginous coloring toward the Delaware, has been called by Professor Booth the red clay formation. At a few points only toward the bottom of the deposit it brings to view a bed of the felspathic sand, or crumbling sandstone, above referred to. Traced transversely, it is seen to dip beneath the Cretaceous greensand at various points in New Jersey, Delaware, and Maryland, but in Virginia disappears in its eastward dip beneath the Eocene Tertiary.

"How far we may consider this group of sediments in Maryland, Delaware, and New Jersey as merely a continuation of the Virginia formation above described can be determined only by further investigation.

But the discovery in them at Baltimore, by Professor Tyson, of stumps of cycads would seem to bring them into near relation with the formation at Fredericksburg containing similar remains, and to favor their being referred, at least in part, to the horizon of the upper Jurassic rocks. Possibly we may find here a passage group analogous to the Wealden of British geology. Whatever may be the result of further discovery, it would seem to be premature at this time to assume the whole of these deposits from the Potomac northward as belonging to the Cretaceous series.

"Where the Tertiary or Cretaceous rocks are present in this belt there is, of course, no danger of confounding the superficial gravel and cobblestone deposit with the formation just described, but in their absence, which is usual in the river valleys, this deposit rests immediately on the broken and denuded surface of the Secondary, and by the intermixture of materials makes it more difficult to discriminate between them.

"Excellent opportunities for observing the contact of the superficial deposit with the denuded and much older formation below are presented in the neighborhood of Washington, among which may be specially mentioned the vertical cut at the extremity of Sixteenth street, at the base of the hill occupied by Columbian College, and also the continuation of Fourteenth street, ascending the same hill. At the former locality the crumbling felspathic sandstone, or slightly adhering sand, is exposed to a height of about 35 feet, with a very gentle eastern dip, and having the color, composition, and diagonal bedding characteristic of the Fredericksburg and Aquia Creek sandstone. The gravel and cobblestone deposit lying upon it descends with the slope of the hill to the general plain below, resting at a somewhat steep angle against the denuded edges of the underlying beds. From this and other localities it becomes obvious that the latter formation has been deeply and extensively denuded before and during the deposition of the surface strata, which form the chief subject of this communication."

Professor Fontaine commenced his work on the Potomac at about this time, publishing during 1879 a series of three articles in the *American*

Journal of Science entitled Notes on the Mesozoic of Virginia, and including the Triassic in his discussion. The flora received considerable attention and the materials were grouped into the "Fredericksburg belt" and the "Petersburg belt," the one corresponding with what he afterward called the Fredericksburg beds and the other answering to the James River beds, both in large part referable to the Patuxent formation. It was in the part published in the February number of the *American Journal of Science* that the "archaic dicotyledons" of the Potomac were first mentioned in the following language: "With the plants above named, I find certain netted veined leaves, which by their nervation cannot be distinguished from Angiosperms. Had they been found with Cretaceous or Tertiary plants I think no one would hesitate to consider them as such. As, however, they occur with a well-marked upper Jurassic flora, I hesitate to pronounce them to be Angiospermous plants without a more careful study and extended comparison than I have as yet been able to make. They are certainly not 'Dictyophyllum,' which is the genus of fossil ferns that stands nearest to them. But when we find such a development of undoubted Angiosperms in the lowest Cretaceous beds of New Jersey and of the west, we should expect to find at least their ancestors in the Jurassic flora." Further along he speaks of the evidence as to the age of the iron-ore clays as pointing strongly to the conclusion that they were Wealden.

In a lecture by Professor Uhler, an abstract of which was published in 1883, considerable space was given to what is now regarded as part of the Potomac Group, and which he calls Upper Jurassic or Wealden, giving it a thickness of 500 feet in the Baltimore region.

In the spring of 1884 Professor Ward prepared a short paper on Mesozoic Dicotyledons, in which he mentions Fontaine's archaic dicotyledons, which he states are from the Upper Jurassic of Virginia, and expresses the hope that the problem of the origin of this group is at last approaching solution. About this time Professor Fontaine joined the staff of the U. S. Geological Survey, his first administrative report appearing in 1885 in the Sixth Annual Report.

In 1886 the name Potomac formation first appeared in print in a paper contributed by W J McGee to the Report of the Health Officer of the District of Columbia for 1885. In 1887 Professor Fontaine submitted a paper embodying his results to the American Association for the Advancement of Science, a brief abstract of which was published in 1888, from which the following is quoted: "The name Potomac formation has been applied to a series of newer Mesozoic sands, gravels, and clays, sometimes cemented into sandstones and conglomerates, which appear along the inner margin of the Coastal Plain, forming the basal member of the undisturbed Mesozoic and Cenozoic formations of the eastern United States, in Virginia, Maryland, Delaware, and perhaps other States. It comprises two members—an upper, consisting generally of variegated clays which are well exposed about Baltimore, and a lower, consisting predominantly of sands and gravels, well exposed in the bluffs of the Potomac River below Washington. The upper member is known only north of Fredericksburg, and the lower is best developed from Washington to Richmond.

"The age of the formation, as indicated by its flora, appears to coincide approximately with that of the Lower and Middle Neocomian [misprinted Neuronian] of Greenland and Europe."

It was in December, 1887, that Mr. J. B. Hatcher, under instructions from Professor O. C. Marsh, collected a considerable number of vertebrate bones from an iron mine near Muirkirk, Md. He also found in the same beds some small cones representing the genus Sequoia, and much silicified wood and lignite. The bones were described by Professor Marsh and the results published at once. As to the geological significance of these forms, Professor Marsh says:

"The fossils here described, and others from the same horizon, seem to prove conclusively that the Potomac formation in its typical localities in Maryland is of Jurassic age, and lacustrine origin. There is evidence that some of the supposed northern extensions of this formation, even if of the same age, are of marine or estuary origin."

The next year Professor Uhler read a paper before the American Philosophical Society in which the name Baltimorean was proposed for the lower beds and Albirupean for the upper, which, however, included

FIG. 1.—VIEW SHOWING COARSE, HIGHLY INCLINED AND CROSS-BEDDED PATUXENT SANDS NEAR HOMESTEAD, BALTIMORE CITY.

FIG. 2.—VIEW SHOWING KAOLIN IN THE PATUXENT FORMATION IN CUT ON P. B. & W. R. R. NEAR PERRYVILLE, CECIL COUNTY.

strata younger than the Potomac. He enumerated the various types of plant remains which he had collected from the different horizons.

The same year McGee published his paper entitled "Three Formations of the Middle Atlantic Slope," devoting much of his space to the Potomac formation, erroneously referring the Bryn Mawr gravels, the "yellow rocks," above Trenton, New Jersey, and the "sand hills" east of Princeton, New Jersey, to the Older Potomac.

At the meeting of the National Academy of Sciences held in the spring of 1888 Professor Ward prepared a paper on the "Evidence of the fossil plants as to the age of the Potomac formation," which was published in the August number of the *American Journal of Science,* from which the following may be quoted:

"On numerous occasions, dating as far back as 1878, I have expressed the opinion that the dicotyledons could not have had their origin later than the middle Jura, and it will not surprise me if the final verdict of science shall place the Potomac formation, at least the lower member in which the plants occur, within that geologic system. While the remaining types point strongly in this direction, I do not regard the dicotyledons as at all negativing, but even more strongly suggesting, this view.

"Still, it may be admitted that, according to the ordinary modes of arguing from similar statistics, the sum of all the facts here presented would make the Potomac, considered from the view of the flora alone, homotaxially equivalent to the Wealden of England and north Germany, now usually included in the Cretaceous system. If the vertebrate remains are Jurassic and the flora Cretaceous we only have here another confirmation of a law exemplified in so many other American deposits, that, taking European faunas and their correlated floras as the standard of comparison, the plant life of this country is in advance of the animal life. This law has been chiefly observed in our Laramie and Tertiary deposits, but is now known to apply even to Carboniferous and Devonian floras. It is therefore to expected that we shall find it to prevail during the Mesozoic era. If, therefore, it be really settled that the fauna of the Potomac series is homotaxially Jurassic, and we take our starting point from the Old World geology, there will be no more objection to regarding the Potomac flora as Jurassic than there is now in contemplating the Laramie flora as Cretaceous. In fact, so far as the character of the flora is concerned, there is much less difficulty in the case of the Potomac than in that of the Laramie, since, as I have shown, the Potomac flora, viewed in all its bearings, cannot be said positively to negative the reference of the formation to the Jurassic upon the evidence of the plants alone.

"I do not, however, desire to be understood as arguing for the Jurassic age of the Potomac formation. The most that it is intended to claim is that, if the stratigraphical relations and the animal remains shall finally require its reference to the Jurassic, the plants do not present any serious obstacles to such reference."

European paleobotanists having manifested much interest in the Potomac flora, a statement was prepared by Professor Fontaine for Feistmantel, the celebrated Bohemian savant who made it the subject of a paper which appeared in the proceedings of the Royal Bohemian Society in 1889. This same year saw the appearance of Dr. Knowlton's long-delayed work on the fossil wood and lignites of the Potomac formation, a summary of which he had already contributed to the 1888 meeting of the American Association for the Advancement of Science, an abstract also appearing in the *American Geologist.* Professor Uhler also published two additional papers at this time announcing the finding of his Albirupean formation at Ft. Foote and on Piscataway Creek.

In 1890 Professor Fontaine's Monograph was issued. In it are described and illustrated 365 species, so called, of fossil plants, including 75 more or less nominal species of dicotyledons. The age is assumed to be Neocomian, under which term are included the Wealden, Urgonian, and Aptian groups of European geologists.

In Professor Clark's account of the "Third Annual Geological Expedition into Southern Maryland and Virginia," published in 1890, the Albirupean is recognized as distinct from the underlying Potomac. The same year N. H. Darton discussed the Potomac in a paper read before the Geological Society of America, and the literature to date was passed in review by Dr. C. A. White in his Correlation Paper on the Cretaceous, published in 1891.

Nearly twenty years after Tyson's discovery of cycad trunks in the iron-ore beds of Maryland, Mr. Arthur B. Bibbins took up the quest, and during the next few years succeeded in obtaining from the inhabitants of the region a very large number of trunks and fragments. These were submitted for critical study to Professor Ward, who in 1894 published a revision of the genus Cycadeoidea, to which all of the Maryland forms belonged. Mr. Bibbins continued to collect more material, and in 1897 Professor Ward published descriptions of seven species from Maryland.

In a paper entitled "Albirupean Studies," and published in 1892, Professor Uhler makes further contributions to the knowledge of the Potomac, but his stratigraphic conclusions are, according to Professor Ward, set forth in a rather ambiguous manner.

In a paper in *Science,* published in 1894, Professor Ward makes an interesting comparison between the Potomac flora and that from the Mesozoic of Portugal made known by the Marquis Saporta. He suggests the following long-range correlations: James River beds = Infra Valanginian, Fredericksburg beds = Valanginian, Mount Vernon beds = Urgonian, Brooke beds = Aptian, and Raritan beds = Albian. In the same number of *Science* appeared a note by F. A. Lucas on the Vertebrate remains from the Maryland Potomac, Allosaurus, Pleurocœlus, Priconodon and Astrodon being the forms enumerated. The same year Mr. Bibbins published a summary of his Potomac studies, and the Fredericksburg folio of the U. S. Geological Survey by N. H. Darton was issued. It included a large area of the Virginia Potomac, which was described and mapped as a single unit, however.

A number of important papers appeared during 1896. Among these are Professor Ward's elaborate discussion entitled: "The Potomac Formation," in which he subdivides it into The James River Series, The Rappahannock Series, The Mount Vernon Series, The Aquia Creek Series, The Iron Ore Series, The Albirupean Series, and the Island Series. The flora of each is discussed and considerable space is devoted to the newly discovered flora of the clays on the Mt. Vernon estate.

This was followed by Professor Marsh's memoir on "The Dinosaurs of North America," which contained the descriptions and figures of the Maryland material collected from the iron-ore clays by J. B. Hatcher. At the same time appeared Professor Ward's paper on "Some Analogies in the Lower Cretaceous of Europe and America," in which the Potomac was compared with the Wealden of England, the "Scaly Clays" of Italy, and the Mesozoic of Portugal. Toward the close of the year Professor Fontaine's long-delayed geological paper on the Potomac appeared as a Bulletin of the U. S. Geological Survey. It contained admirable descriptions of local sections and the first geological map of the deposits, covering the country between Baltimore and Petersburg. No attempt was made, however, to show the areal extent of the subdivisions of the Potomac, and the Virginia deposits are regarded as Lower and those in Maryland as Upper Potomac. Professor Newberry's monograph on the Amboy clay flora appeared at this time as a posthumous publication under the editorship of Arthur Hollick.

About this time Professor Marsh published two brief papers asserting the Jurassic age of the Potomac as well as of the Cretaceous beds on Long Island and to the eastward. This called forth a discussion in the columns of *Science* which was participated in by Arthur Hollick, L. F. Ward, G. K. Gilbert, R. T. Hill, and Jules Marcou.

In the fall of 1897 Clark and Bibbins published a full summary of the results arrived at in their study of the Potomac of Maryland, dividing it into four formations—the Patuxent, Arundel, Patapsco, and Raritan. The two former formations were provisionally referred to the Jurassic and the two latter to the Lower Cretaceous.

In 1898 Professor Marsh replied to his critics and reasserted the Jurassic age of the Potomac beds.

In 1902 Clark and Bibbins published a second paper on the Potomac of Maryland, in which the conclusions are essentially the same as in their earlier paper. This paper was well illustrated and contained an admirable map showing the areal extent of the different members of the Potomac Group as developed in Maryland, the first of its kind ever published. This same year the Cecil County report of the Maryland

Geological Survey appeared. The Coastal Plain geology was contributed by G. B. Shattuck, that for the Potomac largely from Mr. Bibbins' notes. The three Potomac formations present in that region, the Patuxent, Patapsco, and Raritan, are delineated upon the large scale county map.

In 1906 the Dover folio of the U. S. Geological Survey prepared by Dr. B. L. Miller was published. This included a considerable area in Delaware and northeastern Maryland, in which the Patapsco and Raritan formations were described and mapped.

Although it bears the date 1905 it was in 1906 that Ward's second paper on the Status of the Mesozoic Floras of the United States was issued. Over two hundred and fifty pages are devoted to the Potomac flora of Maryland and Virginia, two additional species of Maryland cycad trunks are described, and the large amount of material collected by Mr. Bibbins for the Maryland Geological Survey and Goucher College is discussed in the systematic part prepared by Professor Fontaine. The correlations and stratigraphy are by Ward, who accepts the Maryland Survey formational names for that State, uniting, however, the Patuxent and Arundel formations. For Virginia the James River and Rappahannock are united and made the equivalent of the Patuxent and Arundel, and the Mount Vernon and Brooke beds are correlated with the Patapsco formation and an excellent map prepared by Mr. Bibbins shows the distribution of the four formations of the Potomac Group in Maryland. Professor Ward's final conclusion was that the whole Potomac Group is of Cretaceous age, the older Potomac forming a part of the European Wealden, which he regards as Cretaceous. The report on the Physical Features of Maryland by Clark and Mathews, published this same year, contained a new geological map of the State on which the different Potomac members are shown, and the text contained a full description and characterization of them.

In 1907 the Patuxent Folio of the U. S. Geological Survey was published by Shattuck, Miller and Bibbins. All the members of the Potomac Group are fully described and mapped.

In 1910 Berry published a short article in the *Journal of Geology* showing that the Raritan formation was of Upper Cretaceous age. This

COMPARATIVE TAXONOMIC TABLE.

W. B. Rogers, 1841.	P. T. Tyson, 1862.	W. B. Rogers, 1879.	Ch. E. Hall, 1881.	W J McGee, 1888.	P. R. Uhler, 1888.
Upper Secondary.	Upper Oölite (iron ore clays). Lower Oölite (sands and clays).	Jurasso-Cretaceous.	Wealden clay.	Upper or clay member. POTOMAC. Lower or sandstone member.	Baltimorean.

W. M. Fontainc, 1889.	L. F. Ward, 1895.	O. C. Marsh, 1896.	Clark and Bibbins, 1897.	L. F. Ward, 1906.
Upper or clay member. POTOMAC or YOUNGER MESOZOIC. Lower or sandstone member.	Iron ore series. Aquia Creek series. Mt. Vernon series. Rappahannock series. James River series.	Potomac or Jurassic Formation.	Patapsco. Arundel. Patuxent.	Brooke. Mt. Vernon. Rappahannock and James River.

same year Clark published a paper describing the progress of the work on the Geology of the Middle and Northern Atlantic Coastal Plain, in which the various formations were briefly discussed and the Lower Cretaceous age of the Patuxent and Arundel formations affirmed. The Raritan was referred to the Upper Cretaceous and the Potomac Group was limited to the Lower Cretaceous. Berry also published a brief paper discussing the southward extension of the Patuxent formation into North Carolina, and showing that the Arundel formation is absent in Virginia, and that the Patapsco formation is transgressed and disappears in central Virginia beneath Tertiary deposits. The latter author also published several systematic papers upon some of the more important genera of Potomac plants.

The accompanying table shows the varying nomenclature of the more important students of the Potomac deposits, commencing with that of W. B. Rogers in 1841.

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STRATIGRAPHIC AND PALEONTOLOGIC CHARACTERISTICS

The Lower Cretaceous deposits of Maryland and adjacent areas have long been studied by many independent workers who have approached the problem from nearly as many different points of view. This fact, together with the proverbially complicated stratigraphy, has given rise to a highly varied taxonomy which is set forth in the previous chapter and the accompanying comparative taxonomic table.

The Lower Cretaceous deposits are more highly differentiated in Maryland than elsewhere along the Atlantic border, as is seen in both their lithologic and paleontologic diversity. The several formations present certain common features which need to be taken into consideration in any discussion of the strata.

The deposits, which are largely sands and clays of varying stratigraphic and lithologic characteristics, are, for the most part, unconsolidated, although certain marked exceptions to this are to be seen in the locally developed sandstone beds in the lower part of the series. The deposits in general dip at progressively lower angles in passing upward in the series, although the Arundel formation affords some striking exceptions to this general rule. Again, the deposits thicken down the dip within the limits of the area of outcrop, although they apparently thin farther to the seaward, as shown by the well borings in which Lower Cretaceous strata are encountered. The stratigraphic relations show that after the deposition of the Patuxent and Arundel formations they were gradually transgressed toward the northward by the Patapsco formation before the close of Lower Cretaceous time. A study of the organic remains reveals a gradual progress in the types of plant life from the Patuxent through the Arundel and Patapsco, especially in the gradual advent of dicotyledonous types of plant life. These various features will be fully discussed in the descriptions of the several formations.

The Potomac Group

The Potomac Group, originally named by McGee for the deposits thus characterized in this report, was divided by Clark and Bibbins into the Patuxent, Arundel, and Patapsco formations, although they and others included within the Potomac certain higher deposits of somewhat similar character (Raritan formation) which are now recognized as of Upper Cretaceous age. A sufficient lithologic and paleontologic difference occurs in these higher deposits to warrant the restriction of the term Potomac to those formations characteristic of the Potomac River region where they were first described by McGee under the name of the "Potomac formation."

THE PATUXENT FORMATION

Name and Synonymy.—The Patuxent formation was so designated from the Patuxent River in Maryland, in the drainage basin of which its deposits were first recognized as an independent formation and named by Clark and Bibbins.[1] It is in part the "feldspathic sandstone" of Rogers, the "lower oolite" of Tyson, and the "Fredericksburg" or "lower sandstone member" of Fontaine and McGee. It includes most of the "James River" and a part of the "Rappahannock" and "Aquia Creek series" of Ward, and also a part of the "Baltimorean" of Uhler.

Areal Distribution.—The Patuxent formation extends across the State in an irregular and at times interrupted belt, some 5 or 6 miles in average width, from the Delaware line through Elkton, Baltimore, and Laurel to the city of Washington. It forms generally the landward border of the Coastal Plain, although its outcrop is in places buried beneath later deposits while seaward its surface continuity is interrupted by the principal water-ways, such as the Susquehanna, Gunpowder, Patapsco, and Potomac rivers.

Outliers are found on the crystalline rocks to the west of the main body of the deposits, the two most conspicuous being the outliers at Catonsville and Lutherville. The former occupies one of the highest levels containing Coastal Plain deposits while the latter is found in a limestone valley a hundred feet lower than similar beds not far to the southeastward.

The Patuxent deposits in the Fall-line zone afford a very broken relief in the vicinity of the stream channels. The exposed hillocks of Patuxent materials with their slight cover of vegetation often suggest a bad land topography. Patuxent deposits have been observed in Maryland from over 400 feet in elevation near Catonsville to below 400 feet in a well at Indian Head.

Lithologic Character.—The materials constituting the Patuxent formation are on the whole arenaceous, although argillaceous elements likewise appear. The sands, which are predominantly cross-bedded, are

[1] Jour. Geol., vol. v, p. 481, 1897.

sharp and the gravel mostly subangular, and not as well rounded as that of the overlying Pleistocene. The sand and gravel often contain a considerable admixture of kaolinized feldspar, producing what is known as arkose. To the indurated derivative Rogers gave the name "feldspathic sandstone." Extensive deposits of rather fine and even-grained sandy gravel occur near the base of the formation, notably in the valley of Herring Run, at Roland Park, and near Cub Hill in Baltimore County, where the materials have been employed to a greater or less extent as road metal and for concrete. The basal gravels are often coarse and cobbly, and adjacent to the crystalline floor are often indurated by hydrous iron oxide to a resistant ferruginous conglomerate. Toward the northward, in the vicinity of Perry Hall, Baltimore County, and in the Broad Creek valley in Cecil County, the basal conglomerate is of light color and is filled with angular fragments of quartz. Buff-colored sands of fine-grained texture with some admixture of brownish loam are common in the vicinity of Baltimore City, where they have been extensively employed as building sands. White glass sands somewhat arkosic have been worked to some extent at Westport in Baltimore County. The Patuxent sands are often indurated by hydrous oxide of iron and take on very irregular and fantastic shapes, including hollow cylinders, intricately corrugated plates and spherical and ellipsoidal gourds having the local names of "sand bullets," "sand clams," etc. These indurated phases are well developed at the Homestead sand pits near the old Patterson mansion in Baltimore City. A ferruginous oolite is occasionally found, especially in the vicinity of Washington, this phase recalling Tyson's term "Lower Oolite" for the deposit. The Patuxent sands are very varied in color, the most distinctive being purple, which is perhaps due to slight traces of manganese in the deposits.

The clays of the Patuxent formation are much less important than the sands, with which they occur either as pellets or larger masses in the arkosic materials or in interbedded streaks and lenses which at times are of considerable extent. They commonly consist of kaolinized material of greater or less purity, and locally known as "Fuller's earth." The clays are prevailingly white, but are at times of various delicate shades of red, yellow, brown, maroon, and lavender, in piebald tints and patterns of great beauty. The purple coloring is very characteristic. Extensive lenses of these brilliantly colored clays occur in the eastern part of the city of Baltimore, where they constitute an important resource for the brick industry. They were penetrated to a depth of 40 feet in the excavations for the new outfall sewer for Baltimore City without reaching their base, and were so resistant as to require the almost constant use of the mattox. At Bayview these same clays were so resistant as to require blasting. The clays are at times drab or black in color, from the admixture of carbonaceous matter. Very definite beds of lignite occur at some points, notably near Jessups and at Clifton Park, at both of which points the lignite has been employed to some extent as a fuel, although the beds are rarely more than a foot in thickness and are of small horizontal extent. Lignitized twigs, limbs, and trunks always strongly compressed as well as fossil leaves are not uncommon in these deposits. Lignitized stumps have occasionally been found in erect positions. The comminuted carbonaceous matter is at times so abundant in the clays as to produce an earthy lignite of dead-black color. A deposit of this character filled with lignitized stems occurs in the valley of Broad Creek, Cecil County overlying the basal conglomerate before mentioned. Occasionally the drab or lignitized clays carry carbonate of iron as at Gaither's Dam in Stony Run, Anne Arundel County, but the deposits are of small economic importance.

Deposits of red and yellow hydrous oxide of iron are at times found in sufficient extent to possess economic value as pigments. Such deposits frequently occur at the top of sand beds which are overlaid by drab clays, as at the base of the terra cotta clays at Federal Hill.

Strike, Dip, and Thickness.—The strike of the Patuxent formation in Maryland is in a general northeast-southwest direction, becoming more nearly north and south as the valley of the Potomac is reached, to the south of which, in Virginia, the strike is north and south.

The dip of the beds is to the southeast but is variable in amount, especially in proximity to the Fall-line, where in places it largely exceeds the dip of the main body of the deposits farther eastward. The dip to the

FIG. 1.—VIEW SHOWING ERODED UPPER SURFACE OF THE PATUXENT OVERLAIN BY SUNDERLAND DEPOSITS, BELT LINE CUT NEAR CHARLES STREET, BALTIMORE CITY.

FIG. 2.—VIEW SHOWING PATUXENT-ARUNDEL CONTACT, SOUTH SHORE OF SPRING GARDENS, THE PROBABLE LOCALITY WHERE TYSON COLLECTED THE HISTORIC JOHNS HOPKINS CYCAD STUMP, BALTIMORE COUNTY.

east of the Fall-line varies from 50 to 90 feet in the mile, the average being about 60 feet in the mile.

The rate of dips in feet per mile at various points is:

	FEET		FEET		FEET
Burtonsville	75	Perry Hall	66	Battle Swamp	73
Laurel	65	Loreley	100	Throdors	100
Ilchester Hill	68	North of Joppa	60-80	Bay View	90
Relay	200	Abingdon	100	Egg Hill	80
Catonsville	114	Harford Furnace	70	Cherry Hill	60
House of Refuge	75	Carsins	100	Barksdale	45
Baltimore	80-90	Aberdeen	109	Grays Hill	50
Towson	66	Aldino	100	Iron Hill	50
Cub Hill	58	Webster	100	Chestnut Hill, Del.	50

The altitude of the Patuxent beds in the Lutherville area previously mentioned is anomalous, for besides lying at a lower level than the deposits farther to the seaward the dip is slightly to the northwestward.

From the above facts it is apparent that the deposits near the Fall-line have been subjected to greater deformation than the beds farther eastward, still in no instance is there any certain evidence of actual faulting along this line, although the high angle of dip at Relay, the elevated position of the beds at Catonsville, and the abnormal altitude of the strata at Lutherville, all point to unusual structural conditions that may find their explanation in the faulting of the strata.

The maximum thickness of the Patuxent formation in Maryland is not less than 350 feet and may considerably exceed that amount. In the well boring at Indian Head it has been penetrated for a thickness of 353 feet without reaching the crystalline floor. In northern Virginia, at Alexandria, the brewery well shows 380 feet of Patuxent materials. Toward the landward margin of the Patuxent formation less thicknesses are found, the deposits frequently not exceeding 150 to 200 feet. A similar thinning of the formation occurs seaward, as shown by the deeper well borings in eastern Maryland and Virginia.

Stratigraphic and Structural Relations.—The Patuxent formation, as the basal formation of the Coastal Plain, rests directly on the crystalline rocks of the tilted and submerged margin of the Piedmont Plateau. This surface more or less eroded and trenched before the deposition of Patuxent sediments has been elsewhere described as the Weverton peneplain. Monadnocks rise from its surface, as at Grays Hill, now surrounded by Potomac deposits. These underlying rocks in Maryland consist, as far as known, only of crystalline rocks of early Paleozoic and pre-Paleozoic age, although both farther north and south the Newark formation of Triassic age here and there reaches to the Coastal Plain border. The slope of this ancient surface which has been regarded as of late Jurassic or early Cretaceous age, is quite uniformly about 75 feet in the mile towards the southeast, although local differences occur due to the irregularities of the surface previously described.

The Patuxent formation is sometimes irregularly overlain unconformably in Maryland by the Arundel formation, which apparently occupies post-Patuxent drainage lines that had been warped before the deposition of the Arundel sediments. Covering both formations unconformably, and in the absence of the Arundel resting directly on the Patuxent formation, is the Patapsco formation, which in Virginia, where the Arundel formation is absent everywhere, comes in contact with the Patuxent formation. In the absence of both of these formations of the Potomac Group later formations of Upper Cretaceous, Tertiary and Quaternary age are found overlying the Patuxent deposits unconformably.

The internal structure and stratigraphy of the Patuxent formation is at times very complex, more so than that of any of the other Coastal Plain formations. Contemporaneous erosion planes, very coarse and steeply inclined cross-bedding and alternations of extremely dissimilar and sharply demarked beds and lenses in irregular attitudes, although not the rule, are not at all uncommon.

At times small folds occur in the beds in contact with the crystalline rocks which are apparently due to local expansions in the latter, as the result of their hydration. An interesting fold of this character is seen in the pits of the Maryland Clay Company at Northeast, Cecil County, as the result of the kaolinization of the feldspathic rocks.

To what extent the beds have been subjected to larger structural changes cannot be readily determined. The abnormalities in dip in the vicinity of the Fall-line have been already referred to, and the possibility of faulting suggested, although no definite evidence on that point exists. It is evident, however, that a warping of the beds occurs whether with or without dislocation of the strata. The main body of the deposits may well have been subjected to deformation in the many differential movements which are known to have taken place in the Coastal Plain in post-Patuxent time. Furthermore, some of the marked changes in dip in the later formations, as notably in the Magothy formation along the line of the Chesapeake and Delaware Canal, suggest the possibility of actual folding of the underlying formations.

Organic Remains.—Although the Patuxent deposits are in general unfossiliferous because of their coarse character, nevertheless a considerable flora has been collected from clay balls and lenses and the more argillaceous sands, especially from beds of this age in the Rappahannock and James river valleys in Virginia.

This flora includes a large element made up of survivors from the older Mesozoic, and is rich in species and individuals referred to the fern genera *Cladophlebis* and *Onychiopsis*. Other genera of ferns, such as *Acrostichopteris, Schizæopsis, Scleropteris, Tæniopteris, Ruffordia,* etc., are less common. A variety of cycad remains testifies to the abundance of this type of plant, represented for the most part in the Maryland area by the silicified trunks of *Cycadeoidea,* of which several different species are known. Cycad fronds, less common in Maryland, are abundant in the more argillaceous deposits of this age in Virginia, and include a variety of genera such as *Nilsonia, Podozamites, Zamites, Williamsonia, Ctenopteris, Ctenopsis, Ctenis,* etc. Perhaps the most striking of these remains are the large forms of *Nilsonia* and the splendid fronds of *Dioonites.*

Among the gymnosperms are species of *Sphenolepsis, Baiera, Brachyphyllum, Frenelopsis, Nageiopsis, Arthrotaxopsis, Sequoia,* and *Cephalotaxopsis.* These are for the most part genera that range from the late Triassic to the Upper Cretaceous. They are abundant in the Patuxent and represent families which in the modern flora are largely natives of other continents.

Supposed, but altogether doubtful, angiosperms, the most ancient known, are represented by the genera *Rogersia, Proteæphyllum,* and *Ficophyllum,* which perhaps should be considered the remains of foliage of the gymnospermous order Gnetales.

The known fauna of the Patuxent is represented by a single fish found in the James River area, but it is extremely probable that the rich dinosaurian fauna of the overlying and closely related Arundel formation flourished during Patuxent time, since in the west the representatives of this fauna occur in the Morrison formation conformably below the Kootanie formation, which carries the representatives of the Patuxent flora.

THE ARUNDEL FORMATION

NAME AND SYNONYMY.—The Arundel formation was named from Anne Arundel County, Maryland, where the deposits of this formation were first recognized as a distinct unit by Clark and Bibbins.[1] It is the lower portion of the "upper oolite," or "Iron-Ore Clays" of Tyson, a part of the "Variegated Clays" of Fontaine, and McGee, and of the "Baltimorean" of Uhler, and is the equivalent of the "Iron-Ore series" of Ward.

AREAL DISTRIBUTION.—The Arundel formation outcrops in an irregular and partially interrupted belt that extends from the head of Bush River, in Harford County, to Washington, D. C. This belt adjoins that of the Patuxent formation to the west, and reaches its maximum width of 7 miles in the northern portion of Prince George's County, its usual width being from 3 to 5 miles. Where the formation is not overlain by later deposits it generally forms broad dome-shaped hills. The observed vertical range of the Arundel deposits is from 300 feet above tide to the landward to 368 feet below to the seaward.

LITHOLOGIC CHARACTERS.—The Arundel formation consists typically of drab, more or less lignitic clays, carrying nodules, geodes, flakes, and ledges of earthy iron carbonate or siderite. The nodules or geodes are

[1] *Loc. cit.*, p. 485.

FIG. 1.—VIEW SHOWING INDURATED LEDGES IN THE PATUXENT FORMATION, W STREET NEAR 12TH STREET, WASHINGTON, D. C.

FIG. 2.—VIEW SHOWING FLOODED IRON MINE IN THE ARUNDEL FORMATION NEAR MUIRKIRK.

often septarian, and their cavities are commonly lined by brown velvety masses of siderite crystals, which change to brown hematite on exposure to the air. The materials of the Arundel formation are so strikingly homogeneous, as compared with those of the underlying Patuxent and overlying Patapsco, that its deposits have served as a datum plane for Potomac stratigraphy in Maryland, and the iron produced is prized for its high tensile strength.

The clays are commonly free from grit, but are at times sandy, and to the landward the sand may predominate, as in the vicinity of Washington. The clays are not infrequently pyritous and gypseous, both minerals commonly occurring in druses. The gypsum druses frequently line the septarian nodules but also occur free in the clays, as at Spring Gardens. The clays are in general unctuous or "fat," and are an important resource for brick, terra cotta, and pottery manufacture. They have been worked for these purposes at several points, but will undoubtedly be much more extensively employed in the future.

The siderite deposits known locally as "oolite ore" are changed commonly at the surface, and in the clays poor in carbon to greater depths into hydrous oxide of iron or limonite, known locally as "brown ore." These ores have been mined since early Colonial days, one furnace at Muirkirk being still in operation.

The lignitic element in the deposits, which gives to the clays their characteristic drab color, at times becomes so pronounced as to form well-defined lignite beds, which have been locally used as fuel, as at Soper Hall Hill, Anne Arundel County. The lignite is at times finely scattered through the clays, at other times trunks, limbs, twigs, and leaves are found well preserved, the stumps in some instances being found in erect position with their roots intact as they grew. At times the woody fibre may be partly replaced by siderite or by pyrite, as at Reynolds' iron mine at Hanover.

Strike, Dip and Thickness.—The strike of the Arundel formation is essentially parallel to that of the Patuxent toward the north, being about northeast to southwest and gradually becoming more nearly north and south as southern Maryland is reached.

The dip of the beds is to the southeast, and is in general at the rate of about 50 feet in the mile. It is greater in the Fall-line zone, as shown in the Putty Hill, Carney, and Camp Chapel areas, and is less to the eastward.

The observed thickness of the Arundel formation varies from a few feet to about 100 feet or perhaps 125 feet in the middle of the belt in central Maryland. It apparently thins seaward, as shown by the well boring at Sparrows Point.

STRATIGRAPHIC AND STRUCTURAL RELATIONS.—The Arundel formation overlies the Patuxent formation unconformably, occupying what appear to be old drainage lines therein, but extending beyond these to the seaward where it spreads into a more or less continuous sheet. The formation rarely comes in contact with the crystalline rocks, but a few instances are known, as at one locality north of Relay and in the Camp Chapel area.

The deposits are unconformably overlain by the Patapsco formation, or in the absence of the latter by the later Tertiary and Quaternary formations.

The internal stratigraphic and structural features are relatively simple, the strata consisting for the most part of widely extended beds or lenses of clay with included beds of lignite and iron ore. Some cross-bedding is found in the basal beds landward but it is unusual. The strata give evidence of deformation similar to the Patuxent beds in the Fall-line zone, and are likewise affected by the general warping of the underlying Patuxent previously described.

ORGANIC REMAINS.—Both animal and plant remains occur in the Arundel, its manner of deposition favoring the preservation of both.

The Arundel fauna represents, so far as known, three orders: Dinosauria, Crocodilia, and Testudinata.

The dinosaurs represent all of the sub-orders, including two of the heavier, megalosaurian carnivores, *Allosaurus* and *Creosaurus,* and one of the lighter, compsognathus type, *Cœlurus.* The quadrupedal Sauropoda are represented by at least one genus, possibly two, *Pleurocœlus* and *Astrodon,* including two or three species in all, while of the Orthopoda there are two, one the unarmored *Dryosaurus*, the other, *Priconodon*, evidently belonging to the armored group or Stegosauria.

The dinosaurs show none of the remarkable over-specialization of the later types, but, on the contrary, represent the order at the crest of the evolutionary wave, before the signs of decadence set in. Unfortunately, owing to an almost utter dearth of terrestrial Jurassic deposits, nothing is known of dinosaurian evolution in America from Newark time until we come to the horizon under consideration. In Europe the record, though still meagre, is more complete; but it represents in every instance more primitive types than those of the Potomac and the Morrison.

The flora is of the same type as that of the Patuxent, most of the genera and a large number of the species of the latter having been found in the Arundel and where unknown the presumption is strong that they still existed in nearby areas, since the known Arundel flora contains no new or younger elements than does the Patuxent, and indicates that the marked change in the flora of the Potomac occurred during the time interval represented by the unconformity between the Arundel and the overlying Patapsco formation.

The Arundel formation also contains poorly preserved representatives of fresh-water molluscs.

THE PATAPSCO FORMATION

Name and Synonymy.—The Patapsco formation was named by Clark and Bibbins[1] from the Patapsco River in Maryland, in the drainage basin of which stream the deposits are well exposed and were first studied as an independent formation. It was included by Rogers in his "Upper Secondary" or "Jurasso-Cretaceous"; by Tyson together with the preceding formation in his "Upper oölite." It was with the Arundel included by McGee in his upper or "varicolored" clay member. The formation was not differentiated either by Marsh, Fontaine, Ward, or Darton in their Potomac. It corresponds in part to what Fontaine termed the Baltimore beds, and includes Ward's Mt. Vernon series and

[1] *Loc. cit.*, p. 489.

part of his Aquia Creek series as well as what he also called the Brooke beds.

AREAL DISTRIBUTION.—The Patapsco formation outcrops in Maryland in a belt of varying width extending from the Delaware line southwestward to the District of Columbia to the east of the preceding formation. To the south of Washington it is found along the valley of the Potomac to below Mattawoman Creek. From the Delaware line to the District the belt has a width of about 5 miles, south of which it narrows appreciably until it finally disappears in Charles County, although continued on the west bank of the Potomac in Virginia. It is a much more continuous belt than the preceding Arundel formation.

Outliers are found resting on the Patuxent formation. The surface is rolling, resistant caps frequently occurring as the result of the ferruginous crusts which are often developed. The Patapsco deposits have been found all the way from hills 300 feet and more in elevation to a depth of about the same amount in well borings.

LITHOLOGIC CHARACTERS.—The Patapsco formation consists of sands and clays which differ, however, from those of the Patuxent formation in the predominance of the argillaceous elements, especially the variegated clays. The arkosic sands and gravels are much less common than in the Patuxent formation. They are more common toward the southern part of the area, where they at times become indurated, forming a part of the well-known "Virginia freestone" of the Aquia Creek area. A band of pebbles frequently marks the base of the formation, as in the Hanover region. A bed of broken and redeposited ironstone crusts may take the place of the pebbles, as near Hawkins Point on the Patapsco River.

The most characteristic materials are the highly colored and variegated clays with their red, drab, and chocolate colors. The clays often grade into or are interbedded with sandy clays, sands, and gravelly sands. They are at times lignitic, a typical illustration being the lignitic sandy clay at Fort Foote. Pellets of fossil resin at times occur with the

FIG. 1.—VIEW SHOWING THE PATUXENT-ARUNDEL CONTACT IN BELT LINE CUT NEAR THE EASTERN BOUNDARY OF BALTIMORE CITY.

FIG. 2.—VIEW SHOWING EROSION OF OLD IRON MINE IN THE ARUNDEL FORMATION, SCHOOLHOUSE HILL, BALTIMORE COUNTY.

lignites. Small deposits of pyrite are also found in the same beds. The variegated clays which commonly exhibit a great variety of exceptionally rich and delicate tints in irregular patterns often grade horizontally into massive drab and black clays, which are often lignitic and occasionally iron- or leaf-bearing. The sand sometimes contains pellets or balls of white clay. They are frequently cross-bedded, although not as strongly so as the sands in the Patuxent formation. Red ochre, known as "paint rock" or "paint stone," occurs near the base and summit, and sometimes within the formation, while flakes of sandy and ocherous limonite with botryoidal inferior surfaces are not uncommon at certain horizons. The variegated clays often contain small pieces of flattened limonite quite uniform in size. The drab and chocolate-colored clays have been worked at some points for iron carbonate in the Middle River region, but the amount of ironstone is small compared with that in the Arundel formation.

Strike, Dip, and Thickness.—The strike of the Patapsco formation is essentially the same as that of the two preceding formations. The direction changes slightly due to the structural features involved in the central portion of the area by which the Patapsco formation gradually transgresses the earlier formations, both toward the north and toward the south, which slightly affects the direction of the strike in the same areas.

The dip is to the eastward at the rate of about 40 feet in the mile, although it is somewhat increased within the Fall-line zone. The thickness of the Patapsco formation is somewhat in excess of 200 feet, the maximum thickness being observed in a well boring at Bowie, near the Raritan-Patapsco contact, where a thickness of 260 feet was found. The wells at Sparrows Point show a thickness of 204 feet, but it is possible that the upper beds had been eroded before the Pleistocene deposits were laid down. At Red Hill, Cecil County, a thickness of 130 feet has been observed, while at Grays Hill, in the same county, it reaches 100 feet.

STRATIGRAPHIC AND STRUCTURAL RELATIONS.—The Patapsco formation rests unconformably on the underlying formations and at the 340-foot hill at Relay transgresses them and rests on the crystalline rocks. Toward the north the Patapsco deposits gradually transgress the underlying formation, and in Delaware and Pennsylvania rest directly on the crystalline rocks at a number of points. Monadnocks of crystalline rock penetrate the Potomac formations at several points in northeastern Maryland and the adjoining portion of Delaware.

The Patapsco formation was much eroded prior to the deposition of the Raritan, so that marked irregularities are found in the line of contact which represent rather pronounced inequalities in the upper surface of the Patapsco. In general the line was well defined, and at some points is marked by a line of broken and redeposited iron crusts. In the absence of the Raritan, which gradually thins out towards the south, the Patapsco formation is overlain unconformably by later Cretaceous or Eocene deposits, while in the absence of both later Cretaceous and Tertiary deposits, the Patapsco formation is often overlain unconformably by Pleistocene deposits.

The internal stratigraphy and structure of the Patapsco formation is somewhat complex, on account of the great difference in the character of the materials, ranging, as they do, from very plastic and highly variegated clays to coarse sands, the latter occurring in lenses and beds which at times considerably complicate the stratigraphy, although they are not sufficiently continuous to make it possible to subdivide the Patapsco into members of more than local importance. Such local lithologic terms have been employed by others, but the very circumscribed limits of these beds render their use very problematical.

Some warping of the beds evidently occurs along the Fall-line, as shown by the differences in dip, and it is quite possible that actual faults occur, although on account of this continuity of the strata and their frequent cover of later deposits it is impossible to determine this point definitely. As already pointed out, the marked changes in dip seen in some of the later formations, and particularly the Magothy formation along the line of the Chesapeake and Delaware Canal, suggest the possibility of actual folding in the Patapsco and earlier formations.

ORGANIC REMAINS.—The Patapsco deposits have yielded a few specimens of poorly preserved unios and an extensive flora, including representatives of the Pteridophyta, Cycadophytæ, Gymnospermæ, and Angiospermæ. The ferns, cycads, and conifers represent for the most part the dwindling remnants of the Patuxent-Arundel flora, some species being common to all three formations and the genera being largely identical. The fern genera *Scleropteris, Schizæopsis* and *Tæniopteris* have disappeared, but *Ruffordia, Cladophlebis,* and *Onychiopsis* are still common. Petrified remains of a species of *Tempskya* and impressions of fronds of a peculiar new genus of ferns, *Knowltonella,* are highly characteristic of this formation. Among the cycads *Podozamites* and *Zamites* are represented, but the genera *Nilsonia, Dioonites, Ctenis, Ctenopteris,* and *Ctenopsis* have disappeared. Silicified trunks of *Cycadeoidea* have been found in the Patapsco, but it is questionable if they have not been reworked from the older formations.

Among the gymnosperms *Laricopsis, Baiera, Cephalotaxopsis,* and *Arthrotaxopsis* are no longer represented. Species of *Widdringtonites* and *Pinus* are new and characteristic, while the genera *Sequoia, Sphenolepis, Brachyphyllum,* and *Nageiopsis* are still present.

The marked distinctness and more modern aspect of the Patapsco flora is due, however, to the abundance of Dicotyledonæ, which foreshadow and were undoubtedly for the most part ancestral to the Dicotyledonæ of the Upper Cretaceous Raritan formation.

The more characteristic of these are the various species of *Araliaephyllum, Sterculia, Cissites, Celastrophyllum, Populophyllum,* etc. The compound leaves of *Sapindopsis* are one of the most striking dicotyledonous elements present. Three species are known and all are strictly confined to this horizon.

LOCAL SECTIONS

I. Section at "Red Hill," along the west slope of Gray's Hill, Cecil County, beginning at 200 feet above tide.

		Feet.
Cretaceous. Raritan	Coarse reddish sand and evenly-bedded dark brown sandstone ledge	10
	Yellow and buff sand and corrugated iron stone	10
	Tough white clay reddish in places	7
Patapsco	Massive variegated red and drab clay, the latter slightly lignitic and containing obscure leaf impressions. Lenses of white, water-bearing sand near base	130
Patuxent	Sand, not exposed at surface, to tide level	43
	Total	200

II. Shannon Hill near Northeast, Cecil County.

		Feet.
Pleistocene or Recent	Loam and red clay	5-10
Cretaceous. Raritan	Dense plastic chocolate colored clay with flakes of iron carbonate carrying leaf impressions	10
Patapsco	Light colored sand	8
	Sandy chocolate colored clay	10
	Drab and light colored clay and sand grading into west member	8
	Chocolate clay, slightly lignitic	7
	Variegated clay	18
	White sand	1
	Variegated clay	35
	Yellow and purple sand and ferruginous sandstone	5
	Total	112

III. Section of Baltimore and Ohio Railway cutting at Foy's Hill, Cecil County, beginning 270 feet above tide.

		Feet.
Recent	Gravelly loam-"wash"	5
Cretaceous. Raritan	Fine white sand	11
	Brown loamy sand, more or less gravelly and arkosic toward base	12
	White chinaware clay, more or less iron tinted, and varicolored, at times grading horizontally and vertically into micaceous sand and becoming gravelly and arkosic toward the base	10-20
Patapsco	Very dense, richly variegated clay, to and below the track level	10+
	Total	58

FIG. 1.—VIEW SHOWING EROSION OF ARUNDEL CLAYS, HARTKE IRON MINE NEAR HANOVER, HOWARD COUNTY.

FIG. 2.—VIEW SHOWING REYNOLDS IRON MINE IN THE ARUNDEL FORMATION, I MILE SOUTH OF HANOVER, ANNE ARUNDEL COUNTY.

IV. Well Section at Sparrows Point, Baltimore County, Well No. 4, beginning 10 feet above tide.

		Feet.	Inches.
Recent	Artificial filling	10	
Pleistocene. Talbot	Medium coarse buff sand	12	
	Coarse light drab sand	53	
	Drab calcareous clay, with remains of marine invertebrates	20	
Cretaceous. Patapsco	Light colored plastic clay	22	
	Very coarse gravel	23	
	White sand	5	
	Fine gravel	5	
	Hard brown clay	15	
	Fine buff sand	13	
	Fine white water-bearing sand	32	
	Very coarse gravel	8	
	Hard sticky fine red clay	32	
	Coarse water-bearing sand	12	
	Data from the neighboring coke oven well carries the section beyond this point. Beginning at 220 feet from surface, near base of the foregoing member.		
	Red clay	62	
	White sand	9	
	Red clay	4	
	Hard sand	5	
Arundel (?)	Tough red clay	74	
	"Flint rock" (probably iron carbonate)	0	3⅜
	Soft blue clay, iron nodules at one level	23	8⅝
Patuxent	Gray sand	21	
	Red clay	6	6
	Unknown	71	
Crystalline rocks.	Granite at	495	

V. Section of Baltimore and Ohio Railway cutting east of Bay View Station, Baltimore County, beginning at 130 feet above tide.

		Feet.
Cretaceous. Patapsco (?)	Buff, ferruginous sands, often indurated and capping the hilltop	10-20
Arundel	Drab stratified leaf-bearing clays, occupying a depression in the surface of the Patuxent[1]	0-15
Patuxent	White and varicolored, more or less indurated, cross bedded sands and gravels, somewhat argillaceous and with lenses of sandy clay to the level of the railway track	5-20
	Total	53

[1] See list of species in Tables of Distribution.

VI. Section of Belt Line cut near Eastern boundary, Baltimore City, beginning 180 feet above tide.

		Feet.
Pleistocene.		
Sunderland	Brown more or less gravelly loam, at times with reworked iron crusts. Occasional loose ferruginous sandstone masses at base	20
Cretaceous.		
Patapsco	Hard, irregularly bedded, buff sand with thin corrugated plates of iron sandstone toward the eastward	0-15
Arundel	Mostly massive dark red, yellow or mottled clay somewhat sandy, locally wanting	0-20
Patuxent	White and varicolored, often micaceous and cross bedded sand and sandy clay, with crusts and ledges of sandy mammalary limonite near the top	20
	Coarse white sandy micaceous gravel, locally indurated toward summit by hydrous iron oxide, exposed	10-20
	Total	95

VII. Well section at "Smith's Distillery," Baltimore.

Tyson published in 1860 a record of strata penetrated by this well on Northwest harbor, which presents a typical Patuxent section. The well began at 10 feet above tide.

		Feet
Recent	River mud	52
Cretaceous.		
Patuxent	Sand, gravel and boulders	6
	Hard blue clay	9
	Red clay	6
	Red ocher	5
	White sand	4
	White clay	32
	White sand and gravel, water-bearing	8
	White sand, gravel and boulders, water-bearing	7
Crystallines	Gneiss	7
	Total	129

VIII. Well section at Torsch Packing Company, Chesapeake Wharf, Baltimore, beginning 10 feet above tide.

		Feet.
Recent	Shells	8
	Mud	7
	Mud with shells and gravel	7
Cretaceous.		
Patuxent	Red clay	8
	White clay	15
	Sandy white clay	15
	Sand rock	5
	Impervious white clay	15
	Water-bearing white sand	22
	Estimated to bed rock	48
	Total	150

IX. Section at Federal Hill, Baltimore, at Baltimore Terra Cotta Works, Covington and Ostend Streets and beginning about 70 feet above tide.

			Feet.	Inches.
Cretaceous.	Patapsco	Sandy clay, sand and ferruginous sandstone, with silicified wood and red clay laminae...	5	10
		Carbonaceous clay with flakes of white and brown iron ore..........................	1	4
		"Alum clay," "yellow horse clay," yellow ochre, and variegated clay, at times sandy and containing iron crusts and tubes........	34	6
		Bluish clay and potters clay with semi-erect stumps and horizontal logs of lignite, impregnated with pyrite. Occasional fern impressions	7	6
		Darker blue slaty clay, without fossils........	3	
		Gray slaty clay, with profusion of plant remains[1]	2	
		Sandy clay	2	
		Indurated ferruginous layers................		¼
		Commercial red ochre........................		⅗
	Patuxent	Iron sandstone		⅕
		White sand	7	
		Fine white sand with white clay balls........	4	
		Building sand and indurated gravel, near tide.	4	
		The well at the Torsch packing house carries this section downward (allowing for dip) as follows:		
		White clay	15	
		Arenaceous white clay......................	15	
		Sand rock	5	
		White impervious clay......................	15	
		White water-bearing sand....................	22	
		Total about	145	

X. Section at "Lower Smith's Banks," 1 mile south of Hawkins Point, Anne Arundel County.

			Feet.
Pleistocene.	Talbot	Brown massive and stratified loam with a few well-rounded pebbles toward base......................	6
Cretaceous.	Patapsco	Variegated argillaceous sand and sandy clay, iron crusts toward and at base where there is a local unconformity	4-8
		Extremely dense, massive and tough, richly variegated clays	20
		Continued downward by an artesian well at Ft. Armistead, Hawkins Point, as follows:	
		Pink sandy clay....................................	40
		Fine buff sand......................................	20
		White and buff mottled clay..........................	16
		Total	110

[1] See list of species in Tables of Distribution.

XI. Section at "Deep Ditch," Schoolhouse Hill, Baltimore County, beginning 230 feet above tide.

		Feet.
Cretaceous.		
Patapsco	...Argillaceous sand, more or less iron-stained, with variegated clay and ferruginous crusts; ash-colored, lignitic and somewhat indurated toward the base....	10
Arundel	Slightly indurated, ferruginous ledge, with leaf impressions and casts of cones	1
	Drab-colored clays, with beds of lignite and white and brown iron ore, containing occasional fern impressions; teeth and bones of dinosauria; basal ferruginous ledge. Extensively mined for iron..........	50
Patuxent	Compact yellowish, reddish and variegated sand, locally carbonaceous; brown clay containing flakes of iron ore (hydrous oxide); lead-colored clay with indeterminate fragments of plants; ferruginous sandstone ledge with "pipe ore" (corrugated iron stone), silicified trunks of *Cycadeoidea marylandica* (Font.) Ward in situ..	30
	Dense jointed clay of great variety and delicacy of tint, red, liver-colored, and white predominating; "paint rock" (red ochre) and lenses of coarse hard sandy arkosic gravel with balls of white clay and silicified wood	20
	Cross-bedded sand slightly carbonaceous.............	10
	Unknown, about	30
Crystallines	....Gneiss, exposed near Arbutus.........................	
	Total	151

XII. Section of "Red Stone" Baltimore and Ohio Railway cutting near Lansdowne, Baltimore County, 140 feet above tide.

		Feet.
Cretaceous.		
Arundel	....Drab clays, iron-bearing in the immediate vicinity....	10
Patuxent	...Buff, white and richly iron-tinted sand and clay (the sands at times indurated by iron) white "pipe clay" and red ochre..	30
	Total	40

XIII. Section at Reynolds' Iron Mine, Piney Run, 1 mile south of Hanover, Anne Arundel County, beginning 100 feet above tide.

		Feet.	Inches.
Cretaceous.			
Patapsco	White and light brown sand and gravel with iron stone crusts..........................	10	
	White and variegated argillaceous sand, clay and red paint clay, more or less indurated at base	10	
	Ferruginous ledge more or less conglomeritic..		3
Arundel	......Dense drab laminated clay, at times lignitic and with occasional undeterminable fern impressions. Nodules, flakes and ledges of carbonate of iron in many courses (partly determined by boring)......................	70	
	Total	90	3

XIV. Section at "Timberneck Iron Mine" on Licking Run, 1 mile southwest of Hanover, Howard County, 200 feet above tide.

		Feet.
Cretaceous. Patapsco	Reddish sand somewhat gravelly with corrugated iron sandstone	12
	Variegated argillaceous sand and compact sandy clay with clay pellets	20
Arundel	Drab lignitic and at times pyritous clay, very dense, and carrying pellets, nodules, flakes and ledges of iron carbonate to bed of Licking Run	100
Patuxent	White clay, exposed in bed of Licking Run	5
	Total	137

XV. Section at Baltimore and Ohio Railway cutting, between Jessup's and Montevideo Stations, beginning 290 feet above tide.

		Feet.
Pleistocene. Sunderland	Loam, gravelly loam and ferruginous conglomerate grading into sand and gravel at the base	0-15
Cretaceous. Patapsco	Brownish drab clay with fragmental masses of hematitic ochre carrying leaf and cone impressions	2-6
	Light colored clay, grading over into red and variegated clay	6+
	Bog iron ore	1
	Gravel	3
Arundel	Lignitic clay, carrying iron carbonate and dinosaurian bones	60
	Light drab clay with "white ore" containing occasional casts of mollusca	10
Patuxent	Generally loosely-bedded, white and vari-colored sand, argillaceous gravelly and arkosic sand and sandy clay, with much interbedded lignite to and below level of railway tracks	60
	Total	161

XVI. Section at "Old Blue Bank" iron mine, near Muirkirk, Prince George's County, 230 feet above tide.

		Feet.
Recent	Surface wash consisting of sandy gravel	4
Cretaceous. Patapsco	Mottled gravelly loam with silicified wood	12
Arundel	Massive drab clay with septarian nodules of earthy siderite; bones of dinosauria near the base	20
	Highly lignitic lense with white charcoal ore	2
	Tough blue clay with white ore	15
Patuxent	White sand, exposed by boring	10+
	Total thickness	63+

XVII. Section at Florida Avenue and Sixteenth Street, Washington, D. C., beginning at 180 feet above tide.

		Feet
Pliocene (?). Lafayette	Red loam, gravelly loam and gravel with cobbles and boulders toward base	8
	Reddish brown stratified loam, vari-colored loam and clay interlaminated with brown sand	10
	Ferruginous gravel with boulders of crystalline and Newark rocks	10
Cretaceous. Patuxent	Arkosic cross-bedded pebbly sand with clay pellets, slightly carbonaceous in places	15
	Light greenish drab sandy clay	6
	Total	49

XVIII. Well section at Pumping Station at Soldier's Home, Washington, D. C., beginning 200 feet above tide.

		Feet.
Cretaceous. Patuxent	Red clay	2
	Red gravel	2
	White gravel	3
	White clay	4
	Yellow clay	30
	Black loamy sand	6
	White gravel, water-bearing	6
	White sand	2
	Red clay	4
	Blue potter's clay	16
	Lignite	2
	Quartz sand, water-bearing	13
	Blue clay	50
	Sand and abundant water	8
	Gravelly clay	13
	Gravelly clay mixed with sand	2
Crystalline	"Soft rock"	5
	"Hard 'granite' rock" in vein	5
	Gravel and sand, water-bearing	1
	Hard "nigger-head" rock	304
	Total	478

XIX. Section at East Washington Heights, near Overlook Inn, beginning 280 feet above tide.

		Feet.
Pliocene (?). Lafayette	Loam and gravel	15
Miocene. Calvert	Fine yellow ocherous clay ("marlite") closely jointed with occasional small leaf imprints, grading into mealy sand, iron crusts at summit	40
Cretaceous. Matawan	Dark colored, somewhat glauconitic sand	15
Magothy	Light drab laminated sandy clay, at times carbonaceous	8
	Loose buff, brown, yellow, gray, and white sugary sands, more or less cross-bedded, and indurated, with light drab leaf-bearing clay	25

		Feet.
Raritan	Massive and stratified bluish drab clay, at times lignitic and pyritous and occasionally blotched with red ochre	10
	White clay in local lenses. Massive and stratified light-colored and drab clay, interbedded	10
Patapsco	Dense variegated and drab, jointed clay grading at times into sand, lower portion more or less covered by flanking of Pleistocene and wash	100+
	Red and drab clay with ferruginous sandstone largely covered by flanking of Pleistocene and wash	70+
Patuxent	Beginning 20 feet below tide. Cross-bedded arkosic sand, with interbedded clay, estimated	440
Crystallines	At level below tide of 460 feet.	
	Total	744

XX. Section at Fort Foote, Prince George's County, about 200 yards below Notley Hall Wharf.

		Feet.
Pleistocene.		
Wicomico	Sandy gravel with cobbles and boulders	10
Cretaceous.		
Patapsco	Tough, variegated clay	12
	Strongly cross-bedded medium fine grayish carbonaceous sand compact toward top with interbedded lenses of stratified drab or chocolate-colored clay charged with comminuted vegetable matter and occasional well-preserved leaf impressions [1]	30
	Dense, tough, chloritic, variegated clay to tide	10-12
	Total	64

XXI. Section at Fort Washington, Prince George's County, at excavation east of wharf.

		Feet.
Pleistocene.		
Wicomico	Coarse gravel	8
Eocene.		
Aquia	Red sand with casts of Turritella, Dosiniopsis, Cytherea, Crassatella, Ostrea, etc	12
Cretaceous.		
Matawan	Light variegated sand, slightly glauconitic	10
	Dark micaceous sand with *Cyprimeria densata*, *Crassatella vadosa*, *Cuculaea vulgaris*, etc	10
Patapsco	Dense, massive, jointed, variegated and drab clay, gypseous above, occasional ironstone crusts	55
	(Exposed near wharf) light gray lignitic sand, with much iron stained clay balls and with lenticular pockets of dark gray lignitic clay carrying indistinct impressions of plants	4
	Total	99

[1] See list of species in Tables of Distribution.

XXII. Section at High Point, ½ to ¾ mile below Glymont, Charles County.

		Feet.
Pleistocene.		
Talbot	Loam and gravel	15
Cretaceous.		
Patapsco	Interbedded buff and more or less arkosic sand, loose and cross-bedded, with light drab clay, iron crusts at base	20
	Irregularly interbedded brown and light drab clay, grading down to brown sandy clay	7
	Brown sandy clay, with greenish-drab, chloritic, sandy clay at tide	55
	Total	97

XXIII. Section on Stump Neck, Charles County.

		Feet.
Pleistocene.		
Talbot	Brown gravelly loam	3
	Sand, gravel and cobbles	12
Cretaceous.		
Patapsco	Cross-bedded, compact sand slightly arkosic	8
	Massive green chloritic clay to tide, with lenses of drab clay carrying leaf impressions[1]	4
	Total	27

INTERPRETATION OF THE POTOMAC DEPOSITS

Potomac deposition was probably preceded by extensive base-leveling of the eastern side of the continent, with accompanying widespread rock disintegration. Stimulated by elevation and seaward tilting, the revived streams transported these materials to their present position. The fact that these deposits consist very largely of redeposited Piedmont crystallines, and to a less extent of Appalachian strata, is what might be expected, but the circumstance that no clearly defined trace of redeposited Newark materials has been found in the Potomac deposits of Maryland is somewhat surprising. From this we must infer either that the Newark was not to any great extent exposed to Potomac erosion, or that its materials were not sufficiently consolidated to permit of transportation, except in so finely divided a condition as to be unrecognizable. It is quite certain that during maximum Potomac subsidence a large body of Newark materials, especially beyond the limits of Maryland, was beneath tide level, and therefore not exposed to subaërial influences. Inasmuch as the Potomac beds themselves, particularly the basal ones, have since that date undergone considerable induration, often without

[1] See list of species in Tables of Distribution.

NEAR VIEW OF LAYERS OF CARBONATE OF IRON NODULES IN THE ARUNDEL CLAYS, REYNOLDS IRON MINE, 1 MILE SOUTH OF HANOVER, ANNE ARUNDEL COUNTY.

the agency of iron oxide, we may suppose that the subaërial Newark sandstones of that date, if consolidated at all, were considerably less resistant than, for example, during the early Pleistocene, in the deposits of which the Newark materials are abundantly represented.

The basal deposits of the Potomac Group, produced by the initial warping of the continental border and described as the Patuxent formation indicate in their arkosic character their proximity to the source of supply, which was the extensively disintegrated Piedmont crystallines. It is assumed that the Weverton peneplain, upon which the oldest known Coastal Plain sediments were deposited, extended as a land surface to the eastward of the present coast line. The epeirogenic movement, which stimulated erosion and inaugurated the Potomac cycle of deposition was undoubtedly a differential warping, with the focus near the present Fall-line. This may have resulted in the formation of a broad, shallow basin near or below sea level, from which the waters of the Atlantic Ocean were largely excluded. McGee has compared the Potomac deposition with that of the present Gulf of California, although the lack of any evidence of an invertebrate fauna in the Patuxent formation renders such an interpretation unlikely. A gradual tilting of the coastal border of the Weverton peneplain would seem more nearly to explain the facts, since it is well known that sea coasts with an almost imperceptible gradient like that of the present west coast of the Floridian peninsula, show characters identical with those coasts which are separated from the open ocean by barriers in the form of reefs or sand bars. It seems probable that the inner marginal Patuxent beds, which alone are available for study, were largely continental deposits made up of an ever-varying and complex combination of fluviatile, æolian, and lacustrine sediments which merged in passing to the eastward with estuarine or littoral sediments. The well-rounded and rarely flattened pebbles are characteristic of fluviatile action, as is the presence of cobbles, often of large size, which are so prominent in some of the Virginia outcrops. The cross-bedding of so much of the arenaceous materials which pass horizontally into clay lenses and which contain rolled clay balls is also especially characteristic of fluviatile forces, and æolian forces may likewise be called upon to explain cross-bedding, although it would seem that the latter class of deposits are practically negligible when the materials are considered as a whole. The quickened streams at the inauguration of the Patuxent built out alluvial fans with comparative rapidity and afforded little opportunity for the preservation of terrestrial vegetation or of the aquatic life of the Patuxent rivers or lakes. The fossil plants which are so sparingly distributed in the Patuxent represent for the most part fragments of coniferous stems or coriaceous bits of foliage which successfully resisted the trituration of the coarse sediments. Only one Patuxent exposure, that at Fredericksburg, Virginia, has furnished an extensive flora, and this was contained in a single somewhat more argillaceous lens of very limited extent. Elsewhere a considerable flora has been found in redeposited masses or balls of purer clay, which were evidently transported from their original place of deposition in the quiet waters of some Weverton oxbow or lake, and therefore antedate in their origin and their contained flora that which was contemporaneous with their final deposition in the Patuxent sands. That the contained flora is not appreciably different from that of the balance of the Patuxent flora indicates that this time interval, while long according to human standards, was short when measured in terms of geological processes. Such meagre fragments of the aquatic life of the Arundel and Patapsco epochs as are preserved, a few almost undeterminable fresh-water gastropods, tiny pelecypods and unios, indicate that conditions similar to those outlined above persisted until the close of the Potomac.

The Patuxent deposits, like those of the succeeding Arundel and Patapsco formations, reflect in a large measure the character of the Piedmont materials which lie immediately to the westward. Where these materials were highly feldspathic the sediments are strongly arkosic. This is a very characteristic feature of the Patuxent deposits, and one which continues unchanged as far as eastern Alabama, a distance of several hundred miles. Where gabbros or other rocks rich in the iron minerals are found near the eastern margin of the Piedmont, as in the vicinity of Baltimore, the derived sediments are ferruginous, and this is especially noticeable in the concentration of the iron in the Arundel formation, and to a less extent in the Patapsco. Where the chloritic schists of the Piedmont are developed near its eastern margin, as in the northern Virginia area, the Patuxent clay lenses tend to be greenish in color.

The close of the Patuxent epoch was probably marked by a slight elevation of its deposits and a trenching of the surface by streams: or perhaps the process was merely one of differential warping. This was followed by a subsidence or tilting, which was emphasized to the landward by the occupation of the ancient valleys by swamp deposits. The tough clays of the Arundel formation, charged with lignitic accumulations, in which tree trunks are at times found erect with their roots intact, find their most satisfactory explanation on this basis. It was in these ancient swamps and estuary marshes that the iron, derived to a considerable extent from the adjacent areas of basic eruptives, was deposited, first, no doubt, as bog ore, which by contact with the excess of carbonaceous materials was later altered to the carbonate and redeposited in its present nodular form. It was in these swamps that the remains of dinosauria became entombed. On this hypothesis the lenses of Arundel clays represent crudely the ancient drainage lines of the eroded surface of the Patuxent terrane. The widening of the areas seaward may possibly be interpreted on the basis of lagoon deposits into which the Arundel estuaries merged.

The Pleistocene "buried-forest" deposits of the Chesapeake shores may furnish some clue to the origin of the Arundel iron-ore clays, as well as similar beds in the Patuxent and Patapsco formations. The Pleistocene deposits of this character appear to have originated by the impounding of the estuaries by sand spits—a process which may be observed at many points within the Chesapeake and elsewhere at the present day. The closed estuary then speedily silted up and was converted into a peaty cypress swamp in which bog iron ore was deposited. Meanwhile the bay shore adjoining the mouth of the swampy estuary was gradually receding by virtue of wave action until the swamp materials themselves were invaded and more or less cut away. This process was followed, or perchance attended, by gradual subsidence, which resulted in the deposition on the newly wave-cut surface of a new and later member. Emergence followed, and the waves of the Recent period are now actively cutting away both the more recently deposited beds and the basal remnant of the older ones, with their beheaded cypress trunks and knees, imbedded in peat. In the basal clays of this Pleistocene swamp deposit, penetrated by the roots of the trees, one finds an occasional, imperfectly formed nodule of iron carbonate, so characteristic of the Arundel. When exposed to the air it rapidly changes to a bright vermilion ochre.

There is little question that some such process as this has figured to a considerable extent in the genesis of certain of the lesser lenses of drab, lignitic, iron-bearing clay occurring at various horizons throughout the Potomac Group; but the large scale—both vertical and horizontal—on which the Arundel formation, or "iron-ore clays" proper, is developed cannot well be explained entirely by this simple theory. Landward tilting must be retained as the chief explanation for the Arundel clays until a more satisfactory interpretation can be brought forward.

The well-marked unconformity occurring at many points between the Arundel and Patapsco formations, notably in the West Hanover district, indicates emergence and a distinct erosion interval prior to Patapsco deposition, and the marked changes in the floras would seem to indicate that this interval was a long one, during which the Arundel sediments, if originally continuous, were removed by erosion from large areas.

The highly colored and variegated clays of the Patapsco formation, like the iron-bearing Arundel clays, evidently bear some relation to the great basic eruptive masses, plentifully iron-bearing, which lie to the north and west of them. This phase of the sedimentation is somewhat more prominent in central Maryland, where the rocks of this character are not only well developed, but nearest the eastern margin of the Piedmont belt. It is also probable that these ferruginous Patapsco clays were also in part redeposited from the more richly iron-bearing clays of the subjacent Arundel. The Patapsco sands were doubtless derived to a considerable extent from those of the Patuxent terrane.

That the seaward tilting was not continuous or persistent in the same

FIG. 1.—VIEW SHOWING PATAPSCO SANDS OVERLYING ARUNDEL CLAYS, CEDAR HILL MINE, TIMBERNECK, 1 MILE SOUTHWEST OF HANOVER.

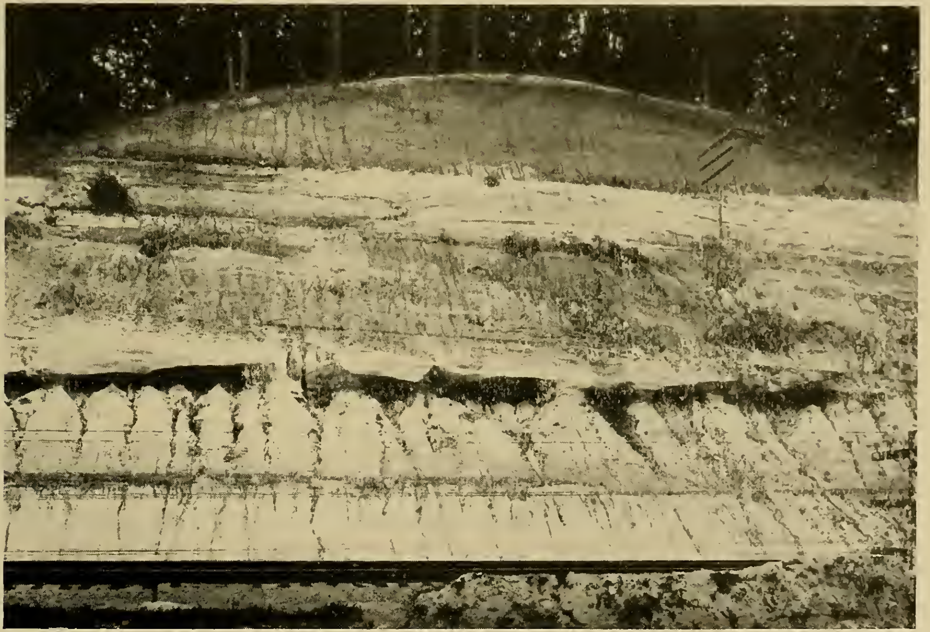

FIG. 2.—VIEW SHOWING LEDGES OF INDURATED SAND IN THE PATAPSCO FORMATION WHICH IS OVERLAIN BY GREENSANDS OF THE AQUIA EOCENE IN CUT OF R. F. & P. R. R., NEAR AQUIA CREEK, VIRGINIA.

direction is evidenced by the varying character of the deposits and the statigraphic relations which the several formations sustain to each other. In the succeeding chapters the surface configuration, both of the crystalline floor and of the Potomac Group is discussed, and some possible interpretations advanced.

The greater thickness of the formations of the Potomac Group along a belt somewhat to the eastward of the Fall-line may have emphasized the downward movements in this portion of the Coastal Plain during Potomac time. On the other hand, the gradual removal of the weight over the Piedmont region by the removal of its residuals has possibly occasioned an upward movement of that area as well as of immediately adjacent Coastal Plain regions. The accumulating results of these tendencies, particularly the first mentioned, from the beginning of Potomac time until the present, have been the weakening of the crystalline floor near the landward border of the Coastal Plain, accompanied by monoclinal folding and even faulting on a limited scale. The studies of McGee in the upper Chesapeake area, and of others to the northward and southward, fully convinced him that displacement had actually occurred, although no very definite evidence was adduced in demonstration of the same. Other writers, including Fontaine, however, believe that we have to do merely with sedimentation across a pre-Potomac escarpment. In the opinion of the authors of this paper, the Fall-line phenomena in Maryland, and elsewhere, afford considerable evidence of actual displacements. A number of carefully constructed vertical sections on a large scale have been made across the Fall-line zone, and these show in nearly every instance evidence of this.

Evidence of the actual displacement in the Potomac beds is very clearly defined in the vicinity of Relay, Maryland, and this is further strengthened by the fact that the Miocene beds at Catonsville, near by, lie considerably higher than the normal dip of the main body of the Miocene deposits calls for.

At the openings of the Maryland Clay Company, at Northeast, Maryland, there occurs a well-defined example of an anticline in the Patuxent beds which is believed by Ries to have been produced by the hydration of the subjacent feldspathic rock in the process of its decomposition into the residual kaolin mined at this point. Though the scale on which the folding occurs is small, the phenomena afford a suggestion as to the possible causes of some of the lesser irregularities in the Patuxent beds which lie near the crystalline floor.

Surface Configuration of Crystalline Floor and its relation to Potomac Basin of Deposition

The basal beds of the Potomac Group rest on a more or less uneven surface of crystalline rocks, in which certain of the more important drainage lines of the present day were already established, as is shown both at the marginal contact and by the well borings near the landward border of the formations.

The great increase in the dip of the Patuxent and succeeding formations along the Fall-line has already been alluded to, as well as the evidence that it represents in part at least a fault scarp.

It is significant, however, that there is a marked though less pronounced decline in the dip of the strata eastward of the Fall-line all the way to the seaward margin of the Coastal Plain. The evidence for this is furnished by the deep-well borings in Delaware, Maryland, and Virginia, the number of which is not as great as could be desired, although they all show, without exception, a progressively lessened dip of the beds as the distance from the landward margin increases.

The following wells of the middle Atlantic slope reach the crystalline rocks and show the following rates of descent of the crystalline floor:

Location of well.	Distance from point where crystalline rock surface reaches tide level.	Depth of crystalline rock surface below tide level.	Rate of descent per mile.
	Miles.	Feet.	Feet.
Ice works, South Wolf Street, Baltimore	¾	151	200
Baltimore Copper Works, Baltimore	2	187	93.5
Farnhurst, Delaware	2	111	55+
Middletown, Delaware	12	452	37.7
Sandy Point, Virginia	2	270	135
Quantico, Virginia	2	210	105
North End Point, Virginia	72	1,162	15.7

These records indicate a rapid slope near the Fall-line with a lessening seaward, although actual elevation is suggested in the crystalline floor in the Middletown, Delaware, area, which may represent an extension of an axis from Iron, Chestnut, and Grays hills to the southeastward. They also show an actual thinning of the Potomac deposits to the seaward, as shown by the well at North End Point, where the thickness of the Potomac beds is only one-half the normal thickness at the outcrop.

The record of the well borings becomes of the highest significance when it is remembered that this crystalline surface has been receiving along its seaward margin progressively greater and greater loading through deposition since Potomac time. The conclusion is readily reached that subsidence took place gradually, and that any barriers which existed along the eastern margin of the Potomac basin were depressed below sea level.

Marsh and McGee, as well as most other writers, have expressed their belief in such a barrier, although not adducing any further concrete evidence of the same than the non-marine character of the Potomac sediments. McGee has suggested, as above stated, that a Potomac barrier may have been comparable in character and extent to the existing peninsula of Lower California. Another possible, although perhaps less plausible, interpretation of these phenomena is found in the hypothesis of incipient folding in Potomac time.

Such interpretations as have been suggested in the foregoing discussion may be understood as but an imperfect and more or less speculative attempt to reduce to language a long-continued series of events which in the actual complexities of the interacting factors involved baffles description.

Surface Configuration of Potomac Deposits and its Possible Interpretation

The records of deep artesian well borings to the eastward of the Potomac belt indicate some clearly defined irregularities in the rate of decline of the Potomac surface. It will be seen from the following table that only a single record shows a greater decline than 25 feet, while most of them show a descent much less than this amount, in one instance (Crisfield) even less than the observed average landward dip ($12\frac{1}{2}$ feet) of the Eocene deposits which immediately overlie the Potomac beds to the southward.

Location of well.	Distance from point where Potomac surface reaches sea level.	Depth of surface below tide level.	Rate of descent in feet per mile.
	Miles.	Feet.	Feet.
Rock Hall, Maryland............	7	240	34
Claiborne, Maryland	19	440	23
Tunis Mills, Maryland.........	24	430	18
Tilghman's Island, Maryland....	27	400	15
Gloucester Court-House, Virginia	38	600	16
Williamsburg, Virginia	38	550±	14.5
North End Point, Virginia......	62	920	15
Crisfield, Maryland	91	964	10.6

According to these records, there is a marked lessening in the decline of the Potomac surface far to the seaward. When the surface of the Raritan formation is likewise considered there seems to be an actual rise in this surface in the Eastern Shore of Maryland and Delaware, between the Chester and Choptank rivers, although it again declines eastward a little farther seaward, as shown by the boring at Gloucester Court House, Virginia. Whether we have to do with an erosional irregularity in the Potomac surface or with incipient deformation, the facts at hand do not permit us to determine. If the irregularity is due to the latter cause, the axis of the anticline would not seem to be coincident with that of the peninsula of Delaware, but would cross the latter in a northeast-southwest direction. A depressed barrier, such as has above been indicated, may well have served as the seaward buttress in such deformation. Whether there may be more than one of these axial prominences in the Potomac surface is a question of much interest, but which cannot be answered with the data at hand.

The lessening in the descent of the Potomac surface far to the seaward, as indicated by borings at North End Point and Crisfield, is in general in harmony with the relations of the subjacent crystalline floor above described.

FIG. 1.—VIEW SHOWING MASSIVE VARIEGATED CLAY OF THE PATAPSCO FORMATION, NEAR HAWKINS POINT, ANNE ARUNDEL COUNTY.

FIG. 2.—VIEW SHOWING PATAPSCO SANDS AND CLAYS OVERLAIN BY PLEISTOCENE SANDS, B. & O. R. R. CUT, ROSEDALE HILL, BALTIMORE COUNTY.

DISTRIBUTION OF THE FAUNA AND FLORA.

The following tables show the geological and geographical distribution of the animal and plant remains which have been collected in the deposits of the Potomac Group both in the State of Maryland and in the contiguous areas of the District of Columbia and Virginia. The species recorded in these tables will be fully described in subsequent chapters.

TABLE SHOWING THE DISTRIBUTION OF THE ANIMAL REMAINS.

	Arundel.					Patapsco.
	Maryland.				District of Columbia.	Virginia.
	Near Muirkirk.	Bladensburg.	Branchville.	Arlington.	Washington.	White House Bluff.
DINOSAURIA.						
Allosaurus medius	*	......	......	......	......	......
Creosaurus potens	......	......	......	......	*	......
Cœlurus gracilis	*	......	......	......	......	......
Pleurocœlus nanus	*	......	......	......	......	......
Pleurocœlus altus	*	......	......	......	......	......
Astrodon Johnstoni	......	*	......	......	......	......
Dryosaurus grandis	*	......	......	......	......	......
Priconodon crassus	*	......	......	......	......	......
CROCODILIA.						
Goniopholis affinis	......	......	*	......	......	......
GASTROPODA.						
Bythinia arundelensis	......	......	......	*	......	......
Viviparus marylandicus	......	......	......	*	......	......
Viviparus arlingtonensis	......	......	......	*	......	......
PELECYPODA.						
Cyrena marylandica	......	......	......	*	......	......
Unio potapscoensis	......	......	......	......	......	*

The fossil plants which are much more abundant than the animal remains, are recorded in the tables which occupy the following six pages. All those occurring in the District of Columbia are listed as well as certain forms from the Potomac deposits of Virginia, although not all of the forms which have been found in the latter state are included.

	PATUXENT																			
	MARYLAND				DISTRICT OF COLUMBIA					VIRGINIA										
	Ft. Worthington (Baltimore)	Broad Creek	Springfield	Clifton (Baltimore)	Terra Cotta	Ivy City	Montello	New Reservoir	16th Street	Colchester Road	Lorton (Telegraph Station)	Cockpit Point	Potomac Run	Kankeys	Woodbridge	Fredericksburg	Alum Rock	Dutch Gap	Trents Reach	Neabsco Creek
FILICALES																				
Schizaeopsis americana																*				
Rufordia acrodentata																		*		
Rufordia Goepperti						*										*		*	*	
Acrostichopteris cyclopteroides																		*		
Acrostichopteris adiantifolia											*		*			*				
Acrostichopteris parvifolia													*			*		*	*	
Acrostichopteris pluripartita								*			*					*		*	*	
Acrostichopteris longipennis																				
Acrostichopteris expansa																*		*	*	
Knowltonella Maxoni																				
Dicksoniopsis vernonensis																				
Cladophlebis Browniana		?				*		*			*		*			*	*	*		
Cladophlebis constricta																*				
Cladophlebis rotundata																*		*		
Cladophlebis virginiensis													*			*		*		
Cladophlebis parva												*	*			*				
Cladophlebis Albertsii											*		*			*		*	*	
Cladophlebis Ungeri											*				*	*		*		
Cladophlebis distans		*									*					*		*		
Dryopterites macrocarpa																		*		
Dryopterites pinnatifida																				
Dryopterites cystopteroides																*				
Dryopterites elliptica													*							
Dryopterites dentata											*		*					*		
Dryopterites virginica													*							
Aspleniopteris pinnatifida																*				
Aspleniopteris adiantifolia																*				
Onychiopsis latiloba								?			*					*		*		
Onychiopsis psilotoides								*	*				*			*		*	*	
Onychiopsis brevifolia											*		*			*		*		
Onychiopsis Goepperti						*		*		*		*	*			*		*	*	
Onychiopsis nervosa			*			*		*					*			*		*		
Sagenopteris latifolia											*									
Sagenopteris elliptica													*	*						
Sagenopteris virginiensis																*				
Tempskya Whitei[1]																				
Taeniopteris auriculata													*			*				
Taeniopteris nervosa											*		*			*				
Scleropteris elliptica											*	?	*	*		*		*		
Thinnfeldia Fontainei													*							
Thinnfeldia granulata											*		*					*		
Thinnfeldia rotundiloba													*			*				
Thinnfeldia marylandica																				
LYCOPODIALES																				
Selaginella marylandica																				
EQUISETALES																				
Equisetum Lyelli			?													*		*		
Equisetum Burchardti					*			*			*	*						*		
CYCADOPHYTAE																				
Cycadeoidea marylandica[2]																				
Cycadeoidea Tysoniana																				

[1] Found eroded out of Patapsco formation along Deep Run and Stony Run and on Patuxent Neck.
[2] This species occurs in situ in the Patuxent formation near Arbutus. Localities for other species of

ARUNDEL																	PATAPSCO																				
MARYLAND															DISTRICT OF COLUMBIA		MARYLAND											VIRGINIA									
Baltimore	Bay View	Soper Hall	Bewley Estate	Hobbs Mine	Germans Mine	Reynolds Mine	Howard Brown Estate	Tip Top	Hanover	Arlington	Lansdowne	Contee	Muirkirk	Riverdale	Langdon	Queens Chapel Road	Grays Hill	Poplar Point	Muddy Creek	Federal Hill (Baltimore)	Wellhams	Ft. Washington	Vinegar Hill	Fort Foote (Rosiers Bluff)	Near Glymont	Stump Neck	Overlook Inn	Mt. Vernon	White House Bluff	Hell Hole	Chinkapin Hollow	Dumfries Landing	Widewater	Aquia Creek	Brooke	72-Mile Post	Deep Bottom
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Cycadeoidea are not tabulated, since none have been found which have not been reworked into younger deposits.

	PATUXENT																			
	MARYLAND				DISTRICT OF COLUMBIA					VIRGINIA										
	Ft. Worthington (Baltimore)	Broad Creek	Springfield	Clifton (Baltimore)	Terra Cotta	Ivy City	Montello	New Reservoir	16th Street	Colchester Road	Lorton (Telegraph Station)	Cockpit Point	Potomac Run	Kankeys	Woodbridge	Fredericksburg	Alum Rock	Dutch Gap	Trents Reach	Neabsco Creek
CYCADOPHYTAE—Continued																				
Cycadeoidea McGeeana [1]																				
Cycadeoidca Fontaineana																				
Cycadeoidea Goucheriana																				
Cycadeoidea Uhleri																				
Cycadeoidea Bibbinsi																				
Cycadeoidea Clarkiana																				
Cycadeoidea Fisherae																				
Dioonites Buchianus								?			*	*		*				*	*	
Ctenopteris insignis													*			*				
Ctenopteris angustifolia													*							
Ctenopteris longifolia																*				
Ctenopsis latifolia													*			*				
Zamiopsis dentata								?								*				
Zamiopsis petiolata																*				
Zamiopsis laciniata																*				
Nilsonia oregonensis																				
Nilsonia densinerve																*				
Zamites tenuinervis														*		*		*		
Zamites crassinervis													*	*		*		*		
Dichotozamites cycadopsis																				
Cycadeospermum marylandicum																				
Cycadeospermum obovatum																				
Cycadeospermum acutum													*				*			
Cycadeospermum rotundatum														*						
Cycadeospermum spatulatum													*			*		*		
Podozamites subfalcatus											*									
Podozamites acutifolius											*							*		
Podozamites inaequilateralis												*	*	*						
Podozamites distantinervis									*				*			*		?		
Podozamites Knowltoni																				
Podozamites lanceolatus											*									
GINKGOALES																				
Baiera foliosa																		*		
CONIFERALES																				
Nageiopsis longifolia											*	*	*	*		*		*		
Nagciopsis angustifolia									*				*			*		*		
Nageiopsis zamioides												*	*			*		*		
Cephalotaxopsis magnifolia													*			*		*		
Cephalotaxopsis brevifolia													*			*		*		
Brachyphyllum crassicaule																		*	*	
Brachyphyllum parceramosum								*			*									
Araucarites aquiensis																				
Araucarites patapscoensis																				
Abietites macrocarpus		*														*		*		
Abietites longifolius													*			*		*		
Abietites foliosus																		*		
Abietites marylandicus																				
Pinus vernonensis																				
Cupressinoxylon Wardi				*			*													*
Cupressinoxylon McGeei								*												
Frenelopsis ramosissima																*				

[1] Localities for this and the following species of *Cycadeoidea* are not tabulated, since none have been

ARUNDEL															PATAPSCO																						
MARYLAND															DISTRICT OF COLUMBIA		MARYLAND											VIRGINIA									
Baltimore	Bay View	Soper Hall	Bewley Estate	Hobbs Mine	Germans Mine	Reynolds Mine	Howard Brown Estate	Tip Top	Hanover	Arlington	Landsdowne	Contee	Muirkirk	Riverdale	Langdon	Queens Chapel Road	Grays Hill	Poplar Point	Muddy Creek	Federal Hill (Baltimore)	Wellhams	Ft. Washington	Vinegar Hill	Fort Foote (Roslers Bluff)	Near Glymont	Stump Neck	Overlook Inn	Mt. Vernon	White House Bluff	Hell Hole	Chinkapin Hollow	Dumfries Landing	Widewater	Aquia Creek	Brooke	72-Mile Post	Deep Bottom
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found which have not been reworked into younger deposits.

	PATUXENT																			
	MARYLAND				DISTRICT OF COLUMBIA					VIRGINIA										
	Ft. Worthington (Baltimore)	Broad Creek	Springfield	Clifton (Baltimore)	Terra Cotta	Ivy City	Montello	New Reservoir	16th Street	Colchester Road	Lorton (Telegraph Station)	Cockpit Point	Potomac Run	Kankeys	Woodbridge	Fredericksburg	Alum Rock	Dutch Gap	Trents Reach	Neabsco Creek
CONIFERALES—Continued																				
Frenelopsis parceramosa																			*	
Sphenolepis Kurriana						*		*			*		*	*		*		*	*	
Sphenolepis Sternbergiana											*	*	*		*	*	*			
Laricopsis angustifolia																		*	*	
Arthrotaxopsis expansa			?								*	*	*					*	*	
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Sequoia ambigua											*	*	*			*		*		
ANGIOSPERMAE																				
Cyperacites potomacensis																				
Plantaginopsis marylandica																				
Alismaphyllum Victor-Masoni																				
Populus potomacensis																				
Populophyllum minutum																				
Populophyllum reniforme																				
Nelumbites virginiensis																				
Nelumbites tenuinervis																				
Menispermites potomacensis																				
Sapindopsis variabilis																				
Sapindopsis magnifolia																				
Sapindopsis brevifolia																				
Celastrophyllum denticulatum																				
Celastrophyllum parvifolium																				
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Celastrophyllum acutidens																				
Celastrophyllum Brittonianum																				
Celastrophyllum Hunteri																				
Celastrophyllum albaedomus																				
Cissites parvifolius																				
Sassafras bilobatum																				
Sassafras parvifolium																				
Sassafras potomacensis																				
Araliaephyllum crassinerve																				
Araliaephyllum magnifolium																				
INCERTAE SEDIS																				
Hederaephyllum dentatum																				
Ficophyllum serratum																*				
Ficophyllum oblongifolium													*			*		*		
Proteaephyllum reniforme																*		*		
Proteaephyllum ovatum													*			*		*		
Rogersia longifolia														*		*		*		
Rogersia angustifolia													*			*				
Rogersia angustifolia parva																				
Aristolochiaephyllum crassinerve																				
Aristolochiaephyllum ? cellulare																				

ARUNDEL																	PATAPSCO																				
Maryland															District of Columbia		Maryland											Virginia									
Baltimore	Bay View	Soper Hall	Bewley Estate	Hobbs Mine	Germans Mine	Reynolds Mine	Howard Brown Estate	Tip Top	Hanover	Arlington	Lansdowne	Contee	Muirkirk	Riverdale	Langdon	Queens Chapel Road	Grays Hill	Poplar Point	Muddy Creek	Federal Hill (Baltimore)	Wellhams	Ft. Washington	Vinegar Hill	Fort Foote (Rosiers Bluff)	Near Glymont	Stump Neck	Overlook Inn	Mt. Vernon	White House Bluff	Hell Hole	Chinkapin Hollow	Dumfries Landing	Widewater	Aquia Creek	Brooke	72-Mile Post	Deep Bottom
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THE GEOLOGIC PROVINCE

The Maryland Lower Cretaceous formations constitute part of a belt of deposits of that age extending from Pennsylvania to eastern Alabama. They are apparently embraced within the confines of a single geologic province, although in places transgressed by strata of Upper Cretaceous, Tertiary and Quaternary age.

The Maryland deposits afford the most complete sequence of Lower Cretaceous strata within this district. Three formations are here recognized, each with clearly defined lithologic characters, but separable likewise by easily recognizable unconformities.

Characteristic plant fossils have been found both in Maryland and Virginia, but are unknown elsewhere, although fragmentary plant remains[1] are known to occur in the Alabama deposits, the Lower Cretaceous age of which has been recognized by Berry, although the material thus far collected is too poorly preserved for specific determination or exact correlation with other floras.

To the northward of Maryland the Arundel and Patuxent formations are gradually transgressed by the unconformably overlying Patapsco formation, which in turn gradually disappears by the overlapping of the Raritan formation in western New Jersey and eastern Pennsylvania, except at a few localities to the west of the city of Philadelphia,[2] where outliers of the Patapsco formation have been found with distinctive lithologic characters.

Southward in Virginia the Patapsco formation disappears near Fredericksburg, except for a single outcrop of this age in the James River valley near City Point. The Arundel formation is not known to occur south of the Potomac River. With the single exception above noted, the Patuxent formation is the only one exposed in south central and southern Virginia, where in the valley of the James River some of the most fossiliferous beds of this formation have been found. Although they are separated at the surface from the deposits of the same formation farther

[1] Collected by Dr. L. W. Stephenson.

[2] Philadelphia Folio, U. S. Geological Survey, p. 9, 1909.

north through the transgression of younger formations, the continuity of the beds is assumed from the similarity of the flora with its many identical species, as well as from the characteristic lithology.

Deposits formerly called by the name of the Cape Fear formation, but evidently a continuation southward of the Patuxent formation of Virginia, are found in North Carolina. Here again the transgression of the Tertiary and the Quaternary formations interferes with the continuity of the outcrop, although there is no reason to doubt that the deposits are continuous beneath the later strata. No fossils have thus far been discovered in the deposits of North Carolina, but the strata occupy the same stratigraphic position here at the base of the Coastal Plain series as farther north, and are unconformably overlain by Upper Cretaceous formations. The deposits are also strikingly similar to those of the Patuxent formation in Virginia and Maryland, and it seems to be a reasonable assumption that they constitute part of the same formation.

To the south of North Carolina similar deposits have been long known to extend through South Carolina and Georgia into eastern Alabama.[1] The more southern occurrences have been erroneously associated with the Tuscaloosa deposits farther westward in Alabama and Mississippi, from which, however, they are entirely distinct, both in stratigraphic position and lithologic character, while they are separable everywhere by marked unconformities from the overlying Upper Cretaceous deposits, as shown by the broader structural relations of the district. They are unquestionably to be associated with the Patuxent beds farther north whether the same formational name is employed throughout the entire district or not. Notwithstanding the evidence in favor of a single formational unit being found at the base of the Coastal Plain series all the way from Maryland to Alabama, it must be admitted that a transgressing sea

[1] Dr. L. W. Stephenson and Mr. E. W. Berry under the direction of Dr. T. Wayland Vaughan, have greatly enlarged our knowledge of the stratigraphy and paleontology of the South Atlantic and Gulf States, and the results of their work have been available for the comparisons with the southern district south of North Carolina.

throughout so extended a coast line may well involve considerable time for its accomplishment, and if the transgression proceeded from the north toward the south, as seems probable, the deposits in Alabama would necessarily be somewhat younger than those in Virginia and Maryland.

The differential movements to which the Coastal Plain has everywhere been subjected may readily cause, through transgression or interformational denudation, a greater or smaller portion of an earlier formation to be exposed along the line of outcrop. It must not therefore be assumed that deposits at every outcrop show exact equivalency; in fact, the basal strata of the Patuxent formation in central Virginia affords evidence of older floral elements than the deposits elsewhere. It may well be therefore that portions of the more southern strata are younger than the more northern beds of this widely extended formational unit.

A much more extended study of Lower Cretaceous deposits in the south may reveal a larger assemblage of organic remains than has hitherto been found. The animal remains are practically limited to the Arundel formation in Maryland, while an extensive flora characterizes the Patuxent and Patapsco in both Maryland and Virginia. A discovery of similar floras elsewhere within the province, both in the northern and the southern districts, would add largely in the final elucidation of the problems presented.

The following table presents in tentative form the correlation of the Lower Cretaceous deposits throughout the Atlantic Coastal plain.

Pennsylvania and Delaware	Maryland	Virginia	North Carolina	South Carolina	Georgia and Eastern Alabama
Patapsco	Patapsco.....	Patapsco	....	....	?
....	Arundel	....	....	....	Lower Cretaceous "Tuscaloosa" in part
....	Patuxent....	Patuxent....	Patuxent	Patuxent....	?

THE LOWER CRETACEOUS FLORAS OF THE WORLD

BY

EDWARD W. BERRY

Introductory

The Lower Cretaceous, because of the thickness of its deposits, the time interval which it embraces, and the resulting change in plant and animal life, has been considered by certain American geologists to constitute one of the major divisions of the geological column under the name Comanchean, although the utility of this term and its ultimate survival is doubtful. Invertebrate paleontologists have taken the lead in determining its subdivisions, the main criteria being the succession of the molluscan faunas, among which the Cephalopoda and the aberrant Rudistæ, Chamidæ, etc., are chiefly relied upon.

Since, except for the initial Cretaceous deposits both in this country and abroad, the conditions in the materials preserved from erosion and available for study are mainly those of marine deposition, fossil plants are unrepresented or only partially represented at a large number of levels. Consequently, they occupy a secondary place in the paleontological correlation of the Lower Cretaceous as a whole. These floras are, however, of extraordinary interest, since toward the close of the Lower Cretaceous modern types make their appearance in considerable numbers, and it seems probable that the evolution of the angiosperms, the dominant class of the Tertiary and post-Tertiary floras, was accomplished if not inaugurated during this period.

While the nomenclature of the subdivisions of the Lower Cretaceous varies in different countries and with different authors the following of the last edition of De Lapparent are generally understood and are used in the present discussion:

ALBIAN (d'Orbigny 1842)	(Gault)
APTIAN (d'Orbigny 1842)[2]	Gargasian (Kilian 1887)[1] Bedoulian (Toucas 1888)
BARREMIAN (Coquand 1861)[2]	includes the Urgonian (d'Orbigny 1850) and the Rhodanian (Renevier 1854)
NEOCOMIAN (Thurmann 1835)[2]	Hauterivian (Renevier 1874) Valanginian (Desor 1854)

As a step in the preparation of the chapter on correlation the various Lower Cretaceous floras have been tabulated, and since they present much that is of interest the following abstract seems worthy of publication. No attempt has been made to completely revise authors' identifications, and a number of minor papers have been omitted. After sketching briefly what is known of these floras a brief analysis is attempted.

The étages Neocomian, Urgonian, Aptian, and Albian we owe largely to the genius of d'Orbigny. Since the massive limestones of the Urgonian at Orgon, in the lower valley of the Durance, represent such a local type of sedimentation and fauna, French geologists have advocated the substitution of the term Barremian, from Barrême in the Basses Alpes, for this stage, which is also sometimes made an upper division of the Neocomian.

With regard to the term Wealden which occupies such a prominent place in geological literature it is quite certain that it represents a phase dependent upon the physical conditions accompanying deposition, which obviously may have been inaugurated at slightly different times in different areas, and which may have persisted longer in some areas than in others. Its use should therefore be dissociated from the idea of a chronologic unit and restricted, if used at all, to the stratigraphic unit represented by deposits of this type.

[1] Kilian in Frech, Lethæa geognostica, 2 Teil, 3 Band, Kreide, 1 Abt., Palæocretacicum, 1907.

[2] Subcretaceous (Gumbel 1881), Eocretaceous (De Lapparent) Palæocretaceous (Kilian 1907).

The discussions of the age of the Wealden rival in volume those of the Rhætic, Hercynian, and Laramie questions. As transitional deposits the Wealden may well be partly of Jurassic age, but of late years it has come to be accepted as a non-marine facies of the Neocomian, since, where it is present, the lowest marine beds of the Neocomian are said to be absent. That the flora (Seward, Ward) and fauna (Smith Woodward, Marsh) are Jurassic in type is not to be wondered at, indeed it would be remarkable if it were otherwise, since Nature knows no units, and boundary lines in conformable deposits are purely utilitarian or academic. This being true, international rather than provincial usage should prevail, and a unified time scale becomes an urgent necessity.

In the recent masterly summary by Emile Haug (Traité, 1910) the Cretaceous is divided into three major divisions—the Eo-, Meso-, and Neocretaceous; the Eocretaceous corresponding to the original usage of the Neocomian, the Mesocretaceous being made up of the Albian, Cenomanian and Turonian stages. This treatment has much to commend it, as can be appreciated by an inspection of Haug's tables of the range of the characteristic fossils. The paleobotanical evidence, while less full, lends considerable support to such an arrangement, which is also in accord with the diastrophic fact that the extensive transgression of the sea which culminated in the Upper Cretaceous was inaugurated in Albian time.

Lower Cretaceous deposits of various ages occupy large areas in South America, Asia, and Australia, and doubtless in time, as a result of more detailed examination, they will yield their quota toward the completion of the records of distribution of the Cretaceous floras.

The Neocomian Stage[1]

The name we owe in the first instance to Thurmann (1835). It is derived from Neuchatel (Neocomum), the marine beds of this stage being typically developed in the Swiss area.

[1] This term is used throughout in the restricted sense as consisting of the étages Valanginian and Hauterivian and not as synonymous or coextensive with Eo- or Palæo-cretaceous.

The Neocomian marks the culmination of the upper Jurassic emergence, and is emphasized by littoral, estuarine and various types of continental deposits, such as the Morrison and Kootanie of the west and the Wealden of Europe. Marine deposits continue uninterruptedly along the Pacific coast of both North and South America, the Cretaceous flora being observed for the first time in the upper portion of the Knoxville beds in the former area. The Neocomian sea of Mexico appears not as yet to have reached the international boundary.

Deposits of this age are typically developed in southern Europe and northern Africa. The eastern and southern coasts of Africa were also receiving sediments as well as a large area in southern Asia. Eastern Greenland shows Neocomian deposits, and an arm of the sea extends southward across central Russia (Petchorian). Along the eastern coast of North America the initial transgression of the Cretaceous sea is not recorded in outcropping deposits of a typically marine character until Upper Cretaceous time, those of the Lower Cretaceous lying buried from observation far to the eastward.

Floras in the marine deposits of this stage are scarce and unimportant biologically, although they are of considerable stratigraphic importance if they are of terrestrial origin, in furnishing data for correlation. Often these fossils are impressions of seaweeds or similar indefinite objects.

Switzerland

From the marine beds in the cantons of Berne, Vaud, Appenzell in Switzerland, and Rapatz in Freiberg Heer[1] has described the following:

Aulacophycus pedatus Heer
Bambusium neocomense Heer
Caulerpa Lehmanni Heer
Chondrites serpentinus Heer
Chondrites neocomensis Heer
Discophorites angustilobus Heer
Discophorites Fischeri Heer
Fucoides friburgensis Heer
Gyrophyllites Oosteri Heer
Gyrophyllites pentamerus Heer
Sphaerococcites meyrati Fischer-Ooster
Zamites (Dioonites) Kaufmanni Heer

[1] Heer, Fl. Foss. Helvetiæ, vierte abth., 1877.

The second is a supposed grass, the last a cycad, and the balance are indefinite fucoidal-like remains.

Portugal

The Lower Cretaceous of Portugal furnishes a nearly complete section largely the result of the stratigraphic and paleontologic studies of Choffat. The fossil plants have been elaborated for the most part by the late Marquis Saporta, whose large work appeared in 1894.[1] The only considerable previous work on these floras was the valuable contribution by Heer in 1881.[2]

The Portuguese deposits are of great interest, not only because of the similarity in floral evolution with the Potomac, shown by the contained floras, but also for the reason that they are largely checked by intercalated marine faunas.[3] Saporta records the following species from Portuguese beds classed as Neocomian. It is needful to point out that this author's specific lines are finely drawn, resulting in a multiplication of species scarcely warranted by the character of the materials.

Abietites acicularis Sap.
Adiantum aneimiæfolium Sap.
Adiantum subtilinervium Sap.
Alismacites primævus Sap.
Bambusium latifolium Heer
Brachyphyllum corallinum Heer
Brachyphyllum obesum Heer
Caulinites atavinus Heer
Caulinites fimbriatus Sap.
Cedrelospermites venulosus Sap.
Changarniera dubia Sap.
Cheirolepis Choffati Sap.
Cladophlebis argutidens Sap.
Cladophlebis Browniana (Dunk.) Sew.
Cladophlebis derelicta Sap.
Cladophlebis Ungeri (Dunker) Ward
Cladophlebis fissipennis Sap.

[1] Saporta, Fl. Foss. Port., Trav. Géol. Port., Lisbon, 1894.
[2] Heer, Cont. Fl. Foss. Port., Trav. Géol. Port., Lisbon, 1881.
[3] Ward has given the historical details and a somewhat elaborate discussion in a review of Saporta's great work. Science (N. S.) vol. i, 1895, pp. 337-346.

Cladophlebis minor Sap.
Cladophlebis minutissima Sap.
Cladophlebis sinuatilobula Sap.
Cladophlebis subcycadina Sap.
Ctenopteris ultima Sap.
Cyclopitys Delgadoi Sap.
Cyclopteris tenuestriata Heer
Dictyopteris anomala Sap.
Dictyopteris infracretacica Sap.
Dictyopteris tenella Sap.
Equisetites Burchardti Dunk.
Frenelopsis leptoclada Sap.
Frenelopsis occidentalis Heer
Glossozamites brevior Sap.
Glossozamites dilaceratus Sap.
Glossozamites modestior Sap.
Lonchopteris lusitanica Sap.
Marattia minor Sap.
Matonidium Althausii (Dunker) Ward
Microlepia pluripartita Sap.
Neuropteridium spinulosum Sap.
Neuropteridium torresianum Sap.
Oleandridium tenerum Sap.
Onychiopsis Mantelli (Brongn.) Sew.
Osmunda retinenda Sap.
Pagiophyllum Heerianum Sap.
Palæocyparis flexuosa Sap.
Pecopteris Choffatiana Heer
Pecopteris dilacerata Sap.
Phlebomeris ? falciformis Sap.
Phyllites problematicus Sap.
Poacites gemellinervis Sap.
Poacites paucinervis Sap.
Poacites striatifolius Sap.
Poacites tenellus Sap.
Podozamites ? acutus Sap.
Podozamites ellipsoideus Sap.
Podozamites linearis Sap.
Podozamites oviformis Sap.
Pteridoleimma spoliatum Sap.
Pteridoleimma tripartitum Sap.
Rhizocaulon elongatum Sap.
Rhizocaulon vertus Sap.
Ruffordia Gœpperti (Dunk.) Seward
Scleropteris debilior Sap.
Sequoia lusitanica Heer

Sequoia subulata lusitanica Sap.
Sphenolepidium debile Heer
Sphenolepis Kurriana (Dunk.) Schenk
Sphenolepis Sternbergiana (Dunk.) Schenk
Sphenopteris capillaris Sap.
Sphenopteris Choffatiana infracretacica Sap.
Sphenopteris cuneifida Sap.
Sphenopteris debiliformis Sap.
Sphenopteris dissectifolia Sap.
Sphenopteris dissectiformis Sap.
Sphenopteris flabellinervia Sap.
Sphenopteris flabellisecta Sap.
Sphenopteris ginkgoides Sap.
Sphenopteris Gomesiana Heer
Sphenopteris lobulifera Sap.
Sphenopteris lupulina Heer
Sphenopteris plurinervia Heer
Sphenopteris pseudolepida Sap.
Sphenopteris subtilinervis Sap.
Stachypteris minuta Sap.
Thuyites densior Sap.
Thuyites pulchelliformis Sap.
Widdringtonites debilis Sap.
Widdringtonites pygmæus Sap.
Williamsonia minima Sap.
Yuccites fractifolius Sap.

There are 45 species of ferns, 20 species of conifers, and only 9 species of cycads represented. The *Williamsonia, Yuccites, Changarniera,* and *Poacites striatifolius* are considered Proangiospermæ, and the balance of the species of *Poacites,* as well as *Rhizocaulon, Alismacites,* and *Caulinites* are classed as Monocotyledonæ, *Phyllites problematicus,* and *Cedrelospermites* are referred to the Dicotyledonæ with a query.

It may be noted that seven species (one equisetum, four ferns, and two conifers), cosmopolitan Lower Cretaceous types, are present in the Potomac flora, while sixteen of the genera are represented in the Maryland-Virginia area.

France

In France the Wealden type of sedimentation is developed according to De Lapparent south of Beauvais in the Pays de Bray (see Kilian) and in Hainaut. From this area Brongniart[1] recorded five species of characteristic Lower Cretaceous plants in 1849. These were *Lonchopteris Mantelli, Pachypteris gracilis, Brachyphyllum Gravesii, Zamites Brongniarti,* and *Carpolithus Mantelli.*

Cornuel[2] recorded some additions to the flora in 1866 which he obtained from beds of Neocomian age in the Paris basin, and Saporta[3] and others have made minor contributions. The flora as a whole is poorly developed, and has, in a country so rich in Carboniferous, Jurassic, and Tertiary plant beds, attracted but little attention. The following forms have been recorded:

Brachyphyllum Gravesii (Pomel) Brongniart
Equisetum Burchardti Dunker *(Carpolithus Mantelli)*
Pinus aspera Cornuel
Pinus gracilis Cornuel[4]
Pinus elongata d'Orbigny
Pinus rhombifera Cornuel
Pinus submarginata Cornuel
Protopteris Buvignieri Brongniart[5]
Sphenopteris Fittoni Seward *(Pachypteris gracilis)*
Sphenopteris Delgadoi Saporta[6] (possibly same as *Fittoni*)
Weichselia reticulata (S. & W.) Ward
Zamites Brongniarti (Mantell) Brongniart

England

The flora of the English Wealden, using that term in the more restricted sense for the Hastings beds and the overlying Weald Clay (H. B. Woodward) is of interest not only because its flora is the only European flora outside of Portugal which has been revised in recent years, but

[1] Brongniart, Tableau, 1849, pp. 107, 108.

[2] Cornuel, Des cônes de pins trouves dans les couches fluviolacustres de l'étage néocomién du bassin parisien, etc. Bull. Soc. géol. Fr. (2e série), tome xxiii, 1866, pp. 658-673, pl. xii. Note sùr les cônes de Pinus elongata découverts a Saint-Dizier (Haute-Marne) et sur des cônes de cèdre du sable vert de la Houpette (Meuse), Bull. Soc. géol. Fr. (3e série) tome x, 1882, pp. 259-263.

[3] Saporta, Notice sur les végét. foss. de la craie infér. des environs du Havre, Mém. Soc. Géol. de Normandie, 1877.

[4] The name of this species is preoccupied by Saporta's Tertiary species from Aix in Provence.

[5] Brongniart, Tableau, 1849, pp. 35, 111

[6] Saporta, Rev. gén. bot. tome v, 1893, p. 365, pl. iv, fig. 5.

also from the striking similarity in lithology between it and the Potomac beds.

The flora has been elaborated by Seward[1] who gives an abridged historical sketch of its study in his introduction. The following species are recorded:

Acrostichopteris Ruffordi Sew.
Algites catenelloides Seward
Algites valdensis Seward
Androstrobus Nathorsti Sew.
Anomozamites Lyellianus (Dunk.)
Becklesia anomala Sew.
Bennettites sp.
Bennettites Carruthersi Sew.
Bennettites Carruthersi var. *latifolius* Sew.
Bennettites Gibsonianus Carr.
Bennettites Saxbyanus (Brown)
Brachyphyllum obesum Heer
Brachyphyllum spinosum Sew.
Bucklandia anomala (S. & W.)
Carpolithes sp.
Chara Knowltoni Sew.
Cladophlebis Albertsii (Dunk.)
Cladophlebis Browniana (Dunk.)
Cladophlebis Dunkeri (Schimp.)
Cladophlebis longipennis Sew.
Conites (Araucarites) sp.
Conites armatus Sew.
Cycadites Rœmeri Schenk.
Cycadites Saportæ Sew.
Cycadolepis
cf. *Dichopteris lævigata* (Phill.)
Dictyophyllum Rœmeri Schenk
Dioonites Brongniarti (Mant.)
Dioonites Dunkerianus Göpp.
Equisetites Burchardti Dunk.
Equisetites Lyelli Mantell
Equisetites Yokoyamæ Sew.
Fittonia Ruffordia Sew.
Leckenbya valdensis Sew.
Marchantites Zeilleri Sew.
Matonidium Althausii (Dunker) Ward
Microdictyon Dunkeri (Schenk)
cf. *Nageiopsis heterophylla* Font.
Nilsonia schaumburgensis (Dunk.)

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[1] Seward, Wealden Flora, pt. i, 1894; pt. ii, 1895.

Onychiopsis Mantelli (Brongn.)
Onychiopsis elongata (Geyler)
Otozamites Gœppertianus (Dunk.)
Otozamites Klipsteinii (Dunk.)
Otozamites Klipsteinii superbus Sew.
Otozamites Klipsteinii longifolius Sew.
Otozamites sp., cf. *O. Reibeiroanus* Heer
Pagiophyllum crassifolium (Schenk)
Pagiophyllum sp.
Pinites Carruthersi Gard.
Pinites Dunkeri Carr.
Pinites Ruffordi Sew.
Pinites Solmsii Sew.
Protopteris Witteana Schenk
Ruffordia Göpperti (Dunk.)
Ruffordia Göpperti var. *latifolia* Sew.
Sagenopteris acutifolia Sew.
Sagenopteris Mantelli (Dunk.) Schenk
Sphenolepis Kurriana (Dunk.) Schenk
Sphenolepis Sternbergiana (Dunk.) Schenk
cf. *Sphenolepidium (Sequoia) subulatum* Heer
Sphenolepidium sp.
Sphenopteris Fittoni Sew.
Sphenopteris Fontainei Sew.
Tæniopteris Beyrichii (Schenk)
Tæniopteris Beyrichii var. *superba* Sew.
Tæniopteris Dawsoni Sew.
Tempskya Schimperi Corda
Thuites valdensis Sew.
Weichselia reticulata (S. & W.) Ward
Withamia Saportæ Sew.
Yatesia Morrisii Carr.
Zamites Buchianus (Ett.)
Zamites Carruthersi Sew.
Zamites Carruthersi var. *latifolius* Sew.

These include 2 algæ, 1 chara, 1 bryophyte, 3 equiseta, 23 ferns, 16 conifers, and 24 cycadophytes. Twelve of the widespread species are present in the Potomac flora. There are 16 common genera represented in the two areas and a number of distinct, but closely related species in the two floras.

Belgium

Dumont divided the Aachenian of Hainaut into an upper and a lower stage, but in recent years Belgian geologists have restricted Dumont's term to the Upper Cretaceous of Aix-la-Chapelle, and have proposed the term Bernissartian (Purves, 1883) for the Lower Cretaceous, which is often spoken of as Wealden and was formerly considered the age of the Gault. That both these horizons, as well as several intermediate ones, are present in this area is not at all improbable. The floras have been studied by Coemans,[1] Saporta,[2] and more recently by Seward.[3] Professor Bommer is engaged at the present time in studying well-preserved plant material of this age from near Brussels.[4] A list of the recorded species includes the following:

Adiantites sp., Seward
Algites sp., Seward
Cedrus corneti Coemans
Cladophlebis Ungeri (Dunker) Ward
Cladophlebis Browniana (Dunker) Seward
Conites minuta Seward
Cycadeoidea (Cycadites) Schachti (Coemans)
Equisetites ? sp., Seward
Gleichenia ? (in fruit) Saporta
Gleichenites sp., Seward
Laccopteris Dunkeri Schenk
Leckenbya valdensis Seward
Lycopodites sp., Seward
Matonidium Althausii (Dunker) Ward
Onychiopsis psilotoides (Stokes and Webb) Ward
Pinites Solmsii Seward
Pinus Andræi Coemans
Pinus Briarti Coemans
Pinus depressa Coemans
Pinus gibbosa Coemans
Pinus Heeri Coemans
Pinus Omalii Coemans
Pinus Toillezi Coemans

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[1] Cœmans, Fl. foss. du premier étage du terrain crétacé du Hainaut. Mém. Acad. Roy. Belg., tome xxxvi, 1867.

[2] Dupont, Sur la découverte d'ossements d'Iguanodon, de poissons et de végétaux dans la fosse Sainte-Barbe du charbonage de Bernissart, Bull. Acad. Roy. Belg., (2e série), tome xlvi, 1878, pp. 387-408 (plants determined by Saporta on page 396).

[3] Seward, La Flore Wealdienne de Bernissart, Mém. Mus. Roy. d'Hist. Nat. de Belg., Année 1900.

[4] Bommer, Nouveau gite de végét. découvert dans l'argile Wealdienne de Bracquegnies (Hainaut), Bull. Soc. belge. de Géol. Paléont. et Hydrol., tome vi, 1892, p. 160.

Protorhipis Rœmeri Schenk
Ruffordia Gœpperti (Dunker) Seward
Sagenopteris Mantelli (Dunker) Seward
Sphenopteris delicatissima Schenk
Sphenopteris Fittoni Seward
cf. *Tœniopteris*, Seward = *Nilsonia* (?)
Weichselia reticulata (Stokes and Webb) Ward

The Belgium flora is of a very fragmentary character, but apparently includes one or more vague algal remains, 15 or 16 varieties of ferns, 1 lycopod, 1 equisetum, only 1 cycad, and 10 conifers.

Germany

The serious study of the flora of the German Wealden may be said to have begun with Dunker's oft-quoted monograph, which appeared in 1846. In the German area (northwest Germany, Hanover, and the Holland frontier) the Hastings sand of England is represented by the Diester (Hils) sandstone, while the upper or argillaceous member is called the Weald clay (Wälderthon). The term Wealden has sometimes been amplified to include the underlying Purbeck, as is the case in Kayser's well-known text-book. Other writers consider the German Wealden older than that of England,[1] a view certainly not supported by the flora.

The most important contributor to our knowledge of the German Wealden flora is Schenk,[2] although Ettingshausen and others have made minor contributions. A partially revised list of the recorded species includes the following:

Abietites Linkii (Roemer) Dunker
Alethopteris cycadina Schenk
Alethopteris Huttoni (Dunker)
Anomozamites Schaumburgense (Dunker)
Baiera pluripartita Schimper
Cladophlebis Browniana (Dunker) Seward
Cladophlebis Ungeri (Dunker) Ward
Clathraria Lyelli Stokes and Webb

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[1] Pavlow and Lamplugh, Argiles de Speeton et leurs équivalents. Moscou, 1892.

[2] Schenk, Die Flora der nordwestdeutschen Wealdenformation, Palaeontographica, Band xix, 1871, pp. 203-276, pl. xxii-xliii; Band xxiii, 1876, pp. 157-163, pl. xxv, xxvi.

Cycadites Rœmeri Schenk
Dioonites Dunkerianus (Goeppert)
Dioonites Gœppertianus (Dunker)
Equisetum Burchardti Dunker
Hausmannia dichotoma Dunker
Jeanpaulia Brauniana Dunker
Lomatopteris Schimperi Schenk
Marsilidium speciosum Schenk
Matonidium Althausii (Dunker) Ward
Microdictyon (Laccopteris) Dunkeri (Schenk)
Onychiopsis psilotoides (Stokes and Webb) Ward
Pachyphyllum curvifolium (Dunker) Schenk
Pachyphyllum crassifolium Schenk
Pecopteris Murchisoni Dunker
Protopteris Witteana Schenk
Pterophyllum Lyellianum Dunker
Ruffordia Gœpperti (Dunker) Seward
Sagenopteris Mantelli (Dunker)
Sphenolepis Kurriana (Dunker) Schenk
Sphenolepis Sternbergiana (Dunker) Schenk
Spirangium Jugleri (Ettings) Schenk (probably not a plant)
Sphenopteris delicatissima Schenk
Sphenopteris adiantifrons Ettingshausen
Sphenopteris Fittoni Seward
Tempskya Schimperi Corda

The ferns are largely in the majority in this list, numbering 18 species, while the conifers furnish but 7 species and the cycads 6 species.

From the neighboring area of Westphalia Hosius and von der Marck[1] have described the following species, which they designate as Neocomian:

Abietites Linkii (Roemer) Dunker
Dioonites abietinus Miquel
Laccopteris Dunkeri Schenk
Lonchopteris recentior Schenk
Pinus Quenstedti Heer ?
Pitcairnia primœva Hosius and Von der Marck
Podozamites œqualis Miquel
Protopteris punctata Sternberg
Pterophyllum blechniforme Hosius and Von der Marck
Pterophyllum Germari E. v. Otto
Pterophyllum saxonicum Reich ?
Sagenopteris neocomiensis Hosius and Von der Marck

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[1] Hosius and Von der Marck, Die Flora der westfälischen Kreideformation, Palaeontographica, Band xxvi, 1880, pp. 80-95; Nachtrag, Band xxxi, 1885, p. 231.

Sphenolepis Kurriana (Dunker) Schenk
Sphenolepis Sternbergiana (Dunker) Schenk
Weichselia reticulata (Stokes and Webb) Ward (*Ludovicæ* Stiehler)
Zamites iburgensis Hosius and Von der Marck
Zamites nervosus Schenk

Saxony

The Neocomian sandstones of Langenberg, near Quedlinburg. of Westerhausen, etc., in Saxony, formerly considered of Quader age, have furnished a considerable flora, Stiehler[1] having described three species from this region as long ago as 1858. Schulze,[2] in 1888, added considerably to the list of plants, and more recently Richter[3] has been elaborating this flora in a most careful manner. He follows von Koenen in correlating the Wealden with the Berriasian below the ammonite zones of the Valanginian and Hauterivian. A partially revised list of the recorded species is as follows:

Alethopteris cycadina Schenk
Alethopteris revoluta Schenk
Baiera münsteriana (Presl) Heer (obviously an incorrect identification of this Rhætic species)
Cylindrites spongioides Goeppert
Gleichenia cf. *giesekiana* Heer
Gleichenia longipennis Heer
Gleichenia cf. *rotula* Heer
Glossozamites Schenkii Heer
Hausmannia dichotoma Dunker
Hausmannia gracillima Richter
Hausmannia Kohlmanni Richter
Hausmannia Sewardi Richter
Hausmannia spuria Richter

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[1] Stiehler, Die Flora des Langeberges bei Quedlinburg, Palaeontographica, Band v, 1855-1858, pp. 71-80, pl. xii-xv.

[2] Schulze, Ueber die Flora der subhercynschen Kreide, Zeits. gesammt. Naturw. Halle, Band lx, 1887, pp. 440-470.

[3] Richter, Neocompflanzen der Kelb'schen Sandgrube bei Quedlinburg, Zeits. deutsch. geol. Gesell., Band li, 1899, Verhandlungen, pp. 39-41. Beitr. z. Flora der unteren Kreide Quedlinburgs. Teil i. Die Gattung Hausmannia Dunker und einige seltenere Pflanzenreste. Leipzig, 1906, pp. 27, pls. 7. Teil ii. Die Gattung Nathorstiana P. Richter und Cylindrites spongioides Goeppert. Leipzig, 1909, pp. 12, pl. 6. Cylindrites spongioides Goeppert und Nathorstiana P. Richter, Monatsber. Deutsch. Geol. Gesell., Band lxii, 1910, pp. 278-284.

Matonidium Althausii (Dunker) Ward
Microdictyon regale Richter *(=Laccopteris ?)*
Moriconia cyclotoxon Debey and Ettings. (obviously a wrong identification of this Upper Cretaceous species)
Nathorstiana arborea Richter
Nathorstiana gracilis Richter
Nathorstiana squamosa Richter
Onychiopsis psilotoides (Stokes and Webb) Ward
Pandanus Simildæ Stiehler
Phlebopteris dubia Richter *(=Laccopteris)*
Pterophyllum Ernestinæ Stiehler
Pteridophyllum fastigiatum Schulze
Schizoneuropsis posthuma Richter
Sphenolepis Kurriana (Dunker) Schenk (*imbricata* Roemer)
Sphenolepis Sternbergiana (Dunker) Schenk (cf. *Sequoia falcifolia* Schulze)
Weichselia reticulata (Stokes and Webb) Ward (*Ludovicæ* Stiehler)
Zamites speciosus Heer
Zamites sp., Schulze

This flora is remarkable for the large number of ferns which it contains, the genus *Hausmannia* of the Dipteriaceæ being especially well represented.

Sweden

Nathorst, as quoted by Seward in his Wealden flora, is the authority for the statement that Lower Cretaceous floras are absent from the Scandinavian region.

Africa

The Uitenhage series of South Africa is often referred to the Upper Jurassic. Fossil plants were recorded from these rocks by Tate[1] many years ago, and more recently Seward has revised[2] and added to[3] the flora. The latter author considers these beds as of approximately the same age as the English Wealden. The following species are recorded:

Araucarites rogersi Seward
Benstedtia sp., Seward[4]
Brachyphyllum sp., Seward

[1] Tate, On the Secondary Fossils from South Africa, Quart. Journ. Geol. Soc. Lond., vol. xxiii, 1867, pp. 139-175, pls. v-ix.
[2] Seward, Ann. S. Afr. Mus., vol. iv, 1903, pp. 1-46, pls.
[3] Seward, Notes on Fossil Plants from South Africa, Geol. Mag., Dec. v, vol. iv, 1907, pp. 481-487, pls. xx, xxi.
[4] Stopes has recently shown that these supposed cycad remains are conifers.

Bucklandia sp., cf. *anomala* Carruthers
Carpolithus sp., Seward
Conites sp., A, sp., B
Cladophlebis Browniana (Dunker) Seward
Cladophlebis denticulata forma *atherstonei* Seward
Cycadolepis Jenkinsiana (Tate) Seward
Nilsonia Tatei Seward
Onychiopsis psilotoides (Stokes and Webb) Ward
Osmundites Kolbei Seward[1]
Phyllotheca Whaitsi Seward
Sphenopteris Fittoni Seward
Sphenopteris sp., Seward
Tæniopteris sp., cf. *arctica* Heer
Taxites sp., Seward
Zamites africana (Tate) Seward
Zamites Morrisii (Tate) Seward
Zamites recta (Tate) Seward
Zamites rubidgei (Tate) Seward

New Zealand

The two species, *Polypodium Hochstetteri* Unger, and *Sphenopteris Fittoni* Seward, have been recorded from New Zealand beds which have been tentatively correlated with the Wealden by Seward.

Peru

The explorations of Professor Steinmann in Peru during 1903-1904 resulted in the discovery of Neocomian plants at several localities. These were described by Neumann[2] in 1907. Still more recently a large collection was made by Captain Berthon, which is being studied by Professor Zeiller, who has published one preliminary paper.[3] The recorded species are:

Cladophlebis Browniana (Dunker) Seward
Equisetites Lyelli Mantell
Equisetites Peruanus Neumann
Otozamites Gœppertianus (Dunker) Seward

[1] The anatomy of this form was subsequently described by Kidston and Gwynne-Vaughan.

[2] Neumann, Beitr. z. Kennt. der Kreidef. Mittel-Peru, Neues Jahrb. xxiv, Beilage Band, 1907. (Plants on pp. 74-87, pl. i, ii.)

[3] Zeiller, Comptes rendus, tome cl, 1910, p. 3.

Rhynchogoniopsis neocomiensis Neumann
Weichselia reticulata (S. & W.) Ward
Zamiostrobus crassus (L. & H.) Goeppert
Zamiostrobus aff. *index* Saporta

Japan

The major divisions of the Mesozoic are all represented in Japan, the Cretaceous to a greater extent than the Triassic or Jurassic. It is developed over large areas in northern Japan and also in southern Japan.[1] Rocks classed as Bathonian by the Japanese paleontologists furnish an extensive flora,[2] several species of which continue into the Lower Cretaceous of that country.

The Neocomian plants which were first studied by Nathorst[3] occur in the Ryoseki series which is widely distributed and contains several fossiliferous horizons, so that unlike most Neocomian plant deposits those of Japan are intimately associated with beds containing marine invertebrates, such as Trigonia, Avicula, Belemnites, Cyrena, and various Stephanoceratidæ. The final elaboration of this flora we owe to Professor Yokoyama[4] who compares it with the European Wealden and the American Potomac, regarding it as representing the whole of the Neocomian. The total number of species recorded are the following:

Adiantites yuasensis Yokoyama
Cladophlebis Browniana (Dunker) Seward
Cladophlebis Nathorsti Yokoyama
Cladophlebis Ungeri (Dunker) Ward (*P. Geyleriana* Nathorst)
Cyparissidium ? japonicum Yokoyama
Dicksonia tosana Yokoyama
Dicksoniopteris Naumanni Nathorst
Dioonites Buchianus (Ettings.) Born.
Dioonites Buchianus angustifolius Fontaine
Glossozamites parvifolius Yokoyama
Lycopodites sp., Nathorst

[1] Outlines of Geol. of Japan, 1902, compiled by Imp. Geol. Surv., pp. 48-74.

[2] Yokoyama, Jurassic Plants from Kaga, Hida, and Echizen, Journ. Coll. Sci. Imp. Univ., vol. iii, 1889.

[3] Nathorst, Beitr. Mes. Fl. Japans. Denks. k. Akad. Wiss., Wien, Band lvii, 1890.

[4] Yokoyama, Mesozoic Plants from Kozuke, Kii, Awa, and Tosa, Jour. Coll. Sci., Imp. Univ., vol. vii, 1895.

Macrotæniopteris (?) marginata Nathorst (probably a *Nilsonia*)
Nilsonia Johnstrupi Heer
Nilsonia schaumburgensis (Dunker)
Nilsonia pterophylloides Yokoyama
Onychiopsis elongata (Geyler) Yokoyama
Onychiopsis elegans Yokoyama
Pecopteris cf. *virginiensis* Fontaine[1]
Podozamites lanceolatus minor Heer
Podozamites lanceolatus latifolia Nathorst
Podozamites pusillus Velenovsky
Podozamites sp., Yokoyama
Pteris (?) sp., Yokoyama
Ptilophyllum cf. *cutchense* Morris
Sphenopteris tenuicula Yokoyama
Thyrsopteris sp., Yokoyama
Torreya venusta Yokoyama
Zamiophyllum Naumanni Nathorst

The list embraces 1 lycopod, 12 ferns, 13 cycads, and but 2 conifers. Five of the species are present in the Potomac flora, and there are three or four additional species in the Japanese flora which are closely related to American forms.

China

From the Mesozoic basin in the province of Ssu-ch'nan in southwestern China, Professor Yokoyama[2] has reported a Lower Cretaceous flora which he regards as of Neocomian age. The forms recognized are:

Cladophlebis sp., Yokoyama
Coniopteris nitidula Yokoyama
Glossozamites acuminatus Yokoyama
Glossozamites Hoheneggeri (Schenk)
Podozamites lanceolatus (L. & H.) Schimper

Spitzbergen

The Mesozoic flora of Spitzbergen has been revised recently by Nathorst.[3] Although the plants from Cape Staratschin, discovered by Nordenskiöld in 1872, were regarded by Heer as of Lower Cretaceous

[1] This form should probably be included in *Cladophlebis Browniana*.
[2] Yokoyama, Mesozoic Plants from China, Journ. Coll. Sci., Imp. Univ., vol. xxi, 1906.
[3] Nathorst, Zur Mesozoischen Flora Spitzbergens, Kgl. Svenska Vetens.-Akad. Handl., Band xxx, No. 1, 1897.

age, and were so described,[1] Nathorst has considered them as of Upper Jurassic age. In his geology of Spitzbergen[2] the possibility of this flora being of Neocomian age is pointed out, but in a still later publication[3] he states that the paleobotanical and paleozoölogical lines of evidence are finally in harmony in regarding the beds as Upper Jurassic, his original opinion.[4] This flora probably lived so near the end of the Jurassic, if, indeed, it may be called a Jurassic flora, as to come within the elastic term Wealden; in fact, Seward[5] recognized its Wealden affinities in 1895.

Combining the flora from Cape Staratschin, as revised by Nathorst, with that discovered at Advent Bay by DeGeer in 1882, as elaborated by the same author, yields the following list:

Baiera graminea Nathorst
Baiera spetsbergensis Nathorst
Carpolithus sp. *A*, *B*, *C*
Cedroxylon cavernosum (Cramer) Schenk
Cedroxylon pauciporosum (Cramer) Schenk
Cladophlebis sp., *A*, *B*
Drepanolepis angustior Nathorst
Drepanolepis rotundifolia (Heer) Nathorst
Elatides curvifolia (Dunker) Nathorst
Equisetites sp. (?) Nathorst
Feildenia Nordenskiöldi Nathorst
Gleichenia sp., Nathorst
Lycopodites Sewardi Nathorst
Pagiophyllum (?) sp., Nathorst
Pinites (Pityostrobus) Conwentzi Nathorst
Pinites (Pityophyllum) Lindstromi Nathorst
Pinites (Pityophyllum) Staratschini (Heer) Nathorst
Pinites (Pityophyllum) cf. *Solmsii* (Seward) Nathorst
Pinites (Pityospermum) cuneatus Nathorst
Pinites (Pityospermum) sp., Nathorst
Pinites (Pityolepis) pygmæus Nathorst
Pinites (Pityolepis) tsugæformis Nathorst
Pinites (Pityocladus) sp., *A*, *B*
Rhizomopteris sp., Nathorst

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[1] Heer, Kgl. Svenska Vetens.-Akad. Handl., Band xiv, No. 5, 1876; Fl. Foss. Arct., Band iv, 1877, pp. 48-50.

[2] Nathorst, Beitr. z. Geol. Bären. Insel, Spitzbergens u. k. Karl.-Landes, Bull. Geol. Inst. Upsala, vol. x, 1910, pp. 360-369.

[3] Nathorst, Aftryck ur Geol. Fören., Nov., 1910, pp. 1-9.

[4] Nathorst, Verhandl. k.-k. geol. Reichs., 1883, No. 2. p. 25.

[5] Seward, Wealden Fl., pt. ii, 1895, p. 233.

Sphenopteris (?) DeGeeri Nathorst
Sphenopteris sp., A, B
Schizolepis cylindrica Nathorst
Schizolepis (?) retroflexa Nathorst
Stenorrhachis (?) clavata Nathorst
Tæniopteris Lundgreni Nathorst (cf. *Beyrichii* Schenk)
Thinnfeldia arctica Heer
Xenoxylon phyllocladoides Gothan

Heer's supposed monocotyledon *Hypoglossidium antiquum* is considered by Nathorst as the impression of some coniferous scale, *Baiera cretosa* is considered a fern petiole, and *Baiera dichotoma* an undeterminable plant fragment: *Sphenopteris sp. A* is considered as close to the widespread *Onychiopsis psilotoides,* while *Cladophlebis sp. A* suggests the widespread *Cladophlebis Albertsii,* and *Cladophlebis sp. B* the equally widespread *Cladophlebis Browniana.* The two species of Baiera recognized are close to the Potomac species *Baiera foliosa,* and upon the whole the present writer is disposed to consider the flora as exhibiting a Lower Cretaceous rather than an Upper Jurassic facies, whatever may be its exact stratigraphic position. In this connection mention should be made of the fossil wood described by Gothan[1] from this and the nearby island of King Charles Land. His identifications include

Anomaloxylon magnoradiatum Gothan
Cedroxylon transiens Gothan
Cedroxylon cedroides Gothan
Cedroxylon phyllocladoides Gothan
Cupressinoxylon cf. *McGeei* Knowlton
Phyllocladoxylon sp., Gothan
Piceoxylon antiquis Gothan
Protocedroxylon araucarioides Gothan
Protopiceoxylon extinctum Gothan
Thylloxylon irregulare Gothan
Xenoxylon latiporosum (Cramer) Gothan

Kootanie

A history of the study of the fossil plants of the Kootanie formation down to 1905 is given in Professor Ward's monograph (*loc. cit.*). The

[1] Gothan, Die Fossilen Hölzer von König Karls Land, Kgl. Svenska Vetens.-Akad. Handl., Band xlii, No. 10, 1907.

principal contributors have been Dawson,[1] Newberry,[2] and Fontaine.[3] More recently Dr. Knowlton[4] has published an account of some interesting additions to this flora. The combined list after eliminating part of the synonyms is as follows:

Abietites longifolius (Font.) Berry
Acrostichopteris fimbriata Knowlton
Adiantum montanense Knowlton
Angiopteridium canmorense Dawson
Anomozamites acutiloba Heer ?
Anomozamites sp., Dawson
Antholithes horridus Dawson
Asplenium Dicksonianum Heer (= *Onychiopsis Gœpperti ?*)
Asplenium martinianum Dawson
Baiera brevifolia Newberry
Baiera longifolia (Pomel) Heer = *Baiera cretosa* Schenk
Baieropsis sp., Dawson = *Acrostichopteris ?*
Carpolithus virginiensis Fontaine
Carpolithus sp., Dawson
Cephalotaxopsis sp., Dawson
Chiropteris spatulata Newberry
Chiropteris Williamsii Newberry
Cladophlebis angustifolia Newberry
Cladophlebis Browniana (Dunk.) Seward
Cladophlebis constricta Fontaine
Cladophlebis Fisheri Knowlton
Cladophlebis distans Fontaine
Cladophlebis virginiensis Fontaine
Cladophlebis virginiensis montanensis Fontaine
Cladophlebis heterophylla Fontaine

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[1] Dawson, On the Mesozoic Floras of the Rocky Mountain region of Canada, Trans. Roy. Soc. Can., vol. iii, sec. iv, 1885, pp. 1-22, pl. i-iv. Dawson, Cretaceous Floras of the Northwest Territories of Canada, Amer. Nat., vol. xxii, 1888, pp. 953-959. Dawson, Correlation of Early Cretaceous Floras in Canada and the United States, Trans. Roy. Soc. Can., vol. x, sec. iv, 1892, pp. 79-93.

[2] Newberry, School of Mines Quarterly, vol. viii, 1887, p. 329. Newberry, Flora of the Great Falls Coal Field, Montana, Amer. Journ. Sci. (iii), vol. xli, 1891, pp. 191-201, pl. xiv.

[3] Fontaine, Description of Some Fossil Plants from the Great Falls Coal Field of Montana, Proc. U. S. Natl. Mus., vol. xv, 1892, pp. 487-495, pl. lxxxii-lxxxiv. Fontaine, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1906, pp. 284-315, pl. lxxi-lxxiii.

[4] Knowlton, Description of a Collection of Kootanie Plants from the Great Falls Coal Field of Montana, Smith. Misc. Coll. (quarterly issue), vol. l, pt. i, 1907, pp. 105-128, pl. xi-xiv.

Cladophlebis parva Fontaine
Cladophlebis sp., Dawson
Cycadeospermum rotundatum Fontaine ?
Cycadeospermum montanense Fontaine
Cyperites sp., Dawson
Dicksonia montanensis Fontaine
Dicksonia pachyphylla Fontaine
Dicksonia sp., Dawson
Dioonites borealis Dawson
Dryopteris angustipinnata montanensis (Font.) Knowlton[1]
Dryopteris monocarpa (Font.) Knowlton
Dryopteris montanensis (Font.) Knowlton = *Cladophlebis Ungeri* (Dunk.) Ward ?
Dryopteris kootaniensis Knowlton
Equisetum Phillipsii (Dunk.) Brongniart
Equisetum Lyellii Mantell
Ginkgo lepida Heer
Ginkgo nana Dawson
Ginkgo sibirica Heer
Ginkgo sp., Dawson (nuts)
Glyptostrobus grœnlandicus Heer
Laricopsis longifolia latifolia Fontaine
Lycopodites ? montanensis Fontaine
Nageiopsis longifolia Fontaine
Nilsonia schaumburgensis (Dunk.) Nathorst
Oleandra arctica Heer
Oleandra graminæfolia Knowlton
Onychiopsis brevifolia (Font.) Berry ?
Onychiopsis Gœpperti (Schenk) Berry
Onychiopsis latiloba (Font.) Berry
Onychiopsis psilotoides (S. & W.) Ward
Osmunda dicksonioides Fontaine
Pagiophyllum sp., Dawson
Pecopteris montanensis Fontaine
Pinus anthraciticus Dawson
Pinus susquæensis Dawson
Podozamites distantinervis Font. ?
Podozamites lanceolatus (L. & H.) Schimper
Podozamites latipennis Heer
Podoxamites inæquilateralis (Font.) Berry
Podozamites nervosa Newb.
Protorhipis Fisheri Knowlton
Pterophyllum montanense (Font.) Knowlton
Sequoia acutifolia Newb.

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[1] The type of this variety has been referred by the writer to *Cladophlebis Albertsii* (Dunk.) Brongniart. The writer has referred the Potomac forms usually referred to *Dryopteris* to the less definite form-genus *Dryopterites*.

Sequoia ambigua Heer
Sequoia fastigiata Heer ?
Sequoia Reichenbachi (Gein.) Heer
Sequoia rigida Heer
Sequoia Smittiana Heer
Sphenolepis Sternbergiana (Dunk.) Schenk
Sphenolepis Kurriana (Dunk.) Schenk
Sphenolepis sp., Dawson
Sphenopteris sp., Dawson
Taonurus incertus Dawson
Taxodium cuneatum Newberry
Widdringtonites ramosus (Font.) Berry ?
Williamsonia ? sp., Dawson
Zamites acutipennis Heer
Zamites apertus Newberry
Zamites arcticus Goeppert
Zamites borealis Heer
Zamites montana Dawson

The Kootanie flora comprises 1 lycopod, 2 equiseteæ, 34 species of ferns, 19 cycads, and 25 conifers. One monocotyledon, a Cyperites, is reported by Dawson, but it is of absolutely no significance, and a number of the other species in this flora listed on the authority of Dawson are of very questionable value. The Kootanie and Potomac floras have about a score of species in common, as well as others not positively identified, and a number of closely allied forms.

Wyoming

The cycad trunks from the Freezeout Hills of Carbon County, Wyoming, come from the Atlantosaurus beds of Marsh (Morrison formation). Opinion is divided as to whether they are of late Jurassic or early Cretaceous age, the weight of the evidence leaning toward the latter assumption. The species, all of which have been described by Ward,[1] are:

Cycadella Beecheriana Ward
Cycadella carbonensis Ward
Cycadella cirrata Ward

[1] Ward, Description of a New Genus and Twenty New Species of Fossil Cycadean Trunks from the Jurassic of Wyoming, Proc. Wash. Acad. Sci., vol. i, 1900, pp. 253-300. Ward, Jurassic Cycads from Wyoming, Mon. U. S. Geol. Surv., vol. xlviii, 1906, pp. 179-203, pls. xlvi-lxiii.

Cycadella compressa Ward
Cycadella concinna Ward
Cycadella contracta Ward
Cycadella crepidaria Ward
Cycadella exogena Ward
Cycadella ferruginea Ward
Cycadella jejuna Ward
Cycadella jurassica Ward
Cycadella gelida Ward
Cycadella gravis Ward
Cycadella Knightii Ward
Cycadella Knowltoniana Ward
Cycadella nodosa Ward
Cycadella ramentosa Ward
Cycadella Reedi Ward
Cycadella verrucosa Ward
Cycadella wyomingensis Ward

In this connection a single species from this same horizon in Wyoming (Beulah clays) should be mentioned. It is

Cycadella utopiensis (Ward) Wieland

Pacific Coast

On the Pacific coast of North America the Shasta Group has been divided primarily into Knoxville and Horsetown beds. These have been at times called formations, at other times, as in Monograph xlviii of the U. S. Geological Survey, the Shasta is called a formation. Again the series is united with the Upper Cretaceous as the Shasta-Chico series, while local formational names have also been used in parts of the area. The history of the study of the floras was fully detailed by Professor Ward in 1906 (*loc. cit.*). Still more recently Knowlton[1] has conclusively shown that the Knoxville beds are largely of Upper Jurassic age, the so-called Shasta flora being confined to the extreme upper part of the great thickness of apparently conformable beds which have been referred to the Knoxville. The writer is not concerned with the question of nomenclature in the present connection, and has used the term Shasta throughout the systematic part of the work to designate that part of the Knoxville, which is of Lower Cretaceous age, as shown by the contained

[1] Knowlton, Amer. Journ. Sci. (iv), vol. xxx, 1910, pp. 33-64.

flora. Combining the various contributions which have been made to the subject yields the following list of species:

FLORA OF UPPER KNOXVILLE BEDS

Abietites sp., Fontaine
Acaciæphyllum ellipticum Fontaine[1]
Angiopteridium canmorense Dawson ?
Angiopteridium strictinerve latifolium Fontaine
Cephalotaxopsis magnifolia Fontaine ?
Cladophlebis Browniana (Dunker) Seward
Cladophlebis parva Fontaine
Cladophlebis Ungeri (Dunker) Ward
Cladophlebis virginiensis Fontaine
Ctenis sp., Knowlton
Cycadeospermum californicum Fontaine
Dicksonia pachyphylla Fontaine
Dioonites Buchianus (Ettings.) Born.
Dioonites Buchianus abietinus (Font.) Ward
Dioonites Buchianus rarinervis Fontaine
Equisetum texense Fontaine ?
Gleichenia Nordenskiöldi Heer ?
Hausmannia ? californica Fontaine
Matonidium Althausii (Dunker) Ward
Nageiopsis longifolia Fontaine ?
Nilsonia californica Fontaine
Nilsonia Stantoni Fontaine
Nilsonia ? sambucensis Ward
Nilsonia schaumbergensis (Dunker) Nathorst
Oleandra graminæfolia Knowlton
Onychiopsis psilotoides (Stokes & Webb) Ward ?
Proteæphyllum californicum Fontaine[2]
Pterophyllum ? lowryanum Ward
Sagenopteris elliptica Fontaine
Sagenopteris Mantelli (Dunker) Schenk
Sagenopteris nervosa Fontaine
Sequoia Reichenbachi (Gein.) Heer
Tæniopteris sp., Knowlton
Zamites arcticus Goeppert
Zamites tenuinervis Fontaine

The foregoing list includes 1 equisetum, 14 ferns, 14 cycads, and 4 conifers. It shows 15 species identical with Potomac forms and several

[1] This was identified as *A. pachyphyllum* by Fontaine but is identical with *A. ellipticum.* It is not an Angiosperm nor is it related to what this author called *Acaciæphyllum* from the Potomac which is referred to *Thinnfeldia.*

[2] This is an absolutely unidentifiable fragment and might be a fern, cycad, gymnosperm or angiosperm.

others which are tentatively identified with them. The upper or Horse town beds have furnished the following flora:

FLORA OF THE HORSETOWN BEDS

Abietites macrocarpus Fontaine
Acaciœphyllum ellipticum Fontaine[1]
Angiopteridium canmorense Dawson ?
Angiopteridium strictinerve latifolium Fontaine
Cephalotaxopsis magnifolia Fontaine ?
Cladophlebis Browniana (Dunker) Seward
Cladophlebis heterophylla Fontaine
Ctenopsis latifolia (Fontaine) Berry
Cycadeoidea Stantoni Ward
Dioonites Buchianus (Ettings.) Born.
Dioonites Buchianus abietinus (Font.) Ward
Dioonites Dunkerianus (Goepp.) Miq.
Gleichenia Gilbert-Thompsoni Fontaine
Menispermites californicus Fontaine[2]
Nageiopsis longifolia Fontaine ?
Nilsonia oregonensis (Fontaine) Berry
Phyllites Fontainei Berry
Pinus shastensis Fontaine
Populus ? Ricei Fontaine[3]
Sagenopteris elliptica Fontaine
Sagenopteris nervosa Fontaine
Sagenopteris oregonensis Fontaine
Saliciphyllum californicum Fontaine[4]
Saliciphyllum pachyphyllum Fontaine[4]
Sequoia ambigua Heer
Sequoia Reichenbachi (Gein.) Heer
Sphenolepsis Sternbergiana (Dunker) Schenk
Zamites tenuinervis Fontaine

The conifers are more abundant than in the Upper Knoxville beds, 7 species being recorded. There are 9 cycads and 6 ferns, as well as 4 more or less vague angiosperms. Nine species are identical with Potomac forms.

[1] Not an Angiosperm and unrelated to Potomac species referred to this genus by Fontaine which prove to be identical with *Thinnfeldia.*

[2] This is probably an Angiosperm but there are no visible characters which warrant its reference to this genus.

[3] This looks like a fragment of a Dicotyledon but is unidentifiable generically.

[4] These two forms might belong to any division of vascular plants. They are probably Angiosperms but do not even show venation characters.

QUEEN CHARLOTTE ISLANDS

In 1872 James Richardson[1] discovered and described fossiliferous Lower Cretaceous on the Queen Charlotte Islands. A more elaborate account of the geology was published in 1880 by Geo. M. Dawson.[2] The flora has been studied by Sir William Dawson[3] and Penhallow.[4] A combined list of their determinations is as follows:

Cupressinoxylon sp., Dawson
Cycadeocarpus (Dioonites) columbianus Dawson
Ginkgo pusilla Dawson
Neuropteris heterophylla Brongniart
Nilsonia polymorpha cretacea Penhallow
Osmundites skidegatensis Penhallow
Sagenopteris elliptica Fontaine
Sagenopteris Nilsoniana (Brong.) Ward
Sagenopteris oblongifolia Penhallow
Sequoia Langsdorfii (Brongn.) Heer
Tæniopteris plumosa Dawson
Taxoxylon sp., Dawson
Zamites crassinervis Fontaine
Zamites tenuinervis Fontaine

The bulk of the foregoing names are obviously incorrect identifications, e. g., *Neuropteris heterophylla* is a typical carboniferous Pteridosperm, one of the *Sagenopteris* species is Jurassic and the *Nilsonia* is Rhætic, while the *Sequoia* is Tertiary.

BRITISH COLUMBIA

What is probably the northward extension of the Shasta-Chico series outcrops at various localities in British Columbia and probably in the Yukon territory, but the areas are so remote and scattered that the details of the geology and the fossil floras have only been worked out in a preliminary manner.

[1] Richardson, Geol. Surv. Can. Rept. of Progress for 1872-73, p. 56ff.
[2] Dawson, G. M., Geol. Surv. Can. Rept. of Progress for 1878-79, pp. 1-239B.
[3] Dawson, W., *Ibid.*, Rept. of Progress for 1872-73, pp. 66-71.
[4] Penhallow, Trans. Roy. Soc. Can., vol. viii, sec. iv, 1902, pp. 3-29, pls. i-vi; *Ibid.*, pp. 31-91, pl. vii-xvi.

Recently Professor Penhallow[1] has studied the collections made by Dr. R. A. Daly along the International Boundary in the Cascade Mountains (49th parallel) and near Rossland in the Sheep Creek valley about 120 miles to the eastward. His determinations include the following:

Aspidium fredericksburgense Fontaine
Cladophlebis skagitensis Penhallow
Cycadites unjiga Dawson
Fruit of Exogen *(Dorstenia ?)*
Gleichenia Gilbert-thompsoni Fontaine
Gleichenia sp.
Glyptostrobus europæus (Brongn.) Heer
Myrica serrata Penhallow
Nilsonia brevipinna Penhallow
Pinus sp. (vague leaves and seed)
Populus cyclophylla Heer
Quercus coriacea Newberry
Quercus flexuosa Newberry (?)
Salix perplexa Knowlton (?)
Sassafras cretaceum Newberry

Without studying the materials it is not possible to discuss this small list intelligently although several of the identifications are obviously improbable and more than one horizon is evidently represented. The *Cladophlebis* is not new and might represent a distal portion of the frond of any of previously described species of the *Cladophlebis virginiensis* type. The *Gleichenia* is obviously not referable to that genus and the material identified as *Glyptostrobus* is probably *Arthrotaxopsis* or *Widdringtonites,* while considerable doubt attaches to all of the dicotyledons enumerated.

ALASKA

The supposed Neocomian beds which contain fossil plants in the Cape Lisburne region of Alaska are very probably of Upper Jurassic age, as indicated by Knowlton's studies. They are therefore omitted in the present discussion, since the contained flora at best is small and not especially noteworthy.

Mexico

From the supposed Neocomian of Tlaxiaco Nathorst[2] has reported *Pseudofrenelopsis Felixi, Sequoia ambigua* and *Sequoia Reichenbachi.*

[1] Penhallow, Trans. Roy. Soc. Canada, 3d series, vol. i, sec. iv, 1908, pp. 287-349, pls. i-ix.

[2] Nathorst in Felix & Lenk, Beitr. Geol. u. Palaont. Mexico, Theil ii, 1893, pp. 51-54.

The Barremian Stage

Portugal

The floras classed as probably of Urgonian age in Portugal are not all precisely fixed in the Lower Cretaceous section, and some of the species in the following list may be from the Aptian, a matter of no great moment in the present connection. In common with the floras from the other horizons in the Portuguese Mesozoic, the Barremian flora was collected through the efforts of Choffat and elaborated by Heer and Saporta, and large collections in the hands of the latter at the time of his death have never been described.

The recorded species include the following:

Ancimidium lobulatum Saporta
Aneimidium minutulum Saporta
Aneimidium tenerum Saporta
Blyttia infracretacea Saporta
Brachyphyllum obesum Heer
Carpites burmanniæformis Saporta
Carpites plicicostatus Saporta
Choffatia Francheti Saporta
Cladophlebis Dunkeri (Schimper) Seward
Cladophlebis sinuatilobula Saporta
Comptoniopteris cercalina Saporta
Delgadopsis rhizostigma Saporta
Dicotylophyllum cerciforme Saporta
Dicotylophyllum corrugatum Saporta
Dicotylophyllum hederaceum Saporta
Dicotylophyllum lacerum Saporta
Equisetum sp., Saporta
Frenelopsis occidentalis Heer
Isœtes Choffati Saporta
Jungermannites vetustior Saporta
Lycopodites Francheti Saporta
Lycopodites gracillimus Saporta
Lycopodites Limai Saporta
Onychiopsis Mantelli (Brongn.) Seward
Poacites acicularis Saporta
Poacites cercalinus Saporta
Poacites plurinervulosus Saporta
Podozamites ? acutus Saporta
Protorhipis Choffati Saporta
Rhizocaulon elongatum Saporta

Ruffordia Gœpperti (Dunk.) Seward
Sphenolepidium debile Heer
Sphenolepis Kurriana (Dunk.) Schenk
Sphenolepis Sternbergiana (Dunk.) Schenk
Sphenopteris acutidens Saporta
Sphenopteris aneimiœformis Saporta
Sphenopteris angustiloba Heer
Sphenopteris cercalensis Saporta
Sphenopteris cordai (Dunk.) Schenk
Sphenopteris cuneifida Saporta
Sphenopteris linearisecta Saporta
Sphenopteris lobulifera Saporta
Sphenopteris plurinervia Heer
Sphenopteris polyclada Saporta
Sphenopteris pygmœa Saporta

One species each of *Isoetes, Equisetum,* and *Jungermannites* are described, the first being a very convincing type. There are 3 species of *Lycopodites,* 22 species of ferns, 5 conifers, and only a single cycad. The paucity of cycad remains is in remarkable contrast with most floras of about this age, the Kome flora of Greenland and the Barremian flora of Austrian Silesia each having 11 cycads.

Saporta refers *Delgadopsis* and *Protorrhipis* to his Proangiosperms, although the second is unquestionably a fern. The species of *Poacites* and *Rhizocaulon* are considered as monocotyledons and *Choffatia* as a dicotyledon, although the evidence for all of these forms is of a character which is far from trustworthy.

There are five species which are present in the Potomac flora and several others which are closely allied types.

France

Remains of plants in the marine deposits of the Barremian of France are scanty and unrepresentative.[1] The recorded species include:

Araucaroxylon barremianum Fliche
Cedrus Lennieri Saporta
Cedroxylon reticulatum Saporta
Cedroxylon barremianum Fliche

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[1] Saporta, Notice sur les végét. foss. de la Craie infér des environs du Havre, 1877. Fliche, Cont. à la fl. foss. de la Haute-Marne (infra crétacé), Bull. Soc. Sci. Nancy, 1900, pp. 1-23.

Cupressineæ sp., Fliche
Cunninghamites elegans (not this species)
Filicales (stem)
Sarcostrobilus Paulini Fliche
Tænidium pinnatisectum Saporta

England

The floras of the Lower Cretaceous of England above the Wealden are scanty and inadequately described. The following list compiled by Ward in 1896 includes the recorded remains from the Lower Greensand and Atherfield beds (Urgonian-Aptian). These will probably receive a modern treatment in the work on the Cretaceous which Dr. Stopes of Manchester is preparing for the British Museum:

Cycadeoidea Gibsoni (Carr.) Ward
Cycadeoidea inclusa (Carr.) Ward
Cycadeoidea maxima (Carr.) Solms-Laubach
Cycadeostrobus Walkeri Carruthers
Dracæna Benstedi Koenig[1]
Fittonia squamata Carruthers
Fucoides bignoriensis Mantell
Fucoides sp.
Pinites Benstedi (Mantell) Endl.
Pinites cylindroidea Gardner
Pinites Leckenbyi Carruthers
Pinites Mantelli Carruthers
Pinites oblongus (L. and H.) Endl.
Pinites patens Carruthers
Pinites pottoniensis Carruthers
Pinites sussexiensis (Mantell) Brongn.
Weichselia reticulata (S. & W.) Ward

Austria-Hungary

Ettingshausen[2] in 1852 described a number of so-called Wealden plants from Moravia and from Zöbing in lower Austria, and 19 years later Schenk[3] published his admirable account of the flora of the Wernsdorfer schichten from Austrian Silesia in the northern Carpathians. The age

[1] Stopes has recently shown this to be coniferous.

[2] Ettingshausen, Beitrag zur näheren kenntniss der Flora der Wealden-periode, Abhandl. k. k. geol. Reichsanstalt, Wien, Band i, Abth. iii, No. 2, 1852, pp. 1-32, pls. i-v.

[3] Schenk, Die fossilen Pflanzen der Wernsdorfer Schichten in den Nord-karpathen, Palaeont., Band xix, 1871, pp. 1-34, pls. i-vii.

of this flora has been commonly accepted as Urgonian (Barremian) since Schenk's publication. The recorded species include:

Baiera cretosa Schenk
Cedroxylon Schenk
Chondrites furcillatus Roemer
Confervites setaceus Ettingshausen
Cycadites Brongniarti Roemer
Cycadites Heerii Schenk
Cycadopteris Dunkeri Schenk
Cyclopteris squamata Ettingshausen
Cunninghamites elegans (Corda) Endl. (not this species)
Dioonites Buchianus (Ettingshausen) Born.
Eolirion primigenium Schenk
Equisetum Burchardti Dunker
Frenelopsis Hoheneggeri (Ettingshausen) Schenk
Lonchopteris recentior (Ettingshausen) Schenk = *Weichselia ?*
Onychiopsis psilotoides (Stokes and Webb) Ward
Podozamites Hoheneggeri Schenk
Podozamites obovatus Schenk
Podozamites Zittellii Schenk
Sagenopteris Mantelli (Dunker)
Sargassites Partschii Ettingshausen
Sequoia Reichenbachii (Geinitz) Heer
Sphenolepis Sternbergiana (Dunker) Schenk
Tæniopteris zöbingiana Ettingshausen
Widdringtonites gracilis Heer ?
Zamites affinis Schenk
Zamites Gœpperti Schenk
Zamites nervosus (Ettingshausen) Schenk
Zamites ovatus Schenk
Zamites pachyneurus Schenk

The flora includes 3 algæ, 1 equisetum, 5 ferns, 2 ginkgos, 11 cycads, and 5 conifers. The remarkable *Eolirion,* which has been suggested as representing a survival of the Paleozoic *Cordaites,* and which Saporta regarded as a Proangiosperm, is one of the features of this flora. Seven of the species are present in the Potomac flora and others are closely allied types.

Steinmann[1] has described a calcareous alga, *Boueina Hochstetteri* Toula[2] of the family Codiaceæ from the Upper Neocomian limestone

[1] Steinmann, Ber. Naturf. Gesell. z. Freiburg, Band xi, 1899, pp. 62-72.
[2] Toula, Sitz. k. Akad. Wiss., Wien, lxxxiii, i, 1883, pp. 1319-1324, pl. v, fig. 10, pls. vii-ix.

(probably Barremian) near Pirot in southeastern Servia. Other supposed lower Cretaceous plants from southeastern Europe, such as those from Solymos and Bucsava in Hungary are now considered Jurassic (Tithonian).

Russia

Although Murchison[1] states that the Wealden is absent in Russia, Auerbach,[2] as long ago as 1844, figured and described fossil plants from the sandstones of Klin (Klin'schen sandstein) in the province of Moscow. Eichwald[3] at one time regarded these sandstones as of Quader age, although in 1865 he refers them to the Neocomian.[4] Dunker, who examined Trautschold's plants considered the age as Wealden, and this is the opinion adopted by the latter who has given the only complete account of this flora.[5] The species are as follows:

Araucarites hamatus Trauts.
Alethopteris metrica Trauts. = *Matonidium ?*
Asplenites desertorum Trauts. = *Cladophlebis*
Asplenites Klinensis Trauts. = *Weichselia reticulata* (S. & W.) Ward
Auerbachia echinata Trauts.
Calamites sp., Trauts. = *Equisetum*
Cladophlebis Browniana (*Alethopteris Reichiana* Trauts.)
Cladophlebis Albertsii (*Pecopteris Whitbiensis* Trauts.)
Cycadites acinaciformis Trauts.
Equisetites sp., Trauts.
Glossopteris solitaria Trauts. (= *Sagenopteris*)
Microdictyon Dunkeri Schenk (*Pecopteris decipiens* Trauts.)
Odontopteris dubia Trauts. = *Cladophlebis*
Pecopteris Althausii Trauts. = *Matonidium Althausii* (Dunker) Ward
Pecopteris explanata Trauts. = *Matonidium Althausii* (Dunker) Ward
Pecopteris nigrescens Trauts. = *Weichselia reticulata* (S. & W.) Ward
Pecopteris pachycarpa Trauts. = *Matonidium Althausii* (Dunker) Ward
Polypodites (Lonchopteris) Mantelli Trauts. = *Weichselia reticulata* (S. & W.) Ward
Phyllites regularis Trauts.

[1] Murchison, Geol. Russia, vol. i, 1845, p. 260.
[2] Auerbach, Bull. Soc. imp. nat. Moscou, vol. xvii, 1844, 1, p. 145, pl. v.
[3] Eichwald, *Ibid.*, vol. xxxiv, 1861, 4, p. 432.
[4] Eichwald, Lethæa Rossica, vol. ii, pt. i (1865), 1868, pp. 1-71.
[5] Trautschold, Nouv. Mém. soc. nat. Moscou, vol. xiii, 1871, pp. 189-236, pl. xviii-xxii.

Pinus elliptica Trauts.
Reussia pectinata Goepp.
Ruffordia Gœpperti (*Sphenopteris auerbachi* Trauts.)
Thuyites ecarinatus Trauts.

Both Valanginian, Hauterivian and Barremian deposits are represented in central Russia these three stages being capable, according to Pavlow, of a two-fold division into Petchorian below and Simbirskian above. The fossil plants, according to recent authorities, are considered of Barremian age.

A number of forms recorded in the earlier work of Eichwald (*loc. cit.*, 1865) are not mentioned by Trautschold, and while they have little precise value, either botanical or stratigraphical, they may be given for the sake of completeness. They are:

Araucarites crassifolius Corda
Amygdalus taurica Eichwald
Cerasus meridionalis Eichwald
Cupressinoxylon ucranicum Goeppert
Cycadites affinis Eichwald
Cycadites contiguus Eichwald
Equisetites notabilis Eichwald
Fasciculites ambiguus Eichwald
Geinitzia prisca Eichwald
Keckia ambigua Eichwald
Psammopteris knorriæformis Eichwald
Quercus spathulata Eichwald

Greenland

The most interesting, as well as the most extensive, flora which has been referred to this horizon in the Lower Cretaceous is the Kome flora of Heer[1] found along the north side of the *Nugsuak* peninsula in West Greenland, in latitude 70° 45′ north (215 metres). Since White and

[1] Heer, Foss. Fl. v. Nordgrönland, Kreide Flora, Fl. Foss. Arct., Band i, 1868, ii, Specieller Theil, pp. 78-85, pls. xliii, xliv. Die Kreide-Flora der Arctischen Zone, Kgl. Svenska Vetens-Akad. Handl., Band xii, No. 6, 1874, pp. 31-92, pls. i-xxv; Fl. Foss. Arct., Band iii, 1874. Nachträge zur Foss. Fl. Grönlandes, Kgl. Svenska Vetens.-Akad. Handl., Band xviii, No. 2, 1880, pp. 3-8, pls. i, ii. Fl. Foss. Arct., Band vi, Abth. i, Theil ii. Flora Fossilis Grönlandica, Theil i. Die Flora der Komeschichten, Meddelelser om Grönland, Copenhagen, Femte Hefte, 1883, pp. 79-202. Fl. Foss. Arct., Band vi, Abth. ii, pp. 1-19, pls. i-iv. Fl. Foss. Arct., Band vii, 1883, pp. 151-157.

Schuchert[1] have discovered additional dicotyledons in the Kome beds, from which hitherto only *Populus primæva* was known, and have also demonstrated the presence of the Atane series on the north shore of the peninsula, just how much reliance can be placed upon Heer's list of species as having come from a single horizon is uncertain, and some doubt is raised regarding the Urgonian (Barremian) age which was held by Heer, and so confidently stated in the French abstract at the end of the fifth volume of "Meddelelser om Grönland," 1893, by Johnstrup.

The list of species recorded includes the following:

Adiantum formosum Heer
Acrostichites egedianus Heer
Aneimidium Schimperi Heer
Anomozamites cretaceus Heer
Aspidium ursinum Heer
Asplenium Boyeanum Heer
Asplenium Dicksonianum Heer
Asplenium lapideum Heer
Asplenium Nauckhoffianum Heer
Asplenium Nordenskiöldi Heer
Baiera cretosa Schenk
Cladophlebis Albertsii (Dunker)
Cyparissidium gracile Heer
Cyperacites hyperboreus Heer
Cyperacites arcticus Heer
Czekanowskia dichotoma Heer
Dicksonia bellidula Heer
Dicksonia Johnstrupi Heer
Dictyophyllum Dicksoni Heer
Eolirion primigenium Schenk
Equisetum amissum Heer
Equisetites annulatioides Heer
Equisetites grœnlandicus Heer
Fasciculites grœnlandicus Heer
Frenelopsis Hoheneggeri (Ettings.) Schenk
Ginkgo arctica Heer
Ginkgo tenuistriata Heer
Gleichenia acutipennis Heer
Gleichenia comptoniæfolia Ettings.
Gleichenia delicatula Heer
Gleichenia Gieseckiana Heer

[1] White and Schuchert, Cretaceous Series of the West Coast of Greenland, Bull. Geol. Soc. Am., vol. ix, 1898, pp. 343-368, pls. xxiv-xxvi.

Gleichenia gracilis Heer
Gleichenia longipennis Heer
Gleichenia micromera Heer
Gleichenia nervosa Heer
Gleichenia Nordenskiöldi Heer
Gleichenia optabilis Heer
Gleichenia rigida Heer
Gleichenia rotula Heer
Gleichenia thulensis Heer
Gleichenia Zippei (Corda) Heer
Glossozamites Schenkii Heer
Glyptostrobus grœnlandicus Heer
Inolepis imbricata Heer
Laurus (?) sp., Knowlton
Lycopodium redivivum Heer
Marsilea (?) grandis Heer
Nathorstia angustifolia Heer
Nathorstia firma Heer
Nilsonia Johnstrupi Heer (identified by Knowlton)
Oleandra arctica Heer
Osmunda petiolata Heer
Pecopteris Andersoniana Heer
Pecopteris arctica Heer
Pecopteris Bollbrœana Heer
Pecopteris borealis Brongniart
Pecopteris hyperborea Heer
Pecopteris komensis Heer
Pinus Crameri Heer
Pinus Eirikiana Heer
Pinus lingulata Heer
Pinus Olafiana Heer
Pinus Peterseni Heer
Poacites borealis Heer
Populus primæva Heer
Protorhipis cordata Heer
Pteris frigida Heer
Pterophyllum concinnum Heer
Pterophyllum lepidum Heer
Sequoia ambigua Heer
Sequoia gracilis Heer
Sequoia Reichenbachi (Gein.) Heer
Sequoia rigida Heer
Sequoia Smittiana Heer
Sphenopteris borealis Heer
Sphenopteris fragilis Heer
Sphenopteris grevilloides Heer
Sphenopteris lepida Heer
Thuyites Meriani Heer

Torreya Dicksoniana Heer
Torreya parvifolia Heer
Taonurus sp., Knowlton
Zamites acutipennis Heer
Zamites arcticus Goeppert
Zamites brevipennis Heer
Zamites borealis Heer
Zamites globuliferus Heer
Zamites speciosus Heer

This rich flora is remarkable for the variety and abundance of its ferns, possibly due to favorable conditions of humidity. No less than 40 species are differentiated by Professor Heer, the Gleichenias being especially abundant in both species and individuals, often in an excellent state of preservation. The Kome flora includes a supposed Marsilea, a lycopod, 3 equiseta, 3 ginkgoales, 11 cycads, and 18 conifers. *Eolirion* is recorded, *Cyperacites, Poacites,* and *Fasciculites* are held to represent monocotyledons, and the Dicotyledonæ are certainly represented in *Populus* and *Laurus* (?). Only 3 of the Kome species are positively identified in the Potomac flora, but there are a number of additional types which are closely allied and probably a critical revision of the Greenland material would disclose still other similar features.

The Aptian Stage

The Texas Area

The elaborately subdivided Comanche section of Texas and adjacent areas we owe chiefly to the labors of R. T. Hill, and the history of the study of the fossil plants which have been found in these beds has been given by Ward (*loc. cit.*). In the present connection interest centres in the Glen Rose beds of the Trinity, from which a small flora has been described by Fontaine and others. This flora contains the following species:

Abietites Linkii (Roemer) Dunker
Abietites foliosus (Font.) Berry ?
Abietites ? sp., Fontaine
Brachyphyllum parceramosum Fontaine
Carpolithus Harveyi Fontaine
Carpolithus obovatus Fontaine

Cycadeospermum rotundatum Fontaine
Dioonites Dunkerianus (Goepp.) Miquel
Dioonites Buchianus (Ettings.) Born.
Dioonites Buchianus rarinervis Fontaine
Dioonites Buchianus angustifolius Fontaine
Equisetum texense Fontaine
Frenelopsis varians Fontaine
Frenelopsis Hoheneggeri (Ettings.) Schenk
Pagiophyllum dubium Fontaine
Paleohillia arkansana Knowlton [1]
Pinus ? sp., Fontaine
Podozamites acutifolius Fontaine ?
Podozamites ? sp., Fontaine
Sequoia pagiophylloides Fontaine
Sphenopteris valdensis Heer ?
Sphenolepis Sternbergiana (Dunker) Schenk
? Thuyoxylon americanum Unger
Williamsonia texana Fontaine
Zamites tenuinervis Fontaine

It comprises rather widespread Lower Cretaceous types of a resistant character which withstood maceration in littoral marine deposits, and it is therefore not sufficiently representative for close correlation. Only 1 fern is represented. The cycads number 8 species, and the conifers 11. Six Potomac species are more or less satisfactorily identified, and 3 additional are somewhat doubtful.

The Trinity has been regarded by Hill as of Neocomian age, although representing a considerable time interval during its transgression. Douvillé,[2] Kilian,[3] Suess,[4] and others have advanced reasons for considering the base of the Texas Cretaceous as not older than the Aptian, and the flora cannot be said to offer any evidence contrary to this view. A further fact which suggests that the Texas Lower Cretaceous as a whole is younger than it has usually been considered is furnished by certain Albian faunal elements said to be present in the Fredericksburg, and

[1] Knowlton, Bull. Torrey Bot. Club, vol. xxii, 1895, pp. 387-390, tf. 1-3.
[2] Douvillé, Sur Quelques Rudistes Américains, Bull. soc. géol. Fr. (sér. iii), tome xxviii, 1900, p. 218.
[3] Kilian, Sur Quelques gisements de l'étage aptien, *Ibid.* (sér. iv), tome ii, 1902, p. 358. In Frech, Lethæa geognostica, 2 Teil, 3 Band, 1 Abt., Palæocretacicum, 1907.
[4] Suess, Amer. Journ. Sci. (iv), vol. xxxi, 1911, p. 105.

by the presence in the Upper Comanche or Washita division of a flora which is unmistakably of Upper Cretaceous (Cenomanian) age, and which is therefore omitted from the present discussion.

The Black Hills Area

The flora of the so-called Lakota formation of the Black Hills rim in Wyoming and South Dakota may be considered in this place, although it may be more properly referable to the Barremian since Dinosauria are also present in these deposits.[1] The history of discovery has been given in detail by Ward,[2] who, with the collaboration of Fontaine, has been mainly responsible for the elaboration of the flora. A list of the recorded species includes the following:

Acrostichopteris adiantifolia (Fontaine) Berry
Acrostichopteris pluripartita (Fontaine) Berry
Araucarites wyomingensis Fontaine
Araucarites ? cuneatus Ward
Asplenium Dicksonianum Heer (= *Onychiopsis ?*)
Carpolithus barrensis Ward
Carpolithus fasciculatus Fontaine
Carpolithus fœnarius Ward
Carpolithus montium-nigrorum Ward
Cephalotaxopsis magnifolia Fontaine
Cladophlebis parva Fontaine
Cycadeoidea aspera Ward[3]
Cycadeoidea cicatricula Ward
Cycadeoidea Colei Ward
Cycadeoidea colossalis Ward
Cycadeoidea dacotensis Macbride[4]
Cycadeoidea excelsa Ward
Cycadeoidea formosa Ward
Cycadeoidea furcata Ward

[1] Lucas, A New Dinosaur Stegosaurus Marshi, from the Lower Cretaceous of South Dakota, Proc. U. S. Natl. Mus., vol. xxiii, 1901, pp. 591, 592, pls. xxiii, xxiv.

[2] Ward, The Cretaceous Formation of the Black Hills as Indicated by the Fossil Plants, 19th Ann. Rept. U. S. Geol. Surv., pt. ii, 1899, pp. 521-946, pls. liii-clxxii.

[3] Ward, Elaboration of the Fossil Cycads in the Yale Museum, Amer. Journ. Sci. (iv), vol. x, 1900, pp. 327-345, pls. ii-iv; Mon. U. S. Geol. Surv., vol. xlviii, 1906, pp. 315-326.

[4] Macbride, T. H., A New Cycad, Amer. Geol., vol. xii, 1893, pp. 248-250, pl. xi.

Cycadeoidea heliochorea Ward
Cycadeoidea ingens Ward
Cycadeoidea insolita Ward
Cycadeoidea Jenneyana Ward
Cycadeoidea Marshiana Ward
Cycadeoidea McBridei Ward
Cycadeoidea minima Ward
Cycadeoidea minnekahtensis Ward
Cycadeoidea nana Ward
Cycadeoidea occidentalis Ward
Cycadeoidea Paynei Ward
Cycadeoidea protea Ward
Cycadeoidea pulcherrima Ward
Cycadeoidea reticulata Ward
Cycadeoidea rhombica Ward
Cycadeoidea Stillwelli Ward
Cycadeoidea superba Ward
Cycadeoidea turrita Ward
Cycadeoidea wellsii Ward
Cycadeoidea Wielandi Ward [1]
Czekanowskia nervosa Heer (?)
Equisetum Burchardti (Dunker) Brongniart
Gleichenia Zippei (Corda) Heer
Glossozamites Fontaineanus Ward
Nageiopsis longifolia Fontaine (?)
Nageiopsis angustifolia Fontaine (?)
Nilsonia nigracollensis Wieland
Onychiopsis brevifolia (Fontaine) Berry
Onychiopsis Gœpperti (Schenk) Berry
Onychiopsis latiloba (Fontaine) Berry
Onychiopsis nervosa (Fontaine) Berry
Onychiopsis psilotoides (Stokes and Webb) Ward
Pinus susquœnsis Dawson
Scleropteris distantifolia Fontaine
Scleropteris rotundifolia Fontaine
Sequoia sp., Fontaine (cone)
Sphenopteris plurinervia Heer ?
Williamsonia (?) phœnicopsoides Ward
Zamites borealis Heer
Zamites brevipennis Heer

Cycads predominate in this flora with a total of 33 species, but this is probably more apparent than real, and is due to more or less duplication in species founded on the gross characters of silicified trunks. The ferns

[1] Wieland, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1906, pp. 317-325, pl. lxxiii, figs. 15a-d; American Fossil Cycads, Carnegie Institution of Washington, Publ. No. 34, 1906.

number 13 species, and there are 8 conifers and 1 equisetum. Ten Potomac species are more or less satisfactorily represented and 2 or 3 additional are doubtfully represented.

Portugal

The Portuguese beds which have been referred to the Aptian by Choffat and Saporta contain the following flora according to Saporta:

Bambusium latifolium Heer ?
Brachyphyllum confusum Saporta
Brachyphyllum obesum Heer
Carpites burmanniœformis Saporta ?
Caulinites atavinus Heer
Cladophlebis Dunkeri (Schimper) Seward
Ctenidium dentatum Heer
Ctenidium integerrimum Heer
Czekanowska nervosa Heer
Frenelopsis leptoclada Saporta
Frenelopsis occidentalis Heer ?
Laccopteris pulchella Heer
Matonidium Althausii (Dunker) Ward
Onychiopsis psilotoides (Stokes and Webb) Ward
Poacites plurinervius Saporta
Sequoia lusitanica Heer
Sphenolepidium debile Heer
Sphenolepis Kurriana (Dunker) Schenk
Sphenolepis Sternbergiana (Dunker) Schenk
Sphenopteris angustiloba Heer
Sphenopteris plurinervia Heer ?
Sphenopteris tenuifissa Saporta
Tœnidium lusitanicum Heer
Thuyites debilis Saporta
Thuyites pulchelliformis Saporta

Seven of the foregoing are ferns, 2 are cycads, and 11 are conifers. Three of the forms are considered monocotyledons. Four of the species are present in the Potomac flora.

France

The following two species are recorded from beds referred to the Aptian[1] in the French area:

Cylindrites latifrons Saporta
Pinus mammilifer Saporta

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[1] Saporta, Mém. Soc. Géol. de Normandie, 1877.

Germany

Hosius and von der Marck[1] have recorded the following species from the Lower Gault of Westphalia:

Clathraria galtiana Hos. & v. d. Marck
Lonchopteris recentior Schenk
Megalozamia falciformis Hos. & v. d. Marck

Lorenz[2] has described the following fucoidal remains from the Kreideflysch, some of which are of Aptian age:

Caulerpa sp.
Diplopora muhlbergii Lorenz
Fucoides cf. *latifrons* Heer
Granularia sp.
Keckia sp.
Phycopsis affinis Sternb.
Phycopsis arbuscula Fischer-Oost.
Phycopsis intricata Brongn.
Phycopsis Targioni Brongn.

Switzerland

A single species, *Ginkgo Jaccardi,* is described by Heer[3] from Swiss deposits which are considered of lower Aptian age.

Italy

The so-called scaly clays of Emilia, Italy (argiles écailleuses, argille scagliose), have been referred to a number of geological horizons, but of late years, as a result of the studies of Capellini,[4] they have been considered of Lower Cretaceous age, the cycad trunks for which they are chiefly celebrated being considered Aptian. The following species of the latter have been described:

Cycadeoidea Bianconiana Massalongo
Cycadeoidea Capelliniana Solms.
Cycadeoidea cocchiana Caruel

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[1] Hosius and von der Marck, Palæont., Band xxvi, 1880, pp. 77-80, 99.

[2] Lorenz, Bericht Naturf. Gesell. z. Freiburg, Band xii, 1902.

[3] Heer, Fl. Foss. Helvetiæ, vierte Abth., 1877, p. 146, pl. lviii, fig. 20.

[4] Capellini and Solms-Laubach, I tronchidi Bennettitee dei Musei Italiana, Mem. R. Accad. Sci. Inst. di Bologna, ser. v, tomo ii, 1892, pp. 161-206, pls. i-v. Capellini, Le Cicadee Fossili del Museo geologico di Bologna, Mem. R. Accad., Sci. Inst. di Bologna, ser. vi, tomo vi, 1909, pp. 51-69, pls. i, ii.

Cycadeoidea etrusca Cap. and Solms.
Cycadeoidea Ferrettiana Cap. and Solms.
Cycadeoidea imolensis Cap. and Solms.
Cycadeoidea intermedia Ranzani
Cycadeoidea Maraniana Scarabelli
Cycadeoidea Masseiana Capellini
Cycadeoidea montiana Cap. and Solms.
Cycadeoidea Pirazzoliana Massalongo
Cycadeoidea Scarabelli Meneghini
Cycadeoidea veronensis Massalongo

The Albian Stage

The Black Hills Area

In the Black Hills area the Lower Cretaceous of Ward, previously referred to, has been divided by Darton[1] into several formations on the basis of certain lithological differences. The uppermost of these, termed the Fuson formation, contains a considerable flora, which has been correlated with the Albian of Europe. The plants have been described by Ward and Fontaine (*loc. cit.*) and include the following species:

Abietites longifolius (Font.) Berry
Abietites macrocarpus Fontaine
Acrostichopteris pluripartita (Font.) Berry ?
Araucarioxylon Hoppertonæ Knowlton
Arthrotaxopsis grandis Fontaine ?
Carpolithus virginiensis Fontaine
Cephalotaxopsis magnifolia Fontaine
Cladophlebis Ungeri (Dunk.) Ward ?
Cladophlebis wyomingensis Font. (cf. *virginiensis* Font.)
Cycadeospermum rotundatum Fontaine
Equisetum Burchardti (Dunk.) Brongn.
Feistmantelia oblonga Ward
Ficophyllum serratum Font. (not a *Ficophyllum*)
Geinitzia Jenneyi Fontaine
Leptostrobus alatus Ward
Matonidium Althausii (Dunk.) Ward
Pecopteris borealis Brongn. (*Cladophlebis* or *Gleichenia*)
Pinus susquæensis Dawson
Quercophyllum wyomingense Fontaine
Sapindopsis variabilis Fontaine
Sequoia ambigua Heer
Sequoia Reichenbachi (Gein.) Heer

[1] Darton, 21st Ann. Rept. U. S. Geol. Surv., pt. iv, 1901, pp. 489-599.

Sphenolepis Kurriana (Dunk.) Schenk
Ulmiphyllum densinerve Font. (a fern)
Weichselia reticulata (Stokes and Webb) Ward
Zamites (?) sp., Fontaine

Six are ferns, 2 are cycads, 11 are conifers, and 4 are angiosperms. About 13 of the species are identical with Potomac species.

Portugal

The Albian flora of Portugal is very extensive, part of it coming from the Vraconnian (Choffat) and a larger part from older Albian horizons. The following lists of species are taken from Saporta's final revision of these Portuguese floras:

Adiantum dilaceratum Saporta
Adiantum eximium Saporta
Adiantum expansum Saporta
Adiantum tenellum Saporta
Adoxa præatavia Saporta
Aralia calomorpha Saporta
Aralia proxima Saporta
Aristolochia Daveauana Saporta
Aristolochia vetustior Saporta
Baiera cretosa Schenk
Brachyphyllum obesiforme Saporta
Brachyphyllum obesiforme elongatum Saporta
Braseniopsis venulosa Saporta
Braseniopsis villarsioides Saporta
Cissites parvifolius (Font.) Berry
Cissites sinuosus Saporta
Cladophlebis confusior Saporta
Cladophlebis Ungeri (Dunk.) Ward
Cladophlebis Limai Saporta
Cladophlebis obtusiloba Saporta
Cussonia ? lacerata Saporta
Cycadites pygmæus Saporta
Cycadites tenuisectus Saporta
Eolirion lusitanicum Saporta
Frenelopsis occidentalis Heer
Magnolia Delgadoi Saporta
Menispermites cercidifolius Saporta
Myrsinophyllum revisendum Saporta
Nelumbium lusitanicum Saporta [1]
Nelumbium Choffati Saporta [1]

[1] Compt. rénd. 12 Nov., 1894, p. cxix.

Onychiopsis psilotoides (Stokes and Webb) Ward
Palæocyparis obscura Saporta
Palæolepis bicornuta Saporta
Palæolepis emarginata Saporta
Pecopteris dispersa Saporta
Pecopteris minutula Saporta
Peucedanites primordialis Saporta
Phlebomeris ? falciformis Saporta
Phlebomeris spectanda Saporta
Phlebomeris Wilkommi Saporta
Pinites cyclopterus Saporta
Poacites lævis Saporta
Podozamites ellipsoideus Saporta
Podozamites gracilior Saporta
Podozamites Henriquesi Saporta
Podozamites modestior Saporta
Proteophyllum dissectum Saporta
Proteophyllum leucospermoides Saporta
Proteophyllum oxyacanthæmorphum Saporta
Pteridoleimma phycomorpha Saporta
Ruffordia Gœpperti (Dunk.) Seward
Salix infracretacica Saporta
Salix retinenda Saporta
Sassafras protophyllum Saporta
Sequoia subulata Heer *lusitanica* Saporta
Sphæria phylostichoides Saporta
Sphenolepidium debile Heer
Sphenolepis Kurriana (Dunk.) Schenk
Sphenolepis Sternbergiana (Dunk.) Schenk
Sphenopteris crenularis Saporta
Sphenopteris debilior Saporta
Sphenopteris flabellina Saporta
Sphenopteris involvens Saporta
Sphenopteris pseudo-cordai Saporta
Sphenopteris recurrens Saporta
Sphenopteris tenuifissa Saporta

The list includes over 20 ferns, 18 gymnosperms, of which 6 are cycads and 22 angiosperms. Six of the species are represented in the Potomac flora and a number of types are closely allied.

Vraconnian (Upper Albian) of Portugal

Brachyphyllum obesum Heer
Carpites granulatus Saporta
Eucalyptus angusta Saporta
Eucalyptus Choffati Saporta

Eucalyptus proto-Geinitzi Saporta
Frenelopsis occidentalis Heer
Laurus attenuata Saporta
Laurus notandia Saporta
Laurus palæocretacea Saporta
Leguminosites infracretacicus Saporta
Myrica lacera Saporta
Myrica revisenda Saporta
Myrsinophyllum venulosum Saporta
Phyllites inflexinervis Saporta
Phyllites triplinervis Saporta
Proteophyllum daphnoides Saporta
Proteophyllum demersum Saporta
Proteophyllum oblongatum Saporta
Proteophyllum truncatum Saporta
Ravenalospermum incertissimum Saporta
Salix assimilis Saporta
Sapindophyllum brevior Saporta
Sapindophyllum subapiculatum Saporta
Sphenolepis Kurriana (Dunk.) Schenk
Sphenolepis Sternbergiana (Dunk.) Schenk
Viburnum vetus Saporta

Cycadophytes and ferns have not been described from this Vraconnian flora, which is largely made up of angiosperms of Upper Cretaceous affinities. Only two species, the widespread conifers of the genus *Sphenolepis*, are represented in American floras, although practically all of the genera are represented on this side of the Atlantic.

France

The Albian of France has furnished a considerable flora, the elaboration of which is largely the work of Fliche,[1] although Saporta[2] described several species at an earlier date.

The recorded species include the following:

Abietites Chevalieri Fliche
Amphibennetites Bleicheri Fliche
Amphibennetites Renaulti Fliche

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[1] Fliche, Note sur les nodules et bois minéralisés trouvés à St. Parresles-Vaudes (Aube) dans les grès verts infracrétacés, Mém. Soc. Acad. Aube, tome lx, 1897. Fliche, Études sur la Fl. Foss. del 'Argonne, Bull. Soc. Sci. Nancy, 1896.

[2] Saporta, 1877, *loc. cit.*

Araucaria cretacea (Brongn.) Schimper
Araucaria insulinensis Fliche
Araucaria reperta Fliche
Araucaria Revigniacensis Fliche
Araucarioxylon albianum Fliche
Cedroxylon reticulatum Saporta
Cedrophloios Bleicheri Fliche
Cedrus oblonga (L. and H.) Fliche
Cupressinoxylon infracretaceum Fliche
Cycadeoidea argonnensis Fliche
Cycadeoidea colleti Fliche
Cycadeoidea semi-globosa Fliche
Cycadeoidea sp., Fliche
Laurus Colleti Fliche (this may be Cenomanian in age)
Pinus argonnensis Fliche
Pinus Andrœi Coemans
Pinus mammilifer Saporta
Pinus prœmonticola Fliche
Pinus prohalepensis Fliche
Pinus Saportana Fliche
Pinus wohlgemuthi Fliche
Pityoxylon argonnense Fliche
Pityoxylon infracretaceum Fliche
Pityoxylon Thomasi Fliche
Protopteris Buvignieri Brongniart
Protopteris wohlgemuthi Fliche
Pseudo-araucaria Lamberti Fliche
Pseudo-araucaria Loppineti Fliche
Pseudo-araucaria major Fliche
Tsugites magnus Fliche
Yatesia Guillaumoti Fliche
Zamiostrobus Loppineti Fliche

England

The appended list of forms from the English Gault was compiled by Ward in 1896. As has been previously mentioned, the Lower Cretaceous floras are undergoing revision by Stopes.

Fucoides bignoriensis Mantell
Pinites Andrœi (Coem.) Gardner
Pinites gracilis Carruthers
Pinites hexagonus Carruthers
Pinites Mantelli Carruthers
Pinites patens Carruthers
Sequoiites Gardneri Carruthers
Sequoiites ovalis Carruthers

Africa (*Egypt*)

The Nubian sandstone which forms so extensive a part of the surface of the Libyan desert is regarded by De Lapparent as of Albian age.[1] Petrified woods were described by Unger from this area as early as 1843,[2] and again in 1858.[3] Carruthers,[4] Heer,[5] and Schenk[6] have also contributed to the subject. Most of the material described by these authors is Upper Cretaceous or later, Zittel, in his exhaustive report on the materials and results of the Rohlf's expedition,[7] regarding some of the plant horizons as Senonian (*Nicolia, Araucarioxylon,* etc.) and others Danian (*Diospyros, Royena,* etc.).

Considerable uncertainty regarding the exact age of some of the exposures still prevails. Recently Seward[8] records the following extremely fragmentary remains from various Nubian sandstone outcrops in Egypt:

Clathropteris egyptiaca Seward
Weichselia ?
Cladophlebis sp. cf. *Klukia*

These, if correctly identified, would indicate a Lower Cretaceous age, but the remains are so inconclusive, while the outcrop, according to Dr. Hume of the Egyptian Survey, is probably Upper Cretaceous in age (Campanian), so that the probability is all in favor of the *Clathropteris* representing a more recent genus of Dipteriaceæ, and the others of being incorrect identifications, as Professor Seward has already pointed out.

General Character and Distribution

When the species recorded from the Potomac Group are added to the foregoing incomplete lists a very considerable flora is recorded from the

[1] De Lapparent, Traité, tome iii, 1906, p. 1368.
[2] Unger in Endlicher's Genera Plantarum, Suppl. ii, 1843, p. 102.
[3] Unger, Sitzungs. K. Akad. Wiss., Wien, Bd. xxxiii, 1858, pp. 209-233, pls. i-iii.
[4] Carruthers, Geol. Mag., vol. vii, 1870, pp. 306-310, pl. xiv.
[5] Heer, Neue Denks. Schweiz. Gesell. Naturwiss., Bd. xxvii, Abth. i, No. 2, 1876, pp. 11, pl. i.
[6] Schenk, Palæontographica, Band xxx, 1883.
[7] Palæontographica, Band xxx, 1883.
[8] Seward, Geol. Mag., dec. v, vol. iv, 1907, pp. 253-257, tf. 1-3.

Lower Cretaceous as a whole. While this necessarily represents but a small percentage of the species which clothed the earth during that period, it furnishes some data bearing on the march of vegetation during which the transformation from a Jurassic to an Upper Cretaceous and essentially Cenozoic type occurred. This flora shows evidence in the varying proportions which the main types, such as the ferns, cycadophytes, and conifers, bear to one another, that we have represented plants which grew under considerable local differences of soil, altitude, humidity, and precipitation conditions.

It is apparent that the dominant types of the late Jurassic floras continued without marked change throughout the older Cretaceous. These are the ferns, cycadophytes, and gymnosperms. We know little about the Thallophyta, the Bryophyta, or the Lycopodiales. The Equisetales had evidently dwindled to proportions strictly comparable to their present day deployment. The more characteristic fern families of the older Mesozoic, such as the Marattiaceæ, are greatly reduced in importance, and the families[1] Schizæaceæ, Gleicheniaceæ, Matoniaceæ, Osmundaceæ, and Dipteriaceæ, which are of great importance in the early part of the Lower Cretaceous, were destined to be overshadowed by the Polypodiaceæ before the close of the Cretaceous, ferns of this type represented in the eastern United States by various species of *Cladophlebis* and *Onychiopsis* being already the most abundant numerically even as early as the beginning of the Patuxent. Pteridospermæ are unknown, and it is within reason to suppose that this class was no longer represented in the flora of the world.

The Cycadophytes of the early Cretaceous are essentially the familiar, even if too little known, types of the later Jurassic. They are abundant in genera, species, and individuals, and are quite as dominant an element in the earlier Cretaceous as in the Rhætic and Jurassic floras. Before the close of the Lower Cretaceous, however, they became largely extinct. The other gymnospermic types—the Ginkgoaceæ, Taxaceæ, and Pinaceæ

[1] These family names are used in a generalized sense and not as if they were coterminous with our modern groups of the same names.

—are all represented in the early Cretaceous floras. The Ginkgoaceæ, to which some at least of the species of *Baiera* belong, are much less prominent than in the Jurassic. The Taxaceæ are well represented and seem to have been relatively more prominent than at the present day.

The Pinaceæ are relatively well represented, especially when it is remembered that they were largely upland types then as now, and that they lack the advantage over Cycadophytes, and to a certain extent over Ferns as well, of resisting maceration. The Araucariaceæ are an important element among the Lower Cretaceous conifers, some forms in their foliage characters, cone-habit, and anatomy scarcely distinguishable from their well known and rather isolated descendants of the present day. Others, less certainly identified, indicate a considerable adaptive radiation of forms of this general type during all of Cretaceous time.

With regard to the dominant modern class, the Angiospermæ, little of importance can be stated with precision. Certain genera from the oldest Potomac, namely, *Rogersia, Ficophyllum,* and *Proteæphyllum,* have been described as angiosperms. The writer is convinced that these forms are not angiosperms, but are probably Gnetales, although it must be said in all frankness that there is no real evidence one way or the other on this question, and it would do little or no violence to the known facts if some of them were referred to the Filicales, a reference already amply proven for one at least of Saporta's Proangiosperms, the genus *Protorhipis.* The latter author classes a number of indefinite forms from the Neocomian and later Lower Cretaceous horizons of Portugal as Proangiosperms, such fragments as have received the generic appellations of *Poacites, Rhizocaulon,* etc., while other similar fragments are classed as monocotyledons. The evidence of the angiospermic nature of any of these remains is scarcely worthy of confidence. Nothing remotely suggestive of this class is known from the Wealden floras of England, Belgium, or Germany, the Neocomian flora of Japan, the Kootanie flora of Montana and British Columbia, or even from the Barremian of Russia, France, and England. The so-called Urgonian of Greenland contains undoubted dicotyledons, but their exact age is not altogether beyond question, and they may be considerably younger. There is fairly satisfactory evidence of angiosperms in beds which are classed as Aptian, and by the close of the Albian dicotyledons become a considerable element in the floras. As regards species they form 30 per cent of the Patapsco flora, 17 per cent of the Fuson flora, and over 35 per cent of the Albian flora of Portugal.

It would doubtless be interesting to pursue the subject in more detail, to discuss the probable place and manner of origin of this latest and most highly organized class of plants, as well as its early paths of migration, but the subject is so highly speculative that it may well await the enlargement of the bounds of our knowledge.

The same statement is in a measure true of attempts to describe Lower Cretaceous climatic conditions. The floras are so different in every way from those of the present that it is unsafe to lean too strongly on the facts which may be deduced from the present climatic distribution of the sometimes remotely related representatives of these ancient types in the existing flora. It would be foolhardy to guess at actual temperatures. With regard to more general statements and questions of moisture the basis is not quite so insecure. The floras certainly show such slight changes which may be legitimately related to temperatures when they are traced from place to place, that a marked uniformity of temperature conditions over a great many degrees of latitude must be admitted. The accompanying sketch map shows in a general way the location of the known Lower Cretaceous floras. That from Peru is within 15 degrees of the equator, while that from western Greenland is in latitude 70° North, and that from Spitzbergen is from latitude 78° North, and even if the latter is latest Jurassic instead of earliest Cretaceous, it serves equally well to indicate that climatic conditions were much more uniform than they are at the present time.

It seems quite obvious from a consideration of the large-fronded ferns and cycads of the Potomac flora that they could not have withstood a winter as severe as the average winter of to-day in the latitude of Maryland. The petrified woods show seasonal changes, but the width of the active growth-ring is very wide, and that of restricted growth is narrow and more or less irregular, and is as readily explained by a dry season as by a cold winter, nor are there any known deciduous forms.[1] While the data are not conclusive it seems certain that the Potomac climate was considerably warmer than that of to-day, with much less change from

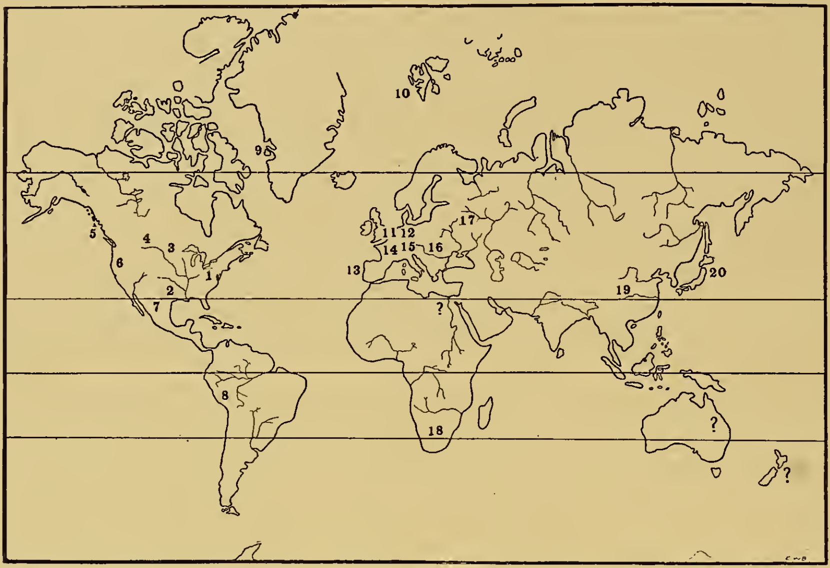

FIG. 1.—Sketch map of the world showing the approximate location of outcrops containing Lower Cretaceous Plants.

1. Potomac Group (Patuxent, Arundel, Patapsco formations), Maryland-Virginia area.
2. Glen Rose beds (Trinity Group), Texas area.
3. Black Hills area (Lakota, Fuson formations).
4. Kootanie area, Montana, British Columbia.
5. Lower Cretaceous, Queen Charlotte Islands.
6. Shasta area (Upper Knoxville and Horsetown beds).
7. Mexico (Neocomian).
8. Peru (Neocomian).
9. Kome beds, Greenland.
10. Spitzbergen (possibly of Jurassic age).
11. Southern England (Wealden, Barremian, Aptian, Albian) and Belgium (Bernissartian).
12. Germany (Wealden, Aptian).
13. Portugal (Neocomian, Barremian, Aptian, Albian).
14. France (Neocomian, Barremian, Aptian, Albian).
15. Switzerland (Neocomian, Aptian) and Italy (scaly clays of Emilia).
16. Austria Hungary (Barremian).
17. Klin Sandstone (Barremian).
18. Uitenhage series.
19. Southwest China (Neocomian).
20. Japan (Neocomian).

season to season, and with a very long growing period. The rainfall must have been ample and fairly well distributed, and the indications point to a rather high percentage of humidity throughout the major portion of

[1] *Laricopsis* and certain cycadophytes such as *Zamites* and *Podozamites* may be exceptions to this statement.

the year. The Patuxent and Arundel floras may be compared with certain modern temperate rain-forests made up of a dense growth of ferns and cycads in more or less pure stands, with occasional conifers towering above the general level of the vegetation, which was relatively low, and gradually predominating in passing from the coast to the uplands.

The Potomac floras, which are the most extensive known floras from the Lower Cretaceous and only rivalled by those from Portugal, serve admirably to indicate the progression of the plant world during the Lower Cretaceous.

Omitting certain forms from the Virginia area which have not yet been studied and which do not materially alter the proportions, and excluding doubtful species like those of *Carpolithus* and other indefinite genera, we find about 100 species in the Patuxent flora. These include 36 species of ferns, 2 equisetums, 29 cycadophytes, 1 Baiera, 24 conifers, 19 of which belong to the Pinaceæ, and the remainder to the Taxaceæ, and 6 altogether doubtful angiosperms. The Arundel flora is only one-third as extensive as the Patuxent and contains but 10 species of ferns, 5 cycadophytes, 13 conifers, including 10 in the Pinaceæ, and 3 in the Taxaceæ, and 5 questionable angiosperms. The Patapsco flora, which is about the same size as that of the Patuxent, contains 23 ferns, the same two equisetums as the Patuxent, 10 cycadophytes, 17 conifers, including 14 Pinaceæ and 3 Taxaceæ, and about 25 angiosperms, most of which are reliably determined.

CORRELATION OF THE POTOMAC FORMATIONS

BY

EDWARD W. BERRY

The character of the evidence in general available for purposes of correlation, has been admirably stated by Bernard,[1] Clark,[2] Ward,[3] and others, and need not be dwelt upon at length in the present connection. Some of the criteria, which may be given greater or less weight, may be briefly enumerated as follows:

1. Identical or closely allied (affiliated) genera and species. This is the old and always useful method of establishing correlations, though it practically ignores the principle of homotaxis. Too much reliance cannot be placed on percentages, and the individual abundance of types is an important factor which should always be carefully considered.

2. Latest appearance of identical or allied types. This is of less value than the next following.

3. Earliest appearance of similar types whose ancestors presumably originated elsewhere.

4. Similarity in stage of development of geographically separated faunas and floras. Facts of morphology, habit, and structure, and of organs and tissues are considered as well as the systematic differentiation.

5. Dominance of certain types or general character of the facies, in part the reciprocal of Nos. 1-4.

6. Diastrophism, or the relation of the broader changes of crustal history to biological history.

[1] Bernard, Éléments de Paléontologie, Paris, 1895.

[2] Clark, Bull. U. S. Geol. Surv., No. 141, 1896, pp. 47-53.

[3] Ward, Principes et méthodes d'étude de corrélation géologique au moyen des plantes fossiles. Compte-Rendu cinq. Sess. Congrés Géol. Internat., Washington, 1891, pp. 97-109. In English in Amer. Geol., vol. ix, 1892, pp. 34-47.

7. Similarity or diversity of contemporaneous physical conditions as reflected by the character of sedimentation and the biota (ecological grouping).

8. Stratigraphic continuity, similarity or diversity of the stratigraphic succession.

One of the first questions to be considered is the relation which the floras of the different Potomac formations bear to one another. The Patuxent flora, comprising about 100 species, contains the following forms, about two score in number, which have not been detected in the Arundel or Patapsco floras:

Schizæopsis americana
Ruffordia Gœpperti
Acrostichopteris cyclopteroides
Acrostichopteris parvifolia
Dryopterites macrocarpa
Dryopterites cystopteroides
Dryopterites dentata
Aspleniopteris pinnatifida
Aspleniopteris adiantifolia
Onychiopsis brevifolia
Sagenopteris latifolia
Sagenopteris virginiensis
Tæniopteris auriculata
Tæniopteris nervosa
Thinnfeldia rotundiloba
Cycadeoidea (probably all nine species)
Ctenopteris longifolia
Ctenopsis latifolia
Zamiopsis petiolata
Zamiopsis laciniata
Zamites crassinervis
Podozamites inæquilateralis
Podozamites distantinervis
Baiera foliosa
Cephalotaxopsis magnifolia
Cephalotaxopsis brevifolia
Cupressinoxylon Wardi
Cupressinoxylon McGeei
Laricopsis angustifolia
Sequoia rigida
Sequoia delicatula
Proteæphyllum reniforme
Proteæphyllum ovatum

The foregoing constitute about 40 per cent of the whole flora, and none of these occur outside of North America except the Ruffordia, which is a widespread Wealden type.

The Arundel flora numbering 33 species contains the following species which are not present in the older Patuxent or the younger Patapsco floras:

Thinnfeldia marylandica
Cycadeospermum marylandicum
Rogersia angustifolia parva
Cedrus Leei

With the exception of these four species, together with *Cycadeospermum obovatum,* all of the species which are recorded from the Arundel formation are common in the Patuxent, while these 4 species and 13 additional forms have not been found in the younger Patapsco flora. The relation of the Arundel to the Patuxent formation is, however, much closer than these figures indicate, since 24 Patuxent species which have not been detected in the Arundel survive in the Patapsco, and therefore must have been present during the deposition of the Arundel, but failed to be preserved or discovered. This leaves the five species enumerated above as the sole distinction between the Patuxent and Arundel floras, and with the exception of the unique *Cedrus Leei* all are older genera well represented by closely allied species in the Patuxent, as well as in other early Cretaceous floras. It is quite probable that if the Arundel flora were more extensively preserved other peculiar types would be discovered, nevertheless it is perfectly apparent that the Arundel flora is closely allied to the flora which preceded it, and the interval separating the two floras, if there was such an interval, was one of short duration. This is strikingly confirmed by the relations existing in the western interior between the Patuxent-Arundel flora, as developed in the Kootanie formation of Montana and British Columbia, and the Arundel vertebrate fauna which finds its closest similarity in the Morrison (Atlantosaurus, Como) fauna.

The two flora's have a great many elements in common, and upon the basis of the floras alone the conclusion would be reached that the base of the Kootanie was approximately the same age or slightly older than the base of the Patuxent. When the faunas are considered it develops that the Morrison fauna, which is considered by many paleontologists to be of Jurassic age, is found conformably beneath the beds containing the Kootanie flora, which is of unquestioned Lower Cretaceous age. Along the Atlantic seaboard this is reversed, and the bulk of the flora corresponding to that of the Kootanie underlies beds containing a large representation of the Morrison fauna, and which also has been considered to be of Jurassic age by Marsh and others.

The Patapsco flora, on the other hand, is decidedly different from the flora of the underlying Arundel formation, and this difference is not so much an extinction of earlier forms, although the extinctions have been considerable, as it is an introduction of higher forms of a decidedly Neocretaceous facies.

The following older Cretaceous species, sixty-one in number, appear to have become extinct before the dawn of the Patapsco. These include 17 ferns, 24 cycadophytes, 1 member of the ginkgoales, 2 taxaceous forms, 10 conifers, and all of the supposed primitive angiosperms, 7 in number:

Schizæopsis americana
Ruffordia Gœpperti
Acrostichopteris cyclopteroides
Acrostichopteris parvifolia
Dryopterites macrocarpa
Dryopterites cystopteroides
Dryopterites dentata
Aspleniopteris pinnatifida
Aspleniopteris adiantifolia
Cladophlebis Albertsii
Onychiopsis brevifolia
Sagenopteris latifolia
Sagenopteris virginiensis
Tæniopteris auriculata
Tæniopteris nervosa
Thinnfeldia rotundiloba
Thinnfeldia marylandica
Cycadeoidea (probably all nine species)
Cycadeospermum marylandicum
Cycadeospermum acutum
Cycadeospermum rotundatum
Cycadeospermum spatulatum

Ctenopteris longifolia
Ctenopteris insignis
Ctenopsis latifolia
Nilsonia densinerve
Dioonites Buchianus
Zamiopsis petiolata
Zamiopsis laciniata
Zamites crassinervis
Podozamites inæquilateralis
Podozamites distantinervis
Baiera foliosa
Cephalotaxopsis magnifolia
Cephalotaxopsis brevifolia
Cupressinoxylon Wardi
Cupressinoxylon McGeei
Arthrotaxopsis expansa
Arthrotaxopsis grandis
Frenelopsis ramosissima
Brachyphyllum parceramosum
Laricopsis angustifolia
Cedrus Leei
Sequoia rigida
Sequoia delicatula
Proteæphyllum reniforme
Proteæphyllum ovatum
Rogersia longifolia
Rogersia angustifolia
Rogersia angustifolia parva
Ficophyllum serratum
Ficophyllum oblongifolium

Forty-one Patuxent-Arundel species are known to persist in the Patapsco flora, while the following Patapsco species are unknown in either the Patuxent or Arundel floras:

Acrostichopteris longipennis
Knowltonella Maxoni
Dicksoniopsis vernonensis
Dryopterites pinnatifida
Tempskya Whitei
Selaginella marylandica
Dichotozamites cycadopsis
Podozamites Knowltoni
Araucarites aquiensis
Araucarites patapscoënsis
Abietites marylandicus
Pinus vernonensis

Widdringtonites ramosus
Cyperacites potomacensis
Plantaginopsis marylandica
Alismaphyllum Victor-Masoni
Populus potomacensis
Populophyllum minutum
Populophyllum reniforme
Nelumbites virginiensis
Nelumbites tenuinervis
Sapindopsis variabilis
Sapindopsis magnifolia
Sapindopsis brevifolia
Celastrophyllum denticulatum
Celastrophyllum parvifolium
Celastrophyllum latifolium
Celastrophyllum acutidens
Celastrophyllum Brittonianum
Celastrophyllum Hunteri
Celastrophyllum albædomus
Cissites parvifolius
Araliæphyllum crassinerve
Araliæphyllum magnifolium
Hederæphyllum dentatum
Aristolochiæphyllum crassinerve
Aristolochiæphyllum ? cellulare
Menispermites potomacensis
Sassafras bilobatum
Sassafras parvifolium
Sassafras potomacensis

The total number of forms introduced with the dawn of the Patapsco formation numbers 42 species and includes 5 ferns, 3 of the genera of which are unknown in the preceding floras; 1 Selaginella, which is a decidedly modern type, unique in the fossil state; 3 cycadophytes, among which the genus *Dichotozamites* is new; 5 conifers, among which the genera *Pinus* and *Widdringtonites* are unrepresented in the Patuxent-Arundel floras, and *Araucarites* doubtfully so; 3 monocotyledons, all modern types; and 25 dicotyledons, which are distributed among 11 genera. All of these genera are unknown in the Patuxent-Arundel flora, and only one, namely, *Populus,* which also occurs in the somewhat uncertain Kome horizon, is known in pre-Albian beds anywhere. Moreover, nearly all of these genera are well represented in Upper Cretaceous floras, although none of the specific types except *Podozamites Knowltoni* and *Celastrophyllum Brittonianum* survive in the succeeding Raritan flora.

It seems obvious that this striking modernization of the flora which is first seen in the Patapsco, corroborated by the well-marked erosional unconformity between the Arundel and Patapsco formations in regions where the former intervenes between the Patuxent and Patapsco, indicates an interval of long duration, an interval during which the angiosperms, which so greatly outnumber any other class of plants in Upper Cretaceous and more recent floras, were evolved.

We are forced to the conclusion that the Patuxent-Arundel floras are essentially a unit of early Cretaceous age whose affinities all lie with the floras which preceded them, while the Patapsco flora, widely removed in time from the Patuxent-Arundel, heralds the approaching dominance of a new and more highly organized type of vegetation which was destined to so largely replace the strictly Mesozoic plant types early in Upper Cretaceous time.

Turning now to a comparison of the Potomac floras with floras outside of the Potomac province we may endeavor to fix their place in the Lower Cretaceous time scale of the world.

THE EUROPEAN FLORAS

It is obvious from a perusal of the discussion in the chapter devoted to the Lower Cretaceous floras of the world that no arguments are necessary to prove that the Patuxent-Arundel flora is post-Jurassic in age, a conclusion amply sustained by Professor Lull's discussion of the reptilian remains from the Arundel beds.

The Patuxent-Arundel flora contains but 2 species which have been recorded from the Portlandian, i. e., *Cladophlebis Browniana* and *Sequoia Reichenbachi,* and one additional older Mesozoic species, *Podozamites lanceolatus,* which, with the *Sequoia,* is of no significance since both continue through the Upper Cretaceous, and both may be composite species.[1] A large number of the genera, however, are well-known Jurassic types, and it is this feature which gives the apparent Jurassic facies to the Potomac, Wealden, and other Neocomian floras.

Sixteen Patuxent species, some of which are doubtful determinations, are present in the European Wealden floras, while 3 additional species are recorded from floras which are classed as Neocomian. There are in addition 12 species which are very similar to foreign Wealden and Neocomian types, as indicated in the table of distribution. There are 13 species present in the foreign Barremian, and 11 additional species which are closely allied to Barremian types.

Comparison with Aptian floras shows 2 identical species and 4 additional allied forms. Eight species continue in the European Albian and 11 additional are similar to European Albian species, largely those of Portugal. When these facts are considered along with those furnished by the Arundel reptilia, and when the Patuxent-Arundel floras are studied in comparison with those from other American Lower Cretaceous localities, the conclusion is reached that the Patuxent and Arundel formations considered as a unit represent all except possibly the earliest part of the Neocomian and all of the Barremian of the standard European section.

Turning to the Patapsco flora it may be noted that none of the species which are peculiar to this flora, when compared with the underlying Patuxent-Arundel floras, occur in the European Cretaceous except *Cissites parvifolius,* which is found in the Albian of Portugal. A considerable number, however, among which may be mentioned *Cyperacites potomacensis, Populophyllum reniforme, Celastrophyllum acutidens,* and *Sassafras potomacensis* are represented by closely allied species in the Albian of Portugal. Moreover, the latter flora closely parallels the Patapsco, in that both mark the first abundant appearance of undoubted dicotyledons and a persistence of a considerable number of the earlier Cretaceous types,

[1] *Dioonites Buchianus* and some few other species have been recorded by various students from Jurassic deposits but the identifications are not above suspicion.

which survive in both the Patapsco flora and that of the Albian of Portugal.

On the basis of this close similarity between these two floras on opposite sides of the Atlantic, and the fact that both mark the first abundant appearance of Dicotyledonæ, and the further fact that the Patapsco formation, is overlain unconformably by the Raritan formation, carrying an abundant and unmistakably Cenomanian flora,[1] the Patapsco formation is considered of Albian age. The unconformity which separates the Patapsco formation from the underlying Potomac beds is believed to represent all or nearly all of the time interval represented by the Aptian stage of European geology.

Having established with a considerable degree of certainty the European equivalents of the Potomac formations, a comparison may be instituted between the flora of the Potomac and that of other North American Lower Cretaceous deposits.

THE TRINITY FLORA OF TEXAS

The Trinity flora is small and poorly preserved and is represented by fragmentary remains of 25 species.

Several of these occur in the Potomac. Of these *Brachyphyllum parceramosum, Cycadeospermum rotundatum,* and *Dioonites Buchianus* do not range above the Arundel, and while three or four species are common to the Trinity and Patapsco floras, these all extend back to the Patuxent. Since there are no characteristic Patapsco species in the Trinity it is conclusively pre-Albian in age. As has previously been mentioned, French paleontologists, upon the evidence of the invertebrate fossils, consider the Trinity to be of Aptian age. The flora is not extensive enough for direct comparison with the relatively scant floras of the European Aptian, and while the writer would be inclined to consider the Trinity as somewhat older than this, the contained flora cannot be said to furnish reliable evidence contrary to such an assumption, since most of the Trinity plants are widespread types, both geographically and

[1] Berry, Journ. of Geol., vol. xviii, 1910, pp. 252-258.

geologically, facts due in a considerable measure to their resistance of maceration. The same statement would apply to the very meagre flora described by Nathorst from Mexico.

The Lakota Flora of the Black Hills

The Lakota flora contains numerous silicified trunks of *Cycadeoidea* similar in their external features and internal organization to those of the Potomac, some of which may prove to be specifically identical when their anatomy shall have been studied. In addition, at least 12 species are common to the Potomac and the Lakota. These include 8 ferns, 1 equisetum, and 3 taxoid conifers, all of which are found in the Patuxent, 8 occur in the Arundel, and 10 occur in the Patapsco. None of the modern types of the Patapsco are present, and the flora is certainly pre-Albian in age. It is not as old as the basal Patuxent, and may be considered to represent the upper part of the Barremian and the lower part of the Aptian of Europe.

The Fuson Flora of the Black Hills

The Fuson flora is a limited one, embracing only 26 identified forms, of which 3 or 4 survive from the Lakota flora. At least 11 of the species are more or less positively identified with species described originally from the Potomac. Six of these range from the Patuxent through the Patapsco. *Cephalotaxopsis magnifolia* is confined to the Patuxent, while on the other hand, *Sapindus variabilis* is one of the type fossils of the Patapsco, and far outweighs the former in any determination of age. There are fragmentary remains of other dicotyledons in this flora, and also a species of *Geinitzia,* a coniferous genus more especially characteristic of Upper Cretaceous horizons. The Fuson therefore is considered more or less synchronous with the Patapsco formation, and Albian in age.

The Kootanie Flora

The Kootanie flora of Montana and British Columbia is an extensive one, consisting of 86 nominal species, of which at least 20 are present in the Potomac and several others are closely related to species which occur in the Potomac. Six of these are forms which do not range above the Patuxent-Arundel in the east. No characteristic Patapsco species is known from the Kootanie, nor have any dicotyledons been discovered. There are also represented several species which are not known from horizons later than the Wealden and Neocomian, while both Dawson and Fontaine have recorded several Jurassic (Oolite) species in this flora, although these particular identifications are not entirely above suspicion, since neither of these students was always as careful as is desirable in some of their comparisons. Nevertheless several types which are usually considered as especially characteristic of Jurassic floras, such as *Ginkgo* and *Protorhipis,* are represented in the Kootanie flora.

There are also present a large number of Kome species (Greenland) and several from the Barremian of Europe, so that the Kootanie cannot be considered younger than the Patuxent-Arundel of Maryland, and it may be in part slightly older, although the two were at least partly contemporaneous.

The Kootanie flora is of especial interest because its relations with the older Morrison formation make it possible to compare the Patuxent-Arundel flora and the contemporaneous reptilian fauna with the corresponding flora and fauna of the Morrison-Kootanie. The age of the Morrison (Atlantosaurus beds of Marsh, Como beds of Scott, Beulah shales of Jenney, etc.) has long been disputed, vertebrate paleontologists, who alone have been competent to speak on the subject, having, with the exception of Williston regarded them as Jurassic. The latter author has on several occasions pointed out their probable Lower Cretaceous age.[1] Lull's studies of the Arundel Reptilia lends considerable weight to Williston's position. Fisher[2] has traced the Kootanie southward into the Big Horn basin, where it was named the Cloverly formation by Darton, and has differentiated the Morrison beneath the former in the Great Falls area, where there is no apparent unconformity between the two. It

[1] Williston, Journ. Geol., vol. xiii, 1905, pp. 342-350; vol. xviii, 1910, p. 93.
[2] Fisher, Economic Geol., vol. iii, 1908, p. 77; Bull. U. S. Geol. Surv., No. 356.

seems probable that this general horizon in the Rocky Mountain area has been regarded as Morrison, where it contains vertebrate remains and Kootanie where it contains plant remains, while to the eastward it may be represented by marine Comanchean deposits. The recent discovery of a Sauropod dinosaur in the Trinity of Oklahoma adds probability to this supposition. While it is no part of the present purpose to discuss at length the stratigraphic or faunal evidence of the age of the Morrison, the presence of the Patuxent-Arundel flora in the Kootanie and the similarities between the Arundel and Morrison faunas would seem to lend strong probability to the view that the Morrison is Lower Cretaceous and not Jurassic. This probability receives additional support from the admitted Upper Jurassic age of the underlying Baptanodon beds, so called.

THE UPPER KNOXVILLE FLORA

The flora of the Cretaceous portion of the Knoxville beds in the Pacific coast region of North America is an extensive one, although the specimens are for the most part fragmentary and poorly preserved. A total of 35 species is recorded from this horizon in the present list (see *supra*). About one-third of these are specifically identical with or closely allied to Potomac species. No dicotyledons are certainly known, and the species with an outside distribution are either forms with a considerable vertical range or are confined to Wealden, Neocomian, or Barremian horizons. Since there is no known unconformity between these beds and the Upper Jurassic portion of the Knoxville it is quite obvious that the former must represent all of the Neocomian and probably the Barremian as well.

THE HORSETOWN FLORA

This flora is directly descended from that of the Upper Knoxville, which it resembles in having 12 out of a total of 28 species in common. Five fragmentary species of dicotyledons have been described from this horizon by Fontaine. They are very incomplete and ambiguous, but probably represent dicotyledons, the botanical affinities of which are entirely conjectural. Since there are no distinctively Patapsco types in this formation it is believed to correspond with all of the Aptian stage of European geology, possibly representing, in addition, the later Barremian and the early Albian.

General Considerations

Additional Lower Cretaceous floras from South America, Europe, Asia, and Africa have been discussed in the preceding chapter, and their arrangement has given ample expression of the writer's opinion of their relative ages as derived from a study of these floras. It does not seem worth while to attempt a detailed analysis of these floras at the present time, since lists of species and citations of authorities have already been given, while the accompanying tables of distribution amply illustrate their points of contact with the floras from the different formations of the Potomac Group.

While the geological range of a large number of these species is not known with precision, the data at hand are sufficient to justify the table of correlations given on page 172, especially as there is a considerable body of stratigraphical and paleozoölogical evidence in confirmation of that which is paleobotanical.

The liability to error in attempting correlations between remote areas is fully appreciated, and it would be unreasonable to suppose that the exact limits of a number of these floras will not be shifted back and forth as new or better evidence is discovered. Nevertheless the relative position of the main body of the respective floras in Lower Cretaceous chronology is believed to rest upon a fairly secure foundation.

Potomac Species Occurrence indicated by stars	Oolite	Purbeck	Portland	Wealden—England	Belgium	Germany	Neocomian—Mexico	Japan	Peru	Germany	Belgium	France	Portugal	Queen Charlotte Islands	Barremian—Greenland (Kome)	Austria	Germany	France	Portugal	Russia	Aptian—England	Portugal	Albian—England	France
FILICALES																								
Schizaeopsis americana																								
Ruffordia acrodentata				*																				
Ruffordia Goepperti				*	*	*		*					*		o	*			*	*				
Acrostichopteris cyclopteroides																								
Acrostichopteris adiantifolia																								
Acrostichopteris parvifolia				o																		o		
Acrostichopteris pluripartita										?									o			o		
Acrostichopteris longipennis																								
Acrostichopteris expansa																								
Knowltonella Maxoni																								
Dicksoniopsis vernonensis															o									
Cladophlebis Browniana			?	*		*		*					*			*								
Cladophlebis constricta										o					o									
Cladophlebis rotundata																								
Cladophlebis virginiensis								o																
Cladophlebis parva																								
Cladophlebis Albertsii				*		*										?				?				
Cladophlebis Ungeri				*	*	*		*					*			*								
Cladophlebis distans																								
Dryopterites macrocarpa																								
Dryopterites pinnatifida																								
Dryopterites cystopteroides																								
Dryopterites elliptica																								
Dryopterites dentata																								
Dryopterites virginica																								
Aspleniopteris pinnatifida																								
Aspleniopteris adiantifolia																								
Onychiopsis latiloba																								
Onychiopsis psilotoides				*	*	*				*			*			*			*			*		
Onychiopsis brevifolia																								
Onychiopsis Goepperti				*		*		*					*		?				*					
Onychiopsis nervosa													o						o			o		
Sagenopteris latifolia				o		o										o								
Sagenopteris elliptica				o		o								*		o								
Sagenopteris virginiensis																								
Tempskya Whitei				o		o																		
Taeniopteris auriculata																								
Taeniopteris nervosa				o		o							o		o									
Scleropteris elliptica																								
Thinnfeldia Fontainei																								
Thinnfeldia granulata								o																
Thinnfeldia rotundiloba																								
Thinnfeldia marylandica																								
LYCOPODIALES																								
Selaginella marylandica																								
EQUISETALES																								
Equisetum Lyelli				*					*															
Equisetum Burchardti				*		*		o					*			*								
CYCADOPHYTAE																								
Cycadeoidia marylandica																								
Cycadeoidia Tysoniana																								
Cycadeoidia McGeeana																								
Cycadeoidia Fontaineana																								

Belgium	Germany	Portugal	Switzerland	Cenomanian	Lakota	Fuson	Trinity—Texas	Kootanie	Upper Knoxville	Horsetown	Raritan	Jurassic—Cal. and Oregon	Spitzbergen	Species with which compared Occurrences indicated by circles
														Baiera cretosa Schenk.
		*					?							Sphenopteris species of Heer.
		o												Sphenopteris flabellina Sap.
					*									
								o						Acrostichopteris fimbriata Knowlton. Acrostichopteris Ruffordi Seward. Sphenopteris flabellisecta and tenellisecta of Saporta.
		o			*	*								Sphenopteris cuneifida, dissectiformis, tenuifissa and flabellina Sap.
		o												Sphenopteris debilior Saporta.
		o												Phlebomeris species of Saporta.
														Dicksonia bellidula Heer.
								*	*	*			?	
								*						Pecopteris species of Heer, Alethopteris cycadina Schenk.
								*	*					Cladophlebis Nathorsti Yokoyama.
					*			*	*					
				?									?	
		*				*		?	*					Dryopteris montanense Knowlton.
								*	*					
		*												
					*			*						
		*			*			*	*				?	
					*			*						
		*			*			*						
		o			*									Sphenopteris species of Saporta.
									?					Sagenopteris Mantelli (Dunker) Schenk.
								*	*					Sagenopteris Mantelli (Dunker) Schenk.
														Tempskya Schimperi Corda.
								o	*	*				Oleandridium Beyrichii Schenk and Oleandra arctica Heer.
														Adiantites lanceus Yokoyama.
								*						
					*									Equisetum ushimarense Yokoyama.

Potomac Species Occurrence indicated by stars	Oolite	Purbeck	Portland	Wealden—England	Belgium	Germany	Neocomian—Mexico	Japan	Peru	Germany	Belgium	France	Portugal	Queen Charlotte Islands	Barremian—Greenland (Kome)	Austria	Germany	France	Portugal	Russia	Aptian—England	Portugal	Albian—England	France
CYCADOPHYTAE—Continued																								
Cycadeoidia Goucheriana																								
Cycadeoidia Uhleri																								
Cycadeoidia Bibbinsi																								
Cycadeoidia Clarkiana																								
Cycadeoidia Fisherae																								
Dioonites Buchianus				*		*		*								*								
Ctenopteris insignis																								
Ctenopteris angustifolia																								
Ctenopteris longifolia																								
Ctenopsis latifolia																								
Zamiopsis dentata																								
Zamiopsis petiolata																								
Zamiopsis laciniata																								
Nilsonia oregonensis				o		o		o																
Nilsonia densinerve																								
Zamites tenuinervis				o										*										
Zamites crassinervis																								
Dichotozamites cycadopsis																								
Cycadeosperum marylandicum																								
Cycadeosperum obovatum																								
Cycadeosperum acutum																								
Cycadeosperum rotundatum																								
Cycadeosperum spatulatum																								
Podozamites subfalcatus																								
Podozamites acutifolius																								
Podozamites inaequilateralis								o					o			o								
Podozamites distantinervis																								
Podozamites Knowltoni			*																					
Podozamites lanceolatus	*	*	*	?		?		?					?											
GINKGOALES																								
Baiera foliosa						o													o					
CONIFERALES																								
Nageiopsis longifolia																								
Nageiopsis angustifolia																								
Nageiopsis zamioides				?																				
Cephalotaxopsis magnifolia																								
Cephalotaxopsis brevifolia																								
Brachyphyllum crassicaule				o															o			o		
Brachyphyllum parceramosum																								
Araucarites aquiensis																								
Araucarites patapscoensis																								
Abietites macrocarpus																								
Abietites longifolius				o											o									
Abietites foliosus																								
Abietites marylandicus																								
Pinus vernonensis					o																			
Cupressinoxylon Wardi																								
Cupressinoxylon McGeei																								
Frenelopsis ramosissima																			o					
Frenelopsis parceramosa																								
Sphenolepis Kurriana				*		*				*			*		?				*	?		*		

Belgium	Germany	Portugal	Switzerland	Cenomanian	Lakota	Fuson	Trinity—Texas	Kootanie	Upper Knoxville	Horsetown	Raritan	Jurassic—Cal. and Oregon	Spitzbergen	Species with which compared Occurrences indicated by circles
...	...	...	...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	...	*	...	*	*	...	...	...	
...	...	...	...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	...	?	...	...	...	
...	...	...	...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	...	...	o	*	*	...	...	...	Nilsonia schaumburgensis (Dunker) Nathorst. Nilsonia Johnstrupi Heer.
...	...	...	...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	*	*	...	...	...	Zamites Carruthersi Seward.
...	...	...	...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	*	*	?	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	...	*	...	...	...	...	...	...	
...	...	o	...	...	...	...	...	*	...	...	...	...	...	Podozamites affinis (Schenk) Schimper, ellipsoideus Saporta and pusillus Yokoyama.
...	...	...	...	...	...	...	...	?	...	...	...	...	...	
...	...	...	...	*	...	...	...	...	...	...	...	...	*	
...	...	...	...	*	...	...	...	...	...	...	...	*	...	
...	...	...	...	...	...	...	...	...	...	...	...	...	o	Baiera Brauniana (Dunker) Brongn. Baiera spetsbergensis Nathorst. Baiera graminea Nathorst.
...	...	...	...	...	?	...	...	?	?	?	...	...	...	
...	...	...	...	...	?	...	...	...	?	...	...	...	...	
...	...	...	...	...	...	...	...	...	?	...	...	...	...	
...	...	...	...	...	*	*	...	...	*	*	...	...	...	Taxites species.
...	...	...	...	...	...	...	...	...	...	...	...	...	...	
...	...	o	...	...	...	...	...	...	...	...	...	...	...	Brachyphyllum obesum Heer. Brachyphyllum obesiforme Saporta.
...	...	o	...	...	...	...	*	...	...	...	...	...	...	Brachyphyllum obesiforme elongatum Saporta.
...	...	...	...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	*	?	...	...	*	...	...	...	Abietites Linkii (Roemer) Dunker.
...	...	...	...	...	...	*	...	*	...	...	...	...	?	Pinites Solmsii Seward.
...	...	...		...	...	...	?	*	...	...	...	...	...	Pinus Peterseni Heer.
...	...	...	...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	...	...	...	...	...	Pinites, cf. Solmsii Seward.
...	...	...	...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	...	...	...	...	?	
...	...	o	...	o	...	...	...	...	...	...	...	...	...	Frenelopsis occidentalis Heer.
...	...	...	...	...	...	...	?	...	...	...	...	...	...	Frenelopsis varians Fontaine.
...	...	*	...	*	...	*	...	*	...	...	...	...	...	

Potomac Species Occurrence indicated by stars	Oolite	Purbeck	Portland	Wealden—England	Belgium	Germany	Neocomian—Mexico	Japan	Peru	Germany	Belgium	France	Portugal	Queen Charlotte Islands	Barremian—Greenland (Kome)	Austria	Germany	France	Portugal	Russia	Aptian—England	Portugal	Albian—England	France
CONIFERALES—Continued																								
Sphenolepis Sternbergiana				*		*							*		?				*					
Laricopsis angustifolia																								
Arthrotaxopsis expansa																								
Arthrotaxopsis grandis																								
Widdringtonites ramosus																								
Cedrus Leei																								
Sequoia Reichenbachi			*		*		*								*	*								
Sequoia rigida															*									
Sequoia delicatula																								
Sequoia ambigua				?			*								*									
ANGIOSPERMAE																								
Cyperacites potomacensis																								
Plantaginopsis marylandica																								
Alismaphyllum Victor-Masoni																								
Populus potomacensis																								
Populophyllum minutum																								
Populophyllum reniforme															o									
Nelumbites virginiensis																								
Nelumbites tenuinervis																								
Menispermites potomacensis																								
Sapindopsis variabilis																								
Sapindopsis magnifolia																								
Sapindopsis brevifolia																								
Celastrophyllum denticulatum																								
Celastrophyllum parvifolium																								
Celastrophyllum latifolium																								
Celastrophyllum acutidens																								
Celastrophyllum Brittonianum																								
Celastrophyllum Hunteri																								
Celastrophyllum albaedomus																								
Cissites parvifolius																								
Sassafras bilobatum																								
Sassafras parvifolium																								
Sassafras potomacensis																								
Araliaephyllum crassinerve																								
Araliaephyllum magnifolium																								
INCERTAE SEDIS																								
Hederaephyllum dentatum																								
Ficophyllum serratum																								
Ficophyllum oblongifolium																								
Proteaephyllum reniforme															o									
Proteaephyllum ovatum																								
Rogersia longifolia																								
Rogersia angustifolia																								
Rogersia angustifolia parva																								
Aristolochiaephyllum crassinerve																								
Aristolochiaephyllum ? cellulare																								

Belgium	Germany	Portugal	Switzerland	Cenomanian	Lakota	Fuson	Trinity—Texas	Kootanie	Upper Knoxville	Horsetown	Raritan	Jurassic—Cal. and Oregon	Spitzbergen	Species with which compared Occurrences indicated by circles
...	...	*	...	...	...	...	*	...	*	...	...	...	...	
...	...	...	...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	...	...	...	...	...	...	...	...	
...	...	...	...	...	...	?	...	...	...	...	...	...	...	
...	...	...	...	o	...	...	...	...	...	...	o	...	...	Widdringtonites Reichii (Ettings.) Heer.
...	...	...	...	...	...	...	...	...	...	...	...	...	...	
...	...	...	*	*	...	*	...	*	*	...	...	...	...	
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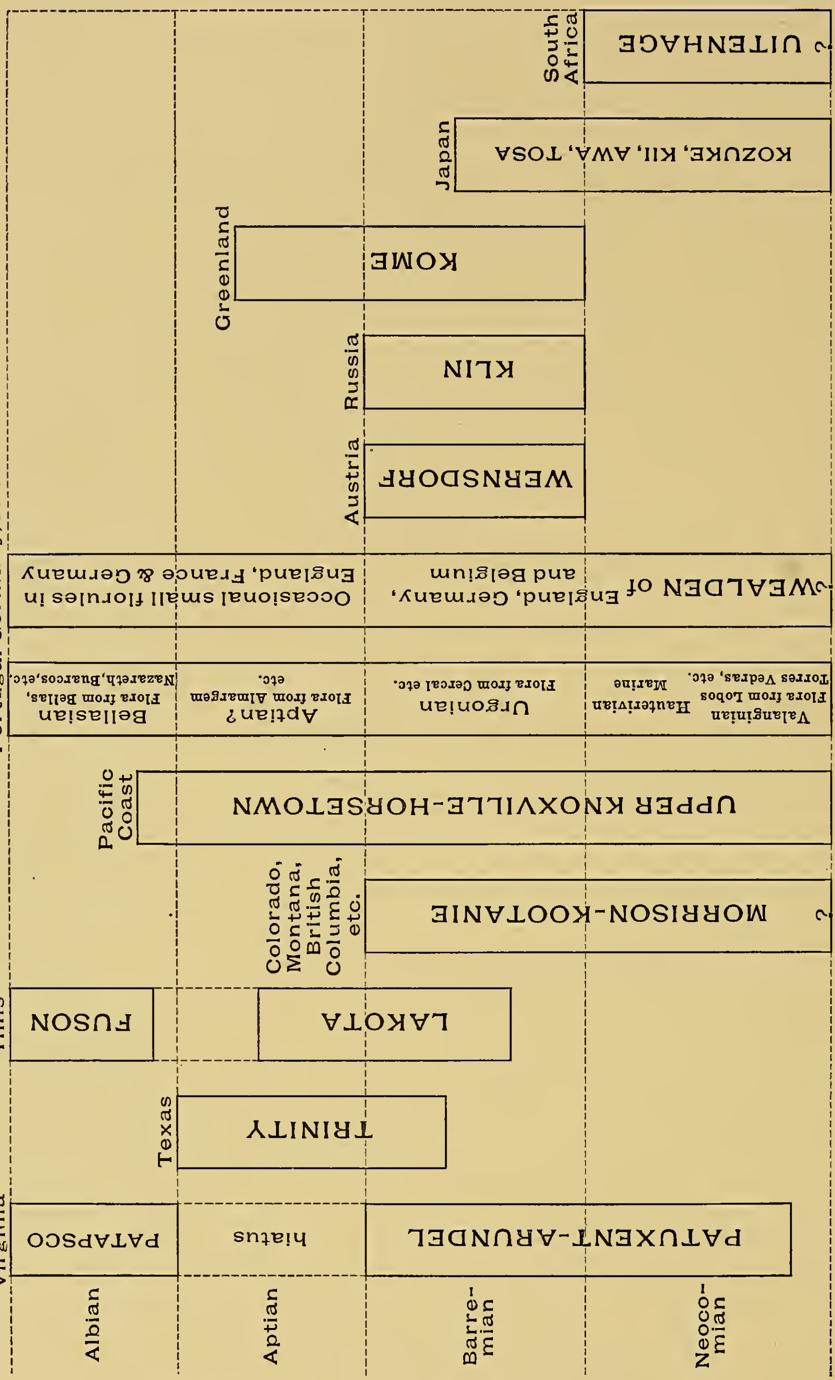
South Africa
UITENHAGE ?
Japan
KOZUKE, KII, AWA, TOSA
Greenland
KOME
Russia
KLIN
Austria
WERNSDORF
England, Germany, etc.
WEALDEN of England, Germany, and Belgium
Occasional small florules in England, France & Germany
Portugal
Valanginian Flora from Lobos Torres Vedras, etc.
Hauterivian Marine
Urgonian Flora from Cercal etc.
Aptian? Flora from Almargem etc.
Bellasian Flora from Bellas, Nazareth, Buarcos, etc.
Pacific Coast
UPPER KNOXVILLE-HORSETOWN
Colorado, Montana, British Columbia, etc.
MORRISON-KOOTANIE ?
Black Hills
LAKOTA
FUSON
Texas
TRINITY
Maryland Virginia
PATUXENT-ARUNDEL
hiatus
PATAPSCO
Albian
Aptian
Barre-mian
Neoco-mian

THE REPTILIA OF THE ARUNDEL FORMATION

BY

RICHARD SWANN LULL

The fossil reptiles of the Potomac, while not so abundant in numbers or kinds as in the Morrison of our Western States, nevertheless compare very closely with the latter, as nearly all of the Potomac genera and, in some instances, very closely allied if not identical species are found in the West.

A striking similarity also prevails between the Potomac on the one hand and the Wealden of Europe on the other, while one important Maryland genus is reported from a lower horizon than the Wealden and none from a higher level.

The Potomac fauna is largely dinosaurian, all of the sub-orders being represented, in addition to which there is a crocodile, together with at least one turtle and a ganoid fish.

The Dinosaurs

The carnivorous dinosaurs are represented by at least three species. One, the common *Allosaurus,* the European representative of which is *Megalosaurus,* may be recognized by feet and limb bones, vertebræ, and teeth. This species, which has been named *Allosaurus medius* by Professor O. C. Marsh, was a creature of large size, comparing very favorably with *Allosaurus fragilis* of the West, the estimated length of which is 34 feet. It walked entirely on the hind feet after the manner of its kind, using the hands for grasping, and never for locomotion. The teeth are sharp pointed, like recurved daggers, with finely serrated edges, and often show a considerable degree of blunting through wear.

Another, much larger form, seems to have been present, though leaving the most meagre record of its existence in the shape of a single vertebra—evidently that of a *Creosaurus,* to which the name of *potens,* the powerful, is given. This animal must have resembled *Allosaurus* very closely.

Beside the huge carnivores, there were lesser ones of the most delicate build, with bones lightened by the development of interior spaces, doubtless filled with air, as in the birds, until an almost paper-like thinness of the bone resulted. The Maryland animal, known only from the teeth and a single claw, resembled in tooth and claw its western allies. The latter Professor Marsh called *Cœlurus,* hollow tail, in allusion to the pneumatic bones, and to the Arundel species he gave the name of *Cœlurus gracilis.* This animal must have been extremely active, preying upon feebler reptiles and possibly upon the primitive mammals and birds of that day.

Of the plant-feeding dinosaurs, the sub-order of great quadrupeds, the Sauropoda are represented by at least one genus, *Pleurocœlus,* possibly by others; but this is not certain.

Pleurocœlus is a long-legged type, apparently of small size, though most of the individuals represented were immature at the time of their death, though, strangely enough, of fairly constant size, which seems to imply either a wholesale slaughter of the young or that they really had reached the average stature, though not full maturity. Of these, two species are represented, one *Pleurocœlus nanus,* the restoration of which is shown on pl. xi, was but 12 feet or so in length by 4 feet in height; a pigmy compared with the colossal bulk of *Brontosaurus* of the West with its length of over 60 feet.

Pleurocœlus nanus is by far the best known of the Potomac dinosaurs for more than half of all the material collected may be attributed to it. It was lightly built, though, in common with its allies, this lightness was largely confined to the skull and backbone, while the limb bones were much more solid in texture. *Pleurocœlus* resembles most closely the form known as *Morosaurus,* a genus of wide distribution, from which it differed mainly in the greater relative length of the fore limbs and of the centra of the vertebræ. The teeth, which are slender, slightly flattened cylinders, sometimes nearly straight, again spoon-shaped, with blunt cutting edges, imply a very soft vegetable food, probably in the form of an aquatic plant, which grew in sufficient profusion to enable these creatures to satisfy their needs. The Sauropoda were apparently of wading habits though, with such small types as this, land locomotion was doubtless not only possible but probable. *Pleurocœlus nanus* has allies so near akin as to be nearly indistinguishable, both in the Morrison beds of the West and the Upper Jurassic (? Kimmeridgian) near Havre, France, while somewhat more remotely related types are reported from the Kimmeridgian of Sussex and of the Isle of Wight.

Another species of *Pleurocœlus*, to which Professor Marsh gave the name of *altus* in allusion to its greater size, is also found in Maryland, though its known remains are very few compared with those of its ally. In size it exceeded that of *Pleurocœlus nanus* by about two and a half times, giving it an estimated length of at least 30 feet. Its limb bones were much slenderer than those of a *Morosaurus* of equivalent length, indicating an animal of greater activity. Another genus, *Astrodon*, described years ago by Dr. Leidy from one or two teeth, is a near ally, if not identical with *Pleurocœlus altus*. Judgment is suspended, however, until further light is forthcoming in the way of more material, for the teeth of *Astrodon* are extremely rare.

To the orthopod or predentate dinosaurs may be referred two genera of Potomac forms, one a lightly built, agile, plant-feeding type, differing from *Pleurocœlus* in many respects, of which two are perhaps the most striking. One is the character of the mouth armament, for, while in *Pleurocœlus* the teeth were fragile structures situated along the jaws, but especially in the front of the mouth, in the form under consideration, *Dryosaurus*, the anterior portion of the mouth was toothless, and doubtless sheathed with horn like that of a turtle, while the teeth were contained in magazines in the cheek portion of the jaws, a relatively simple mechanism, however, when compared with the later Cretaceous types. The other distinctive feature is the bipedal gait, shown by the great difference in size of the fore and hind limbs. Doubtless, however, *Dryosaurus* could rest upon all fours while feeding, using the bird-like hind limbs alone when in motion. *Dryosaurus,* a close ally of *Laosaurus,* the restoration of which is shown on pl. xiii, is found in the Morrison beds of the West in the form of a nearly related species, *Dryosaurus altus.* To the Potomac form, because of its greater size, among other distinctive features, the name of *Dryosaurus grandis* is given. The nearest European ally to the present species is *Hypsilophodon foxii* from the English Wealden beds, smaller and in some respects more primitive than the American types and representing a collateral line of descent.

The larger, more heavily built predentates of the Morrison and of Europe have not as yet been discovered in the Arundel deposits. This, however, is not surprising, for their habits of life differed so essentially from those of the Sauropoda that their remains are rarely found associated in the rocks Another locality for Potomac dinosaurs might readily disclose these larger terrestrial types.

There is another predentate type, known from a number of similar teeth, to which the name of *Priconodon crassus* has been given by Marsh. These teeth indicate a relationship with the armored dinosaurs or Stegosauria, forms which, because of the increasing weight of their protective mail, came down on all fours, not only for resting but for actual locomotion, as the increasing power of the fore limbs gives evidence. Judging from the teeth alone the nearest ally of *Priconodon* is *Palæoscincus costatus* described by Leidy from the Judith River beds of Montana, which are of Upper Cretaceous age. The teeth of the known contemporary (*Stegosaurus*) are much smaller and of a more specialized character. *Stegosaurus,* however, is known to be a remarkably specialized side line, probably the terminal member of its race, as its remains are unknown above the Morrison formation. There were, however, more conservative armored types which persisted until the close of the age of reptiles, and to this race *Priconodon* seems to have belonged. One vertebral centrum has been found in the Arundel beds very similar to that of *Stegosaurus,* except that it is smaller, but, as it represents an immature animal, that distinction has but little weight. It has been provisionally referred to *Priconodon crassus,* but may possibly represent a genuine stegosaur, otherwise unknown.

Other Reptiles

The fauna includes a crocodile, *Goniopholis,* found in the Wealden and Purbeck beds of Europe and in the Morrison of Colorado and Wyoming. The teeth are so similar to those from the western quarries that the name *Goniopholis affinis,* the nearly related, is given to the Potomac type. These are crocodiles of moderate size, 6 feet or more in length, and may have resembled the modern genus *Crocodilus,* with its narrow snout, quite closely in general appearance. In addition to the crocodile there are occasional fragments of bone which give evidence of the presence of a turtle as yet unidentified.

SUMMARY

The Arundel fauna represents, so far as known, three orders: Dinosauria, Crocodilia, and Testudinata. The presence of a ganoid fish is also indicated.

The dinosaurs represent all of the sub-orders, including two of the heavier, megalosaurian carnivores, *Allosaurus* and *Creosaurus,* and one of the lighter, Compsognathoid type, *Cœlurus.* The quadrupedal Sauropoda are represented by at least one genus, possibly two, *Pleurocœlus* and *Astrodon,* including two or three species in all, while of the Orthopoda there are two, one the unarmored *Dryosaurus,* the other, *Priconodon,* evidently belonging to the armored group or Stegosauria.

The dinosaurs show none of the remarkable over-specialization of the later Cretaceous types, but, on the contrary, represent the order at the crest of the evolutionary wave, before signs of decadence set in. Unfortunately, owing to an almost utter dearth of terrestrial Jurassic deposits, nothing is known of dinosaurian evolution in America from Newark time until we come to the horizon under consideration. In Europe the record, though still meagre, is more complete; but it represents in every instance more primitive types than those of the Arundel and the Morrison.

The character of these dinosaurs, and of the crocodile as well, correlates the beds wherein they are found absolutely with the Morrison (Como) of the West. An accurate comparison with European formations is more difficult, as the faunas have fewer forms in common. *Pleurocœlus* is reported from the Kimmeridgian as well as from the Wealden, but that from the former horizon may readily have been ancestral to the Arundel type, although the European material is too fragmentary to admit of a just comparison. Of the other dinosaurs, the affinities seem to be entirely with Wealden forms, *Cœlurus* being found therein, while *Allosaurus* compares in point of size and dentition with the Wealden *Megalosaurus*. *Dryosaurus* has its nearest European ally in *Hypsilophodon*, again a Wealden type, and the crocodile, *Goniopholis*, is reported from the Wealden and its marine equivalent the Purbeckian, not from the older Jurassic levels.

The weight of this evidence would seem to place this fauna beyond the Jurassic into the beginning of Cretaceous times.

SYSTEMATIC PALEONTOLOGY

OF

THE LOWER CRETACEOUS DEPOSITS OF MARYLAND

BY

RICHARD SWANN LULL, WILLIAM BULLOCK CLARK,
AND EDWARD WILBER BERRY

SYSTEMATIC PALEONTOLOGY

LOWER CRETACEOUS

VERTEBRATA

Class REPTILIA

Order DINOSAURIA

Suborder THEROPODA

Family MEGALOSAURIDAE

Genus ALLOSAURUS Marsh

ALLOSAURUS MEDIUS Marsh

Plate XIV, Figs. 1-3

Allosaurus medius Marsh, 1888, Amer. Jour. Sci., ser. iii, vol. xxxv, p. 93.
Allosaurus Bibbins, 1895, Johns Hopkins Univ. Circulars, vol. xv, fig. G.
Antrodemus medius Hay, 1902, Bull. U. S. Geol. Survey, No. 179, p. 489.
Allosaurus medius Hay, 1908, Proc. U. S. Natl. Museum, vol. xxxv, p. 353.

Description.—The type (No. 4972, U. S. National Museum) consists of a single tooth, the other material mentioned by Marsh in his original description being removed to the genus *Dryosaurus* (vide infra, p. 204). Marsh's description of the type is as follows: "The teeth are remarkably flat and trenchant, with the edges finely serrated, and the surface very smooth. . . . One tooth has the crown 30 mm. in height; its antero-posterior diameter at base 15 mm.; and its transverse diameter 7 mm."

There are several larger, better preserved teeth among the material, one of which (No. 5685, Goucher College) shows decided wear. The most perfect is one in the possession of the Hon. Charles E. Coffin,[1] Muirkirk, Maryland (pl. xiv, figs. 1, 2). It is about 3 inches (76 mm.) in length and 1⅛ inches (28.7 mm.) in the antero-posterior diameter. The crenulations of the margin cease about midway toward the root on the anterior convex border, but extend the length of the crown on the posterior edge. There is a slight variation in the size of the crenulations, as they are somewhat coarser in the larger teeth.

[1] Or No. 3121, Goucher College.

The two vertebræ which are here referred to this species indicate an animal of the same approximate size as the teeth and phalanges. One (No. 2534, G. C.), which seems to be a posterior presacral, has a form quite similar to the type of *Allosaurus fragilis,* but relatively somewhat less constricted in the middle. It agrees in having the same somewhat flattened inferior surface. Anteriorly, the centrum has a shallow concavity, while posteriorly it is nearly plane. The pedicels of the neural arch are stout and the neural canal seems to be broader than in the type of *A. fragilis,* possibly owing to the fact that the vertebra is a more posterior one. The two agree in the depression on either side, which, however, is somewhat less marked in the present species.

DIMENSIONS

Length	90.0 mm.
Least diameter of centrum	68.5 mm.
Diameter of anterior face as preserved	105.0 mm.
Diameter of posterior face as preserved	95.5 mm.
Height of centrum	85.0 mm.

The anterior caudal vertebra (No. 2614 a, G. C.) is that of a young individual, as the neural arch had not coössified with the centrum. Internally it seems to have been composed of rather coarse, cancellous tissue with no trace of an internal cavity, as in the type of *Antrodemus,* as figured by Leidy.[1]

The anterior face is slightly concave, the posterior one nearly plane; and while the centrum is constricted decidedly in the middle there is no trace of the lateral depressions seen in the presacrals.

DIMENSIONS

Length	107 mm.
Least diameter	59 mm.
Diameter anterior face	101 mm.
Diameter posterior face	93 mm.
Height of centrum	92 mm.

The first phalanx of the second digit is represented by the proximal half (No. 2536, G. C.), and is peculiar for its height as compared with its width and the two very prominent ridges on the inferior face.

[1] Leidy, Rept. of U. S. Geol. Surv. of Terr., vol. i, 1873, pl. xv, fig. 18.

The articulation is a smooth, cylindrical concavity with no trace of ridges to limit lateral motion. It is probable that it was formerly somewhat cup-like, as the preparator has slightly altered the shape of the bone. The articular end is full of a cancellous tissue, nevertheless there was a well-defined medullary cavity in the shaft. The portion preserved measures in height, 73 mm.; in width, 58 mm.

The first phalanx of the third digit (No. 2521, G. C.) (fig. 2) is entire, most excellently preserved, and presents a decided similarity to the type of *Allosaurus fragilis;* differing therefrom in being more depressed proximally, especially in the broader, flatter under surface. Distally, the present type is not so broad relatively as that of *A. fragilis,* and the articular face is more concave transversely. Altogether the two bones are quite distinct in conformation.

DIMENSIONS

Length	110.0 mm.
Transverse diameter distal face..................	55.0 mm.
Vertical diameter distal face....................	35.5 mm.
Transverse diameter proximal face...............	70.5 mm.
Vertical diameter proximal face..................	50.0 mm.
Least transverse diameter, shaft.................	41.0 mm.

There are also two distal caudals, one No. 5701, the other unnumbered, both of the U. S. National Museum collection, each characterized by a flattened ventral aspect and the development of a slight keel along the sides, giving it a somewhat hexagonal section. The neural spine is reduced to a low ridge fading out posteriorly, while the zygapophyses are much prolonged.

Length of centrum of No. 5701....................	68.7 mm.
Length of centrum of unnumbered specimen......	67.5 mm.

The latter is somewhat stouter and has a more decided upward arch.

Allosaurus medius is a fairly well-defined species, though the only one of the original cotypes referable to it, the tooth, is one of the least distinctive features of the skeleton. The remains which I have referred to it, however, are all from the same locality and formation, and are all relatively about the same proportionate size, judging from the remains of *Allosaurus fragilis.*

Occurrence.—ARUNDEL FORMATION. Near Muirkirk, Prince George's County.

Collections.—U. S. National Museum, Goucher College.

CREOSAURUS POTENS sp. nov.

Plate XIV, Fig. 4

Description.—The type specimen is a vertebral centrum (No. 3049, U. S. National Museum) from the ferruginous conglomerate of Washington, D. C., which seems to represent a theropod dinosaur otherwise unrecognized in the Arundel formation.

The vertebra (fig. 3), evidently a posterior presacral, is of peculiar proportions; nearly as deep as long, and strongly compressed laterally, the lower surface forming a distinct keel, which is nearly straight in profile. The neural canal is broad, though somewhat constricted in the middle of the centrum.

The vertebra differs materially from those of *Allosaurus* in lacking the decided constriction in the middle and in the presence of the keel. It resembles most nearly the vertebræ belonging to the type of *Creosaurus atrox* (No. 1890, Yale Museum), not, however, the one figured by Marsh as *Creosaurus*.[1]

The vertebra in question is much larger than those of the type of *C. atrox,* but the latter show the same compressed form, though with a less straight ventral outline.

The present vertebra is slightly opisthocœlous and its dimensions are as follows:

Length	140.0 mm.
Depth of centrum	128.0 mm.
Width anterior face	98.5 mm.
Width posterior face	97.0 mm.
Least diameter of centrum	78.0 mm.

This vertebra represents by far the largest carnivore known from the Arundel formation.

[1] Marsh, 16th Ann. Rept. U. S. Geol. Survey, pt. i, 1896, pl. xii, figs. 5, 6.

Occurrence.—ARUNDEL FORMATION. Washington, District of Columbia.

Collection.—U. S. National Museum.

Family COELURIDAE

Genus COELURUS Marsh

CŒLURUS GRACILIS Marsh

Plate XV, Fig. 1

Cœlurus gracilis Marsh, 1888, Amer. Jour. Sci., ser. iii, vol. xxxv, p. 94.
Cœlurus gracilis Zittel, 1890, Handbuch der Palaeontologie, Abth. i, Bd. iii, p. 732.
Cœlurus gracilis Hay, 1902, Bull. U. S. Geol. Survey, No. 179, p. 493.

Description.—The type specimen is No. 4973, U. S. National Museum, an ungual phalanx from near Muirkirk, Maryland. Additional material consists of Nos. 3336, 3338, and 8176, Goucher College, and embraces three teeth, the first two coming from the same locality as the type.

The original description is as follows: "The smallest Dinosaur found in these deposits is a very diminutive carnivore, apparently belonging to the genus *Cœlurus*. It was not more than one-half the size of the western species, and its proportions were extremely slender. The bones are very light and hollow, the metapodials being much elongated and their walls extremely thin. An ungual phalanx of the manus measures about 25 mm. in length; and 14 mm. in vertical diameter at the base. This animal could not have been more than 5 or 6 feet in length."

The ungual phalanx is from the manus, and from the great development of the base below the articulation must have constituted a powerful grasping organ when one considers the size of the entire animal.

The teeth resemble very closely that of *Cœlurus* fragilis figured by Marsh,[1] but differ in the almost total reduction of the crenulation of the anterior convex border, which is perfectly smooth in one of the three specimens, has serrations of almost microscopical fineness for a short distance from the tip in the second, while, in the third specimen,

[1] Marsh, 16th Ann. Rept. U. S. Geol. Surv., pt. i, 1896, pl. vii, fig. 1.

the border is broken away where the crenulations would occur if present. The curvature of the teeth is similar in each species, while the variation in size may be accounted for by a difference in the stage of growth of the individual teeth; as it is, two of the Maryland ones are slightly larger than the tooth of *Cœlurus fragilis* figured by Marsh.

Occurrence.—ARUNDEL FORMATION. Near Muirkirk, Prince George's County.

Collections.—U. S. National Museum, Goucher College.

Suborder SAUROPODA

Family MOROSAURIDAE

Genus PLEUROCOELUS Marsh

PLEUROCŒLUS NANUS Marsh

Plate XI; Plate XIV, Figs. 5-8; Plate XV, Figs. 2-5; Plate XVI; Plate XVII; Plate XVIII, Figs. 1, 2

Pleurocœlus nanus Marsh, 1888, Amer. Jour. Sci., ser. iii, vol. xxxv, p. 90, figs. 1-6.

Pleurocœlus nanus Lydekker, 1890, Catal. of Fossil Reptilia and Amphibia in the British Museum, pt. iv, p. 238, fig. 52.

Pleurocœlus nanus Marsh, 1896, 16th Ann. Rept. U. S. Geol. Survey, pt. i, pls. xl, xli.

Pleurocœlus nanus, Hay, 1902, Bull. U. S. Geol. Survey, No. 179, p. 483.

Description.—Type material consists of a cervical vertebra (No. 5678), a dorsal (No. 4968), a sacral (No. 4969), a caudal (No. 4970), all of the U. S. National Museum collection. In addition to these, a caudal vertebra (No. 3372), four metatarsals, and two unguals (No. 2667), a supra-occipital bone (No. 5692), a left dentary (No. 5669), and a tooth (No. 5691) are also in the National Museum.

Marsh's original description of this species is as follows: "The most common fossils secured thus far from the Potomac formation are the remains of a small Dinosaur, which clearly belongs to the Sauropoda, but is by far the most diminutive member of this group yet discovered. Portions of the skull, vertebræ, and limb bones of several individuals have been obtained, and they agree so nearly that they may be referred to one species. They differ somewhat in size, owing, apparently, to a difference in age.

"In comparing these remains with the Sauropoda now known, they appear to resemble most nearly those of the genus *Morosaurus,* so well represented in the Upper Jurassic of the Rocky Mountain region. A careful comparison, however, shows that they belong to a distinct genus. The teeth are of the same general type as those of *Morosaurus,* but their crowns are mainly compressed cones, and not spoon-shaped. The dentary bone is slender and rounded at the symphysis, instead of having the massive, deep extremity seen in *Morosaurus.* The maxillary is also lighter, and less robust. The supra-occipital agrees closely in shape with that of *Morosaurus,* and forms the upper border of the foramen magnum, as in that genus.

"The cervical and dorsal vertebræ are elongate, and strongly opisthocœlous. The latter are much longer than the corresponding vertebræ of *Morosaurus,* and have a very long, deep cavity on each side of the centrum, to which the proposed generic name refers. All the trunk vertebræ hitherto found are proportionately nearly double the length of the corresponding centra of *Morosaurus,* and the lateral cavity is still more elongate. These points are shown in the posterior dorsal vertebra, represented in figs. 1 and 2. The neural arch in this region is lightened by cavities, and is connected with that of the adjoining vertebræ by the diplosphenal articulation.

"The sacral vertebræ in *Pleurocœlus* are solid, as in *Morosaurus,* but much more elongate. The surface for the rib, or process which abuts against the ilium, is well in front, more so than in any of the known Sauropoda. Behind this articular surface is a deep pit, which somewhat lightens the centrum. These characters are seen in the sacral vertebra represented in figs. 3 and 4. The first caudal has the centrum very short, and its two articular faces nearly flat, instead of having the anterior surface deeply concave, as in the other known Sauropoda. The neural spines in this region are compressed transversely. The middle and distal caudals are comparatively short, and the former have the neural arch on the front half of the centrum, as shown in figs. 5 and 6. The bones of the limbs and feet preserved, agree in general with those of the smaller species of *Morosaurus,* but indicate an animal of slighter and more graceful build. The metapodials are much more slender, and the phalanges are less robust than in the other members of the order.

"The known remains of the present species, representing several individuals, indicate an animal not more than 12 or 15 feet in length, and hence the smallest of the Sauropoda. They were found at several localities of the Potomac formation in Prince George's County, Maryland. Regarding the present species as typical, some of the more special characters distinguishing these remains from the known Sauropoda are as follows:

"(1) Teeth with compressed or flattened crowns.

"(2) Dorsal vertebræ with low neural sutures, and elongate excavation in each side of the centrum.

"(3) Sacral vertebræ solid, with a cavity in each side, and with face for rib in front.

"(4) Anterior caudals with flat articular faces, and transversely compressed neural spines.

"(5) Middle caudal vertebræ with neural arch on the front half of the centrum. These characters seem to indicate a distinct family, that may be called the *Pleurocœlidæ.*"

This is by far the best-known species, as nearly all of the more important parts of the skeleton are known, though probably from many different individuals. The known remains are almost entirely those of immature specimens, but are of comparatively constant relative size, showing probably that the animals they represent were of average size. *P. nanus* is about the smallest known sauropod; measuring from 12 to 15 feet in length by 4 to 5 feet in height, but relatively long of limb, especially in front, as the restoration will show.

The Skull.—Of the skull the following portions may be recognized: Left dentary, left maxillary, part of right maxillary, left alisphenoid, and minor skull fragments.

The left dentary is represented by the type specimen No. 5669, U. S. National Museum (pl. xiv, fig. 5). In general form it resembles very closely that of *Brontosaurus,* being much lighter and less deep than that of *Morosaurus.* Anteriorly, it is rounded and abruptly truncated at the symphysis. On the ventral aspect is the open meckelian groove, beginning at the symphysis and sweeping backward to the extreme end. About the mid-length of the bone this groove widens out to form the mandibular fossa, its outer margin extending downward to form a thin, curved plate of bone which forms at least one-half of the outer surface of the jaw. The meckelian groove is not present in the anterior half of the jaw of *Brontosaurus,* though in *Morosaurus grandis* it is very similar, both in position and in extent. There seem to have been at least thirteen teeth in commission at one time, and none of the crowns now visible in the alveoli have the spoon-like shape.

DIMENSIONS

Length of dentary (tangential)	122.0 mm.
Depth at anterior end	30.5 mm.
Depth at posterior end (estimated)	50.0 mm.
Thickness at 3d alveolus	15.0 mm.

The maxillary (pl. xiv, fig. 6) resembles that of *Morosaurus* rather than of *Brontosaurus,* especially in its anterior portion, as the upward process for articulation with the prefrontal, while wanting, seems to have had its origin much further forward than in *Brontosaurus,* indicating a short, high skull, like that of *Morosaurus.* In proportion of thickness to length, the present maxilla again resembles the more robust *Morosaurus* rather than *Brontosaurus.* The number of alveoli in *Morosaurus* is nine, and in *Pleurocœlus* nine or ten as compared with thirteen in *Brontosaurus.* There is, as usual, a corresponding row of foramina on the inner face, opening into a shallow groove.

The dimensions of the left maxilla (No. 5667, U. S. National Museum) are as follows:

Length to mx.-pmx. facet	88.5 mm.
Length of tooth series	71.0 mm.
Thickness	15.5 mm.

The alisphenoid (pl. xvi, fig. 1) (No. 5668, U. S. National Museum) resembles very closely the corresponding bone of *Morosaurus,* though differing somewhat in proportions, being more broadly expanded superiorly.

Anteriorly, the bone united with its fellow, thinning out for the exit of the olfactory lobe. Below is the large, rounded optic foramen, while in the middle of the bone, running from above downward, is a long, narrow foramen, showing a tendency to be constricted into three apertures, probably for the exit of the third and fourth cranial nerves, and possibly for the anterior carotid artery. Behind the long foramen is a sharp crest, which evidently buttressed the post-orbital, as in *Morosaurus*. Posteriorly, just below the origin of this crest is part of the large foramen for the fifth cranial nerve. The dimensions of the bone are as follows:

Fore and aft diameter	48.6 mm.
Vertical diameter	40.0 mm.

The supra-occipital (No. 5692, U. S. National Museum) again agrees closely in shape with that of *Morosaurus*, forming the upper portion of the foramen magnum. It differs from that of *Morosaurus* in forming a relatively broader arch to the roof of the brain case.

Anteriorly, there is, on either side, the sutural surface for articulation with the parietal, but between these articulations there is a finished anterior border which may have been edged with cartilage but which shows no sutural indication. In front of this area a fontanelle must have been situated, probably of a temporary character, and not corresponding to the interparietal or pineal foramen. It must, of course, be borne in mind that we are dealing with a very immature animal.

The principal points wherein the bone differs from that of *Morosaurus* other than that above mentioned are in proportions and in the curves of the various surfaces; the present bone being slightly convex from side to side while that of *Morosaurus* is decidedly concave.

DIMENSIONS

Width	63.0 mm.
Fore and aft diameter	33.7 mm.
Greatest depth	27.0 mm.
Width of foramen magnum	18.5 mm.
Greatest width of brain case	32.2 mm.

Vertebral Column.—The cervical and dorsal vertebræ are elongate and strongly opisthocœlous, though the dorsals evidently became shorter as they approached the sacrum and became less opisthocœlous as well. The vertebræ are all characterized by deep lateral cavities, so deep that they are separated only by a thin septum of bone in the mid-line. Throughout the entire presacral series the vertebræ are relatively much longer than in *Morosaurus,* the comparison being made with a specimen of the latter of equivalent individual age, *Morosaurus latus,* type (No. 1910, Yale Museum), and the latter cavities are also longer, though bearing about the same relation to the length of the centrum.

Many vertebræ have been discovered, but relatively few of them can be placed with certainty, as no two can be proven to have belonged to the same animal. A few, however, may be taken as examples.

The anterior cervical (No. 5700, U. S. National Museum), which appears to be the axis, is the slenderest of all the known vertebræ of *Pleurocœlus,* differing from that of *Morosaurus* in being more slender with the lateral cavities longer, but less deep. Anteriorly, the bone is corroded away, giving it decidedly the appearance of an odontoid process, though the latter shows no sign of sutural union with the body of the vertebra, as in the young *Morosaurus lentus,* which also shows the intercentrum of the axis as a separate element. The neural canal is broad. The posterior cavity is less deep than in the posterior cervicals.

DIMENSIONS

Length	68.5 mm.
Breadth anterior end	32.0 mm.
Breadth posterior end	37.0 mm.
Height of centrum	33.0 mm.

In the posterior cervical (No. 5678, U. S. National Museum), which is that described by Marsh, the pleurocœlous condition seems to have reached its maximum. The lateral depressions are very deep and extend fore and aft into pocket-like cavities, so that the entire centrum is reduced to a shell. The neural canal is broad, but widening out, especially in the rear, and with a slight median longitudinal ridge on its floor. The sutural surfaces for the attachment of the neural arch are exceedingly broad and rugous. The vertebræ in this region are relatively very broad and flat.

DIMENSIONS

Length	96.5 mm.
Breadth of anterior face	67.5 mm.
Breadth of posterior face	63.0 mm.
Depth at anterior end	43.0 mm.
Depth at posterior end	51.0 mm.

The dorsal (No. 4968, U. S. National Museum) (pl. xv, fig. 4), was described by Marsh as a posterior, but is considered by Hatcher[1] an anterior dorsal, "as is evidenced by its strongly opisthocœlian characters and the more extended pleurocentral cavities." Comparing it with the perfect series of the small *Morosaurus lentus,* I should place the bone in question in the mid-dorsal region as the fifth, or possibly the sixth, vertebra. The curvature of the articular faces is less pronounced than in the cervical described above and the lateral cavities, while deep and reaching well forward, are by no means as extensive as in the cervical. Here the neural canal is broad and but slightly constricted in the middle line. The bone is composed of a dense cancellous tissue. The extent of the suture for the neural arch is by no means so broad as in the cervicals. There is in the collection a detached fragment of the neural arch which is lightened by cavities as in the larger Sauropoda.

The dimensions of the type dorsal are as follows:

Length	95.0 mm.
Transverse diameter, anterior end	63.3 mm.
Transverse diameter, posterior end	68.0 mm.
Depth of centrum	63.5 mm.
Maximum width of neural canal	27.0 mm.
Minimum width of neural canal	17.8 mm.

There are no posterior dorsals in the collection such as that described by Hatcher,[2] but, from the similarity between the cervical described by Hatcher and that in the present instance, it is reasonable to suppose that the posterior dorsals will agree approximately as well.

[1] Hatcher, Ann. Carnegie Mus., vol. ii, 1903, p. 10.
[2] Hatcher, Ann. Carnegie Mus., vol. ii, 1903, pp. 9-14, figs. 3, 4.

The sacral (No. 4969, U. S. National Museum) (pl. xv, fig. 5) is apparently the second or third, and, as characterized by Marsh, is solid, as in *Morosaurus*, but much more elongate. The surface for the rib covers the anterior half of the centrum, behind which is a deep pit extending slightly forward into the base of the rib facet, but which does not, however, extend far into the body of the centrum itself. Anteriorly, the articular face is somewhat triangular, with the apex pointing downward; posteriorly, it is more nearly oval. The neural arch was attached to the anterior two-thirds of the centrum, so that the intervertebral foramen for the exit of the spinal nerve was wide, in keeping with the great width of the neural canal.

The dimensions of the sacral are as follows:

Length	76.0 mm.
Anterior diameter	71.5 mm.
Posterior diameter	67.0 mm.
Depth of centrum	57.0 mm.

Almost the entire caudal series is known from the centra and, in a few instances, from the neural arches as well. There is no trace, however, of the chevron bones.

The anterior caudals are short and nearly amphiplatyan, wherein again they resemble *Morosaurus lentus*. The middle and distal caudals have more elongated centra, but they are still relatively short. The anterior caudal (No. 5639, U. S. National Museum) (pl. xvi, fig. 3) is typical, having the shortened centrum with the anterior face slightly concave, the posterior one very slightly so. The facets for the transverse processes are high so that the transverse process must have borne against the neural arch to some extent. Facets for the chevron bones are very slightly indicated. The dimensions of the bone are as follows:

Length	37.5 mm.
Breadth	71.8 mm.
Depth	61.8 mm.

The pedicels of the anterior caudals are stout, with prolonged prezygapophyses. The character of an anterior caudal is shown in fig. 3.

The caudal (No. 4970, U. S. National Museum), one of the cotypes, is somewhat hour-glass shaped, amphicœlous, with the sutures for the neural arch on the forward half. There are prominent facets for the chevron bones at the posterior margin, the anterior ones being less marked, as shown in pl. xvi, fig. 2.

DIMENSIONS

Length	41.5 mm.
Breadth	40.0 mm.
Depth	38.0 mm.

The neural spine bearing the post-zygapophyses of about the tenth caudal is present. It is stout, compressed and elongated fore and aft at the summit. The zygapophyses are about 30° out of the perpendicular. This bone fragment (No. 5650, U. S. National Museum) measures as follows:

Height about	50.0 mm.
Transverse diameter at summit	15.8 mm.
Longitudinal diameter at summit	33.8 mm.

A posterior caudal (No. 5372, U. S. National Museum) (pl. xvi, fig. 4) has the neural arch complete, except the tips of the pre-zygapophyses. It resembles the one just described, except that it is relatively much more slender and shows no trace of facets for the chevron bones. The spine is compressed to a sharp, straight edge, and the articular faces of the centrum are nearly plane.

Length	27.0 mm.
Depth of centrum	19.5 mm.
Height over all	31.0 mm.
Breadth	20.0 mm.

Appendicular Skeleton.—Of the shoulder girdle, the coracoid is known from two specimens besides which the summit of a scapula only has been recognized. Of the coracoids the more complete one is No. 2523, G. C. It seems, however, to have belonged to a larger individual than the average size of the bones would indicate. The imperfect one is more nearly of the general size. It resembles very closely that of *Morosaurus lentus*, except for the form of the glenoid face, which, in *Pleurocœlus*, is broader below and forms a ridge on the outer face, which is sharply elevated above the general level of the bone. The portion containing the foramen has been broken away, but the beginning of a depression leading into it is visible. The distal end of the scapula (No. 2512, G. C.) is not distinctive.

Length of coracoid	133 mm.
Thickness at glenoid surface	58 mm.

A humerus and a femur bear the same catalogue number, 2263, U. S. National Museum, and are of much the same general appearance and color which may indicate that they pertain to the same individual, despite Hatcher's remark that "no two bones or fragments of all that material . . . . were found in such relation to one another as to demonstrate that they belonged to the same individual." It may, however, be safe to assume that they show the average relation of length that these bones bear to each other in *Pleurocœlus*. Compared with the humerus in *Morosaurus*, that under consideration appears more slender, especially at the proximal end, with a less prominent deltoid crest. The distal end is more rectangular when viewed from below than in *Morosaurus*, but the olecranon depression on the posterior aspect is much deeper and longer in *Pleurocœlus*. The bone is less straight, more of an elongated S in the present genus, and is very much longer in proportion to the femur than in *Morosaurus*.

DIMENSIONS

Length	363.0 mm.
Width proximal end	117.0 mm.
Width mid shaft	54.5 mm.
Width distal end	15.0 mm.

The radius (No. 2263, U. S. National Museum) is apparently of the average size. It is less curved than that of *Morosaurus grandis* and relatively somewhat stouter. Its dimensions are:

Length	300.0 mm.
Width proximal end	76.4 mm.
Width mid shaft	34.0 mm.

The ulna is represented by No. 5673, U. S. National Museum, the proximal half, and another unnumbered bone representing a distal half. They do not appear, however, to pertain to the same specimen, as they are too long when added together, though, in other proportions, relatively correct. Viewed proximally, the bone is wider than in *Morosaurus,* the articular face being more L-shaped, while the angles are less acute in keeping with the more rectangular character of the distal end of the humerus. Distally, the ulna shows the same sub-rectangular form, as compared with that of *Morosaurus.*

Length of ulna estimated	320 mm.
Width of proximal end	97 mm.
Depth of proximal end	63 mm.
Width of mid shaft	33 mm.
Width of distal end	69 mm.

No trace of the carpals has been recognized.

The metacarpals (pl. xvii, fig. 1) are long and slender, but the structure of the hand is as yet unknown, except that it seems to have been much longer relatively than in Marsh's restorations of the fore and hind limbs of *Morosaurus grandis.*[1]

Pelvis.—There are no bone fragments which can, with any degree of assurance, be referred either to the ilium or pubis. There is, however, the proximal portion of a bone (No. 5677, U. S. National Museum) which Professor Marsh identified with the ischium. It is much too large, proportionately, to go with the remainder of the skeleton we have been describing, as it approximates that of the young *Morosaurus lentus,* an individual at least half again as large as the average *Pleurocœlus nanus.* The bone is also much thicker and differs in its curvature; nor is there any indication of the rotation of the distal end of the ischium upon the long axis of the bone as in *Morosaurus.* The bone is, however, too defective for a fair comparison.

Femur.—This bone is represented by the perfect specimen bearing the number 2263, U. S. National Museum, and other less perfect material. It differs from that of *Morosaurus lentus* in being much less robust and in the sharp edge of the ridge on the external face below the great trochanter. The lesser trochanter is also much less pronounced in *Pleurocœlus.*

[1] Marsh, 16th Ann. Rept. U. S. Geol. Surv., pt. i, 1896, pl. xxxviii.

DIMENSIONS

Length	394 mm.
Width proximal end	116 mm.
Width mid shaft	60 mm.
Width distal end	106 mm.

The tibia (No. 5657, U. S. National Museum) and the fibula (No. 5656) (pl. xvii, fig. 3) both resemble those of *Morosaurus lentus*, except that they are again much less robust and are relatively very much longer in proportion to the length of the femur, though until the actually associated bones of one animal are found such proportions in *Pleurocœlus* may be open to doubt.

Length of the tibia	330.0 mm.
Width of proximal end	112.5 mm.
Width of distal end	72.5 mm.
Width of mid shaft	42.5 mm.

Dimensions of fibula:

Length	323.0 mm.
Width proximal end	75.0 mm.
Width distal end	48.0 mm.
Width mid shaft	34.5 mm.

The tarsus seems to be represented by an astragalus (No. 5452, U. S. National Museum), which is listed as the type astragalus of *Allosaurus medius*, but does not correspond either to the form of a theropod astragalus or to the dimensions given by Marsh in his original description. The bone is an irregular oval, somewhat pointed at one end, although, as little of the original surface is preserved, it is difficult to tell how much of the present form is correct.

Width	93 mm.
Fore and aft diameter	63 mm.
Greatest thickness	34 mm.

The metatarsals are shorter and more robust than the metacarpals so that the foot is short and compact.

The first metatarsal, that figured, is one of the cotypes (No. 2267, U. S. National Museum). Its dimensions are:

Length	66 mm.
Width of proximal end	53 mm.
Width of distal end	42 mm.

A second metatarsal (No. 5660, U. S. National Museum) has the following dimensions:

Length	77 mm.
Width proximal end	54 mm.
Width distal end	38 mm.

The ungual phalanx, cotype No. 2267, U. S. National Museum, here figured (pl. xviii, fig. 2), has the following measurements:

Length	58.7 mm.
Width proximal end	35.5 mm.
Thickness	18.5 mm.

Occurrence.—ARUNDEL FORMATION. Near Muirkirk, Prince George's County.

Collections.—U. S. National Museum, Goucher College.

PLEUROCŒLUS ALTUS Marsh

Plate XVIII, Fig. 3; Plate XIX, Figs. 1-4

Pleurocœlus altus Marsh, 1888, Amer. Jour. Sci., ser. iii, vol. xxxv, p. 92.
Pleurocœlus altus Hay, 1902, Bull. U. S. Geol. Survey, No. 179, p. 483.

Description.—The type specimen is a tibia and the proximal and distal ends of a fibula (No. 4971, U. S. National Museum). Marsh's original description is as follows: "A larger species, apparently of the above genus, is represented by various remains from the same localities as the specimens just described. A tibia and other limb bones show the animal to have had elongated posterior extremities, at least a third longer proportionately than in *Morosaurus*, which these remains, in some respects, clearly resemble.

"The tibia has the proximal end compressed transversely, with its outline subrhomboidal. The shaft is solid throughout, with the exception of a very small cavity near the middle, and here it is subovate in transverse section. The distal end is much flattened antero-posteriorly, and the notch in the articular face, characteristic of the Sauropoda, is well marked. This tibia is twenty-five inches (635 mm.) in length, with its proximal end seven inches (177 mm.) in fore and aft diameter, and the distal end six inches (152 mm.) in transverse diameter. Both extremities are rugose, indicating a heavy covering of cartilage. The fibula is massive, and its distal end somewhat expanded. The astragalus was free, and is wanting in the present specimen."

The tibia (pl. xviii, fig. 3) has nearly the length of that of *Morosaurus grandis* (No. 1905, Yale Museum) and but little more than half its diameter, indicating an animal of much lighter build. Compared with the type of *Morosaurus lentus* (No. 1910, Yale Museum) the tibia of *Pleurocœlus altus* is at least half again as long. The dimensions of the type are given in Marsh's description above, but there are no fore-limb bones in the collection referable to this species so that the relative length of fore and hind limbs cannot be ascertained.

A metatarsal (No. 5687, U. S. National Museum) (pl. xix, fig. 1) may be provisionally referred to this species, as it has about the same relative proportions as that of *P. nanus*. It is surprisingly heavy when compared with the tibia, however, having fully the bulk of the equivalent bone of *Morosaurus grandis*. Its general form may be ascertained from the figure.

DIMENSIONS

Length	185 mm.
Breadth proximal end	142 mm.
Breadth distal end	113 mm.

There is a middle caudal (No. 5626, G. C.) (pl. xix, figs. 2, 3), which is doubtless referable to this species. It is a solid bone, biconcave, with the neural arch, which is missing, over the anterior portion, as in *P. nanus*. Laterally, it has rather prominent keels, and two lesser ones on its ventral aspect which terminate in the prominent chevron articulations. The transverse processes were situated at the base of the neural pedicels at about the mid-length of the bone. This bone, which is that of a fully mature animal, is here figured. Its dimensions are:

Length	105.0 mm.
Width anterior face	132.0 mm.
Width posterior face	128.0 mm.
Depth of centrum	103.5 mm.

Part of a large proximal caudal is also recognizable, but too defective to characterize.

A large sauropod rib (No. 5010 d, G. C.) may be referred to this species. It is wide at the proximal end, with a prominent tuberculum, and in section is L-shaped at first, broadening out in a shallow U-shape toward the distal end.

Length, estimated	1300 mm.
Distance across articular ends....................	335 mm.

Occurrence.—ARUNDEL FORMATION. Near Muirkirk, Prince George's County.

Collections.—U. S. National Museum, Goucher College.

Genus ASTRODON Johnston

ASTRODON JOHNSTONI Leidy

Plate XIX, Fig. 5

Astrodon johnstoni Leidy, 1865, Smithsonian Contrib. to Knowledge, vol. xiv, art. vi, pp. 102, 119, pl. xiii, figs. 20-23, pl. xx, fig. 10.

Description.—The type (No. 798, Yale Museum) consists of a nearly perfect tooth and the section of another prepared for the microscope. It is thus described by Leidy: "The tooth of *Astrodon*, ... bears considerable resemblance in form to the teeth referred to the *Hylæosaurus*, an associate of the *Iguanodon* and *Megalosaurus*, in the Wealden formation of Europe. The specimen comprises nearly the length of the crown, and is about an inch and a half long. The shaft of the crown is straight, compressed cylindroid, in transverse section ovate, the outer side strongly convex, the inner side much less so. The summit of the crown is compressed conical, curved inward, convex externally, depressed internally, and sub-acute at the lateral borders, one of which is worn in the specimen so as to expose a narrow tract of dentine.

"The transverse section of the tooth beneath the microscope, ... exhibits an interior disk of dentine, with a multitude of minute tubuli radiating from the narrow elliptical section of the pulp cavity, surrounded by a thick layer of enamel."

The dimensions are:

Breadth of crown................................	12.3 mm.
Thickness	10.7 mm.
Length of crown.................................	30.0 mm.

In the collection of Goucher College are two more teeth, one (No. 2604) referable without question to *Astrodon*, differing from the type only in the degree of wear, which has involved not only the apex and the margin on either side, but the greater part of the surface of the crown, so that the characteristic wrinkled aspect is only discernible over a portion toward the fang.

The other specimen (No. 3333) (pl. xix, fig. 4), while nearly as large as the tooth just mentioned, differs from both it and the type in lacking the spoon-shaped curvature characteristic of the others; in fact, it is strikingly like many other teeth in the collections referable to *Pleurocœlus nanus*, except that it is about twice the size of the average of the latter, or about as much larger as the tibia of *Pleurocœlus altus* Marsh (vide supra) exceeds that of *P. nanus.* Moreover, among the number of teeth referable to *P. nanus* there is a considerable range of variation in shape, though no very great difference in size; some of them resembling very closely the type tooth of *Astrodon johnstoni* except for size.

Hatcher[1] has already called attention to this similarity, but made no mention of the great disparity of size, a point brought out by Lucas.[2] I am inclined to agree with Hatcher in considering *Astrodon* and *Pleurocœlus* synonymous, but not in the synonymy of the species *P. nanus* with *Astrodon johnstoni;* for, in spite of the fact that the vertebræ of *Pleurocœlus nanus,* referable to this species, are without exception those of immature animals, they, together with foot and limb bones of appropriate size, as Lucas says, "greatly outnumber all the other vertebrate remains obtained from the vicinity of Muirkirk, Md." This is also true of the teeth referred to this species. *Pleurocœlus altus,* on the other hand, is represented by but few bones, and could readily have been the possessor of teeth like those of *Astrodon johnstoni* as well as of the two specimens mentioned in this section. It is therefore quite possible that *Pleurocœlus altus* should be considered as synonymous with *Astrodon johnstoni,* in which case the latter name would take precedence. It

[1] Hatcher, Ann. Carnegie Mus., vol. ii, 1903, pp. 12-14.

[2] Lucas, Science (N. S.), vol. xix, 1904, p. 436.

seems preferable, however, in view of the rarity of the remains, to let the matter rest in abeyance until further proof is obtained.

Occurrence.—ARUNDEL FORMATION. Bladensburg, Prince George's County.

Collections.—Yale Museum, Goucher College.

Suborder ORTHOPODA

Family CAMPTOSAURIDAE

Genus DRYOSAURUS Marsh

DRYOSAURUS GRANDIS sp. nov.

Plate XIX, Figs. 6, 7; Plate XX, Figs. 1-4

Allosaurus medius Marsh (in part), 1888, Amer. Jour. Sci., ser. iii, vol. xxxv, p. 93.

Description.—The type material consists of a first phalanx of digit iv of the hind foot (No. 5453, U. S. National Museum, cotype of *Allosaurus medius*), an astragalus (No. 5652, U. S. National Museum, ? cotype of *Allosaurus medius*), a proximal phalanx of digit iii (No. 5684, U. S. National Museum), the distal extremities of two metatarsals (Nos. 5684 and 5704 U. S. National Museum), an unnumbered ungual, and the phalanx (No. 2609, Goucher College).

Among the remains referred by Marsh to *Allosaurus medius,* the tooth alone may be with certainty referred to the Theropoda; the "first phalanx of the hind foot," surely, and the astragalus, probably, may be relegated to the ornithopod dinosaurs of the genus *Dryosaurus,* and, together with other material, become the cotypes of a new species.

This species differs from the type of the genus, *D. altus* Marsh[1] (*Laosaurus*), mainly in its greater size and proportions and in the character of the astragalus.

The left astragalus viewed from below is somewhat hour-glass shaped, narrowing toward the calcaneal facet. Viewed anteriorly, the upper margin is seen to be broken away so that the sharp upward process

[1] Marsh, Amer. Jour. Sci. (iii), vol. xvi, 1878, p. 415, pls. ix, x.

from the outer (calcaneal) side is somewhat exaggerated, and gives it a superficial resemblance to the strong upward process of the astragalus of *Creosaurus*. The calcaneal facet is of much greater extent than in *D. altus,* the posterior margin being nearly straight in the present species, whereas in *D. altus* it is sharply curved. The bone under consideration is of less fore and aft diameter than that of *D. altus,* while its transverse diameter is nearly half again as great. This is in part doubtless due to the worn condition of the present type.

The dimensions of the astragalus are as follows:

Transverse diameter	78.0 mm.
Greatest fore and aft diameter	50.5 mm.
Least fore and aft diameter	26.0 mm.
Height	56.0 mm.

Metatarsal ii (pl. xix, fig. 7, left) differs from that of *D. latus* by its larger size, the greater roundness of the articular face, indicating a somewhat more mobile joint, and in the lesser prominence of the outer keel. The depressions upon the lateral faces of both metatarsals are much more pronounced than in *D. altus.* Width of the articular extremity, 34 mm.; fore and aft diameter, 33.5 mm. The bone is extremely hollow; the maximum thickness of the walls of the shaft being 4 mm. The medullary cavity extends well down into the articulation.

Metatarsal iii (pl. xix, fig. 7, right) is also represented by its distal articulation and a small portion of the shaft. It in turn differs from that of *D. altus* in having no median fore and aft depression over its articular face, except a very slight one in front. Its dimensions are as follows:

Width of the articular extremity	43.5 mm.
Fore and aft diameter	33.7 mm.
Width of shaft at fracture 50 mm. above end	29.0 mm.

In this bone the walls are somewhat stouter, measuring 6 mm. as a maximum.

The proximal phalanx of digit iii (No. 5703) is unfortunately from a much smaller individual but differs from that in *D. altus* in having no trace of a median antero-posterior ridge in correspondence with the lack of an equivalent groove in the articulation of the metatarsal. The distal facet of the bone is saddle-shaped with regular curves and no trace of a sharp median groove.

The proximal phalanx of digit iv is represented by two bones, one somewhat smaller than the other. The larger of these (No. 5453, U. S. National Museum) (pl. xx, figs. 1, 2) is part of the cotype of *Allosaurus medius*. The proximal end is concave and there are two very prominent ridges on the palmar aspect of the proximal one-third. Distally it is characterized by a rather pronounced groove in the articular face and the great depth of the external depression. The bone is very hollow, resembling in this respect the metatarsals.

DIMENSIONS

Length	88.0 mm.
Width of proximal end	34.0 mm.
Depth of proximal end	38.5 mm.
Width of distal end	31.5 mm.
Depth of distal end	28.5 mm.
Width of shaft	20.0 mm.

The distal phalanges (pl. xx, fig. 3) are typical with proximal ridge and distal groove, effectually limiting motion other than in the vertical plane.

The ungual (pl. xx, fig. 4), which is here referred to this species, is compressed, triangular in section, the upper face bearing a rather sharp ridge which separates it from those of *Laosaurus consors*, those of *Dryosaurus altus* being unknown. It has a gentle curve with the characteristic slightly hollowed under surface of *Laosaurus* and the smaller *Camptosaurus* species.

DIMENSIONS

Length	55.5 mm.
Height	26.0 mm.
Width	17.0 mm.

Judging from the comparative size of *Dryosaurus grandis* and *D. altus* one would perhaps be justified in assuming the present individual to have attained the length of about 13 feet, using Professor Marsh's estimate of 10 feet for the latter species.

Occurrence.—ARUNDEL FORMATION. Near Muirkirk, Prince George's County.

Collections.—U. S. National Museum, Goucher College.

Family STEGOSAURIDAE

Genus PRICONODON Marsh

PRICONODON CRASSUS Marsh

Plate XX, Figs. 5, 6

Priconodon crassus Marsh, 1888, Amer. Jour. Sci., ser. iii, vol. xxxv, p. 93, figs. 7-9.

Priconodon crassus Marsh, 1896, 16th Ann. Rept. U. S. Geol. Survey, pt. i, pl. xliv, figs. 2a, b, c.

Description.—The type specimen is a single tooth (No. 2135, U. S. National Museum) from near Muirkirk. Marsh's original description is as follows: "The existence of another herbivorous Dinosaur in the same horizon of the Potomac formation is indicated by a number of fragmentary remains, the most characteristic of which is the tooth figured below. This may be regarded as the type specimen. Although resembling somewhat the teeth of *Diracodon* from the Jurassic of the West, it is quite distinct. It has the narrow neck, swollen base, and flattened crown of that genus, but the serrated edges meet above at a sharp angle, instead of forming a wide curve at the apex. The surface shown in fig. 7 is much worn by the opposing tooth. In fig. 9, the pit formed by the succeeding tooth is seen near the top of the fang. The other remains at present referred to this species were not found with this tooth, and hence, their relations to it are uncertain. They will be described more fully elsewhere."

The prominences producing the serration of the edges of the crown are continued down on either face of the crown in delicate, curved ridges except where obliterated through wear. The swollen base is separated from the blade-like crown, forming a prominent shoulder from which a single ridge runs nearly straight upward toward the apex. There remains but little of the fang of the tooth, but it appears to have been nearly cylindrical, as in *Stegosaurus* and *Diracodon.*

DIMENSIONS

Width across crown	9.7 mm.
Thickness	6.3 mm.
Height of crown above shoulder	6.5 mm.

This tooth resembles somewhat that of *Palæoscincus costatus* Leidy,[1] from the Judith River beds, though the type of *Palæoscincus* is slightly smaller than that of the present species. The swelling shoulder in *Priconodon* is more prominent and rounded than in *Palæoscincus,* and in the latter the cusps are much sharper and more prominent, though less numerous on one edge of the crown. The median ridge of *Priconodon* is also lacking.

The tooth of *Priconodon* resembles those of *Diracodon* and *Stegosaurus* in the rounded shoulder, but has the blade of the crown more sharply compressed and is very much larger. The dimensions of the former are: *Diracodon,* 5 mm. wide; *Stegosaurus,* 5.5 mm. (measured from the figure). A specimen, No. 2606, from the collection of Goucher College, Baltimore, is a relatively immense tooth, though badly worn through use and subsequently, so that except for the general shape, the distinctive characters are not clearly discernible. Its dimensions are as follows:

Width	15.7 mm.
Height of crown	14.6 mm.
Thickness of crown	9.3 mm.

The two last measurements have become less through abrasion. This tooth represents a much larger animal, for an individual has teeth of approximately the same size throughout, if one may judge from the jaws of *Diracodon* and *Stegosaurus.* There are, however, in the collection of Goucher College, Baltimore, specimens intermediate in size, and all so worn as to show no clearly defined specific characters which would serve to separate them from the type. These specimens, five in number, are all from the blue charcoal clay of Coffin's Old Engine Bank, Swamp Poodle, near Muirkirk, Maryland. The locality of the type is also the Swamp Poodle, but the precise locality and level are not given.

From the Arundel blue charcoal clay of Contee, Maryland, comes specimen No. 3101, of the Goucher College collection, the centrum of a dorsal vertebra (pl. xx, fig. 6), unlike anything else in the entire mass of Arundel material. It represents a young animal, since the neural arch had not yet coössified with the centrum. The centrum is opisthocœlous, the anterior articular face being plane; the posterior a moderately deep

[1] Trans. Amer. Phil. Soc., vol. xi, 1860, pp. 146-7, pl. ix, figs. 49-52.

concavity. The bone tapers decidedly, as the anterior face is less than four-fifths of the transverse diameter of the posterior. The sides are decidedly concave and meet in a slight keel-like angle inferiorly. The neural canal is extremely narrow, especially at a point just in front of the mid-length of the centrum. There are several tiny, irregularly placed foramina which enter the centrum from the bottom of the canal, the two anterior ones being separated by a slight ridge. The irregular ridges on the articular face for the pedicels of the neural arch are approximately parallel, only radiating at the anterior end of the centrum. The bone appears to be solid, of fine cancellous character, with no trace of lateral depressions, such as one finds in *Pleurocœlus*. This vertebra which evidently came from the mid-dorsal region, compares very closely with a vertebra of *Stegosaurus ungulatus* (cotype No. 1858, Yale Museum), except for size. The two vertebræ differ in the much less relative depth of the posterior concavity in *Stegosaurus,* and in the fact that the anterior and posterior faces are the same diameter in *Stegosaurus,* but there is a similar, though not quite so marked, tapering of the pedicel facets. The groove of the neural canal is wider in *Stegosaurus,* and seems to lack the constriction, but it is quite probable that the neural canal widened perceptibly vertically before narrowing again in the neural arch of *Priconodon.* There is no trace of a keel-like ridge on the lower side of the centrum in *Stegosaurus,* though the curve of the section is sharper here than on the sides. In neither case is there a trace of the capitular rib facet on the centrum, which in *Stegosaurus* is high on the greatly elevated neural arch.

In pl. xvii of the forthcoming monograph of the Stegosauria this bone is figured, together with a longitudinal section, showing its extremely dense cancellous tissue comparable to that of the centrum under discussion. From this comparison it seems reasonably sure that we have here the centrum of a stegosaurian dinosaur which will be provisionally referred to *Priconodon.* Whether it may be referred to *P. crassus* or not is an open question, for the vertebra is much smaller than that of the adult *Stegosaurus ungulatus* while on the other hand the teeth of *Priconodon* are much larger than those of the stegosaur. Leidy says, however, that "we observe no necessary relation of the length of animals in proportion with the size of their teeth."

The dimensions of the centrum are as follows:

Length	69.0 mm.
Depth of anterior face	49.0 mm.
Depth of posterior face	60.0 mm.
Width of anterior face	37.3 mm.
Width of posterior face	49.5 mm.
Depth of posterior concavity	9.5 mm.
Least width of arch facet (ant.)	17.0 mm.
Greatest width of arch facet (post.)	33.2 mm.

The tooth of *Priconodon* comes nearest Leidy's *Palæoscincus* from the Judith River, to which it could readily be ancestral, as the evolutionary tendency on the part of the Orthopoda is to increase the number and decrease the size of teeth.

The vertebra is nearest to *Stegosaurus,* but the equivalent vertebra of *Palæoscincus* is unknown, and the association of vertebræ and teeth is in each case conjectural.

Occurrence.—ARUNDEL FORMATION. Near Muirkirk, Contee, Prince George's County.

Collections.—U. S. National Museum, Goucher College.

Order CROCODILIA

Suborder EUSUCHIA

Family GONIOPHOLIDAE

Genus GONIOPHOLIS Owen

GONIOPHOLIS AFFINIS sp. nov.

Plate XX, Fig. 7

Description.—A crocodile is represented by a number of teeth and part of a scute. The teeth, however, are the most distinctive. They show beyond question the generic characteristics of *Goniopholis:* "stout, rounded, slightly curved, with the enamel ridged and grooved, and well-marked carinæ placed in a plane coincident with that of the curvature of the crown."[1] They resemble very closely a multitude of teeth from

[1] Lydekker, British Mus. Catalogue Reptilia and Amphibia, pt. i, 1888, p. 79.

"Quarry 9," Como, Wyoming (Morrison), preserved in the Yale Museum, which agree in size with those of the type specimen of *Goniopholis* (*Diplosaurus*) *felix* (Marsh). Unfortunately, none of the crowns in the last specimen show their outer surface, but those of the Maryland specimen differ from those from Como by having secondary ridges between the main ridges on the proximal portion of the crown. See figure. The similarity aside from this feature is very great and shows a close relationship with the Morrison type as the specific name implies. The sculpturing on the scute (No. 5465) is coarser than on any of those in the lot of material from Como. This may, however, be due to the portion of the body from which the scute came, and is probably not of importance.

Tooth No. 8175, M. G. S., may be taken as the type.

Length of crown about	25 mm.
Width of crown at base	12 mm.

Occurrence.—Arundel Formation. Branchville, Prince George's County.

Collections.—Maryland Geological Survey, U. S. National Museum.

MOLLUSCA

Class GASTROPODA

Order CTENOBRANCHIATA

Suborder PLATYPODA

Superfamily TAENIOGLOSSA

Family AMNICOLIDAE

Genus BYTHINIA Leach

Bythinia arundelensis sp. nov.

Plate XXI, Fig. 6

Description.—Shell small, turbinate; sutures pronounced; whorls inflated, the last much larger than the earlier ones; surface apparently smooth, except for lines of growth.

This species is represented by a single cast.

Length, 6 mm.; diameter, 4 mm.

Occurrence.—ARUNDEL FORMATION. Arlington, Anne Arundel County, Maryland.

Collection.—Maryland Geological Survey.

Family VIVIPARIDAE

Genus VIVIPARUS Montf.

VIVIPARUS MARYLANDICUS sp. nov.

Plate XXI, Figs. 1-3

Description.—Shell subconical; sutures deep; whorls flattened; surface probably smooth, except for lines of growth; last whorl much larger than the earlier ones.

This species is represented by two casts, of which pl. xxi, fig. 1, is regarded as the type.

Length, 12 mm. (?); diameter, 7 mm.

Occurrence.—ARUNDEL FORMATION. Arlington, Anne Arundel County, Maryland.

Collection.—Maryland Geological Survey.

VIVIPARUS ARLINGTONENSIS sp. nov.

Plate XXI, Figs. 4, 5

Description.—Shell conical, elongate; sutures moderately deep; whorls slightly flattened; surface apparently smooth, except for lines of growth; whorls four in number, the last whorl larger than earlier ones.

This species is represented by two specimens which show the whorls in cross-section; pl. xxi, fig. 4, is regarded as the type.

Length, 11 mm.; diameter, 6 mm.

Occurrence.—ARUNDEL FORMATION. Arlington, Anne Arundel County, Maryland.

Collection.—Maryland Geological Survey.

Class PELECYPODA

Order TELEODESMACEA

Superfamily CYRENACEA

Family CYRENIDAE

Genus CYRENA Lam.

Cyrena marylandica sp. nov.

Plate XXI, Figs. 8, 9

Description.—Shell subtriangular, thin, flattened, obscurely concentrically ridged, inequilateral; the beaks low.

The fragmentary specimens of this species indicate that it belongs to the genus Cyrena.

Length, 12 mm.; height, 6.5 mm.

Occurrence.—Arundel Formation. Arlington, Anne Arundel County, Maryland.

Collection.—Maryland Geological Survey.

Order PRIONODESMACEA

Superfamily NAIADACEA

Family UNIONIDAE

Genus UNIO Retzius

Unio patapscoensis sp. nov.

Plate XXI, Fig. 7

Description.—Shell subovate, elongate, thin, flattened, beak about one-third distance from anterior to posterior end, and low.

The single valve found is a cast which shows clearly the characteristic form of the shell.

Length, 35 mm.; height, 20 mm.

Occurrence.—Patapsco Formation. White House Bluff, Fairfax County, Virginia.

Collection.—U. S. National Museum.

SPOROPHYTA

CLASS PTERIDOPHYTA

Order FILICALES

Family SCHIZAEACEAE

Genus SCHIZAEOPSIS Berry

[Annals of Botany, vol. xxv, 1911, p. 194]

Ferns of unknown habit with repeatedly dichotomous fan-like fronds made up of ribbon-like coriaceous segments. Veins for the most part thin and parallel for the greater part of their course, but forking dichotomously at intervals. Fructifications massed in fusiform bodies of relatively large size, and consisting of numerous closely packed sporangia, whose structure and detailed arrangement are unknown. These fructifications are borne at the distal ends of certain of the veins at varying heights, usually along the margins, but occasionally on the face of the laminæ. Ordinarily they are massed toward the distal ends of the ultimate divisions of the frond, as in the modern *Schizæa elegans*, the ultimate ones appearing as continuations of the ultimate teeth which terminate the distal lacinæ. Spores spherical, thick walled, massively striated.

The fern genus, *Acrostichopteris* (*Baieropsis*), which is very similar in vegetative character to *Schizæopsis*, is best retained for the somewhat similar remains of fronds until definite information is obtainable regarding their reproductive structures, although it is extremely probable that some at least of the species of *Acrostichopteris* should be referred to the Schizæaceæ, and the same remark is equally applicable to certain species ordinarily referred to the genus *Baiera*.[1]

There are abundant theoretical reasons for expecting to find representatives of this family as far back at least as the later Mesozoic. Such

[1] This is, of course, not true of all species of *Baiera*, some of which in their fruiting characters, show conclusively a relationship with *Ginkgo*.

still earlier ferns as have been supposed to exhibit affinities with the Schizæaceæ, as, for example, the Paleozoic genus *Senftenbergia*, are too obscure and indefinite to be of much value, and it seems certain that the older Mesozoic and Paleozoic ferns, at least the Leptosporangiate ones, were too generalized to admit of their being referred to the accepted families, based as the latter are to such a large extent, upon existing species. There is, however, abundant collateral evidence for the view that by the dawn of the Cretaceous the main lines of cleavage which separate the fern-families, as we now know them, were rather clearly defined. In addition to the *Schizæa*-like species here described, the Schizæaceæ were represented in the Lower Cretaceous rocks of both Europe and America by several species referred to the genus *Ruffordia*, which, in the character of its sterile and fertile fronds, resembles the modern genus *Aneimia*.

There is also the well-authenticated Jurassic genus *Klukia* of Raciborski,[1] which seems to fall within this family, and Professor Zeiller[2] has recently called attention to certain fern remains from the Wealden of Peru, which have annulate sporangia of the *Schizeæ* type. Finally, Stopes and Fujii[3] have described structural material from the Upper Cretaceous of Hokkaido, Japan, sufficiently preserved to show some of the soral characters and to warrant the restoration of the sporangium of what they call *Schizæopteris mesozoica*.

While the present genus is thus far confined to the eastern United States, the genus *Acrostichopteris*, which so closely resembles it in vegetative habit and geological position, has been found in the Kootanie formation of Montana and in the Wealden of England, and closely allied, if not identical, forms have been described by Saporta from the Lower Cretaceous rocks of Portugal as various species of *Sphenopteris*.

[1] Raciborski, Engler's Bot. Jahrb., Band xiii, 1891, p. 1.

[2] Zeiller, Comptes rendus, tome cl, 1910, p. 1488.

[3] Stopes and Fujii, Phil. Trans. Roy. Soc. Lond., vol. cci B, 1910, p. 6, tf. 1-3, pl. ii, fig. 1.

SCHIZÆOPSIS AMERICANA Berry

Plate XXII, Figs. 1-9

Baieropsis expansa Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, pl. lxxxix, fig. 1 (non fig. 3; pl. xc, fig. 1; pl. xci, fig. 2; pl. xcii, fig. 5, which are referred to *Acrostichopteris expansa*).

Baieropsis macrophylla Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 212, pl. xc, fig. 6.

Schizæopsis expansa Berry, 1911, Annals of Botany, vol. xxv, p. 194, tf. 1, pl. i, figs. 1-6.

Description.—Fronds relatively large, about 11 cm. in length by 6 cm. in width, apparently short stalked, divided almost to the base into two principal ribbon-like divisions, which, in turn, are almost immediately subdivided dichotomously into two similar subordinate divisions which are dichotomously forked in a like manner at varying heights. In the nearly complete specimen figured from which the restoration has been made, the outer main division of the frond is somewhat less developed and less cut up than the inner main division. The texture is coriaceous. The veins are thin but strong, in some specimens suggesting a double vascular strand; they fork dichotomously near the region where the frond forks, and then repeatedly at varying intervals, but they are, for the greater part of their course, unbranched and approximately parallel. They are somewhat more numerous than in the comparable modern species of *Schizæa*. The fructifications, as preserved, are brownish, spindle-shaped bodies about 4 mm. in length and 1 mm. in diameter. They were observed and figured by Fontaine in the specimens named by him, *Baieropsis macrophylla,* and were considered to be of a pathological nature, i. e., fungal, but were not noticed on the specimen which he included under *Baieropsis expansa,* although they are readily seen in the figure here reproduced, which is from a photograph of the specimen from which Fontaine drew his fig. 1 on pl. lxxxix, of the Potomac flora. These fructifications are borne at the distal ends of certain of the veins at varying heights, usually along the margins, but occasionally on the face of the laminæ. Ordinarily they are massed toward the distal ends of the ultimate divisions of the frond, as in the modern *Schizæa elegans,* the ultimate ones appearing as continuations of the ultimate teeth which terminate the distal laciniæ. Numbers of these fructifications are in organic connection with the fronds, so that there is no room for any mistake in observation. These objects are found upon microscopic examination to be made up of masses of closely packed, relatively large spores, in the ground mass of which there are traces of other tissues which cannot be made out, but which evidently represent peduncles and sporangial walls. These spores are nearly spherical in form, a feature common to the genera *Aneimia* and *Lygodium,* but apparently not to *Schizæa.* They are of large size, averaging about 1/10 of a millimetre in diameter. The tetrad scars are small but well marked, but show no protuberances or ornaments at the outer angles. The walls are thick and strongly striated, another feature of the modern Schizæaceæ, especially of the genus *Aneimia,* and well shown in the fossil spores reproduced on Pl. XXII. The spore contents are for the most part dissipated, only the yellowish exine remaining, and the walls are frequently collapsed so that with a low power they appear cross-lined because of their juxtaposition.

Since only the spores are preserved the morphology of these fructifications is conjectural. They have the appearance of simple fusiform sporangia of gigantic size, but it is believed that they represent a large number of pairs of more or less confluent, or at least close packed, sporangia.

The specimens are found in a partially lithified sandy clay, almost an argillaceous sand, but the sand is fine-grained, so that the fossils are well preserved, as indicated by the specimen photographed. In this specimen the spores were evidently nearly mature, as indicated by their size and configuration. None seen are in tetrads, and yet the sporangia could hardly have dehisced before fossilization, since each tiny rock cavity which represents these fructifications is packed with the spores. In some of the impressions there are faint transverse lines on the matrix as if they marked the line of demarcation between successive pairs of sporangia-bearing branches, and in one case the vein upon which the fructification was borne can be traced the entire length of the fructification, clearly indicating that it is not a gigantic simple sporangium but an aggregate of sporangia comparable to that of the modern genus *Schizæa.* These are both figured (x 4) on pl. xxii.

With regard to the botanical affinity of this species the writer's convictions are indicated in the generic name. No modern group of ferns fulfils the conditions as does the family Schizæaceæ. The fossil fern is identical with various modern tropical members of this family in vegetative habit, no other modern ferns known to the writer resembling

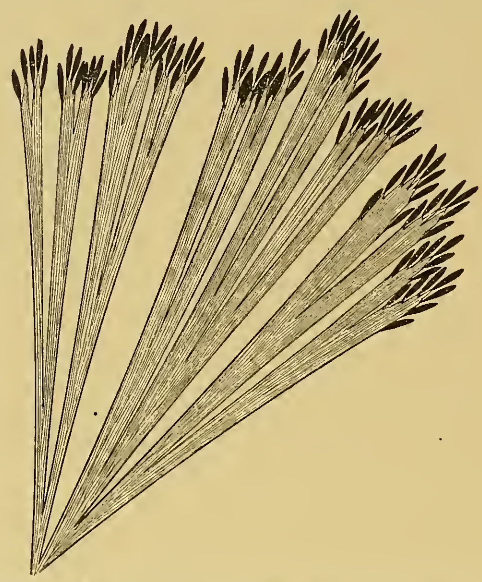

FIG. 2.—Restoration of a frond of Schizæopsis americana Berry, about four-fifths natural size.

it in the character of the fronds except the genus *Rhipidopteris* of the Polypodiaceæ, which has a quite different habit and type of fructification. The venation is closely similar to *Schizæa.* The fructifications are similarly borne and the spores are similar in form and markings to those of the closely allied modern species of *Lygodium* and *Aneimia.* It is believed that the combination of close agreement in vegetative characters with a similar close agreement in fructification characters, in so far as they are determinable from the nature of the material, justifies the reference of these ferns to the family Schizæaceæ, a family which on theoretical grounds we would expect to find represented in the Lower

Cretaceous. Whether the detailed organization of the fructifications conforms to that which obtains in the modern members of the family cannot be determined; presumably there were differences, but these were probably not greater than those between the existing genera referred to this family. A restoration of the fossil drawn from the specimen here figured is shown in text fig. 2.

Since *Baieropsis expansa* was the type of Fontaine's genus *Baieropsis* it cannot be made the type of the new genus *Schizæopsis,* and it is therefore referred to the older genus *Acrostichopteris,* with the members of which it agrees in its known characters. The single specimen from Fredericksburg, which is the type of the present species and genus, and which is different from *Baieropsis expansa,* as defined by Fontaine, must therefore be renamed, a fact which was overlooked when the writer described the present species.

It is very probable that the widespread *Baiera cretosa* Schenk,[1] recorded by Heer,[2] from the Kome beds of Greenland, and by Dawson[3] from the Kootanie of British Columbia, both of these latter records, as well as Schenk's type material from the Barremian of Austrian Silesia (Wernsdorfer Schichten) being fragmentary,[4] is related to *Schizæopsis,* as may also be *Jeanpaulia nervosa* Dunker[5] of the Wealden of Germany. The evidence for considering them referable to the Ginkgoales is certainly very inconclusive, in fact Schenk originally compared his specimens with the modern *Schizæa elegans,* and they are all very different from the true *Baiera* of the Patuxent formation.

Occurrence.—PATUXENT FORMATION. Fredericksburg, Virginia.

Collection.—U. S. National Museum.

[1] Schenk, Palæontographica, Band xix, 1869, p. 5, pl. i, fig. 7.

[2] Heer, Fl. Foss. Arct., Band iii, Abth. ii, 1874, pp. 59, 124, pl. xiii, figs. 13, 14; pl. xvii, fig. 12; pl. xxxv, figs. 8-10 *(Sclerophyllina): Ibid.*, Band vi, Abth. ii, 1882, p. 14 *(Baiera).*

[3] Dawson, Trans. Roy. Soc. Canada, vol. iii, sec. iv, 1885, p. 9, pl. ii, fig. 5 *(Baiera longifolia).*

[4] Nathorst (Kungl. Svenska Veten. Akad. Handl. Band xxx, 1897, No. 1, p. 33), considers the specimens from Spitzbergen which Heer referred to this species in 1877 (*loc. cit.*, Band iv, p. 49) to be fragments of fern stems.

[5] Dunker, Mon. Norddeutsch. Wealdenbildung, 1846, p. 12, pl. v, fig. 3.

Genus ACROSTICHOPTERIS Fontaine

[Mon. U. S. Geol. Survey, vol. xv, 1890, p. 106]

This genus is characterized as follows by its describer: "Fronds probably creeping, with very long, often flexuous rachises, which seem to to have been more or less succulent; pinnæ going off obliquely, long and apparently slender; ultimate pinnæ or pinnules subopposite to alternate, comparatively short, and cut down nearly to the rachis into more or less cuneate-flabellate pinnules or primary segments. These are divided generally into cuneate-flabellate segments, which in turn are separated into oblong segments, ending in oblong, or ovate-obtuse, or acute teeth; pinnules decurrent and forming a wing; nerves slender but distinct, flabellately diverging, forking dichotomously, and ending in the teeth; fructification occurring on the basal segments of the pinnules, in the upper portions of the frond on the upper one alone, in the lower portions on the upper and lower ones, the fructified segments close appressed to the principal rachis. The fructified segments are so modified as to take the form of leathery, rounded, or elliptical segments, which on the lower side are covered by the naked sori, and seen from the upper side, especially when compressed on the clay, look like pods." The fructification characters should be modified to include those of *Acrostichopteris pluripartita,* which appear to represent entire pinnules reduced to fertile segments and not merely basal lobes of otherwise sterile pinnules thus transformed, as appears to be the case in *Acrostichopteris longipennis.*

With all the collected material at hand it is difficult to see any conclusive evidence that the species included in this genus were creeping in habit or had succulent rachises or that the the fertile segments were covered with naked sori. There is some evidence as to fructification characters, but this is most indefinite as regards details, and it may be noted that what are called nut-like seeds when applied to fragments referred by this author to his genus *Baieropsis* are described as above for fragments which he referred to the present genus, although neither the fertile nor the vegetative parts are distinguishable with certainty in these two supposed genera.

Most of the supposed species of *Baieropsis* are referred in the present work to *Acrostichopteris,* with which they are obviously allied in instances where they are not actually identical. They present no characters which are clearly those of the order Ginkgoales, except their subdivided fronds, which are suggestive of *Baiera* or *Jeanpaulia,* but might equally suggest various living Polypodiaceæ, e. g., *Actinopteris* and *Rhipidopteris,* or the family Schizæaceæ. Among fossil species they are very similar to forms referred to *Sphenopteris, Palmatopteris,* etc. Considerations which point away from *Baiera* in the direction of the ferns are the fine inequilateral outline of the leaves (pinnules), their decurrence, and their arrangement in a pinnate manner in a single plane. As has already been shown the species *Baieropsis macrophylla* Fontaine and part of *Baieropsis expansa* Fontaine have furnished fructifications which ally them with the family Schizæaceæ.

With regard to the botanical position of *Acrostichopteris* little is known. According to Fontaine: "The genus in the naked sori is like *Polypodium,* but in most features stands nearest to *Acrostichum,* much resembling the section *Rhipidopteris.* In this latter, however, the fructification is borne on separate pinnules. If we place the fructified pinnules of *Rhipidopteris* as basal segments on the sterile ones, we have a form strikingly like *Acrostichopteris.* This genus has also some resemblance to *Marsilea.*"

Seward,[1] on the strength of Fontaine's conclusions, as quoted above, places the genus in the Polypodiaceæ. Potonié [2] places it as a synonym of his *Palmatopteris* in the artificial group of Sphenopterides.

There is considerable collateral evidence for the reference of these forms to the family Schizæaceæ, or to what answered to this family in a general way in Mesozoic times. This evidence consists of a relationship of this sort shown by fertile specimens of *Baieropsis expansa* Fontaine and *Baieropsis macrophylla* Fontaine, which the writer has united [3] to

[1] Seward, Wealden Fl., pt. i. 1894, p. 60.
[2] Potonié in Engler and Prantl, 1902, p. 490.
[3] Berry, Annals of Botany, vol. xxv, 1911, pp. 193-198.

form the species *Schizæopsis americana,* and which differ but slightly in frond characters from the members of the present genus. Furthermore, there is the close resemblance between the sterile fronds of this genus and those of *Ruffordia,* which, upon fairly satisfactory grounds, has been referred by Seward (*loc. cit.*) to the Schizæaceæ.

Acrostichopteris may be compared with the modern *Actinopteris,* a monotypic genus of the Indoafrican steppes, with the neotropical genus *Rhipidopteris,* or with *Schizæa dichotoma* Sw. and *Schizæa elegans* Sw. of the family Schizæaceæ. It is not closely related to *Acrostichophyllum* Velenovsky (1889), of the Cenomanian of Bohemia. As here delimited it embraces six species in the Maryland-Virginia region. Of these, three species are confined to the basal beds or Patuxent formation, two species range through the whole Lower Cretaceous of this region, and are present as well in both the Lakota and Fuson formations of the Black Hills region, and one species is confined to the Patapsco formation and is widespread in its occurrence. One additional species, suggestive of *Acrostichopteris parvifolia* of the Patuxent formation, and likewise close to the only remaining species, *Acrostichopteris Ruffordi* Seward[1] of the English Wealden, has recently been described by Knowlton[2] from the Kootanie of Montana. Considering for a moment the Portuguese homotaxial deposits we find a considerable number of remarkably similar forms described by Saporta,[3] all of which are referred to the form-genus *Sphenopteris.* Thus from the Upper Jurassic there is *Sphenopteris tenellisecta* Sap., from the Urgonian *S. cuneifida* Sap., from the Aptian *S. flabellisecta* Sap., *S. tenuifissa* Sap., and *S. debilior* Sap. These forms are certainly congeneric with *Acrostichopteris,* and with more representative material doubtless some species would be found to be common to both sides of the Atlantic. Some are more nearly like the forms segregated by Fontaine to form his genus *Baieropsis,* while others are of the type which this author referred to *Acrostichopteris.*

[1] Seward, Wealden Fl., pt. i, 1894, p. 61, pl. vi, fig. 3.
[2] Knowlton, Smith. Misc. Coll., vol. 1, 1907, p. 110, pl. xi, figs. 3, 3a.
[3] Saporta, Fl. Foss. Portugal, 1894, pp. 25, 69, 127, 160, 161.

ACROSTICHOPTERIS LONGIPENNIS Fontaine

Plate XXIII, Figs. 1, 2; Plate XXIV, Fig. 7

Acrostichopteris longipennis Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, p. 107, pl. clxx, fig. 10; pl. clxxi, figs. 1, 5, 7.

Acrostichopteris densifolia Fontaine, 1890, *Ibid.* (pars), pl. clxx, fig. 11; pl. clxxi, figs. 2, 6; pl. clxxii, fig. 13 (non pl. xciv, fig. 4 which is referable to *A. parvifolia* Font.).

Baieropsis foliosa Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 209, pl. xciii, figs. 4-6.

Baieropsis denticulata angustifolia Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 210, pl. cxii, fig. 7.

Baieropsis denticulata angustifolia Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 491.

Acrostichopteris longipennis Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 567.

Acrostichopteris parvifolia Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 558, pl. cxvi, fig. 5.

Baieropsis foliosa Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 481, 482, 489, 504, 508, pl. cx, fig. 9.

Acrostichopteris longipennis Berry, 1910, Proc. U. S. Natl. Mus., vol. xxxviii, p. 627.

Description.—Fronds with relatively long pinnæ, decompound proximad and becoming simpler distad, the ultimate pinnules subopposite to alternate, rather close set. Pinnules inequilateral and slightly decurrent, cut into several narrow sublinear divisions and terminated by two or more subacute teeth. The lower pinnules are wider and more laciniate, and more decidedly alternate on the stout rachis. Venation fine, but distinct, flabellate and dichotomous, ultimate divisions terminating in the apical teeth. The sterile and smaller specimens tend to much greater density than those of larger size or those showing traces of fructifications. The fructifications, which are illy defined in the coarse matrix, are borne on the proximal or distal or both basal segments of the pinnules; the segment or segments involved becomes wider and shorter and elliptical in outline. No details can be made out.

This species is exceedingly common in the Patapsco formation, to which it is confined, being especially common in the beds of this age at Federal Hill. In Virginia it occurs at a large number of localities within this formation.

It is difficult to see what evidence, unless it be the supposed relationship with the modern *Rhipidopteris,* led Fontaine to claim a creeping habit for these forms. The rachis is sometimes more or less flexuous, but not markedly so, and the length is relatively great. Proximally, however, the rachis becomes stouter with decompound pinnæ as broad or broader than they are long. It seems probable that this form was not a ground dweller with creeping rachis or rhizome, nor did it adhere to tree trunks, but reclined or clambered over the abundant erect Lower Cretaceous vegetation, as does the modern *Lygodium.* It appears to be closely related to *Sphenopteris debilior* Sap.[1] of the Albian of Portugal.

Occurrence.—PATAPSCO FORMATION. Near Wellhams, Federal Hill (Baltimore), Maryland. Near Brooke, 72d milepost, Hell Hole, Mouth of Hell Hole (?), White House Bluff, Dumfries Landing, Aquia Creek Cut, and Mt. Vernon, Virginia.

Collections.—U. S. National Museum, Johns Hopkins University, Goucher College.

ACROSTICHOPTERIS ADIANTIFOLIA (Fontaine) Berry

Plate XXIV, Figs. 2, 3

Baieropsis adiantifolia Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 211, pl. xcii, figs. 8, 9; pl. xciii, figs. 1-3; pl. xciv, figs. 2, 3.
Baieropsis adiantifolia Fontaine, 1899, in Ward, 19th Ann. Rept. U. S. Geol. Survey, pt. ii, p. 684, pl. clxviii, fig. 8.
Baieropsis adiantifolia Fontaine, 1906, in Ward, Mon. U. S. Geol. Survey, vol. xlviii, 1905, pp. 510, 528, 538.
Acrostichopteris adiantifolia Berry, 1910, Proc. U. S. Natl. Mus., vol. xxxviii, p. 629.

Description.—" Stems moderately strong; leaves subopposite to opposite, closely placed, often imbricated, subquadrilateral to flabellate fan shaped, narrowed to a wedge-shaped base, and attached by a short pedicel which springs from the lower corner of the leaf, so that the inner margin of the leaves runs close to the main stem, parallel with it, and often overlapping it, while the lower margin of the leaves stands nearly at

[1] Saporta, Fl. Foss., Portugal, 1894, p. 161, pl. xxviii, figs. 5, 5a.

right angles with the main stem; leaves cut down to near the base into two principal laciniæ, and those higher cut into two or more minor laciniæ; ultimate laciniæ very shallow and strap shaped, ending in acute very short teeth, or rarely in narrowly elliptical and subacute ones; all the laciniæ turned outwards or upwards, the lower margins of the leaves being entire or having sometimes an acute tooth; leaves in ascending towards the tips of the leafy branches have their lower margins directed more and more upwards, become smaller, assume more of an elliptical or a wedge shape, have the laciniæ only on the upper margin, and, finally, coalesce to form a terminal leaflet, which at base shows three segments, but whose terminal portions are not seen; nerves fine but distinct, branching at base from a mother nerve, and then dividing repeatedly in a dichotomous manner so as to fill the laminæ, and have the branches ending in the teeth.

"The plant is most frequent at Fredericksburg, but is not abundant there, and is usually in a very fragmentary state. If we look to the shape of the leaves alone this curious plant is much like a fern of the type of *Adiantum*, but the gradations through different forms connect the specimens so closely with the flabellate leaves of *Baieropsis* that they cannot be separated by any good distinctions. The principal difference from the more common and typical forms of *Baieropsis* is found in the greater proportional width of the leaves and the smaller depth of the subdivision."—Fontaine, 1890.

This species is based upon very fragmentary specimens, and it is very doubtful if the material identified from the Patapsco and Arundel formations is the same as that from the Patuxent, the presence of this species from Chinkapin Hollow, Virginia, and Arlington and Fort Foote, Maryland, being each based on a single, very poor specimen.

Occurrence.—Patuxent Formation. Fredericksburg, Lorton (Telegraph station), Potomac Run, Virginia. Arundel Formation. Arlington, Maryland. Patapsco Formation. Fort Foote, Maryland (?); Chinkapin Hollow, Virginia (?).

Collection.—U. S. National Museum.

ACROSTICHOPTERIS CYCLOPTEROIDES Fontaine

Plate XXIV, Fig. 1

Acrostichopteris cyclopteroides Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 109, pl. xciv, fig. 8.
Baieropsis denticulata Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 210, pl. xciii, fig. 7.
Acrostichopteris cyclopteroides Berry, 1910, Proc. U. S. Natl. Mus., vol. xxxviii, p. 630.

Description.—Pinnules rounded, fan shaped, cyclopteroid, divided into two or three principal segments, which are split up into six or more subordinate linear oblong divisions terminated by subacute teeth. Rachis stout. Venation flabellate, the single vein which enters the base repeatedly forking dichotomously, the ultimate divisions entering the teeth.

This species is poorly characterized and is based upon infrequent and very fragmentary material from the single locality cited. It may well represent a slightly variable form of pinnule of one of the other more abundant Patuxent species, e. g., *Acrostichopteris parvifolia* Fontaine. In the foreign Cretaceous it is rather remotely suggestive of *Sphenopteris flabellina* Sap.[1] from the Albian of Portugal.

Occurrence.—PATUXENT FORMATION. Dutch Gap, Virginia.

Collection.—U. S. National Museum.

ACROSTICHOPTERIS PARVIFOLIA Fontaine

Plate XXIV, Figs. 4, 5

Acrostichopteris parvifolia Fontaine, 1890 (pars), Mon. U. S. Geol. Survey, vol. xv, 1889, p. 108, pl. xciv, figs. 5, 9, 10, 12; pl. clxxi, figs. 3, 4; pl. clxxii, fig. 4 (non Font., in Ward, 1906).
Acrostichopteris densifolia Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, pl. xciv, fig. 4 (non balance of citation).
Baieropsis adiantifolia minor Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 212, pl. xciv, fig. 1.
Acrostichopteris parcelobata Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 108, pl. xciv, figs. 6, 7, 11, 14.
Acrostichopteris parvifolia Berry, 1910, Proc. U. S. Natl. Mus., vol. xxxviii, p. 630.

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[1] Saporta, Fl. Foss., Portugal, 1894, p. 160, pl. xxviii, figs. 3, 6.

Description.—Pinnules small and generally remote, the distal ones short, all divided into three principal lobes which are variously dissected and terminated with two or more short, stout teeth. Venation as usual in this genus.

This species is thus far confined to the Patuxent formation of Virginia, the specimens from Maryland so identified by Fontaine proving to belong to *Acrostichopteris longipennis,* which is somewhat similar in appearance but usually much more dense in habit.

The remains are rare and fragmentary at all of the recorded localities except Dutch Gap Canal, where they are not infrequent. They show no traces of fructifications. This species is very closely related to *Acrostichopteris fimbriata* Knowlton[1] of the Kootanie formation of Montana, and likewise to *Acrostichopteris Ruffordi* Seward[2] of the English Wealden. On the continent it is represented by the nearly allied and strictly congeneric species *Sphenopteris tenellisecta* Sap.[3] from the Upper Jurassic, and *Sphenopteris flabellisecta* Sap.[4] from the Aptian of Portugal.

Occurrence.—PATUXENT FORMATION. Dutch Gap, Fredericksburg, Trents Reach, Potomac Run, Virginia (not Federal Hill, Md.).

Collection.—U. S. National Museum.

ACROSTICHOPTERIS PLURIPARTITA (Fontaine) Berry.

Plate XXIV, Fig. 6

Baieropsis pluripartita Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 208, pl. lxxxix, fig. 4; pl. xc, figs. 2-5; pl. xci, figs. 1, 3, 4, 7; pl. xcii, figs. 1, 2, 6.

Baieropsis pluripartita minor Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 208, pl. xci, fig. 5; pl. xcii, fig. 3, 4.

Baieropsis longifolia Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 210, pl. xci, fig. 6.

Baieropsis pluripartita ? Fontaine, 1899, in Ward, 19th Ann. Rept. U. S. Geol. Survey, pt. ii, p. 685, pl. clxviii, figs. 9-12.

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[1] Knowlton, Smith. Misc. Coll., vol. l, 1907, p. 110, pl. xi, figs. 3, 3a.

[2] Seward, Wealden Fl., pt. i, 1894, p. 61, pl. vi, fig. 3.

[3] Saporta, Fl. Foss. Portugal, 1904, p. 25, pl. xiii, fig. 1.

[4] Saporta, *Ibid.*, p. 69, pl. xv, figs. 14, 15.

Baieropsis pluripartita Fontaine, 1906, in Ward, Mon. U. S. Geol. Survey, vol. xlviii, 1905, pp. 479, 481, 482, 505, pl. cvii, fig. 1.

Baieropsis longifolia Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 505, 517, pl. cxi, fig. 3.

Acrostichopteris pluripartita Berry, 1910, Proc. U. S. Natl. Mus., vol. xxxviii, p. 631.

Description.—Pinnules large in size, inequilateral, fan shaped, subopposite, at an acute angle of divergence, narrowly divided almost to the base into three principal and a varying number of narrow linear subordinate segments. Venation of the usual character in this genus, slender but distinct. The apices are usually, if not always broken off so that their character cannot be made out. Rachis comparatively slender.

This species includes certain indefinite fertile specimens upon which Fontaine based the characters of the supposed fruits in his genus *Baieropsis.* This fructification is clearly to be correlated with *Acrostichopteris pluripartita,* since one specimen shows a characteristic pinnule of this species. The preservation is poor and the most that can be made out are oval bodies apparently representing reduced or transformed segments of pinnules, all the segments of which are fertile in this case, and not merely the basal ones as is shown in so many specimens of *Acrostichopteris longipennis.* Fertile specimens of the present species are, on the other hand, very rare and fragmentary.

This species is present in both the Patuxent and Patapsco formations of Maryland and Virginia. It is also recorded somewhat doubtfully from both the Lakota and Fuson formations in the Black Hills rim of Wyoming. In Portugal Saporta describes several very similar forms. These include *Sphenopteris cuneifida* of the Urgonian-Aptian,[1] *Sphenopteris dissectiformis*[2] of the Aptian (?), *Sphenopteris tenuifissa*[3] of the Albian, and *Sphenopteris flabellina,*[4] also of the Albian.

From the Neocomian sandstone near Quedlinburg in Saxony, Richter[5]

[1] Saporta, Fl. Foss. Portugal, 1894, pp. 69, 127, pl. xvi, fig. 11, pl. xxiii, fig. 5.
[2] *Ibid.*, p. 68, pl. xv, fig. 18; pl. xvi, figs. 12, 13.
[3] *Ibid.*, p. 161, pl. xxviii, fig. 4.
[4] *Ibid.*, p. 160, pl. xxix, fig. 16.
[5] Richter, Zeits. deutsch. geol. Gesell., Band li, 1899, Verhandlungen, p. 40.

has mentioned fossils which he states are very close to *Baieropsis pluripartita* Fontaine.

Occurrence.—Patuxent Formation. Fredericksburg, Telegraph Station (Lorton), Trents Reach, Dutch Gap, Virginia; New Reservoir, District of Columbia. Patapsco Formation. Hell Hole, 72d milepost, near Brooke, Virginia; Overlook Inn, Maryland.

Collection.—U. S. National Museum.

Acrostichopteris expansa (Fontaine)

Baieropsis expansa Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 207, pl. lxxxix, fig. 3; pl. xc, fig. 1; pl. xci, fig. 2; pl. xcii, fig. 5 (non pl. lxxxix, fig. 1 which is made the type of the genus *Schizæopsis*).

Description.—" Leaves very large, having probably the width of 12 cm. and the length of over 15 cm., attached by slender pedicels, and apparently distributed as given in the generic description, i. e., pinnately on leafy twigs, which themselves are arranged pinnately on a principal stem, the main stem and branches ending in leaves of the normal kind; leaves divided to near their bases into several principal laciniæ, which in turn are subdivided at varying heights into subordinate laminæ, and these into ultimate ones that are long and narrow, ribbon-like, with the ends not seen; all subdivide dichotomously and diverge so as to give the leaf a fan shape; the ultimate laciniæ, 1.5 mm. wide and under; the nerves distinct, although slender. They fork at the base in the primary laciniæ, and then repeatedly subdivide dichotomously in the laciniæ at varying intervals, the branches being more or less parallel."—Fontaine, 1890.

In its vegetative characters the present species is not very different from *Schizæopsis americana* Berry, being, however, somewhat smaller, with as yet unknown fructification characters and the veins with double vascular strands.

Occurrence.—Patuxent Formation. Fredericksburg, Dutch Gap, Trents Reach, Virginia.

Collection.—U. S. National Museum.

Genus RUFFORDIA Seward

[Wealden Fl., pt. i, 1894, p. 75]

This genus was proposed by Seward for certain ferns previously referred to the frond genus *Sphenopteris,* the fertile pinnæ of which, found in the English Wealden, suggest a relationship with the modern species of *Aneimia,* a relationship fully borne out by the appearance of the sterile pinnæ.

Fronds tri-quadripinnate, triangular in outline, rachis frequently flexuous. Pinnæ alternate, broadly triangular to ovate-lanceolate. Pinnules delicate, decurrent, somewhat variable, with linear acuminate ovate cuneate ultimate divisions, dentate, or denticulate. Veins flabellate, repeatedly forked. Fertile pinnæ considerably reduced with scattered sporangia.

A number of extremely rare and fragmentary Potomac ferns have been described by Professor Fontaine as various species of *Sphenopteris.* Five of these are here united to form the two following species of *Ruffordia.* It is true that no fertile pinnæ have been found in association with the sterile pinnæ in this country, as is the case in the English Wealden, but as nearly as can be made out from such imperfect material as we possess the form and habit of the sterile pinnæ is so close that the identity of the remains from both sides of the Atlantic is reasonably certain. Attention should be called to the resemblance between the pinnæ in *Ruffordia* and in *Acrostichopteris,* interesting in connection with the fact that there are some grounds for supposing that the latter genus is related to the Schizæaceæ.

In any event the American material does not show the specific differentiation assigned by Professor Fontaine, nor is it desirable to perpetuate the use of the generic term *Sphenopteris* for forms younger than the Paleozoic.

RUFFORDIA ACRODENTATA (Fontaine) Berry

Plate XXIII, Figs. 5, 6

Sphenopteris acrodentata Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 90, pl. xxxiv, fig. 4.

Ruffordia Gœpperti var. *latifolia* Seward, 1894, Wealden Fl., pt. i, p. 85, pl. vi, figs. 1, 1a.

Description.—Apparently tripinnatifid, more open and with the ultimate segments shorter and broader than in the following species. Lower pinnules divided almost to the rachis becoming reduced through lobed to simple pinnules distad; summits obtusely rounded, minutely toothed. Venation flabellate. Veins repeatedly forked, the ultimate branches ending in the marginal teeth.

This species is very close to the following, of which it is made a variety by Professor Seward, who states that the English material shows many intermediate forms, although the extremes are different enough. As the scanty American material lacks intermediate forms it has seemed best to treat it as belonging to a distinct species at the same time recognizing its resemblance to the following and the possibility that more representative material might demonstrate their identity.

Occurrence.—Patuxent Formation. Dutch Gap, Virginia. Patapsco Formation. Federal Hill (Baltimore), Maryland.

Collection.—U. S. National Museum.

Ruffordia Gœpperti (Dunker) Seward

Plate XXIII, Figs. 3, 4

Cheilanthites Gœpperti Dunker, 1844, Norddeutsch, Wälderthon, Programm der höheren Gewerbschule in Cassel, 1843-1844, p. 6.

Sphenopteris Gœpperti Dunker, 1846, Mongr. d. Norddeutsch. Wealdenbildung, p. 4, pl. i, fig. 6; pl. ix, figs. 1-3.

Sphenopteris Gœpperti Bronn, 1848, Index pal., vol. 2, p. 1168.

Sphenopteris Gœpperti Brongniart, 1849, Tableau, p. 107.

Sphenopteris Gœpperti Unger, 1850, Gen. et Sp., p. 109.

Sphenopteris Hartlebeni Dunker, op. cit., p. 4, pl. ix, fig. 9.

Sphenopteris Hartlebeni Bronn, *loc. cit.*

Sphenopteris longifolia Dunker (non Phillips nec. Feistm.) op. cit., p. 4, pl. viii, fig. 6.

Sphenopteris adiantifrons Ettingshausen, 1851, Jahrb. d. k. k. Geol. Reichsanst., Jahrg. II, p. 157.

Sphenopteris Jugleri Ettingshausen, 1852, Beitr. z. Fl. d. Wealdenperiode, p. 15, pl. iv, fig. 5.

Sphenopteris Hartlebeni Schimper, 1869, Pal. Végét., tome i, p. 394, pl. xxx, figs. 2, 3.

Sphenopteris longifolia Schimper, *Ibid.*

Sphenopteris Jugleri Schimper, *Ibid.*

Sphenopteris Auerbachi Trautschold, 1870, Der Klin'sche Sandstein, Nouv. Mém. Moscou, vol. xiii, p. 207 [19], pl. xviii, fig. 5.

Sphenopteris Gœpperti Schenk, 1871 (pars) Palæont., vol. xix, p. 7 (209), pl. iv, figs. 4, 5; pl. ix, fig. 2 (non pl. iv, figs. 2, 3).

Sphenopteris Gœpperti Dupont, 1878, Bull. Ac. R. Belg., ser. ii, vol. xlvi, p. 396.

Sphenopteris valdensis Heer, 1881 [pars], Fl. Foss. du Portugal, p. 14, pl. xv, fig. 11.

(?) Sphenopteris sp. Yokoyama, 1889, Jour. Coll. Sci., Imp. Univ. Japan, vol. iii, pt. i, p. 34, pl. xiv, figs. 13, 13a.

Sphenopteris cf. *Gœpperti* Nathorst, 1890, Denks. k. Akad. Wiss., Wein, Band lvii, p. 51, pl. vi, figs. 2, 3.

Cladophlebis sphenopteroides Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 79, pl. xxi, fig. 4.

Thyrsopteris heteromorpha Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 136, pl. lii, fig. 1.

Sphenopteris thyrsopteroides Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 89, pl. xxv, fig. 3; pl. lviii, fig. 5.

Sphenopteris spatulata Fontaine, *Ibid.*, p. 93, pl. l, fig. 4.

Sphenopteris pachyphylla Fontaine, *Ibid.*, fig. 5.

Sphenopteris valdensis Fontaine, 1893, Proc. U. S. Nat. Mus., vol. xvi, p. 263, pl. xxxvi, fig. 2.

Sphenopteris valdensis Saporta, 1894, Fl. Foss. Portugal, p. 126, pl. xxiii, fig. 9; pl. xxiv, figs. 2, 3.

Ruffordia Gœpperti Seward, 1894, Wealden Flora, pt. i, pp. 76, 77, pl. iv, pl. v; pl. x, figs. 1, 2.

Sphenopteris tenuicula Yokoyama, 1895, Journ. Coll. Sci., Imp. Univ., vol. vii, p. 217, pl. xx, fig. 11; pl. xxi, figs. 2, 3; pl. xxviii, fig. 6.

Ruffordia Gœpperti Seward, 1900, Fl. Wealdienne de Bernissart, Mém. Musée d'Hist. nat. Belgique, Année 1900, p. 18, pl. iii, fig. 33.

(?) Cladophlebis sphenopteroides Penhallow, 1905, Summary, Geol. Surv., Canada, 1904, p. 9.

Cladophlebis sphenopteroides Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 519.

Description.—" Sphenopteris fronde tripinnata, apicem cersus bipinnata, pinnis alternis distantibus vel plus minus approximatis, pinnulis alternis clavatis petiolatis apice laciniatis vel subemarginatis, laciniis obovatis, cuneatis, nervis obsoletis, rhacibus tenerrimis canaliculatis."—Dunker, 1846.

Abundant material from the English Wealden has enabled Professor Seward (*loc. cit.*) to considerably amplify our knowledge of this plant by his description of the fertile pinnæ, which are considerably reduced and bear scattered sporangia, the structure of which could not be made out.

The American material which is very limited and poor consists of fragments of pinnæ all from localities in Virginia, and very badly figured by Professor Fontaine, who shows an enormously winged rachis in the specimen he calls *Sphenopteris thyrsopteroides*. Specifically identical fragments are made the basis for two additional species of *Sphenopteris,* i. e., *S. pachyphylla* and *S. spatulata.*

This species is wide ranging and long lived, having been recorded from strata of Neocomian, Wealden, Barremian, or Albian age in England, Germany, Belgium, Russia, Portugal, Austria, and Japan. Although not recorded from the Arctic regions there are a number of forms described by Heer from the Kome beds as species of *Sphenopteris, Jeanpaulia,* and *Asplenium* that are at least very close to this species.

Extremely fragmentary remains from the Trinity division at Glenrose, Texas, which are identified with *Sphenopteris valdensis* Heer by Professor Fontaine are probably referable to this species.

Occurrence.—PATUXENT FORMATION. Fredericksburg, Dutch Gap, and Trents Reach, Virginia; Ivy City (?), District of Columbia.

Collection.—U. S. National Museum.

Family MATONIACEAE (?)

Genus KNOWLTONELLA gen. nov.

Fronds of medium or large size, pseudo-dichotomous in habit, at least in part. Rachis stout. Pinnules linear-lanceolate, acuminate, attached by their entire base (occasional specimens slightly constricted), obliquely placed and usually more or less decurrent. This obliquity increases proximad until finally the rachis may be bordered by long and narrow gradually decreasing wings, which in some specimens appear to be continued downward beyond a fork. Occasionally pinnules higher up will (abnormally) show this alate character. Distad the pinnules become reduced in size and more or less confluent, forming a lamina with serrate marginal teeth of greater or less incision. Texture very coriaceous. Venation immersed. The midvein is prominent below and continues to the apex of the pinnule, although much diminished in calibre. The laterals branch at a wide angle and fork somewhat like those of *Laccopteris;* anastomosis has not been observed, however. The presence of dormant buds at the ends of the primary axes has not been observed. Fructification characters unknown.

This genus, of which the following species is the only one known, is clearly a member of the important Mesozoic fern alliance usually segre-

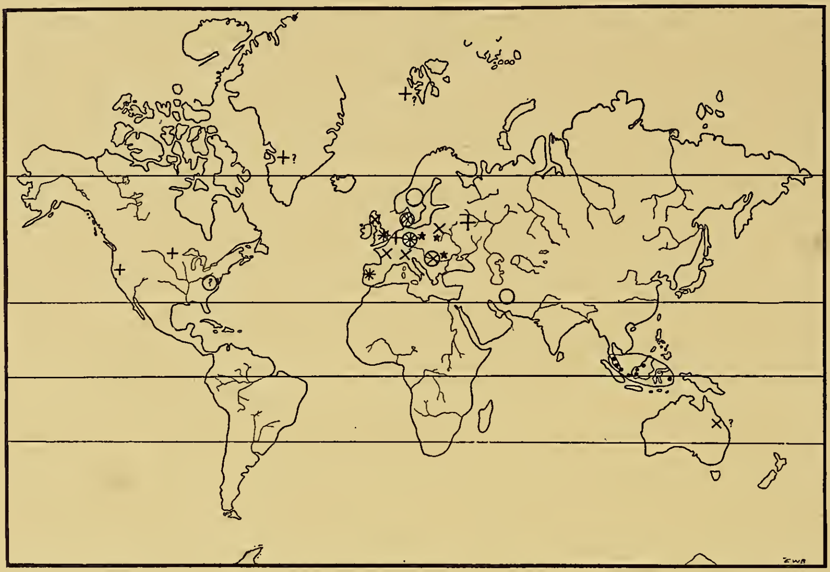

FIG. 3.—Sketch map of the world showing the Mesozoic and existing distribution of the family Matoniaceæ. Circles = Upper Triassic, multiplication sign = Jurassic, plus sign = Lower Cretaceous, stars = Upper Cretaceous, enclosed dots show present occurrences.

gated to form the families Gleicheniaceæ and Matoniaceæ,[1] although the exact line of cleavage between the two, granting that there is such a line, has not been determined with precision for the existing, much less the fossil forms. The pseudo-dichotomy, which is such a characteristic

[1] Christ groups these two families in a separate class which he calls Oligangia. Die Farnkräuter der Erde, Jena, 1897, p. 335.

feature of most of these ferns is rare in the other fern-families, and when present is usually a variable and not a characteristic habit.[1]

The genus, which is obviously unlike any previously known, is named in honor of Dr. F. H. Knowlton, as a slight appreciation of the value of his contributions to our knowledge of fossil plants. As *Knowltonia* has already been used by Salisbury for a member of the Ranunculaceæ, the present genus may be known as *Knowltonella.* The Matoniaceæ, of which but two existing species are known, from a very restricted area in the East Indies, are of considerable importance in the Mesozoic and enjoyed a wide range. The occurrence of the existing species is shown on the accompanying sketch map, as well as the known occurrences of fossil representatives. These have been obtained by plotting the recorded occurrences of *Laccopteris* Presl, *Matonidium* Schenk, *Phlebopteris* Brongniart, *Microdictyon* Saporta, *Gutbiera* Presl, *Carolopteris* Debey and Ettinghausen, and *Marzaria* Zigno, and may in some instances represent incorrect identifications. It will be seen that this family, while apparently present in the Arctic region and in North America, was a prominent element in European Mesozoic floras from the Upper Triassic through the Jurassic and Lower Cretaceous, and continued to be represented well into the Upper Cretaceous. Some of the European material is very satisfactory, and has been the basis for a considerable body of literature.

KNOWLTONELLA MAXONI sp. nov.

Plates XXV, XXVI, XXVII

Description.—Fronds as described for the genus (*supra*). Pinnules of normal form varying in size from 0.6 cm. in length by 1.5 mm. to

[1] For a discussion of the living Gleicheniaceæ see Underwood, A preliminary review of the North American Gleicheniaceæ, Bull. Torrey Bot. Club, vol. xxxiv, 1907, pp. 243-262.

For a comparison of the living and fossil Mationiaceæ see Seward, On the structure and affinities of *Matonia pectinata* R. Br., with notes on the geological history of the Matonineæ, Phil. Trans. Roy. Soc., Lond., vol. cxci, 1899, pp. 171-209, pls. xvii-xx.

6 mm. in width, averaging 1.3 cm. in length by 2.5 mm. in width. Distad the pinnules are united for more than half their length, proximad they are more or less decurrent. There are great irregularities in the latter feature. One secondary limb may be alate for almost half its length, while the other may be pectinate entirely to the base. If it be granted that these forms are comparable with the modern species of *Gleichenia* or *Dicranopteris,* then they show similar irregularities in the suppression and development of the primary axes. Soral characters unknown.

This species is exceedingly abundant at certain localities within the Patapsco formation of the Potomac valley, to which it is thus far confined. Specimens of any size are perfectly characteristic, but small fragments may be readily mistaken for *Cladophlebis, Laccopteris,* and other genera. The varying appearance assumed by this species is well shown on the accompanying plates. From the abundance of the remains at certain outcrops this species must have been gregarious after the manner of the modern *Matonia pectinata, Dicranopteris fulva,* or the various other species of the latter genus, as well as those of the allied genus *Gleichenia.* The alate rachises suggest somewhat the modern *Matonia sarmentosa* Baker. (*Phanerosorus* Copeland, Philip. Journ. Sci., vol. iii, 1908, p. 344.) The writer has seen a specimen of the common *Dicranopteris fulva* (Desv.) Underwood, collected by Mr. W. R. Maxon in Jamaica, which departs widely from the usual form in the direction of *Matonia sarmentosa* Baker, and also in the direction of *Gleichenia* (*sens stricto,* i. e., with short, rounded segments), which also serves to accentuate the relationship between these various forms, since it is conceivable that the alate rachises of *Knowltonella Maxoni* are near the original type (or are morphologically short pinnules which have become fused), and the normal pinnules are acquired just as the form of *Dicranopteris fulva* may be considered as of phlogenetic significance and the normal form the acquired form. Similarly the form of *Matonia sarmentosa,* while due to the specialized habitat of the species, and in that sense acquired, harks back to the ancestral forms whose pinnule characters antedated those of *Matonia pectinata.*

Knowltonella Maxoni is remotely suggestive of the three species of *Phlebomeris* described by Saporta from the Albian of Portugal. It is named in honor of Mr. Wm. R. Maxon, of the National Herbarium, in appreciation of his helpful interest in fossil fern-remains.

Occurrence.—PATAPSCO FORMATION. Stump Neck, near Glymont, Maryland; near Widewater, Virginia.

Collections.—Johns Hopkins University, Maryland Academy of Science.

Family CYATHEACEAE

Genus DICKSONIOPSIS gen. nov.

The genus *Dicksoniopsis* is proposed as a convenient form-genus for fern fronds which show an undoubted relationship with the modern ferns of the tribe Dicksonieæ, but which it is impossible to correlate positively with any of the existing genera of this subfamily. The term *Dicksonites* would be preferable but it is preoccupied, having been used by Sterzel to designate certain Carboniferous and Permian fern-like remains which are not even remotely related to the form under discussion.

Probably most of the older Mesozoic species of *Dicksonia,* of which there are a considerable number, should be referred to the present genus, however, only the single Potomac species is discussed in the present connection.

DICKSONIOPSIS VERNONENSIS (Ward)

Plate XXVIII, Figs. 3, 4

Scleropteris vernonensis Ward, 1895, 15th Ann. Rept. U. S. Geol. Surv., p. 349, pl. ii, figs. 1-3.

Dryopteris virginica Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 491 (non Fontaine, 1890).

Scleropteris vernonensis Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 501, pl. cvii, fig. 10.

Dryopteris parvifolia Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 541, pl. cxiv, fig. 7 (non other citations of this species).

Description.—Frond finely divided, bipinnate or bipinnatifid. Pinnæ alternate, lanceolate in outline, passing distad into inequilaterally lobed pinnules. Pinnules alternate, ascending; the basal pair usually about

50 per cent larger than their fellows and more lobate. The usual type of pinnule is united to the rather slender rachis by a somewhat constricted base. The proximal margin is usually entire, the apex rounded and the distal margin has usually a single rounded lobe, separated from the rounded apical lobe by a shallow sinus. The venation is fine and sparse, and consists essentially of a single forked vein, one limb of which runs to the apex of the pinnule and the other runs to the distal lobe. The fertile pinnæ are slightly reduced in size and more open than the sterile, and bear an elliptical sorus at the apex of the vein which runs to the distal lobe of the pinnule. No details of structure can be made out.

This species was described by Ward in 1895 as a species of *Scleropteris* and compared with *Scleropteris tenuisecta* Saporta from the French Kimmeridge. It resembles this species somewhat in general appearance, and this is especially marked in the case of some of the more open specimens with trilobate pinnules figured by Ward from Mt. Vernon. The fertile specimens show conclusively, however, that this species is closely allied to the modern forms of the tribe Dicksonieæ of the family Cyatheaceæ.

Professor Fontaine has described *Dicksonia pachyphylla* from the Shasta of California and *Dicksonia montanensis* from the Kootanie of Montana, both of which have the lamina almost entirely reduced in the fertile pinnæ.

The most nearly related fossil species is *Dicksonia bellidula* Heer[1] from the Kome beds of Western Greenland. Curiously enough this was originally described by Professor Heer as a species of *Scleropteris*,[2] just as Professor Ward made the same mistake in his identification of the Potomac species. The Arctic species has shorter, broader, and more rounded pinnules or pinnatifid lobes of the pinnæ. It resembles the Potomac species in having a single elliptical sorus at the apex of a vein on the distal margin of each pinnule or pinnatifid lobe of a pinna.

[1] Heer, Fl. Foss. Arct., Band vi, Abth. ii, 1882, p. 1.

[2] Heer, Fl. Foss. Arct., Band iii, Abth. ii, 1874, p. 35, pl. ii, figs. 17c, d, 18; pl. xi, fig. 8.

Occurrence.—ARUNDEL FORMATION. Arlington, Maryland. PATAPSCO FORMATION. Mt. Vernon, White House Bluff, Virginia.

Collection.—U. S. National Museum.

Family POLYPODIACEAE

Genus CLADOPHLEBIS Brongniart

[Tableau, 1849, p. 25]

This genus is essentially a form-genus which is restricted at the present time to include only certain fern remains of Mesozoic age, although this type of frond is practically identical with those of some Paleozoic genera, as, for example, *Pecopteris,* and it can also be closely matched by a variety of Tertiary and living ferns.

Cladophlebis was proposed by Brongniart in 1849 for those species which formed the section *Pecopteris neuropteroides* in his "Histoire des végétaux fossiles," which he regarded as transitional between *Pecopteris* and *Neuropteris.* Certain of their characters were mentioned but no formal diagnosis was attempted. Saporta, who was perhaps the first to define the genus with precision gives the following characterization:

"Frons pinnatim divisa, pinnulæ ab alterutra discretæ vel vix inter se cohærentes rachi tota basi adnatæ aut plus minusve contractæ subque auriculatæ integræ rariusve dentatæ; nervuli e nervo medio orti apicem versus attenuati vel evanidi primum obliqui, dein curvati furcatoque divisi." [1]

Schimper, in 1874, gives a somewhat amplified diagnosis as follows:

"Frondes bipinnatim divisæ, pinnis patentibus, lobis seu pinnulis tota basi insidentibus, interdum confluentibus, raro breviter auriculatis, acuminatis vel obtusis, hic illic, præcipue apice, denticulatis, haud raro sursum subfalcatis; nervo medio sat valido, nervis secundariis sub angulis acutis vel patentioribus orientibus, paulum supra basin dichotomis et repetito-dichotomis, tenuibus et tenuissimis." [2]

Later this author [3] abandons *Cladophlebis* in the belief that the fertile

[1] Saporta, Pal. France, ser. ii, Végétaux, Pl. Jurass., t. i, 1873, pp. 298, 299.
[2] Schimper, Pal. Végét. t. iii, 1874, p. 503.
[3] Schimper in Zittel's Handbuch der Palæontologie, Abth. ii, 1890, pp. 99, 100.

specimens described by Heer justify the reference of these forms to the modern genus *Asplenium.*

The most recent diagnosis is that by Seward, which may appropriately be quoted for the American Cretaceous forms:

"Fronds pinnately divided, pinnæ spreading, lobes or pinnules attached by the entire base or slightly auriculate, acuminate, or obtuse, occasionally dentate, especially at the apex, not rarely subfalcately curved upwards, midrib strong at base, and towards the summit dissolving into branches, secondary veins given off at a more or less acute angle, dichotomous a little above the base, and repeatedly dichotomous.[1]

Much difference of opinion has prevailed regarding the unity and the systematic position of the genus, Saporta[2] having long ago pointed out that Brongniart's Paleozoic species had nothing in common with those of the Mesozoic, and that the Liassic and Oolitic forms, those which the former author was discussing, give evidence of common characters. At the present time there is still lacking evidence from such fructified remains as have been discovered of close relationship between all of the various species of *Cladophlebis.* Thus Heer discovered in the Siberian Jurassic fragments of the *Cladophlebis whitbyensis* type with soral characters which he compared with those of the subgenus *Diplazium* of *Asplenium,*[3] and Schenk has figured fertile pinnules of the same type in the case of the allied *Asplenites rœsserti.*[4] Certain specimens of the Jurassic species *Cladophlebis lobifolia* show that the sporangia in this species were apparently borne in semi-circular pocket-like depressions on the edges of the fertile segments,[5] while the fructifications of *Cladophlebis denticulata* are in the form of narrow, oblong sori parallel with the secondary veins, and are compared by Seward[6] with the modern forms *Asplenium lugubre* and *Phegopteris decussata.* In his latest utterance on this subject he asserts that "there are fairly good grounds for

[1] Seward, Wealden Fl., pt. i, 1894, p. 88.
[2] Saporta, Pal. France, ser. ii, Végétaux, Pl. Jurass., t. iv, 1888, p. 357.
[3] Heer, Fl. Foss. Arct., Band iv, 1877, p. 38, pl. xxi, figs. 3, 4.
[4] Schenk, Fl. Foss. Grenz. Keup. Lias., 1867, p. 51, pl. vii, figs. 7, 7a.
[5] Seward, Jurassic Fl., pt. i, 1900, tf. 23.
[6] Seward, *loc. cit.*, p. 141.

the assertion that some at least of the fronds described under this name are those of Osmundaceæ."[1] Zeiller[2] has recently described a species from the Wealden of Peru, which he considers identical with or very close to *Cladophlebis Browniana,* in which the sporangia are biseriate, oval, and annulate as in the Schizæaceæ. These are said to be very like those of the Jurassic genus *Klukia* of Raciborski. In the Potomac flora we find that fourteen so-called species of *Aspidium* Swartz (*Dryopteris* Adanson), mostly fertile fronds, were described by Fontaine in 1890. These showed mostly large elliptical or reniform sori in rows on each side of the midvein, and located generally on the distal branch of a furcate vein, usually wanting in the apical part of the pinnule. These were compared by this author with modern species of *Aspidium, Cystopteris, Polystichum,* and *Didymochlœna.* The preservation is not of the best, the matrix being coarse, and Fontaine's figures are largely idealized. It has seemed remarkable that the fronds of *Dryopteris* in the Potomac beds were almost always fertile, while those of *Cladophlebis* in intimate association with them were invariably sterile.

By careful comparison it has been possible to correlate the fertile specimens described as *Dryopteris* with the sterile *Cladophlebis* fronds of the same species in five of the types which are represented in the Potomac flora by sterile and fertile fronds, and the presumption is strong, although unverified, that the remaining *Dryopteris* forms represent fertile fronds of *Cladophlebis,* although they are set apart in the present publication in the genus *Dryopterites.* While the foregoing facts are not in unison in regard to the systematic position of *Cladophlebis* they all point to the inclusion of the following American species in the family Polypodiaceæ, or what answered to this family in Lower Cretaceous times, and cast some doubt upon Raciborski's suggestion that *Cladophlebis denticulata* and other species of the same genus were the sterile fronds of Osmundaceous ferns. It is quite possible that ferns of more than one subfamily of the Polypodiaceæ, or, indeed, of other families, are included among the various described species of *Cladophle-*

[1] Seward, Fossil Plants, vol. ii, 1910, p. 345.
[2] Zeiller, Comptes rendus, tome cl, 1910, p. 1488.

bis. It need but be remembered how many unrelated modern ferns have fronds of the Cladophlebis type, as, for example, certain species of Alsophila, Asplenium, Cyathea, Dryopteris, Gleichenia, Onoclea, Osmunda, Polypodium, Pteris, etc., to cast doubt upon the botanical affinity of Clâdophlebis species unless these are attested by a considerable body of evidence. It is believed, however, that the Potomac species are all to be included in the subfamily Dryopterideæ, and because of this and also because their actual identity with the modern genus *Dryopteris*, or, in fact, with any of the modern genera in this subfamily is extremely questionable, it has seemed wiser to use the more general name *Cladophlebis* instead of using *Dryopteris,* where the sterile and fertile fronds have been correlated. Possibly in the end a new generic name, such as Aspidiopteris, will prove to be the most satisfactory solution of the question.

A large number of species of *Cladophlebis* have been described, two species, according to Arber, occurring in the Permo-Carboniferous of India. The genus appears in force in the Keuper and Rhætic, with more than a dozen recorded species. Over a score are recorded during the Jurassic, certain types, such as *Cladophlebis denticulata,* apparently becoming world wide in their distribution. For the Lower Cretaceous Saporta has founded a large number of species based upon Portuguese material, and Fontaine has instituted a still larger number of American species. From the Potomac beds of Maryland and Virginia the latter author recorded 23 different species, besides several varieties of *Cladophlebis,* altogether losing sight of variations and changes due to age, position of the fossils with regard to the frond as a whole, and changes due to the direct action of the environment. These were often based upon such insufficient material that it becomes almost impossible to deal with them with any degree of assurance. In considering all of the more representative material and including with it all of the forms recorded from Maryland, we have a total of eight species, and these eight species include remains which were the basis for twenty-three of Fontaine's species and varieties of *Cladophlebis,* six of his species of *Dryopteris,* and nine of his species of *Pecopteris.*

Cladophlebis Browniana (Dunker) Seward

Plate XXIX, Figs. 1, 2

Pecopteris Browniana Dunker, 1846, Mon. Norddeutsch. Wealdenbildung, p. 5, pl. viii, fig. 7.

Pecopteris Browniana Bronn, 1848, Index Pal., vol. ii, p. 914.

Pecopteris Browniana Brongniart, 1849, Tableau, p. 107.

Pecopteris Browniana Unger, 1850, Gen. et Sp., p. 176.

Alethopteris Reichiana Ettingshausen, 1852, Abh. k. k. geol. Reichs., Band i, Abth. iii, p. 17.

Alethopteris Reichiana Schimper, 1869, Pal. Végét., tome i, p. 569.

Pecopteris Browniana Schenk, 1871, Palæont., Band xix, p. 215, pl. xxvi, fig. 2.

Alethopteris ? Browniana Schimper, 1874, Pal. Végét., tome iii, p. 502.

Pecopteris cf. *Browniana* Nathorst, 1890, Denks. K. Akad. Wiss., Wien, Band lvii, p. 53, pl. v, fig. 5.

Cladophlebis inæquiloba Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 80, pl. xxv, fig. 8.

Cladophlebis petiolata Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 80, pl. xxii, fig. 8.

Cladophlebis oblongifolia Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 74 (pars), pl. vii, fig. 5 (non figs. 3, 4 which are referred to *Cladophlebis virginiensis* Font.)

Cladophlebis crenata Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 75, pl. ix, figs. 7-9; pl. x, figs. 1, 2; pl. xiii, figs. 1-3; pl. xix, fig. 7; pl. xx, fig. 6.

Cladophlebis alata Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 77, pl. xix, fig. 5.

Cladophlebis sp., Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 78, pl. xix, fig. 2.

Pecopteris strictinervis Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 84, pl. xiii, figs. 6-8; pl. xix, fig. 9; pl. xx, fig. 3; pl. xxii, fig. 13; pl. clxx, figs. 5, 6.

Pecopteris ovatodentata Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 85, pl. xv, fig. 8; pl. xxii, fig. 12; pl. xxiii, fig. 1.

Pecopteris microdonta Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 85, pl. xix, fig. 8; pl. xx, figs. 5, 11.

Pecopteris Browniana Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 88, pl. xxii, figs. 10, 11; pl. xxiii, figs. 2-7; pl. xxvi, figs. 3, 13.

Pecopteris virginiensis Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 82, pl. viii, figs. 1-7; pl. ix, figs. 1-6; pl. xxiv, fig. 2; pl. clxix, fig. 3.

Pecopteris constricta Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 86, pl. xx, figs. 1, 2, 4.

Pecopteris socialis Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 87, pl. xxi, fig. 7 (non Heer, 1882).

Pecopteris angustipennis Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 87, pl. xxi, fig. 10.
Pecopteris Browniana Fontaine, 1892, Proc. U. S. Natl. Mus., vol. xv, p. 492.
Pecopteris Browniana Dawson, 1893, Trans. Roy. Soc. Can., vol. x, sec. iv, p. 84, fig. 3.
Pecopteris Browniana Saporta, 1894, Fl. Foss. Portugal, pp. 35, 78, pl. iv, figs. 11-13; pl. x, fig. 19; pl. xi, figs. 9, 10; pl. xii, figs. 2, 3; pl. xv, figs. 19, 29; pl. xvi, figs. 12, 16, 17, 19.
Cladophlebis Browniana Seward, 1894, Wealden Fl., pt. i, p. 99, pl. vii, fig. 4.
Cladophlebis inclinata Fontaine, 1894, in Diller and Stanton, Bull. Geol. Soc. Am., vol. v, p. 450.
Pecopteris Browniana Yokoyama, 1895, Journ. Coll. Sci., Imp. Univ., vol. vii, p. 218, pl. xxiv, figs. 2, 3; pl. xxvii, figs. 1-4, 5c, d.
Pecopteris cf. *virginiensis* Yokoyama, 1895, Journ. Coll. Sci., Imp. Univ., vol. vii, p. 220, pl. xxiv, fig. 1.
Cladophlebis Browniana Seward, 1903, Ann. S. Afr. Mus., vol. iv, p. 10, pl. ii, figs. 1-4, 6.
Cladophlebis Browniana Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 272, 510, 517, 538, 544, 547, 557, 572.
Cladophlebis crenata Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 547.
Cladophlebis alata Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 229, 480, 510, 540, 544, 557, pl. lxv, figs. 17-21.
Cladophlebis inæquiloba Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 510.
Pecopteris virginiensis Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 480, 538, 552, pl. cxvi, figs. 3, 4.
Pecopteris constricta Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 519.
Cladophlebis Browniana Knowlton, 1907, Smith. Misc. Coll., vol. iv, pt. i, p. 108, pl. xi, fig. 1.
Cladophlebis Browniana Knowlton, 1908, in Diller, Bull. Geol. Soc. Am., vol. xix, 1908, p. 386.
Cladophlebis Browniana Berry, 1911, Proc. U. S. Natl. Mus., vol. xli, p. 312.

Description.—Dunker, the original describer of this species, defines it as follows:

"Pecopteris fronde pinnata (bipinnata ?) pinnis lanceolatis, pinnulis linearibus apice obtusis adnatis, opposites et alternis, venis tenerrimis obliquis instructis; rachi tenui."—Dunker, 1846.

The American material which the writer refers to this species is much more abundant than that from abroad, and the foregoing diagnosis may be amplified in the following terms:

Frond bipinnate or tripinnate. Pinnæ elongate, linear in outline.[1] Pinnules approximate, variable in outline, usually obtuse and becoming united distad to form a pinnatifid pinna, which is then constricted and slightly decurrent at the base. Venation of the *Cladophlebis* type, not well seen in the smaller pinnules because of their coriaceous texture.

This is another cosmopolitan species of *Cladophlebis* which may be composite in nature, and which, as commonly preserved in fragmentary specimens, is distinguishable with difficulty from its congeners. It is especially close to *Cladophlebis Albertsii* and *Cladophlebis Ungeri.* It is recorded from the uppermost Jurassic and lowermost Cretaceous in Portugal, from the Neocomian of Japan and from the Wealden of England, Germany, and Austria. From the late Jurassic or early Cretaceous of Spitzbergen Nathorst describes a very similar form as *Cladophlebis sp. B.*[2] In America it has been reported from the Shasta through the Horsetown and in the base of the Chico formation on the Pacific Coast, and from the Kootanie formation of Montana and British Columbia.

It is well scattered and abundant in the Potomac Group occurring in all three of the formations but represented for the most part by incomplete specimens showing slight variations which were made the basis for many species by Professor Fontaine. Material from the Patapsco formation of Maryland shows indistinct oval sori in a single row on either side of the midvein. These are of the type found associated with a number of other American species of *Cladophlebis.*

Professor Zeiller[3] has recently reported fertile fronds of *Pecopteris Browniana,* or of a very similar species from the Wealden of Peru. These are not figured but are described as having biseriate, oval, annulate sporangia, as in the modern family Schizæaceæ, and very like those of the Jurassic genus *Klukia* of Raciborski, thus apparently somewhat different from those of the American representatives of the present species.

[1] The single form which Fontaine identified with this species has pinnæ which shorten rapidly giving the frond a deltoid form, and may be properly referable to the allied species *Cladophlebis Ungeri.*

[2] Nathorst, Kgl. Svenska Vetens.-Akad., Handl., Band xxx, No. 1, 1897, p. 50, pl. ii, fig. 10.

[3] Zeiller, Comptes rendus, tome cl, 1910, p. 1488.

Fragments from the Neocomian of Japan, showing oval sori, are referred to this species by Yokoyama (*loc. cit.*).

Occurrence.—PATUXENT FORMATION. Fredericksburg, Dutch Gap, Alum Rock, Telegraph Station (Lorton), Potomac Run, Virginia; New Reservoir, Ivy City, District of Columbia; Broad Creek (?), Maryland. ARUNDEL FORMATION. Arlington, Hanover, Howard Brown Estate, Maryland. PATAPSCO FORMATION. Brooke and vicinity, Chinkapin Hollow, Virginia; Federal Hill (Baltimore), Vinegar Hill, Maryland.

Collections.—U. S. National Museum, Johns Hopkins University, Goucher College.

CLADOPHLEBIS CONSTRICTA Fontaine

Plate XXIX, Fig. 3

Cladophlebis constricta Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 68, pl. ii, fig. 11; pl. iii, fig. 2; pl. vi, figs. 5, 6, 8-14; pl. xxi, figs. 9, 13; pl. clxix, fig. 2.

Cladophlebis latifolia Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 69, pl. iii, fig. 1; pl. vi, fig. 4.

Cladophlebis constricta Penhallow, 1905, Summ. Geol. Surv., Can., 1904, p. 9.

Cladophlebis virginiensis Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 512, pl. cxi, fig. 7.

Cladophlebis constricta Fontaine, 1906, in Ward, *Ibid.*, vol. xlviii, 1905, pp. 280, 297, 504, 528, 547, pl. lxxi, fig. 26.

Cladophlebis constricta Knowlton, 1907, Smith. Misc. Coll., vol. iv, pt. i, p. 109.

Cladophlebis constricta Berry, 1911, Proc. U. S. Natl. Mus., vol. xli, p. 314.

Description.—Frond large, bipinnate or tripinnate. Principal rachis rather slender. Pinnæ remote, shortening rapidly distad. Proximad they are pinnatifid, changing first into pinnules with undulate margins and then into those with entire margins in passing toward the apex of the frond. Pinnules elliptical in outline, constricted at the base, which is rounded or subauriculate. Venation of the usual Cladophlebis type.

This species has been identified at a number of localities in Maryland and Virginia, but it is not common at any of these. Outside this area it has been reported from the Kootanie of Montana, and very similar forms occur in the Kome beds of Greenland, as, for example, those which

Heer described as *Pecopteris arctica*,[1] *Pecopteris Andersoniana*,[2] and *Pecopteris hyperborea*.[3] Abroad the species described by Schenk[4] from the German Wealden as *Alethopteris cycadina* is very close to the American species, as Fontaine has already pointed out.

Cladophlebis constricta exhibits considerable variation in the degree of remoteness and outline of the pinnules, and may possibly include more than one species, the fact that certain of these aberrant forms come from the low horizon at Fredericksburg, while all of the other occurrences are from Patapsco outcrops lends some credence to this suggestion. The species has been reported by Penhallow from the Kootanie in Canada, but this determination cannot be accepted with certainty.

Occurrence.—Patuxent Formation. Fredericksburg, Virginia. Patapsco Formation. Hell Hole (?), Brooke, Deep Bottom, Virginia; Federal Hill (Baltimore), Vinegar Hill, Ft. Foote (?), Maryland.

Collection.—U. S. National Museum.

Cladophlebis rotundata Fontaine

Cladophlebis rotundata Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 78, pl. xx, figs. 9, 10.

Cladophlebis brevipennis Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 81, pl. xxxvi, fig. 1.

? *Cladophlebis rotundata* Penhallow, 1905, Summary, Geol. Surv. Canada, for 1904, p. 9.

Cladophlebis rotundata Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 491, 510.

Cladophlebis rotundata Berry, 1911, Proc. U. S. Natl. Mus., vol. xli, p. 317.

Description.—" Frond bipinnate or tripinnate, arborescent (?); principal rachis stout, rounded, and prominent; pinnæ short, with a strong rigid rachis; ultimate pinnæ, from the lower part of the frond, with alternate, short, broadly ovate, very obtuse, round-lobed pinnules, those of the upper part of the frond having the lowest pinnules distinct and more or less round-lobed, and towards the summit with pinnules passing through such forms as rotundate, subrhombic, and decurrent to entire

[1] Heer, Fl. Foss. Arct., Band i, 1868, p. 80, pl. i, fig. 13; pl. xliii, fig. 5.
[2] Heer, *Ibid.*, Band iii, Abth. ii, 1874, p. 41, pl. iii, fig. 7, b.
[3] Heer, *Ibid.*, Band i, 1868, p. 81, pl. xliv, fig. 4.
[4] Schenk, Palæont., Band xix, 1871, p. 218, pl. xxxi, fig. 2.

and rounded, the latter having the tips round-lobed and very obtuse; nerves varying according to the position and shape of the pinnules, those of the round-lobed pinnules and of the pinnæ reduced to pinnules flabellately diverging in each lobe, the branches being either forked or simple. The nerves of the subrhombic pinnules have a midnerve, which sends off alternately on each side forked or simple branches. All the nerves are very strongly marked and stout. The leaf-substance is thick and leathery."—Fontaine, 1890.

The foregoing description was written for *Cladophlebis rotundata*, but it requires no alteration to include the rare fragments which were named *Cladophlebis brevipennis*, as the material on which the two were founded is identical, in fact, the description of the latter was practically a paraphrase of the former.

This species, while founded upon rather scant remains, is characterized by the strong venation and the breadth of the short ovate pinnules. It may possibly represent *Cladophlebis constricta* Fontaine, closely resembling the form of this latter species which Professor Fontaine named *Cladophlebis latifolia*. It has been recorded by Penhallow from Yukon Territory in Canada, but the identification is queried as being very doubtful.

Occurrence.—PATUXENT FORMATION. Fredericksburg, Dutch Gap, Virginia. PATAPSCO FORMATION. Mt. Vernon, Chinkapin Hollow, Virginia.

Collection.—U. S. National Museum.

CLADOPHLEBIS VIRGINIENSIS Fontaine

Plate XXIX, Figs. 4-6

Asplenium distans Dawson, 1886, Trans. Roy. Soc. Can., vol. iii, sec. iv, 1885, p. 5, pl. iii, fig. 7 (non Heer).

Cladophlebis virginiensis Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 70, pl. iii, figs. 3-8; pl. iv, figs. 1, 3-6 (non Fontaine, 1906).

Cladophlebis falcata Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 72, pl. iv, fig. 8; pl. v, figs. 1-6; pl. vi, fig. 7; pl. vii, figs. 1, 2.

Cladophlebis acuta Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 74, pl. v, fig. 7; pl. vii, fig. 6; pl. x, figs. 6, 7; pl. xi, figs. 7, 8; pl. clxvi, fig. 5.

Cladophlebis oblongifolia Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 74 (pars), pl. vii, figs. 3, 4 (non fig. 5 which is referred to *C. Browniana*).

Thinnfeldia variabilis Fontaine, 1894, in Diller and Stanton, Bull. Geol. Soc. Am., vol. v, p. 450.

Thinnfeldia variabilis Fontaine, 1896, in Stanton, Bull. U. S. Geol. Surv., No. 133, p. 15.

Thinnfeldia montanensis Fontaine, 1898, in Weed and Pirsson, 18th Ann. Rept. U. S. Geol. Surv., 1896-97, pt. iii, p. 481.

Cladophlebis acuta angustifolia Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 539, pl. cxiv, fig. 5.

Cladophlebis falcata montanensis Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 291, pl. lxxi, figs. 14-20.

Cladophlebis falcata Fontaine, 1906, in Ward, *Ibid.*, vol. xlviii, 1905, pp. 227, 280, 511, 548, pl. lxv, figs. 12-14; pl. cxi, fig. 6.

Cladophlebis acuta Fontaine, 1906, in Ward, *Ibid.*, vol. xlviii, 1905, p. 538, pl. cxiv, figs. 3, 4.

Cladophlebis falcata Knowlton, 1908, in Diller, Bull. Geol. Soc. Am., vol. xix, p. 386.

Cladophlebis virginiensis Berry, 1911, Proc. U. S. Natl. Mus., vol. xli, p. 320.

Description.—Frond large, bi- or tripinnate. Rachis stout and rigid. Ultimate pinnæ long, rather remote, alternate to subopposite. Pinnules ovate to lanceolate and subfalcate in outline, sometimes obtusely pointed, mostly separate to the base, attached by their whole base which is more or less widened. Venation of the type usual in this genus. Margins usually entire, sometimes crenulate to subdentate, becoming entire distad. Texture coriaceous. The degree of separateness of the pinnules, as well as their relative length and breadth and their more or less falcate form, are characters dependent upon the age of the frond or the position of the pinnules on the frond, long, narrow, almost straight proximal pinnules passing gradually into more or less short, broad, and falcate distal pinnules.

This species is not very different from the widespread type of *Cladophlebis,* commonly referred to the species *Albertsii* of Brongniart. It exhibits considerable variation from specimen to specimen, but these variations show so many gradations and are so readily explained when the position of the various fossil fragments upon the frond is taken into consideration that any segregation of them is entirely unwarranted. In general, the pinnules are larger and relatively much wider than in *Cladophlebis Albertsii.*

The present species is very common at certain localities, both in the Patuxent and Arundel formations, and although it apparently survives during the deposition of the Patapsco formation it is less common. Outside of the Maryland-Virginia area remains of this species have been reported from the Shasta beds of California, and from the Kootanie of Montana and British Columbia. Seward (Fossil Plants, vol. ii, 1910, p. 340) refers the bulk of Fontaine's figures of *Cladophlebis virginiensis* Font. to *Todites Williamsoni* (Brongniart), a widespread older Jurassic species, but this reference has no justification. *Cladophlebis Nathorsti* Yokoyama,[1] from the Neocomian of Japan, is very close to the Potomac species.

Occurrence.—PATUXENT FORMATION. Fredericksburg, Dutch Gap, Potomac Run, Virginia. ARUNDEL FORMATION. Arlington, Maryland. PATAPSCO FORMATION. Vinegar Hill, Maryland; Chinkapin Hollow, Virginia.

Collections.—U. S. National Museum, Goucher College.

CLADOPHLEBIS PARVA Fontaine

Plate XXVIII, Figs. 1, 2; Plate XXX; Plate XXXI

Cladophlebis parva Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 73, pl. iv, fig. 7; pl. vi, figs. 1-3.

Cladophlebis sp., Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 81, pl. xxvi, fig. 15.

Aspidium heterophyllum Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 96, pl. xiv, figs. 1-5; pl. xv, figs. 1-5.

Cladophlebis inclinata Fontaine, 1894, in Diller and Stanton, Bull. Geol. Soc. Am., vol. v, p. 450.

Cladophlebis inclinata Fontaine, 1896, in Stanton, Bull. U. S. Geol. Surv., No. 133, p. 15.

Aspidium heterophyllum Fontaine, in Diller and Stanton, *loc. cit.*

Aspidium heterophyllum Fontaine, in Stanton, *loc. cit.*

Dryopteris heterophylla Knowlton, 1898, Bull. U. S. Geol. Surv., No. 152, p. 92.

Cladophlebis parva Fontaine, 1899, in Ward, 19th Ann. Rept. U. S. Geol. Surv., pt. ii, p. 657, pl. clx, fig. 18.

Dryopteris heterophylla Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 483, 550, pl. cxv, figs. 7, 8.

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[1] Yokoyama, Journ. Coll. Sci., Imp. Univ., vol. vii, 1895, p. 220, pl. xxviii, figs. 3, 4, 10, 11.

Cladophlebis parva Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 225, 280, 510, 538, pl. lxv, figs. 5-8.

Cladophlebis parva Knowlton, 1908, in Diller, Bull. Geol. Soc. Am., vol. xix, p. 386.

Cladophlebis parva Berry, 1911, Proc. U. S. Natl. Mus., vol. xli, p. 316.

Description.—Fronds large, bipinnate or tripinnate. Rachis very stout. Pinnæ linear-lanceolate, becoming somewhat falcate in outline distad, and passing from alternate to subopposite. Pinnules relatively wide, falcate, acuminate in the sterile forms, but obtuse in the fertile, variable in size, according to their position, the distal pinnules which represent the reduced pinnæ lower down on the frond are larger and relatively more slender than the pinnules of the lateral pinnæ, which are almost as wide as they are long, and falcate. Between the two orders there is every gradation on each frond through pinnatifid pinnæ to simple pinnule-like forms. Margins entire or slightly crenate, especially in the fertile pinnules, which are wider than the sterile. Sori large, reniform in outline, in three or four pairs on either side of the midvein at the end of a distal branch of a furcate vein. The structure or arrangement of the sporangia cannot be made out, but the spores are preserved in abundance. They are small, ranging from .083 mm. to .05 mm. in diameter, with very thick walls, the outer surface covered with fine granulations not visible with magnifications of 200 diameters or less. The tetrad scars are very distinct. In form as well as size these spores are variable, the smaller possibly immature spores are trigonal in outline while the larger are more nearly spherical. Their varying appearance is well shown in those which are figured. Lateral veins usually but once forked, sometimes simple. Texture coriaceous.

This is a large and handsome species and is represented in the collections by very fair material of both the sterile and fertile fronds. It ranges from the bottom to the top of the Potomac deposits and outside the Maryland-Virginia area is recorded from the Shasta beds of the Pacific Coast, the Kootanie of Montana and the Lakota formation of the Black Hills. There are a number of European Wealden species which are similar to *Cladophlebis parva,* but it is believed to be quite distinct from its contemporaries, although small fragments of almost any of the species of *Cladophlebis* are likely to be confused.

Occurrence.—PATUXENT FORMATION. Fredericksburg, Cockpit Point, Potomac Run, Virginia. ARUNDEL FORMATION. Arlington (?), Maryland. PATAPSCO FORMATION. Vinegar Hill, Maryland.

Collections.—U. S. National Museum, Goucher College.

CLADOPHLEBIS ALBERTSII (Dunker) Brongniart

Plate XXXII, Figs. 3, 4

Neuropteris Albertsii Dunker, 1846, Mon. Norddeutsch. Wealdenbildung, p. 8, pl. vii, figs. 6, 6a.

Cladophlebis Albertsii Brongniart, 1849, Tableau, p. 107.

Neuropteris Albertsii Unger, 1850, Gen. et Sp., p. 83.

Neuropteris Albertsii Ettingshausen, 1852, Abh. k. k. geol. Reichs., Band i, Abth. iii, p. 12.

Alethopteris Albertsii Schimper, 1869, Pal. Végét., tome i, p. 570.

Pecopteris Whitbiensis Trautschold, 1870, Nouv. Mém. Soc. Nat. Moscou, vol. xiii, p. 27, pl. xix, fig. 2.

Alethopteris Albertsii Schenk, 1871, Palæont., Band xix, p. 218, pl. xxvii, fig. 4.

Pteris ? Albertsii Heer, 1882, Fl. Foss. Arct., Band vi, Abth. ii, p. 29, pl. xvi, figs. 5, 6; pl. xxviii, figs. 1-3; pl. xlvi, figs. 22-24.

Pteris Albertini Velenovsky, 1888, Abh. k. böhm. Ges. Wiss., Band ii, p. 15, pl. iv, figs. 6-10 (non fig. 5).

Cladophlebis inclinata Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 76, pl. x, figs. 3, 4; pl. xx, fig. 8.

Cladophlebis denticulata Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 71, pl. iv, fig. 2; pl. vii, fig. 7 (non Nathorst).

Cladophlebis sp., Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 77, pl. x, figs. 5, 8; pl. xx, fig. 7.

Cladophlebis pachyphylla Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 80, pl. xxv, fig. 9.

Cladophlebis sp., Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 77, pl. xv, fig. 6; pl. xix, fig. 3.

Aspidium Oerstedi ? Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 99, pl. xix, fig. 4 (non Heer).

Aspidium angustipinnatum Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 98, pl. xvi, figs. 1, 3, 8; pl. xvii, fig. 1; pl. xix, fig. 10.

Cladophlebis Albertsii Seward, 1894, Wealden Fl., pt. i, p. 91, pl. viii.

Dryopteris angustipinnata Knowlton, 1898, Bull. U. S. Geol. Surv., No. 152, p. 91.

Dryopteris Oerstedi ? Knowlton, 1898, Bull. U. S. Geol. Surv., No. 152, p. 92.

Dryopteris angustipinnata Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 540, 544, 548, pl. cxiv, fig. 6.

Cladophlebis Albertsii Berry, 1911, Proc. U. S. Natl. Mus., vol. xli, p. 310.

Description.—"Neuropteris fronde pinnata (bipinnata ?) pinnulis tenuibus oppositis distantibus, sessilibus, oblongis, basi rotundatis vel subcordatis, apice attenuatis, subobtusis; nervo medio crassiusculo, venis creberrimis tenuissimis obliquis furcatis; rhachi gracili tereti."—Dunker, 1846.

A large amount of material has been referred to this species since Dunker's day, so that his diagnosis may be considerably amplified. In general these forms show the following characters:

Fronds large bipinnate or tripinnate. Rachis stout. Pinnæ linear-lanceolate, alternate to subopposite, becoming pinnatifid distad. Pinnules usually attached by their whole base, which is slightly expanded, contiguous but usually separated to the base, lanceolate, slightly falcate, acuminate. Margin usually entire, more rarely somewhat dentate in the apical portion. Venation of the usual *Cladophlebis* type. Fertile fronds have the rachis more slender than in the sterile fronds. The sori are borne on a distal branch of a furcate vein as in other Potomac species of *Cladophlebis,* and form a row on either side of the midvein of the pinnules, which are otherwise indistinguishable from the sterile pinnules, though inclined to be straighter.

This species has been made to include a large amount of material from various horizons and localities, which in the first instance was described as various species of *Neuropteris, Alethopteris, Pecopteris, Pteris,* etc. It is not at all certain that the result may not be a composite species made up of several distinct species with indistinguishable vegetative characters, and it would not be difficult to select still other forms from various parts of the world which could scarcely be separated from the foregoing.

Cladophlebis Albertsii was not recognized as such in Professor Fontaine's Potomac studies, but it is obvious that the forms described as *Cladophlebis inclinata* and *Cladophlebis denticulata* (this was described as a new species and is decidedly different from Brongniart's species of the same name which Nathorst has referred to *Cladophlebis*), and as *Aspidium angustipinnatum* are identical with each other and with those ferns in the European Wealden which are referred to *Cladophlebis Al-*

bertsii. The additional fragments of Potomac ferns which are referred to this species are not common and are equally unimportant botanically and stratigraphically. The two *Cladophlebis sp.,* Fontaine, are clearly enough referable to this species. *Cladophlebis pachyphylla* is considered as an anomalous pinna with thicker more remote pinnules, which are contracted at the base. It was founded on a single fragment from Fredericksburg, Virginia, and if not an example of this species is simply a distal aberrant pinna of one of the other described species from that locality. The specimen which was the basis for the presence of *Aspidium œrstedi* Heer in this flora is the merest fragment without significance in any way.

The fertile pinnæ of *Cladophlebis Albertsii* agree with those of *Cladophlebis parva* and other Potomac species in the general character, form, and arrangement of the sori, the nature of the material precluding any more detailed information on this point. The sori appear to be confined to the basal part of the proximal pinnules. The present species is closely related to the contemporaneous form *Cladophlebis virginiensis* Fontaine.

It is common in the Wealden of England and Germany, and probably in homotaxial or somewhat younger beds in Austria and Russia. It has been recorded from the Cenomanian of Bohemia and from the Atane beds of Greenland, but both of these determinations may be considered as very doubtful. Nathorst has described a similar form from Spitzbergen as *Cladophlebis sp. A.*[1] In this country it is definitely known only from the Potomac Group. It has been recorded from the Patapsco formation at Vinegar Hill, Maryland, but the single specimen is referred by the writer to *Cladophlebis virginiensis,* which is abundant at this locality.

Occurrence.—PATUXENT FORMATION. Potomac Run, Telegraph Station (Lorton), Dutch Gap, Trents Reach, Fredericksburg, Virginia. ARUNDEL FORMATION. Arlington, Hanover, Bay View, Maryland.

Collections.—U. S. National Museum, Goucher College.

[1] Nathorst, Kgl. Svenska Vetens.-Akad. Handl., Band xxx, No. 1, 1897, p. 49, pl. ii, figs. 9, 11-13.

Cladophlebis Ungeri (Dunker) Ward

Plate XXXII, Figs. 1, 2

Pecopteris Ungeri Dunker, 1846, Mon. Norddeutsch. Wealdenbildung, p. 6, pl. ix, fig. 10.

Pecopteris polymorpha Dunker, 1846, Mon. Norddeutsch. Wealdenbildung, p. 6, pl. vii, fig. 5 (non Brongniart).

Pecopteris Ungeri Brongniart, 1849, Tableau, p. 107.

Pecopteris Ungeri Unger, 1850, Gen. et Sp., p. 177.

Pecopteris polymorpha Unger, 1850, Gen. et Sp., p. 177 (non Brongniart).

Pecopteris Dunkeri Schimp., 1869, Pal. Végét., tome i, p. 539.

Pecopteris Dunkeri Schenk, 1871, Palæont., Band xix, p. 214, pl. xxvi, fig. 1; pl. xxxi, fig. 1.

Pecopteris exiliformis Geyler, 1877, Palæont., Band xxiv, p. 226, pl. xxx, fig. 1.

Pecopteris polymorpha Dupont, 1878, Bull. Ac. Roy. Belg., sér. ii, vol. xlvi, p. 387 (non Brongniart).

Pecopteris exilis Yokoyama, 1890, Journ. Coll. Sci., Japan, vol. iii, p. 35, pl. i, figs. 8-10.

Aspidium parvifolium Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 100, pl. xxi, fig. 6; pl. xxiv, fig. 8; pl. xxv, fig. 10; pl. xxvi, figs. 1, 14, 16, 17.

Pecopteris Geyleriana Nathorst, 1890, Denks. k. Akad. Wiss., Wien, Band lvii, p. 48, pl. iv, figs. 2-6.

Pecopteris sp., Nathorst, *Ibid.*, pl. vi, fig. 4.

Pecopteris brevipennis Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 86, pl. xxi, figs. 1-3.

Pecopteris pachyphylla Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 88, pl. xxvi, figs. 4, 5.

Aspidium Dunkeri Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 101, pl. xxii, figs. 9, 9a, 9b; pl. xxv, figs. 11, 12; pl. xxvi, figs. 2, 8, 9, 18; pl. liv, figs. 3, 9.

Aspidium Dunkeri Fontaine, 1894, in Diller and Stanton, Bull. Geol. Soc. Am., vol. v, p. 450.

Pecopteris Dunkeri Saporta, 1894, Fl. Foss. Portugal, pp. 106, 169, pl. xix, figs. 10, 11; pl. xxviii, figs. 15, 16.

Cladophlebis Dunkeri Seward, 1894, Wealden Fl., pt. i, p. 100, pl. vii, fig. 3.

Pecopteris Geyleriana Yokoyama, 1895, Journ. Coll. Sci., Imp. Univ., vol. vii, p. 219, pl. xxi, fig. 12; pl. xxiii, figs. 1, 1a; pl. xxxviii, fig. 5.

Aspidium Dunkeri Fontaine, 1896, in Stanton, Bull. U. S. Geol. Surv., No. 133, p. 15.

Dryopteris parvifolia Knowlton, 1898, Bull. U. S. Geol. Surv., No. 152, p. 92.

? *Pecopteris Geyleriana* Fontaine, 1899, in Ward, 19th Ann. Rept. U. S. Geol. Surv., pt. ii, p. 654, pl. clx, figs. 9-13.

Cladophlebis Dunkeri ? Seward, 1900, Fl. Wealdienne de Bernissart, Mém. Musée d'hist. nat. Belgique, Année 1900, p. 24, pl. iii, figs. 35-40, 43-46, 51, 52.

Cladophlebis Dunkeri Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 510, 538.

Dryopteris parvifolia Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 486 (non p. 541, pl. cxiv, fig. 7).

Cladophlebis Ungeri Ward, 1906, in Font., in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 228, 510, 538, pl. lxv, figs. 15, 16.

Pecopteris brevipennis Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 510.

Cladophlebis Ungeri Knowlton, 1908, in Diller, Bull. Geol. Soc. Am., vol. xix, p. 386.

Cladophlebis Ungeri Berry, 1911, Proc. U. S. Natl. Mus., vol. xli, p. 318.

Description.—"Pecopteris fronde gracili bipinnata, pinnis petiolatis linearibus alternis, pinnulis adnatis opposite ovato-oblongis obtusis remotiusculis, nervo obsoleto venisque obliteratis; rhachi tenui tereti."—Dunker, 1846.

A more extended and satisfactory diagnosis is that written by Professor Fontaine for his *Aspidium Dunkeri,* which will answer not only for that material but for all of the other supposed species founded by Fontaine upon various fragments of *Cladophlebis Ungeri.* It is as follows: "Frond bipinnate or tripinnate, arborescent; principal rachis stout and rigid; ultimate pinnæ alternate, short, linear-lanceolate; pinnules alternate or subopposite, short, closely placed, narrowed at the base, cut more or less deeply into lobes or teeth which are ovate or oblong, obtuse or subacute, very small, those of the fertile portions of the frond standing nearly perpendicular to the rachis and having in each lobe or pinnule a simple lateral nerve which bears a sorus on its summit, those of the sterile and more common portions more obliquely placed, mostly subacute, with nerves in each lobe that fork simply in the upper ones, and in the lower ones are composed of a midnerve with alternate simple branches; leaf-substance thick; sori very minute, club-shaped or elliptical, visible distinctly only with the help of a lens, and present only in the pinnules of the lower part of the pinnæ, and mostly found on the lobes towards the base of these."

This species was described by Dunker in 1846 from the Wealden of northern Germany as *Pecopteris Ungeri* and *Pecopteris polymorpha.* Schimper in 1869 renamed the latter *Pecopteris Dunkeri* as the specific name *polymorpha* had been used by Brongniart in 1828. Schenk two years later, with Dunker's original specimens before him, announced that Dunker's *Ungeri* and *polymorpha* were synonyms. He did not, however, restore Dunker's name nor has Seward done so in his discussion (1894) of this species in the Wealden flora. In accordance with the prevailing system of nomenclature Dunker's original name must be used for this species, and this proposal was made by Ward in 1906. Seward in 1894 referred the species to the genus *Cladophlebis,* and while the American material available in the present treatment of this species is not as complete as might be desired it furnishes some evidence regarding the fertile fronds of still another species of *Cladophlebis.* The character of the fertile material is rather vague, and while it is clearly congeneric with a number of other of Fontaine's species of *Aspidium,* it is hardly sufficient evidence of their relationship with that modern genus. The present species is close to *Cladophlebis Browniana,* and is apparently a cosmopolitan Lower Cretaceous type, since indistinguishable material occurs not only in the English and Continental Wealden deposits (Belgium, Germany, Austria), but in the Neocomian of Portugal and Japan, and in the Uitenhage series of South Africa. Material from Japan shows obscure fruiting fragments in which the pinnæ are narrowed, and there is apparently a single sorus to each pinnule (Nathorst, *loc. cit.,* pl. iv, figs. 3-5, of these fig. 3 is referred to *Weichselia Mantelli* by Seward, 1894). The species is also reported from the Albian of Portugal by Saporta. In America it is not rare in the Potomac beds, and rather doubtful remains are referred to this species from the Shasta beds of California and from the Fuson formation of the Black Hills area. It is probably represented in the Kootanie formation of Montana by *Dryopteris montanense* (Font.) Knowlton.[1] Prof. Seward in a recent paper (1903, *op. cit.*) expresses his belief that this species is identical with *Cladophlebis Browniana,* such differences as are observable being merely individual and not specific. This may well be the case, the two are certainly closely allied. There is, however, a serious danger involved

[1] Fontaine, Proc. U. S. Natl. Museum, vol. xv, 1892, p. 490, pl. lxxxii, figs. 1-3; pl. lxxxiii, figs. 2-3a.

in uniting under a single specific name fern fronds from all quarters of the globe which closely resemble each other, and probably future study will show that even the present treatment is faulty in this particular.

Occurrence.—PATUXENT FORMATION. Woodbridge, Fredericksburg, Dutch Gap, Telegraph Station (Lorton), Virginia. PATAPSCO FORMATION. Chinkapin Hollow, Virginia.

Collection.—U. S. National Museum.

CLADOPHLEBIS DISTANS Fontaine

Plate XXXII, Figs. 5, 6

Cladophlebis distans Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 77, pl. xiii, figs. 4, 5.

Aspidium fredericksburgense Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 94, pl. xi, figs. 1-6; pl. xii, figs. 1-6; pl. xvi, fig. 9; pl. xix, figs. 6, 7.

Dryopteris fredericksburgensis Knowlton, 1898, Bull. U. S. Geol. Surv., No. 152, p. 92.

Cladophlebis distans Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 280, 572.

Dryopteris fredericksburgensis Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 280, 512, 538, 548, pl. cxii, fig. 2.

Aspidium fredericksburgense Penhallow, 1908, Trans. Roy. Soc., Can. (iii), vol. i, sec. iv, p. 307.

Cladophlebis distans Berry, 1911, Proc. U. S. Natl. Mus., vol. xli, p. 315.

Description.—Frond large and coarse, bipinnate or tripinnate. Rachis very stout and rigid. Pinnæ of the ultimate order mostly alternate, rarely opposite or subopposite, with rigid and proportionally rather slender rachises, very long, linear. Pinnules alternate, oblong or ovate, obtuse, slightly falcate, and usually with a somewhat rounded and slightly constricted base, separate, more or less remote, in some specimens those of the lower pinnæ with crenate margins, those of the upper ones entire, passing in the middle part of the frond through pinnules with undulate margins. Leaf-substance thick and leathery. Midvein of the usual *Cladophlebis* type, that is, strong at base and dissolving into branches at the summit; lateral veins of the crenate and undulate pinnules in groups in each tooth, composed of a midvein which sends off alternate simple branches, or else of forked veins with one of the branches forking again; those of the pinnules with entire margins usually once forked, all quite distinct; fertile specimens rare. Sori very large, elliptical or reniform in shape, and distributed in two rows, one on each side of the midvein, attached to the summit of the upper branch of a furcate vein.

This species is quite generally distributed throughout the Potomac formations, although there is but one recorded occurrence from the Arundel formation. It is abundant in the Patuxent formation at Fredericksburg, and outside the Maryland-Virginia area it has been recorded from the Kootanie formation of Montana and British Columbia and the Shasta of the Pacific coast province.

The sterile and fertile pinnæ are closely similar in outline and venation, the former being much more abundantly represented than the latter. They are both very similar to those of *Cladophlebis parva* Fontaine, and may be compared with a number of European and Kome species of *Cladophlebis, Alethopteris, Pecopteris,* etc.

Occurrence.—Patuxent Formation. Fredericksburg, Dutch Gap, Telegraph Station (Lorton), Virginia; Broad Creek, Maryland. Arundel Formation. Arlington, Maryland. Patapsco Formation. Chinkapin Hollow, Virginia.

Collection.—U. S. National Museum.

Genus DRYOPTERITES gen. nov.

The desirability of an additional form-genus for the reception of the fossil remains of ferns which resemble those of the recent genus *Dryopteris* of Adanson,[1] but fail to furnish conclusive diagnostic characters, is obvious. The probability of a large and dominant modern genus like *Dryopteris* preserving its generic integrity when traced back to a time as remote as the Lower Cretaceous is altogether unlikely and the number of other modern genera with species whose foliar characters are similar to some of the many modern species of *Dryopteris* is another reason for abandoning the modern name for the Lower Cretaceous forms, and a third reason might be furnished by the action of the last International Botanical Congress which decided to "conserve" the name *Aspidium* of Swartz,[2] although Adanson's name for these modern forms preceded it by more than the span of a generation.

[1] Adanson, Fam. Pl., vol. ii, 1763, p. 20.

[2] Swartz. Schrad, Jour. Bot., vol. ii, 1800, p. 4.

The genus *Dryopterites* may be defined as follows: Fronds large, bi- or tripinnate or pinnatifid, pinnules dentate, crenate, lobate, or entire, attached by their whole base or slightly constricted basally. Venation of the *Cladophlebis* type, the single midrib becoming attenuated distad by the branching off of numerous simple or forked lateral veins. Sori not elongated, but elliptical, circular or reniform in outline, borne in a single row on either side of the midvein toward the end of a lateral vein or on a distal branch of a lateral vein. Minute structure not discernible.

The genus *Dryopteris* has upwards of four hundred existing species of wide geographical distribution and consequent difference in size, form, and habit. Of these about 25 occur in North America. The fossil species which have been referred to *Dryopteris* number upwards of fifty forms and include about 18 from the Lower Cretaceous, six from the Upper Cretaceous, and about twenty from the various Tertiary horizons. Schimper,[1] in 1869, in treating the then known fossil species, referred to *Aspidium*, as *Dryopteris* was then called, refers all but two from the relatively recent Upper Miocene (Tortonian) to the form genus *Pecopteris.*

The eighteen species just mentioned from the Lower Cretaceous include fourteen from the Potomac Group, which Professor Fontaine so identified. These have been found in a number of instances to be identical with remains referred to *Cladophlebis,* with which they have been united whenever the evidence warranted such a course. After this process of elimination there remained the following six, more or less illy defined, types which are here referred to *Dryopterites,* as indicative of their resemblance both in form and soral characters, as far as these are decipherable, to *Dryopteris.*

The writer is strongly of the opinion that the following forms are closely allied to some of those which are discussed under *Cladophlebis,* and perhaps several are identical with such forms. The materials are, however, so scanty, poorly preserved, and inconclusive that a conservative course demands that they be kept separate.

[1] Schimper, Pal. Végét., tome i, 1869.

Regarding the botanical relations of the following forms, there is little doubt of their being included with propriety in the Polypodiaceæ, or in that assemblage of ferns which represented this family in Lower Cretaceous time.

Dryopterites macrocarpa (Fontaine)

Aspidium macrocarpum Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 103, pl. xvii, fig. 2.
Dryopteris macrocarpa Knowlton, 1898, Bull. U. S. Geol. Survey, No. 152, p. 92.

Description.—"Sterile frond not seen; fertile frond showing only a skeleton imprint; principal rachis stout and rigid; plant most probably arborescent; rachis of the ultimate pinnæ stout and rigid; shape and dimensions of the pinnules not disclosed; apparently large, elongate-oblong, attached by the entire base, alternate; midnerve rather slender, straight; lateral nerves simple, and bearing at their summits the sori arranged in a row on each side of the midrib. The sori are very large, reniform in shape, and seem to have been situated near the margin of the pinnules. Under a good lens the sporangia may be seen arranged often in a band near the margin of the sori."—Fontaine, 1890.

No new material identical with this type has been subsequently collected. The fern seems to have been a large one and the type material is too poorly preserved to justify the description of the shape of the sorus or the arrangement of the sporangia. It is very probable that this form is identical with one or the other of the fertile forms referred by the writer to *Cladophlebis distans* Fontaine, *Cladophlebis parva* Fontaine, and *Cladophlebis Albertsii* (Dunker) Brongniart, the latter being an especially probable affinity.

Occurrence.—Patuxent Formation. Dutch Gap, Virginia.

Collection.—U. S. National Museum.

Dryopterites pinnatifida (Fontaine)

Aspidium pinnatifidum Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 101, pl. xxi, fig. 15.
Dryopteris pinnatifida Knowlton, 1898, Bull. U. S. Geol. Survey, No. 152, p. 92.

Description.—"Frond unknown; probably bipinnatifid; reduced pinnæ or pinnules, linear, cut pinnately nearly to the rachis into ovate-falcate obtuse lobes or pinnules; leaf-substance thick and leathery; sori in a row on each side of the midrib, elliptical in shape and small, placed on the simple lateral nerves within the margin of the lobes."—Fontaine, 1890.

This so-called species is based on very rare and fragmentary material and is undoubtedly identical with other material referred to this genus or to *Cladophlebis.* Professor Fontaine compared it with *Didymochlœna,* but it is absolutely worthless for either stratigraphic or botanical purposes.

Occurrence.—PATAPSCO FORMATION. Bank near Brooke, Virginia.

Collection.—U. S. National Museum.

DRYOPTERITES CYSTOPTEROIDES (Fontaine)

Aspidium cystopteroides **Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 99, pl. xvi, fig. 2.**

Dryopteris cystopteroides **Knowlton, 1898, Bull. U. S. Geol. Survey, No. 152, p. 91.**

Description.—"Sterile fronds not seen; rachis of ultimate pinnæ slender; pinnules alternate, attached by the middle portion of the base, crenately toothed, obtuse; sori rather large, in two rows, one on each side of the midrib, placed near the margin, on the summit of the uppermost branch of the nerves; subglobose in shape, similar to those of *Cystopteris,* with an inflated indusium at base; nerves branching palmately in each tooth."—Fontaine, 1890.

No new material is available for study. It is probably identical with what is here called *Dryopterites virginica.*

Occurrence.—PATUXENT FORMATION. Fredericksburg, Virginia.

Collection.—U. S. National Museum.

DRYOPTERITES ELLIPTICA (Fontaine)

Aspidium ellipticum **Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 95, pl. xiii, figs. 9, 10.**

Dryopteris elliptica **Knowlton, 1898, Bull. U. S. Geol. Survey, No. 152, p. 92.**

Description.—"Frond bipinnate or tripinnate, arborescent; rachis of the principal pinna stout and rigid; ultimate pinnæ alternate, short, oblong-lanceolate, terminating in an elliptical obtuse pinnule or lobe, which is similar to the pinnules lower down on the pinna; lower pinnules distant, elliptical in shape, obtuse, attached by the middle of the much narrowed base, or by the midnerve alone; upper pinnules attached by the entire widened base; uppermost ones united towards the tip of the pinnæ; all very thick and leathery in texture; lateral nerves not distinct, but apparently simple, and bearing the sori on their summits: sori pear-shaped or truncate-elliptical, in two rows, one on each side of the midnerve; sterile forms not seen."—Fontaine, 1890.

No new material is available for study and the type material is very poor. While it is probable that this does not represent a distinct species no definite conclusion is possible without more abundant and better preserved material.

Occurrence.—PATUXENT FORMATION. Near Potomac Run, Virginia. PATAPSCO FORMATION. Near Brooke, Virginia.

Collection.—U. S. National Museum.

DRYOPTERITES DENTATA (Fontaine)

Aspidium dentatum Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 102, pl. xxv, figs. 6, 7, 14, 15.

Aspidium microcarpum Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 103, pl. lix, figs. 2, 12; pl. lx, figs. 6, 7.

Dryopteris dentata Knowlton, 1898, Bull. U. S. Geol. Survey, No. 152, p. 91.

Dryopteris microcarpa Knowlton, 1898, Bull. U. S. Geol. Survey, No. 152, p. 92.

Description.—"Frond tripinnate; principal rachis comparatively stout and rigid; ultimate pinnæ alternate, very short, linear-lanceolate; pinnules membranaceous, alternate, lower ones separate to the base, upper ones united and reduced to lobes; lower pinnules broadly ovate, acute, narrowed to the base, and subpetiolate, cut nearly to the midnerve into ovate, acute teeth, reduced in the upper part of the compound pinnæ to ovate, obtuse lobes and teeth; sori very small, subreniform or globose, placed within the margin on the summit of the alternate simple lateral nerves; nerves in each of the pinnules and lobes, composed of a midnerve, with simple alternate lateral ones on each side; in the uppermost lobes the nerves become one or more times forked, without a midnerve."—Fontaine, 1890.

The foregoing description is that of *Aspidium dentatum*, but it applies equally well to *Aspidium microcarpum*. It is curious that these two supposed species, both present in the same outcrop and identical except for the fact that in the one case they were sterile and in the other showed traces of sori, should have been made the basis of two distinct species. The reference of the Dutch Gap specimens here is not above question.

Occurrence.—PATUXENT FORMATION. Dutch Gap, near Potomac Run, Telegraph Station (Lorton), Virginia.

Collection.—U. S. National Museum.

DRYOPTERITES VIRGINICA (Fontaine)

Aspidium virginicum Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 97, pl. xv, fig. 14.

Aspidium oblongifolium Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 100, pl. xxi, fig. 5.

Dryopteris virginica Knowlton, 1898, Bull. U. S. Geol. Survey, No. 152, p. 93 (non Fontaine, 1906).

Dryopteris oblongifolia Knowlton, 1898, Bull. U. S. Geol. Survey, No. 152, p. 92.

Description.—"Frond bipinnate or tripinnate; arborescent ?; rachis of the principal pinna stout and rigid; pinnæ of ultimate order reduced to pinnules in the terminal portions of the penultimate pinnæ, alternate, linear-lanceolate, passing through pinnately lobed pinnæ into pinnules with entire margins; leaf-substance thick and leathery; nerves slender, immersed in the leaf-substance, and seen with difficulty; pinnules of the lower pinnæ opposite, separate to the base; attached by the entire base, elongate oblong, subacute, with denticulate margins; sterile form of the frond not seen; sori comparatively small, reniform, in two rows, one on each side of the midnerve of the pinnules, and placed at the summit of the upper branch of a forking nerve."—Fontaine, 1890.

The description quoted is that of *Aspidium virginicum*, but it fits the species as emended here, the form previously described as *Aspidium oblongifolium* being entirely inadequate for framing a description. The two are clearly identical. The occurrence of this species at the locality near Brooke, which is within the Patapsco formation, is queried, since the material is indecisive and the forms identified by Professor Fontaine (1906) as this species from the Mt. Vernon beds, which are of Patapsco age, prove to be identical with what Professor Ward named *Scleropteris vernonensis,* which in turn is not a *Scleropteris,* but by the character of its fertile fronds is related to *Dicksonia.*

Occurrence.—Patuxent Formation. Near Potomac Run, Virginia. Patapsco Formation. Near Brooke (?), Virginia.

Collection.—U. S. National Museum.

Genus ASPLENIOPTERIS Fontaine

[Mon. U. S. Geol. Surv., vol. xv, 1890, p. 117]

This genus was characterized in the following terms by its describer: "Frond bipinnate or tripinnatifid; pinnules linear-lanceolate, or oblong, acute to obtuse, lobed or toothed, sori proportionally very large, elongate to narrowly elliptical, in a row on each side of the midrib, one in each lobe or tooth, inserted on thick supports or segments, which represent the transformed segments or lobes, placed on the anterior margin of these, and running down nearly their entire length."

The foregoing diagnosis unduly emphasizes the thickening of the fertile lobes, which are but little, if any, thickened. Professor Fontaine compares the genus with *Dicksonia clavipes* Heer, but there is little in common between the two. The Potomac forms are very poorly preserved, and in some respects they suggest the fertile parts of *Onychiopsis.* However, after a thorough canvas of the Filicales, the writer has decided to retain the genus in the tribe Asplenieæ. No additional soral characters could be made out and no traces of spores were found.

Aspleniopteris pinnatifida Fontaine

Plate XXVIII, Figs. 5, 6

Aspleniopteris pinnatifida Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 118, pl. xxii, figs. 1-3, 6, 7 (non Fontaine 1894, 1896).

Description.—"Frond tripinnatifid; rachis of the primary pinna or of the frond very stout, rigid, and straight; pinnæ or pinnules alternate, varying much in length according to position, with strong, rigid rachises;

sterile pinnules linear-lanceolate, subacute, lower ones very long, much diminished in length in ascending, cut more or less deeply into crenate and rounded teeth and lobes; lateral nerves in each lobe flabellate diverging, with the branches forked or simple, nerves very strong and distinct; fertile pinnæ or pinnules very long, with strong, rigid rachises, linear, subacute; lobes or teeth reduced to thick leathery supports, which bear the narrowly elliptical sori on the anterior face; the sori very long, almost as long as the lobes, standing one in each lobe, apparently included between the two branches of a nerve that forks at the insertion."—Fontaine, 1890.

The foregoing description should be modified by eliminating the fancied thick soral peduncles which do not exist. As Professor Fontaine has pointed out there is no adequate proof that the sterile and fertile specimens belong to the same species. The species is an insignificant element in the oldest Potomac, and none other than the type material has been collected. The accompanying plate is from a photograph of the specimen which formed the basis for Fontaine's idealized fig. 6 on pl. xxii of the Potomac flora (*loc. cit.*). The specimen is poor, the matrix being coarse, and the fern is represented by a brownish impression showing merely the outlines. No minute characters or spores could consequently be made out.

In some respects the fertile pinnæ suggest those of *Onychiopsis,* the pinnules are less reduced, however, and the sori appear to be single. The sori are thick and about 3 mm. in length by a trifle under 1 mm. in width.

This species was doubtfully listed from the Shasta by Diller and Stanton in 1894,[1] and by Stanton [2] in 1896, on the authority of Professor Fontaine, who afterward described the material as a new species of *Dicksonia.*[3]

Occurrence.—PATUXENT FORMATION. Fredericksburg, Virginia.

Collection.—U. S. National Museum.

[1] Diller and Stanton, Bull. Geol. Soc. Am., vol. v, 1894, p. 450.
[2] Stanton, Bull. U. S. Geol. Surv., No. 133, 1896, p. 15.
[3] Fontaine in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1906, p. 224, pl. lxv, fig. 1.

ASPLENIOPTERIS ADIANTIFOLIA Fontaine

Aspleniopteris adiantifolia Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 118, pl. xvi, fig. 6.

Description.—" Sterile frond not seen; fertile frond bipinnate or bipinnatifid; pinnules or lobes reduced to leathery thick pedicels or supports, which bear on their anterior or upper margin narrowly elliptical or oblong sori; sori proportionally very large."—Fontaine, 1890.

This species was based upon the single specimen figured by Fontaine, which is so poorly preserved that it has not been refigured. It was found in association with the preceding species, and it seems very probable that it represents merely a poorly preserved and perhaps abortive or pathological fertile pinna of the former.

Occurrence.—PATUXENT FORMATION. Fredericksburg, Virginia.

Collection.—U. S. National Museum.

Genus ONYCHIOPSIS Yokoyama

[Jour. Coll. Sci., Japan, vol. iii, 1890, p. 26]

Yokoyama characterized this genus as follows: " Fertile segments different from the sterile. Sori terminal, linear, on each side of the midrib, parallel with the margin, involucrate; the involucrum of each side confluent over the midrib." It was based on a Japanese Jurassic species originally described by Geyler as *Thyrsopteris elongata* and founded upon sterile pinnules. The discovery of fertile pinnules by Yokoyama led to the erection of the present genus, which is very close to the modern genus *Onychium* Kaulfuss, which is made a subgenus of *Cryptogramme* R. Brown by Diels in Engler and Prantl's Natürlichen Pflanzenfamilien (1899), although there seems to be but slight warrant for Diel's treatment.

Seward, in working over the abundant Wealden material in the British Museum, found that the widespread species which usually went by the name of *Sphenopteris Mantelli* Brongniart was congeneric with Yokoyama's species mentioned above, and he therefore redescribed Brongniart's species as *Onychiopsis Mantelli,* redefining the genus in the following terms[1]: " Frond tripinnate, main rachis slender, may be winged,

[1] Seward. Wealden Fl., pt. i, 1894, p. 40.

pinnæ alternate, approximate, lanceolate. Pinnules narrow, lanceolate, acute, alternate, the larger ones serrate, and gradually passing into pinnules with narrow ultimate segments. Fertile pinnæ with alternate elliptical pinnules which differ in shape from the sterile pinnules and have the sporangia on the lower surface, giving them the appearance of raised elliptical bodies."

The most abundant and characteristic ferns of the Potomac Group were referred by Professor Fontaine to *Thyrsopteris* Kuntze, an existing monotypic genus of the family Cyatheaceæ inhabiting the island of Juan Fernandez. Of these some forty species, so called, were described. They were all based on sterile fronds or parts of fronds, often extremely small and inadequate fragments. Professor Fontaine, after quoting Heer's diagnosis of *Thyrsopteris*,[1] writes:

"This description, given by Heer for the genus *Thyrsopteris*, so far as the portion pertaining to the sterile frond is concerned, agrees well with a large number of species in the Potomac flora. These I place provisionally in the genus *Thyrsopteris*, on account of the great resemblance that the shape of the pinnules, the lobing, and the nervation show to the sterile forms of various species determined to be *Thyrsopteris* by their fructification. As, however, no fructification is found in the Potomac species, the placing of these plants in the genus must be regarded as provisional. It is quite possible that some of them belong to *Aspidium* and *Dicksonia*. The genus *Thyrsopteris* seems to be eminently a Jurassic type of fern. However, it may prove to be with the fructification of the various species assigned in this memoir to this genus, it is probable that they are at least distinct and true species. The great variety and comparative abundance of these forms show that this type was developed in the Potomac flora to an unusual degree. They surpass all other types, even that of *Cladophlebis*, and give a decided Jurassic facies to the assemblage of ferns found in this flora. Even if we cannot by fructification determine the affinities of fossils with living plants, the large development of sterile forms of well-marked types is of importance in fixing the character of a flora. It should be noted that a number of

[1] Heer, Fl. Foss. Arct., Band iv, Abth. ii, 1877, p. 28.

the species of *Thyrsopteris* described in the following pages show a good many features similar to those of *Sphenopteris Mantelli*, as described by Schenk and Heer" (p. 120).

Professor Fontaine does identify *Sphenopteris Mantelli* from one locality in the Potomac belt, that at Federal Hill, Baltimore, and in discussing its bearing upon the age of the deposits he says:

"Now in the Potomac flora not only is *S. Mantelli* present in beds which show plants of the most recent facies existing in the formation, but there is a very important group of ferns which, although placed in the genus *Thyrsopteris*, have nearly the nervation and foliage typified in *S. Mantelli*. The great development in the Potomac of ferns of the general type of *S. Mantelli* gives strong evidence of Wealden or somewhat later age. A somewhat later age than Wealden is indicated, perhaps, as most of the species are somewhat modified, so as to depart more or less from the typical *S. Mantelli*, and to assume the facies of *Thyrsopteris*. The other species of *Sphenopteris* give little help in fixing the age of the Potomac strata" (p. 338).

Thus while the most prominent fern element in the Potomac Group belongs to a different genus and different family, its resemblance to the *Sphenopteris Mantelli* type is so pronounced that it furnishes an argument for the nearly homotaxial age of the containing deposits, surely a curious logic. In his latest work this author identifies a species of *Onychiopsis* from three localities in Virginia and Maryland (Hell Hole, 3 sp.; New Reservoir, 1 sp., and Fort Foote, 2 sp.).

Again, in discussing *Thyrsopteris* at the end of his Potomac flora (1890), he writes: "It is true that, as no fructification has been found on these ferns, they may be incorrectly placed in the genus *Thyrsopteris*. Still, the very great development in the Potomac flora of ferns with a foliage and nervation so characteristic of the later Jurassic and Lower Cretaceous cannot be without significance. This type of fern is much the most common in the Potomac strata. The species, most of them well characterized, number forty. They are distributed over the whole of the Potomac area, and a number of them are among the most common ferns at the localities yielding them. This group, more than any other, tends to give a Mesozoic facies to the Potomac flora. They have almost or quite passed away in the interval between the time of the deposition of the lower Potomac and that of the oldest Cretaceous of New Jersey. Their absence in the flora of the latter group greatly adds to the comparatively recent aspect of this latter. A number of these Thyrsopterids have the same type of foliage as the Wealden ferns, *Sphenopteris Mantelli* Brongn.; *S. Gœpperti* Dunker; *S. cordai* Schenk; *S. plurinervia* Heer; and *S. Gomesiana* Heer, as well as the Urgonian plants *Asplenium Dicksonianum* Heer; *A. Nauckhoffianum* Heer, and various Dicksonias, such as *D. Johnstrupi* Heer. It is a significant fact that this type of foliage, so common towards the close of the Jurassic and in the oldest Cretaceous, is the most abundant single type in the Potomac strata also. Such a general prevalence of a type is more significant of geological relationship than the identification of a few species common to two formations. It is not worth while to examine in detail the affinities of the different species. Most of them are new and unique. One or two have some resemblance to Oolitic species, while a greater number may be grouped as belonging to the two Wealden types *S. Mantelli* and *S. Gœpperti*."

It will be seen from these lengthy quotations how uncertain the author of these forty species of *Thyrsopteris* was of their real botanical affinity, and when the student turns from the text and figures to the actual specimens, the strictures of Professor Seward (Wealden Fl., pt. i, 1894, p. 56 *et seq.*) are abundantly justified. There are twenty-six species described from a single clay lens at Fredericksburg, Virginia. If the reader will pause to ask himself where in the history of the earth or in the living flora twenty-six species of a single genus of ferns can be found in a single circumscribed clay lens or growing in a single circumscribed area, grave doubt as to their validity at once arises, and even if we predicate their having been gathered together by a river system it must needs have been a remarkable river system to have gathered together all of these ferns along with over fifty other species of ferns and fifty species of gymnosperms, in all one hundred and sixty different species, and deposited them in one quiet pool where clay was forming, a pool not over

15 feet in diameter as preserved and only 4 feet thick, the recognizable remains practically all coming from the basal 3 to 5 inches.

With the large amount of material at his disposal the writer finds it altogether impossible to differentiate the forty species described by Professor Fontaine from the Potomac Group. There are two main types, the narrow pinnule type, that identified in some of the Baltimore specimens as *Sphenopteris Mantelli* by Fontaine, and including some of the forms described as new species of *Thyrsopteris,* and the broader type exemplified by the foreign *Sphenopteris Gœpperti.* It is to the latter that a large number of the Potomac forms belong. Three additional species, which include the balance of the *Thyrsopteris* forms, are characterized. In perusing the synonymy of the species which follow, the question is likely to rise in the mind of the reader whether or not the process of ignoring minor differences has not been carried too far, so that it is needful to point out the reasons which have led to the present treatment. The main reason is, of course, that it was found impossible to fix upon any characters of specific value that would hold good for material other than the individual specimen upon which they were based. That the author of these species could not tell them one from the other is quite obvious in looking over the material which passed through his hands, specimens identical in all particulars at one time receiving one name and on a subsequent occasion another, even counterparts of the same specimen being, in at least one instance, identified as distinct species.

These ferns were of large size with tripinnate fronds, so that it is easy to see how one or two species with slight individual variations in form could, when broken up into fragments and fossilized in a matrix for the most part of very arenaceous clay, form the basis for numerous species. The pinnæ from the base of the frond will differ more or less from those higher up and the basal pinnules of the individual pinnæ will differ decidedly from the distal ones. It is possible in the more complete Potomac specimens to trace these variations and so get a number of Fontaine's types on a single specimen. It therefore seems wiser to consider the bulk of the forms as exemplifying slight variations, due largely to position, rather than to allow them specific or even varietal rank. The published drawings of these forms, especially the enlarged pinnules showing detail, are for the most part inaccurate and idealized to such an extent, or are composites so that even the experts in the National Museum often find it impossible to decide which specimens represent Fontaine's drawings.

With regard to our taking up the genus *Onychiopsis* of the Polypodiaceæ rather than *Thyrsopteris* of the Cyatheaceæ it may be said that while *Thyrsopteris,* as a strictly form-genus, may not be open to any great degree to criticism, it implies a relationship with the existing species which the evidence does not substantiate, so that the best modern usage refers the older types of this sort to the genus *Coniopteris* Brongniart, and the later ones to this genus *Onychiopsis.* It is quite possible that the modern genus *Thyrsopteris* was a prominent Jurassic and older Cretaceous type, there being many parallel cases, as, for example, the gymnospermous genus *Ginkgo.* Some of the evidence is at least sufficient to prove that forms named *Thyrsopteris* are referable to the family Cyatheaceæ, so that in considering the Potomac forms we have to decide whether the fact that the Jurassic forms like *Thyrsopteris Maakiana* and *Thyrsopteris Murrayana* of Heer are members of the Cyatheaceæ shall be given greater or less weight than the fact that the same type of sterile frond very abundant in the Lower Cretaceous from England to Japan has fertile pinnules like those of the genus *Onychium* of the Polypodiaceæ. It is true that only sterile pinnules are known from the Potomac deposits, but the fertile parts have been found associated, and in organic connection with these identical sterile pinnules in California, Japan, England, Belgium (?), Bohemia, and Portugal. The writer prefers to believe that the latter evidence is entitled to the greater weight. The modern genus *Onychium* has several widely distributed, chiefly tropical, species of Japan, China, India, Persia, Abyssinia, and the East and West Indies. In this connection attention should be called to the fertile specimens from Fredericksburg described as *Aspleniopteris pinnatifida,* since this type which is referred to the Asplenieæ is very similar to the fertile pinnæ of a specimen of *Onychiopsis Gœpperti* from Japan, kindly communicated by Professor Yokoyama.

Onychiopsis latiloba (Fontaine)

Plate XXXIII, Figs. 1, 2

Sphenopteris latiloba Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 90, pl. xxxv, figs. 3-5; pl. xxxvi, figs. 4-9; pl. xxxvii, fig. 1.

Thyrsopteris brevipennis Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 124, pl. xxxiv, fig. 3; pl. xxxvi, fig. 2; pl. xxxvii, figs. 3, 9; pl. xxxviii, fig. 1; pl. xli, fig. 4.

Thyrsopteris divaricata Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 125; pl. xxxvii, figs. 5-8; pl. clxx, fig. 1.

Thyrsopteris crenata Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 127, pl. xxxix, figs. 1, 2.

Thyrsopteris brevipennis Fontaine, 1899, in Ward, 19th Ann. Rept. U. S. Geol. Surv., pt. ii, p. 662, pl. clxii, fig. 1a.

Sphenopteris latiloba Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 281, 479, 491, 511, 534, 557.

Thyrsopteris divaricata Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 504, 511, 517, 521.

Onychiopsis latiloba Berry, 1911, Proc. U. S. Natl. Mus., vol. xli, p. 332.

Description.—Frond large tripinnate; principal rachis very stout, sometimes winged. Leaf-substance thin but coriaceous. Primary pinnæ opposite or subopposite with a stout, rigid rachis, which is often somewhat flexuous; ultimate pinnæ remotely placed, very short, decurrent, passing towards the summit of the principal pinna or of the frond through lobed pinnules into entire ones. Pinnules somewhat remotely placed, cuneate at base, those in the lower part of the frond cut more or less deeply into oblong acute to obtuse lobes, passing towards the tips of the ultimate pinnæ into lobed pinnules like those of the upper part of the frond, and at the tips into ovate or oblong lobes and teeth. In the upper part of the frond they are elliptical, three lobed, or entire. All the pinnules and segments are broad. The ultimate pinnæ and the pinnules of the lower part of the frond usually terminate in three lobed segments or in broad, elliptical pinnules. The veins are copiously branched, diverging flabellately into the lobes and teeth, and are very distinct and strong, although not coarse.

This is a fine, large species, probably arborescent, and quite distinct from the other species of *Onychiopsis*. It is common throughout the Potomac but rather less abundant in the Patapsco formation than in the older beds. It has been recorded from the Lakota formation in the

Black Hills area and from the Kootanie formation in both Montana and British Columbia. There is some variation exhibited by the various forms referred by the writer to this species, and some of the smaller ultimate pinnæ are readily confused with other species of *Onychiopsis.* The specimen figured is characteristic, and well shows the distinctness of this type when represented by reasonably complete material.

Occurrence.—PATUXENT FORMATION. Fredericksburg, Dutch Gap, Telegraph Station (Lorton), Virginia; New Reservoir (?), District of Columbia. ARUNDEL FORMATION. Bewley Estate (?), Bay View (common), Maryland; Langdon, District of Columbia. PATAPSCO FORMATION. Deep Bottom, Mt. Vernon, Hell Hole (?), Chinkapin Hollow (?), Virginia; Federal Hill (Baltimore), Maryland.

Collections.—U. S. National Museum, Johns Hopkins University, Goucher College.

ONYCHIOPSIS PSILOTOIDES (Stokes and Webb) Ward

Plate XXXV; Plate XXXVI, Figs. 7-9

Hymenopteris psilotoides Stokes and Webb, 1824, Trans. Geol. Soc., London, 2d ser., vol. i, p. 424, pl. xlvi, fig. 7; pl. xlvii, fig. 2.

Hymenopteris psilotoides Sternberg, 1825, Fl. Vorwelt, Tentamen, p. xxii.

Sphenopteris Mantelli Brongniart, 1827, in Mantell, Illus. of the Geol. of Sussex [revised ed.], p. 55, pl. i, figs. 3a, b; pl. iii, figs. 6, 7; pl. iii*, fig. 2.

Sphenopteris Mantelli Brongniart, 1828, Prodrome, p. 50; Hist. végét. foss., 1828, p. 170, pl. xlv, figs. 3-7.

Sphenopteris Mantelli Mantell, 1833, Geol. S. E. England, p. 241.

Sphenopteris Mantelli Sternberg, 1833, Fl. Vorwelt, vol. ii, pts. v, vi, p. 56.

Cheilanthites Mantelli Goeppert, 1836, Syst. Fil. Foss., p. 231.

Cheilanthites denticulatus F. A. Roemer, 1839 [non (Brongn.) Göpp.], Verst. d. Norddeutsch. Oolithen-Gebirges, Nachtrag, p. 9, pl. xvii, fig. 1a.

Confervites fissus Dunker, 1844, Program d. höheren Gewerbschule in Cassel, 1843-1844, p. 5.

Sphenopteris Mantelli Unger, 1845, Syn. Plant. Foss., p. 59.

Confervites fissus Dunker, 1846, Monogr. d. Norddeutsch. Wealdenbildung, p. 1, pl. i, fig. 1.

Sphenopteris Römeri Dunker, *Ibid.*, p. 3, pl. i, figs. 3, 4, 4a, 5.

Sphenopteris tenera Dunker, *Ibid.*, p. 3, pl. viii, fig. 5.

Sphenopteris Mantelli Dunker, 1846, Monogr. d. Norddeutsch. Wealdenbildung, p. 2, pl. i, fig. 4a.

Sphenopteris Mantelli Bronn, 1848, Index Pal., p. 1169.

Sphenopteris Mantelli Unger, 1850, Gen. et Sp., 1850, p. 108.
Sphenopteris Mantelli Bronn, 1852, Leth. geogn., vol. ii, 1851-52, p. 49, pl. xxviii, figs. 4a, b.
Sphenopteris Mantelli, Ettingshausen, 1852, Abh. k. k. geol. Reichs, p. 14, pl. iv, figs. 3, 4.
Microlepia Mantelli Ettingshausen, 1865, Farnkrauter der Jetztwelt, p. 216.
Sphenopteris antipodum Tate, 1867, Quart. Jour. Geol. Soc., London, vol. xxiii, p. 146, pl. vi, fig. 3.
Sphenopteris Mantelli Schimper, 1869, Pal. Végét., tome i, p. 393; *Ibid.*, vol. iii, 1874, p. 469.
Sphenopteris Mantelli Schenk, 1871, Palæontographica, Band xix, p. 6 (208), pl. ii, figs. 1-8; pl. iv, fig. 6 (?); *Ibid.*, vol. xxiii, 1875, p. 158, pl. xxviii, fig. 12.
Sphenopteris Gœpperti Schenk, 1871 (pars), Palæont., Band xix, p. 7, (209), pl. iv, fig. 3 (non figs. 2, 4, 5 or pl. ix, fig. 2).
Sphenopteris Mantelli Heer, 1881, Cont. Fl. Foss. Port., p. 12, pl. xi, figs. 1-5; pl. xii, figs. 2b, 2bb.
Aspidium Oerstedi Lesquereux, 1888, Proc. U. S. Nat. Mus., vol. xi, p. 32 in part, quoad Cat. U. S. Nat. Mus., No. 2434, Lesquereux's Nos. 913-915a.
Sphenopteris Mantelli Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 91, pl. i, figs. 1, 2.
Sphenopteris Mantelli Nathorst, 1890, Denks. k. Akad. Wiss., Wien, Band lvii, p. 55.
Thyrsopteris insignis Fontaine, 1890, Monogr. U. S. Geol. Survey, vol. xv, 1889, p. 127, pl. xxxix, fig. 4; pl. xl, fig. 1; pl. xli, fig. 6; pl. xlii, figs. 1, 2, 4; pl. xliii, figs. 1, 3.
Thyrsopteris insignis angustipennis Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 128, pl. xlii, fig. 3; pl. xliii, fig. 2.
Thyrsopteris angustifolia Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 131, pl. xliv, fig. 4; pl. xlv, fig. 3; pl. xlviii, fig. 2; pl. xlix, figs. 3, 4; pl. lv, fig. 2; pl. lviii, fig. 8.
Thyrsopteris microphylla Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 131, pl. xlv, figs. 1, 2, 4, 5.
Thyrsopteris rarinervis Fontaine, 1890, Mongr. U. S. Geol. Survey, vol. xv, 1889, p. 123, pl. xxvi, figs. 6, 7; pl. xliii, figs. 4-6; pl. xliv, figs. 1, 2, 5; pl. xlix, fig. 2; pl. clxix, figs. 6, 7.
Sphenopteris Mantelli Engelhardt, 1891, Kreidepflanzen von Niederschöna, Abh. Isis Dresden, p. 79.
Sphenopteris Mantelli Saporta, 1891, Compt. rendus, tome cxiii, p. 250.
Sphenopteris Mantelli Saporta, 1894, Fl. Foss. Portugal, pp. 72, 124, 157, pl. xv, figs. 8-12; pl. xviii, fig. 5; pl. xxiii, figs. 1, 2, 8; pl. xxviii, fig. 2; pl. xxix, fig. 1; pl. xxx, figs. 9, 10; pl. xxxi, figs. 1, 2.
Onychiopsis Mantelli Seward, 1894, Wealden Flora, pt. i, p. 41, figs. 4, 5 on p. 50, fig. 6 on p. 52, pl. ii, fig. 1, pl. iii, figs. 1-4.
Thyrsopteris dentifolia Fontaine, 1899, in Ward, 19th Ann. Rept. U. S. Geol. Survey, pt. ii, p. 660, pl. clxi, figs. 6-9.

Onychiopsis Mantelli Seward, 1900, Fl. Wealdienne de Bernissart, mém. Musée Roy. d'hist. nat. de Belgique, Année 1900, p. 15, pl. i, figs. 17-19; pl. ii, figs. 20, 21.

Onychiopsis Mantelli Seward, 1903, Ann. S. Afr. Mus., vol. iv, p. 5, pl. i; pl. v, fig. 1.

Thyrsopteris insignis Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 521.

Thyrsopteris angustifolia Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 516.

Thyrsopteris rarinervis Fontaine, 1906, in Ward, Mongr. U. S. Geol. Survey, vol. xlviii, pp. 225, 484, 491, 514, 517, 518, 519, 521, 528, 548, 558, pl. lxv, figs. 2-4; pl. cxiii, figs. 2, 3.

Onychiopsis psilotoides Ward, 1906, in Fontaine, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 155 (name only).

Onychiopsis psilotoides Fontaine, 1906, *Ibid.*, pp. 506, 518, 528, pl. cxi, fig. 4; pl. cxiii, fig. 1.

Onychiopsis Mantelli Richter, 1906, Beitr. z. Fl. der unteren Kreide Quedlinburgs, Teil. 1, p. 6.

Onychiopsis psilotoides Knowlton, 1908, in Diller, Bull. Geol. Soc. Am., vol. xix, 1908, p. 380.

Onychiopsis psilotoides Berry, 1911, Proc. U. S. Natl. Mus., vol. xli, p. 330.

Description.—" S. foliis bipinnatifidis, pinnis approximatis virgatis fastigiatis, pinnulis obliquis, omnibus integris uninerviis, angustis, cuneatis, apice oblique truncatis et subemarginatis; parte exteriori longius producta."—Brongniart, 1828.

" Frond tripinnate, ovate lanceolate, rachis winged and prominent; pinnæ lanceolate, alternate, approximate, given off from the main rachis at an acute angle. Pinnules alternate, narrow, lanceolate acuminate, uninerved, of nervation type Cœopteridis (Luerssen, in Rabenhorst's Krypt. Fl., vol. iii, p. 11) ; the larger ones serrate and gradually passing into pinnæ with narrow ultimate segment. Fructification in the form of sessile or shortly stalked linear ovate segments with rugose surfaces, and terminating usually in a very short awn-like apical prolongation."—Seward, 1894.

The foregoing are respectively the first and last diagnoses of this species and will suffice for the Maryland forms, with the exception that fertile specimens are altogether unknown thus far in this region.

This species is not nearly so common in the Potomac as is *Onychiopsis Gœpperti,* although it appears to have a wider range and to be more common abroad. It occurs at all horizons in the Potomac, however, a vertical range which is paralleled by its range from the Valanginian through the Barremian into the Albian of Portugal. Elsewhere in Europe it has been found in the Wealden of England, Belgium, and Germany, the Neocomian near Quedlinburg, Saxony, and in the Barremian of Austria. Forms which are identical, according to Seward (*loc. cit.*) are found in the Uintenhage series of South Africa, while Nathorst has described similar remains from the Jurassic-Cretaceous boundary in Spitzbergen as *Sphenopteris sp. A.*[1] In this country outside of the Potomac it is found in the Kootanie at Great Falls, Montana; in the Shasta beds of California, and in the Lakota formation of the Black Hills.

The forms identified as this species from the supposed Jurassic near Cape Lisburne, Alaska, have been shown by Knowlton to be forms of *Dicksonia.* Saporta, in his treatment of the Portuguese forms, leaves them in the genus *Sphenopteris,* but thinks that they are more closely related to certain modern species of *Davallia* than to *Onychium.* His figures, however, do not bring this out with any degree of certainty. Professor Seward, in discussing specimens from South Africa (*loc. cit.*), unites with this species the Japanese Jurassic and Cretaceous forms designated as *Thyrsopteris elongata* Geyler and *Onychiopsis elongata* Yokoyama. The reason for the proposed change is the discovery in the English Wealden of more extensive material which showed the *psilotoides* type of pinnule distad and the *elongata* type of pinnule proximad. It is quite possible that the remains from the English Wealden are all of one species, but it certainly does not follow that the synonymy follows such a disposition. The American remains identified with the *elongata* type show that the forms with broader segments are not portions of fronds with the distal basal characters of *psilotoides,* although there is in most ferns more or less diminution in size upward.

Through the kindness of Prof. Yokoyama the writer has received specimens of *elongata* from the Jurassic of Kaga, Japan, and these are certainly specifically distinct, especially in the fertile pinnæ, from the English forms of *psilotoides.* They are therefore included in the present

[1] Nathorst, Kgl. Svenska Vetens.-Akad., Handl., Band xxx, No. 1, 1897, p. 49, pl. ii, fig. 14.

discussion under *Onychiopsis Gœpperti,* which is retained as a distinct species.

Occurrence.—PATUXENT FORMATION. Fredericksburg, Dutch Gap, Trents Reach, near Potomac Run, Virginia; New Reservoir, 16th Street, District of Columbia. ARUNDEL FORMATION. Langdon, District of Columbia; Bay View, Maryland. PATAPSCO FORMATION. Federal Hill (Baltimore), Stump Neck, near Wellhams, Maryland; near Brooke, Widewater, Hell Hole, Virginia.

Collection.—U. S. National Museum.

ONYCHIOPSIS BREVIFOLIA (Fontaine) Berry

Plate XXXIV, Figs. 1, 2

Thyrsopteris brevifolia Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 121, pl. xxiv, figs. 5, 10.

Thyrsopteris dentata Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 121, pl. xxiv, figs. 4, 6, 7, 9; pl. xxv, figs. 1, 2.

Thyrsopteris pachyphylla Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 135, pl. l, fig. 3.

Thyrsopteris nana Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 141, pl. lvi, figs. 4, 8.

Thyrsopteris heterophylla Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 142, pl. lviii, fig. 3.

Thyrsopteris sphenopteroides Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 143, pl. lviii, fig. 6.

Thyrsopteris squarrosa Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 143, pl. lix, fig. 3.

Thyrsopteris retusa Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 144, pl. lix, fig. 10.

Thyrsopteris brevifolia Fontaine, 1899, in Ward, 19th Ann. Rept. U. S. Geol. Surv., pt. ii, p. 660, pl. clxi, figs. 10-15.

Onychiopsis brevifolia Berry, 1911, Proc. U. S. Natl. Mus., vol. xli, p. 329.

Description.—Frond small, bipinnate or tripinnate. Rachises rather slender, often winged. Pinnæ alternate to subopposite, relatively long and narrow, divided below, pinnatifid distad. Pinnules much narrowed at the base, decurrent, obliquely toothed or divided, the extent depending upon their position on the frond, triangular ovate to lanceolate in outline. Veins somewhat flabellate, once or twice forked or simple. Texture coriaceous.

This species is not common in the Potomac and is confined to the basal beds in the Virginia area, although it has also been reported from the Lakota formation in the Black Hills region and from the Kootanie formation of Montana. It is represented in the Virginia area by quite a large number of mostly fragmentary specimens showing slight variations in the character of the pinnule-lobes or teeth which were made the basis for distinguishing eight species by Professor Fontaine. It is possible that more than one type is included in the species as defined by the writer, the nature of the material rendering certainty out of the question, but if the test of the validity of a species be the possibility of its being recognized a second time by either the original author or other students, it must be admitted that these eight so-called species are not good species.

Onychiopsis brevifolia differs from *Onychiopsis Gœpperti* and *psilotoides* principally in the smaller fronds, less robust pinnules, which are also less ascending, and in the much less elongate character of the pinnæ and especially the pinnules. It is a much smaller and less robust form than *Onychiopsis latiloba,* from which it is readily distinguished, but approaches somewhat close to *Onychiopsis nervosa.* The latter species is on the whole a larger form with less elongate and more triangular pinnæ, and the pinnules have more entire margins, the lobes or teeth being rounded and not angular. The veins are also more numerous.

Occurrence.—PATUXENT FORMATION. Fredericksburg, Dutch Gap, Potomac Run, Telegraph Station (Lorton), Virginia.

Collection.—U. S. National Museum.

ONYCHIOPSIS NERVOSA (Fontaine) Berry

Plate XXXVI, Figs. 1-6

Thyrsopteris nervosa Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 122, pl. xxv, figs. 4, 5, 16; pl. xxxvii, figs. 2, 4; pl. xxxix, fig. 5; pl. xl, fig. 6.

Thyrsopteris Meekiana Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 125, pl. xxxviii, figs. 2-4, 8; pl. l, figs. 7, 8; pl. li, fig. 3.

Thyrsopteris crassinervis Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 130, pl. xli, figs. 1-3.

Thyrsopteris pecopteroides Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 135, pl. li, fig. 1.

Thyrsopteris heteroloba Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 139, pl. liii, fig. 4.

Thyrsopteris obtusiloba Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 143, pl. lviii, figs. 7, 10.
Thyrsopteris crassinervis Fontaine, 1899, in Ward, 19th Ann. Rept. U. S. Geol. Surv., pt. ii, p. 658, pl. clxi, figs. 3, 4.
Thyrsopteris pecopteroides Fontaine, 1899, *Ibid.*, p. 661, pl. clxi, figs. 16-19.
Adiantites parvifolius Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 558, pl. cxvii, fig. 1.
Thyrsopteris nervosa Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 511, 517, 519, 521, 528, 548, 571.
Thyrsopteris Meekiana Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 519, 565; pl. cxix, fig. 1.
Thyrsopteris crassinervis Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 513, 528, pl. cxii, figs. 5, 6.
Onychiopsis nervosa Berry, 1911, Proc. U. S. Natl. Mus., vol. xli, p. 327.

Description.—Frond bipinnate or tripinnate. Principal rachis medi-umly stout, somewhat flexuous, sometimes winged in the upper part. Pinnæ alternate or subopposite, ovate to ovate-lanceolate in outline, becoming entire apically, the pinnules passing into dentate teeth while the ultimate pinnæ become dentate pinnules. This character renders distal fragments quite different in appearance from the normal form of this species, and quite like *Cladophlebis*. In some individuals the pinnæ lower down on the frond assume this form, constituting the supposed species *Thyrsopteris crassinervis* of Professor Fontaine and well shown in the specimens figured from Chinkapin Hollow and near Glymont. Every gradation is shown, however, between this type and the usual type of pinnæ made up of alternate, very oblique, decurrent pinnules, usually rather deeply cut into subrhombic basal lobes which become ovate or elliptical lobes, and finally teeth in passing distad. Base contracted, subpetiolate. Veins numerous and slender, but very distinct, branching obliquely, flabellate, repeatedly forked, subparallel. Texture coriaceous.

While the fragments of the fronds of this species are all small the plant which bore them must have been of quite considerable dimensions. Representative material is readily distinguished from the other species of *Onychiopsis* recognized, but small fragments are liable to confusion with *Onychiopsis brevifolia,* in fact Professor Fontaine founded no less than six nominal species upon such fragments, all of which are believed by the writer to represent slight variations of a single species.

It is widely distributed throughout the Potomac Group, but not common at any outcrop. Outside this area it has been reported from the Lakota formation of the Black Hills. Practically identical remains from the Lower Cretaceous of Portugal are described by Saporta as various species of *Sphenopteris*.

Occurrence.—Patuxent Formation. Fredericksburg, Dutch Gap, Potomac Run, Virginia; New Reservoir, Ivy City, District of Columbia; Springfield, Maryland. Arundel Formation. Langdon (frequent), District of Columbia. Patapsco Formation. Chinkapin Hollow, Virginia; Ft. Foote, near Glymont, Vinegar Hill (?), Federal Hill (Baltimore), Maryland.

Collections.—U. S. National Museum, Maryland Academy of Science, Goucher College.

Onychiopsis Gœpperti (Schenk) Berry

Plate XXXIV, Figs. 3, 4

Sphenopteris Gœpperti Schenk, 1871 (pars), Palæontographica, Band xix, 1871, p. 7 (209), pl. iv, fig. 2 (non figs. 3-5 or pl. ix, fig. 2).

Thyrsopteris elongata Geyler, 1877, Palæontographica, Band xxiv, p. 221.

Thyrsopteris elongata Schenk, 1883, in Richthofen's China, Band iv, p. 263, pl. liv, fig. 1.

Dicksonia elongata Yokoyama, 1886, Bull. Geol. Soc., Japan, vol. i, No. 1, p. 5.

Onychiopsis elongata Yokoyama, 1890, Jour. Coll. Sci., Japan, vol. iii, p. 27, pl. ii, figs. 1-3; pl. iii, fig. 6d; pl. xii, figs. 9, 10.

Onychiopsis elongata Nathorst, 1890, Denks, k. Akad. Wiss., Wien, Band lvii, pp. 44, 48, 50, 51, 52, 53, 54, pl. v, fig. 3; pl. vi, fig. 5.

Thyrsopteris alata Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 124, pl. xxxvi, fig. 3.

Thyrsopteris Meekiana angustiloba Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 126, pl. xxxviii, figs. 5-7, 9; pl. xliii, fig. 8; pl. xliv, fig. 3; pl. xlvii, fig. 4; pl. xlviii, fig. 1; pl. liv, figs. 2, 11; pl. lv, fig. 1; pl. lvi, figs. 1, 3.

Thyrsopteris angustiloba Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 134, pl. xlviii, figs. 3-5; pl. lv, fig. 3.

Thyrsopteris densifolia Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 129, pl. xxxix, fig. 3; pl. xl, figs. 2-5; pl. li, fig. 5.

Thyrsopteris decurrens Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 130, pl. xliii, fig. 7; pl. xlvi, figs. 2, 4; pl. xlix, figs. 5-7.

Thyrsopteris virginica Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 120, pl. xxiv, fig. 1.

Thyrsopteris pachyrachis Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 132, pl. xlvi, figs. 3, 5; pl. xlvii, figs. 1, 2; pl. xlix, fig. 1.
Thyrsopteris elliptica Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 133, pl. xxiv, fig. 3; pl. xlvi, fig. 1; pl. l, figs. 6, 9; pl. li, figs. 4, 6, 7; pl. liv, fig. 6; pl. lv, fig. 4; pl. lvi, figs. 6, 7; pl. lvii, fig. 6; pl. lviii, fig. 2.
Thyrsopteris distans Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 134, pl. xlvii, fig. 3; pl. liv, fig. 8.
Thyrsopteris pinnatifida Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 136, pl. li, fig. 2; pl. liv, figs. 4, 5, 7; pl. lvii, fig. 7.
Thyrsopteris varians Fontaine. 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 137, pl. lii, figs. 2-4; pl. liii, figs. 1-3; pl. liv, fig. 10; pl. lvii, fig. 2.
Thyrsopteris rhombifolia Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 138, pl. lii, fig. 5; pl. liv, fig. 1.
Thyrsopteris bella Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 139, pl. liii, fig. 5; pl. lv, figs. 6, 7; pl. lvi, figs. 2, 5; pl. lvii, figs. 1, 5; pl. lviii, fig. 4.
Thyrsopteris microloba Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 140, pl. lvii, fig. 4.
Thyrsopteris microloba alata Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 140, pl. lv, fig. 5; pl. lviii, fig. 1.
Thyrsopteris inæquipinnata Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 142, pl. lvii, figs. 3, 8.
Thyrsopteris rhombiloba Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 144, pl. lix, fig. 7; pl. lx, fig. 8.
Sphenopteris Gœpperti Saporta, 1894, Fl. Foss. Portugal, pp. 71, 123, 159, pl. xviii, fig. 6; pl. xxiii, fig. 8; pl. xxix, fig. 6.
(?) Onychiopsis elongata Seward, 1894, Wealden Fl., pt. i, p. 55, pl. ii, fig. 2.
Thyrsopteris elliptica Fontaine, 1898, in Ward, 18th Ann. Rept. U. S. Geol. Survey, pt. iii, p. 482.
Thyrsopteris elliptica Fontaine, 1899, in Ward, 19th Ann. Rept. U. S. Geol. Survey, pt. ii, p. 659, pl. clxi, fig. 5.
Thyrsopteris pinnatifida Fontaine, 1899, in Ward, 19th Ann. Rept. U. S. Geol. Surv., pt. ii, p. 658, pl. clxi, figs. 1, 2.
Thyrsopteris Meekiana angustiloba Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 557.
Thyrsopteris densifolia Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 484, 511, 517.
Thyrsopteris decurrens Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 484, 491, 511, 525, pl. cxi, fig. 11.
Thyrsopteris pachyrachis Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 487, 538, 557.
Thyrsopteris elliptica Fontaine, 1906, in Ward, Mongr. U. S. Geol. Survey, vol. xlviii, 1905, pp. 290, 484, 514, 517, 528, 557, pl. lxxi, figs. 12, 13.
Thyrsopteris pinnatifida Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 511.
Thyrsopteris bella Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 491, 511.

Thyrsopteris microloba alata Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 281.

Thyrsopteris elliptica Knowlton, 1907, Smith. Misc. Coll., vol. iv, pt. i, p. 110.

Onychiopsis Goepperti Berry, 1911, Proc. U. S. Natl. Mus., vol. xli, p. 325.

Description.—" Frond slender, bi-tripinnated; sterile pinnæ alternate or rarely opposite, elongated, their length rapidly increasing towards the lower part of the frond; pinnules alternate, acutely directed forward, lanceolate or linearly-lanceolate, entire or lobed, or even pinnately parted; lobes or partitions acute at apex and acutely directed forward just like the pinnules themselves. Venation obsolete, secondary veins simple, each going into a lobe. Fertile pinnules elongated, with a linear terminal sorus on both sides of the midrib."—Yokoyama, 1890.

A very large number of Fontaine's species of *Thyrsopteris* fall within the limits of this species. There is, to be sure, some variation in the relative length and breadth of the pinnules, but the material shows every gradation of form, it being possible to select individual pinnules from a single frond fragment which exemplify several of the supposed types. On the whole, the pinnules are somewhat more robust than in the foreign material, and the rachis is inclined to be stouter and may or may not be winged.

This is an exceedingly common form in the Potomac from the oldest to the youngest stratum, and it has also been recorded from the Kootanie of Montana at Great Falls, Geyser, etc., and possibly some of Dawson's identifications of *Asplenium Dicksonianum* Heer from the Canadian Kootanie should also be referred to this species. It also occurs in the Lakota formation of the Black Hills. Abroad it is rather rare in the English and German Wealden, but its geological distribution in the Lower Cretaceous of Portugal rivals that of eastern America, since it comprises considerable material from the Valanginian, Barremian, and Albian terranes. With regard to its occurrence in the Neocomian of eastern Asia, Yokoyama writes (*loc. cit.*) that it is the " chief and characteristic fossil of the Japanese flora, being found in all of the fossil localities."

That this species or *Onychiopsis psilotoides,* or both, occur in the Kome beds of western Greenland seems probable, and several of Heer's species of *Asplenium,* notably *Asplenium Dicksonianum* Heer,[1] suggest themselves for comparison. While the writer has not ventured to include any of them in the synonymy of this species, they certainly are very close to this type in appearance. The English forms are questioned in the synonymy, since Prof. Seward[2] considers the Wealden material identical with that of *Onychiopsis psilotoides.* This may be true of the English material, but it cannot apply to that from America and Asia, as the writer has shown under the discussion of *Onychiopsis psilotoides.*

Occurrence.—PATUXENT FORMATION. Fredericksburg, Trents Reach, Cockpit Point, Dutch Gap, near Potomac Run, Colchester Road (Pohick Creek ?), Virginia; New Reservoir, Ivy City, District of Columbia. ARUNDEL FORMATION. Langdon, District of Columbia; Arlington, Maryland. PATAPSCO FORMATION. Federal Hill (Baltimore), Ft. Foote, Overlook Inn, Vinegar Hill, Maryland; near Brooke, White House Bluff, Mt. Vernon, Chinkapin Hollow, Virginia.

Collections.—U. S. National Museum, Goucher College.

Family HYDROPTERACEAE

Genus SAGENOPTERIS Presl

[In Sternberg, Fl. Vorwelt, Bd. ii, 1838, p. 164]

This genus was founded by Presl in 1838 upon material from the Rhætic beds of Strahlendorf, near Bamberg, which he named *Sagenopteris rhoifolia,* although admitting that it was identical with that described two years earlier by Sternberg as *Acrostichites inæquilateralis.* As it is now generally admitted that the *Filicites Nilsoniana* of Brongniart, described in 1825 from the Rhætic beds of Schonen, is the same species, the proper specific name of the type becomes *Sagenopteris Nilsoniana,* as pointed out by Ward in 1906.

Presl characterized the genus as follows: "Frons pinnata, pinnis ternatim rarius binatim compositis. Venæ tenuissimæ, ramosissimæ,

[1] Heer, Fl. Foss. Arct., Band iii, Ab. 2, 1874, p. 31, pl. i, figs. 1-5; *ibid.*, Band vi, Ab. 2, 1882, pp. 3, 33, pl. ii, fig. 2; pl. xxxii, figs. 1-8.

[2] Seward, Ann. S. Afr. Mus., vol. iv, 1903, p. 7.

æquales, in maculas irregulariter hexagonoideas elongatas confluentes. Costæ crassæ usque ad apicem pinnularum excurrentes."

Schimper redescribed the genus in 1869,[1] adding the following epidermal characters: "Epidermide superiore inæqualiter rectangula, inferiore polygono-areolata stomatibusque pertusa." He concluded from the latter fact that *Sagenopteris* was without representatives in the modern flora, and that it could not be related to the modern *Marsilea,* which it resembled, and which was thought to lack stomata on the lower surface of the pinnæ. Nathorst, one of the strongest supporters of this latter relationship, points out that stomata do occur in this position in *Marsilea,* and that the abundant fruits which occur in the Rhætic beds near Palsjö, associated with *Sagenopteris undulata* Nathorst, and which cannot be referred to the conifers or cycads, are, in the absence of angiosperms, the sporocarps of *Sagenopteris,* a conclusion independently arrived at by Heer. Similar sporocarps, if they are sporocarps, are described by Zigno from the Oolite of Italy. Although Solms-Laubach is inclined to doubt the validity of Nathorst's argument, and Seward recently[2] reiterates his belief that *Sagenopteris* is a true fern and not a Rhizocarp, most authors[3] place the genus among the Hydropteraceæ, a view to which Schimper subscribes in Zittel's Handbuch. Attention should be called in this connection to a specimen figured by Fontaine from near Potomac Run, Virginia, purporting to show the remains of fructification characters in the form of a series of dots which, according to this author, would place the specimen "in the *Dictyopteris* group of *Polypodium.*" The characters indicated are not visible on this particular specimen at the present time and no importance is attached to them by the writer.[4]

[1] Schimper, Pal. Végét., tome i, 1869, p. 640.

[2] Jurassic Fl., pt. ii, 1904, p. 93. Since this was written vol. ii of Seward's Fossil Plants has been received. In this work the probable relationship between *Sagenopteris* and *Marsilea* is admitted.

[3] Nathorst, Heer, Schimper, Schenk, Saporta, Potonié, Zeiller, etc.

[4] Salfeld, in a recent discussion of the Jurassic plants of northern Germany (Palæont., Band lvi, 1909, p. 17), states that he found fructifications on the pinnules of *Sagenopteris Nilsoniana* Brongniart, but he brings forward no evidence to support his statement.

Sagenopteris may be defined in the light of our present knowledge as follows: Stipe long and rather stout, bearing apically palmately arranged pinnæ which are usually four in number. Pinnæ variable in outline, even on the same stipe, asymmetrical, linear-lanceolate to ovate. Venation reticulate, the meshes more or less elongate. Basally, a stout midrib is present which rapidly becomes attenuated and disappears through the anastomosing branches which it gives off. Fructification in the form of oval or spherical bodies resembling sporocarps (?).

Remains which have been referred to *Sagenopteris* are described by Feistmantel from the late Paleozoic, but these are now regarded as belonging to *Glossopteris*. Undoubted specimens of *Sagenopteris* appear in the Keuper, and the genus is prominent in Rhætic and Liassic floras, continuing without perceptible abatement through the balance of the Jurassic. There are seven or eight species in the Lower Cretaceous, mostly American, although *Sagenopteris Mantelli* is also rather widespread in Europe. There are three species in the Potomac Group, one of which also occurs in the Shasta of California and the Lower Cretaceous of the Queen Charlotte Islands. In the Upper Cretaceous a single species is recorded from the Cenomanian of Bohemia, and this reappears according to Hollick, in the Cretaceous of Chappaquidick Island, Massachusetts. A true *Marsilea* also occurs at this horizon,[1] and from an earlier horizon Schenk[2] describes *Marsilidium speciosum*.

SAGENOPTERIS LATIFOLIA Fontaine

Sagenopteris lâtifolia Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 148, pl. xxvii, fig. 10.

Description.—"Frond unknown; pinnules apparently subquadrilateral, narrowed gradually to the base and rapidly to the summit; midnerve in the lower part of the pinnule strong, in the upper part dissolving into branches; lateral nerves going off very obliquely, branching near the midrib, turning outward, and then by repeated branching and

[1] Hollick, Bull. N. Y. Bot. Gard., vol. iii, 1904, p. 409, pl. lxxi, figs. 1-3.
[2] Schenk, Palæont., Band xix, 1871, p. 225 (23), pl. xxvi (v), figs. 3, 3a.

anastomosis forming long, rather regular, elliptical to rhombic meshes, which fill the lamina."—Fontaine, 1890.

This species was based upon two very fragmentary specimens, of which the more complete was figured. It does not differ appreciably from a number of the broader Jurassic species, nor does it offer any very conclusive differences from the Wealden species *Sagenopteris Mantelli* (Dunker) Schenk which Fontaine records from the Shasta beds of the west coast, and with which the Potomac species may be identical.

Occurrence.—Patuxent Formation. Near Telegraph Station (Lorton), Virginia.

Collection.—U. S. National Museum.

Sagenopteris elliptica Fontaine

Sagenopteris elliptica Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 149, pl. xxvii, figs. 9, 11-17.

Chiropteris spatulata Newberry, 1891, Amer. Jour. Sci. (iii), vol. xli, p. 199. pl. xiv, figs. 1, 2.

Sagenopteris sp., Fontaine, 1894, in Diller and Stanton, Bull. Geol. Soc. Amer., vol. v, p. 450.

Sagenopteris sp., Fontaine, 1896, in Stanton, Bull. U. S. Geol. Survey, No. 133, p. 15.

Sagenopteris elliptica Penhallow, 1902, Trans. Roy. Soc. Can. (ii), vol. iv, sec. iv, p. 41.

Sagenopteris elliptica Fontaine, 1906, in Ward, Mon. U. S. Geol. Survey, vol. xlviii, 1905, p. 236, pl. lxv, figs. 39, 40.

Sagenopteris sp., Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 238, pl. lxv, fig. 46.

Chiropteris spatulata Knowlton, 1907, Smith. Misc. Coll., vol. l, pt. i, p. 114.

Description.—Stipe stout, apparently crowned with five palmately arranged pinnæ. No pinnæ have been found attached, but one specimen shows five lying disposed around the summit of the stipe. If these really were attached as described by Fontaine they may represent simply a variation and not even constitute a specific character, although no five-parted *Sagenopteris* has been heretofore described. Pinnæ variable in size, inequilateral, lanceolate to ovate, obtusely pointed above, gradually narrowed below, 3.5 cm. to 10 cm. in length by 0.7 cm. to 3.6 cm. in greatest width, the upper or terminal ones being the largest. Midrib broad at the base, disappearing before reaching the apex. Lateral veins branching at a variable acute angle, anastomosing to form irregular meshes which are subrhombic in some specimens and very much elongated

FIG. 4.—Restoration of Sagenopteris elliptica about natural size.

with few anastomoses in others. Fontaine describes minute elevations between the veins on the lower surface which he thinks indicate polypodiaceous fructifications. These are said to be distinctly seen only with the aid of a lens, and yet they are 0.5 mm. long in the specimen figured natural size. The present writer has failed to find any trace of these supposed fructifications.

This species is not common in the later Potomac, and the specimens from Federal Hill, Maryland, are not perfect enough to determine with certainty their identity with those from near Potomac Run, Virginia. Penhallow has recorded this same form from the Queen Charlotte Islands, and it is frequent in the Shasta of California. The Kootanie occurrence is based on forms described by Newberry as a species of *Chiropteris* and differentiated from *Sagenopteris,* primarily because of the infrequency of anastomosis of the veins and the consequent elongation of the meshes. This is a feature which is also emphasized in some of the eastern specimens, and also in some of those from California, and it seems quite probable that the Kootanie plant is identical with these others.

Seward thinks that the American plant may be identical with the European Jurassic species *Sagenopteris paucifolia* (Phillips) Ward. Its similarity to *Sagenopteris Mantelli* (Dunker) Schenk may also be pointed out, the latter usually having the midrib a much less prominent feature than it is in the American plant. In connection with the supposed five pinnules of the present species it is interesting to recall that in *Marsilidium speciosum,* a possibly related form, described by Schenk (*op. cit.*) from the Wealden of Osterwald, the pinnules are considered to be six in number.

Occurrence.—Patuxent Formation. Near Potomac Run and Kankeys, Virginia. Patapsco Formation. Federal Hill (Baltimore), Maryland.

Collection.—U. S. National Museum.

Sagenopteris virginiensis Fontaine

Sagenopteris virginiensis Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 150, pl. cxxxviii, fig. 13; pl. cxxxix, fig. 1.

Description.—" Frond unknown; shape of pinnules not seen, probably broadly elliptical or oval; stipe or petiole of pinnules apparently long; midnerve toward the base very strong, dissolving in branches toward the apex; areolation very distinct, formed by lateral nerves which go off obliquely and curve outwards to meet the margin, forking repeatedly, and anastomosing to form meshes that are irregular in size and shape, being mostly elongate, oblong, or subrhombic."—Fontaine, 1890.

No additional material referable to this species having been discovered, its claim to validity rests upon the foregoing meagre description and the rare fragments figured by Fontaine which might equally well be referable to either of the other Potomac species. In fact such a disposition would probably do no violence to the facts.

Occurrence.—PATUXENT FORMATION. Fredericksburg, Virginia.

Collection.—U. S. National Museum.

Family MARATTIACEAE (?)

Genus TAENIOPTERIS Brongniart

[Prodrome, 1828, p. 61]

Brongniart gives the following diagnosis of *Tæniopteris* in his Prodrome[1]:

> Fronde simple, entière, étroite, à bords parallèles, transversée par une nervure moyenne, forte, épaisse, qui s'étend jusqu'à l'extrémete; nervures secondaires presque simples ou bifurquées à la base, presque perpendiculaires sur la nervure moyenne.

The type was the Jurassic species *Tæniopteris vittata;* which was compared with the existing genera *Danæa* and *Angiopteris* of the Marattiaceæ.

This diagnosis is repeated in Latin without material change in the Histoire.[2] In a later[3] work the same author institutes various comparisons with modern ferns, and points out that the genus probably includes forms of diverse botanical affinities. Three groups are recognized: (1) Those with simple fronds like *Tæniopteris vittata,* which suggest modern forms of *Acrostichum;* (2) those with pinnate or bipinnate fronds with articulated pinnæ like *T. Münsteri,* which Brongniart is positive is a member of the Marattiaceæ, and (3) those with non-articulate pinnate fronds like *T. Bertrandi.*

[1] Prodrome, 1828, p. 61.
[2] Brongniart Hist. végét. foss., 1831, p. 262.
[3] Brongniart, Tableau, 1849, p. 21.

The genus has been ably discussed in its Mesozoic aspects by Saporta, Zigno, Schenk, Schimper, Seward, and other authors, the former especially, while following Brongniart's original characterization of *fronds usually simple,* considerably extends his diagnosis.[1] Saporta's diagnosis is quoted in a recent work by Seward[2] and need not be repeated. The latter author uses the genus in a wide sense following Nathorst in including under it such other genera as *Oleandridium, Angiopteridium, Marattiopsis, Danæopsis,* etc., in which the evidence of relationship seems insufficient for the use of names implying affinity with the respective modern genera. His characterization may be quoted with profit: "Frond simple or pinnate, usually lanceolate or linear-lanceolate, apex acute or occasionally obtusely terminated; a well-marked midrib from which lateral veins are given off either at right angles or more or less obliquely; these may be unbranched or acutely forked as they pass toward the leaf margin."[3] The relation of the simple species to those with pinnate fronds is uncertain, although they may possibly all belong to the same stock. It proves to be an almost impossible task in the absence of any but the best preserved material to distinguish between Tæniopteris-like forms and the remains of such a cycadaceous genus as *Nilsonia.* The lateral attachment of the lamina in the former and its superior attachment in the latter are characters which are very often obscured in the process of fossilization and the usual segmentation of the *Nilsonia* fronds is also a character which is not constant.

The genus is abundant in the late Paleozoic, the Paleozoic forms having been discussed by Zeiller, White, and others, the latter author pointing out[4] their probable filiation with the *Megalopteris* stock, which extends back to the Middle Devonian. Species of *Tæniopteris* are abundant during the Mesozoic, and occasional occurrences are recorded during the Cenozoic. It may be seriously questioned, however, whether the Paleozoic and post-Paleozoic Tæniopterids belong to the same stock.

In the Potomac Group several species have been described under the

[1] Saporta, Pl. Jurass., tome i, 1873, p. 430.
[2] Seward, Wealden Flora, pt. i, 1894, p. 122.
[3] Seward, Wealden Flora, pt. i, 1894, p. 124.
[4] White, Bull. Geol. Soc. Amer., vol. iv, 1893, pp. 119-132.

genus *Angiopteridium,* which it has seemed best to refer to *Tæniopteris* in the absence of all traces of fructification and the consequent lack of certainty regarding their taxonomic position. Species also occur in the Shasta beds of California, and probably in the Kootanie of Montana and British Columbia. It is also a common type in the European Wealden.

Regarding the botanical affinity of the various forms of *Tæniopteris,* it seems very probable that the bulk of them are closely related to the Marattiaceæ, a family with which they are allied by nearly all of the authors mentioned. In fact most authors ally them directly with living genera; thus Schimper[1] positively refers the Rhætic species *Tæniopteris Münsteri* to the modern genus *Marattia,* a conclusion which it is difficult to dispute after seeing the magnificent fruiting specimens figured by this author. Schenk,[2] on the other hand, thinks this species is closest to *Angiopteris,* while Raciborski, from the study of fruiting specimens from Poland, which he identifies with this same species, is equally sure of the correctness of Schimper's conclusions. To mention one or two other instances, Schenk[3] is sure that *Danæopsis marantacea* (Presl) Heer from the Keuper is a true *Danæa,* and it would be equally difficult to point out the differences between the modern species and the forms of *Danæa* which Zigno describes from the Jurassic of northern Italy.[4]

Zeiller has suggested that *Tæniopteris* fronds grew in tufts from a creeping rhizome as does the modern *Scolopendrium.* In a measure confirming this suggestion Chapman[5] has recently furnished grounds for identifying *Rhizomopteris Etheridgei* Seward from the Jurassic of Australia as the rhizome of one of the abundantly associated species of *Tæniopteris.* Organic connection cannot be made out but these two fossils greatly exceed all other plant remains in the deposits, and certain specimens show the basal parts of *Tæniopteris* fronds crushed in various positions along the rhizomes.

[1] Schimper in Zittel's Handbuch, 1890, p. 85.
[2] Schenk, Die foss. Pflanzenreste, 1888, p. 30.
[3] Idem, p. 35.
[4] Flora fossilis formationis Oolithicæ, Padova, 1856-1885.
[5] Chapman, Records Geol. Surv., Victoria, vol. iii, pt. i, 1909, p. 105.

TÆNIOPTERIS AURICULATA (Fontaine) Berry

Angiopteridium auriculatum Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 113, pl. vii, figs. 8-11; pl. xxviii, fig. 1.

Tæniopteris auriculatum Berry, 1910, Proc. U. S. Natl. Mus., vol. xxxviii, p. 634.

Description.—"Frond pinnate; pinnules thick and leathery, long linear, subacute, remotely placed, free to the base, auriculate at base, attached by the midrib alone; auricles of the bases of the pinnules overlapping the upper surface more or less; midrib of pinnules rather stout and rigid; lateral nerves often obscurely shown, fasciculate or bifurcate, and towards the tips simply forked.

"The plant is rare at each locality, but is most common at Fredericksburg. It is something like *Pteris longipennis* Heer,[1] but there is no reason to think that it is a *Pteris.* It also resembles *Pecopteris salicifolia*[2] Oldham and Morris. The forms figured in figs. 8, 9, 11 occur at Fredericksburg; fig. 10 occurs at the locality near Potomac Run. This is different from the others in the great length of the pinnules and in the fasciculate nerves, which are bifurcate, with the branches again forking near their tips. The nerves are obscure on the upper surface of the pinnules. The main rachis is stout and keeled on the under surface, as is shown in fig. 9. On the upper surface the auricles at the base of the pinnules overlap more or less the surface of the main rachis."—Fontaine, 1890.

No new material referable to this species has been collected.

Occurrence.—PATUXENT FORMATION. Fredericksburg and Potomac Run, Virginia.

Collection.—U. S. National Museum.

TÆNIOPTERIS NERVOSA (Fontaine) Berry

Plate LXXVII, Fig. 1

Angiopteridium nervosum Fontaine, 1890, Mon. U. S. Geological Survey, vol. xv, 1889, p. 114, pl. xxix, fig. 2.

Angiopteridium densinerve Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 115, pl. xxix, fig. 4.

[1] Heer, Foss. Fl. Arct., Band vi, Abth. ii, pl. x, figs. 5-13.

[2] Foss. Flora of the Rajmahal series, pl. xxvii, fig. 2.

Angiopteridium pachyphyllum Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 115, pl. xxix, fig. 5.

Angiopteridium strictinerve Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 116, pl. xxix, figs. 8, 9 (non Font., in Ward, 1906).

Angiopteridium strictinerve latifolium Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 116, pl. xxx, figs. 1, 5.

Anomozamites angustifolius Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 167, pl. xxx, fig. 3 (non. fig. 2).

Anomozamites virginicus Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 168, pl. xxx, fig. 4; pl. xxxi, fig. 3.

Angiopteridium strictinerve latifolium Fontaine, 1906, in Ward, Mon. U. S. Geol. Survey, vol. xlviii, 1905, p. 241, pl. lxvi, figs. 8-10.

Tæniopteris nervosum Berry, 1910, Proc. U. S. Natl. Mus., vol. xxxviii, p. 634.

Description.—Habit unknown, indications in one or two specimens that the frond was pinnate in character. Pinnæ (or frond) linear-lanceolate to elongate-lanceolate. Length unknown, apparently ranging from 10 cm. to 30 cm. Maximum width 1.2 cm. to 5 cm. Texture coriaceous. Midrib rather stout and prominent. Lateral veins thin but distinct, especially on the lower surface, more or less closely placed, parallel, curving backward from the midrib, and then straight or slightly curved upward to the margin. Angle of divergence wide, 45° to 90°. Veins either simple or forked, the forking usually near the base, both kinds often shown on a single specimen.

This species is based entirely upon very fragmentary material, which served Fontaine for the differentiation of five species of *Angiopteridium* and two species of *Anomozamites.* There is absolutely no ground for the reference of any of the material to the genus *Anomozamites,* and it is all obviously identical. There is some slight variation from specimen to specimen, for example the midrib is somewhat less stout in *Angiopteridium nervosum* and *densinerve,* as delimited by Fontaine, and the angle of divergence is somewhat more acute in the latter, but these are not characters of specific value. If similar recent fronds, such as those of *Oleandra, Angiopteris,* or *Marattia* be examined, the size of the midrib, the remoteness or closeness of the lateral veins and their angle of divergence will be found to vary through much wider limits, a single frond often exhibiting the extremes in this respect.

A single specimen from Fredericksburg figured by Fontaine (1890, pl. xxix, fig. 9), and showing apparently the basal portion of three pinnæ lying in the same plane and direction, and two of them attached to stout bits of rachis, is the only evidence that the fronds were pinnate and not simple. These may represent aërial stalks, or they may equally well be interpreted as fragments of a rhizome or a rootstock.

This species is not common in the Potomac Group, and is confined to the Patuxent formation. Similar remains are described from both the Knoxville and Horsetown beds of the Pacific Coast, and similar fragmentary specimens are described by Saporta[1] from the Valanginian of Portugal and referred to Schimper's genus *Oleandridium*. In the European Wealden there is *Oleandridium Beyrichii* Schenk[2] from Germany and England which Seward refers to *Tæniopteris*, and two other forms of questionable distinctness which the latter author describes from the English beds.[3] *Oleandra arctica* Heer[4] from the Kome beds of Greenland may be compared with the Potomac Tæniopterids. Newberry[5] identifies this species in the Kootanie of Montana, the latter forms at least being probably identical with the Virginia species.

Occurrence.—Patuxent Formation. Fredericksburg, near Potomac Run; near Telegraph Station (Lorton), Virginia.

Collection.—U. S. National Museum.

Genus TEMPSKYA Corda

[Beitr. z. Fl. der Vorwelt, 1845, p. 81]

This peculiar genus was founded by Corda in 1845, who diagnosed it in the following terms: "Truncus . . . . Rhachis rotundata, plicata vel alata; cortice crassiuscula, fasciculis vasorum ternatis, majori clauso vel lunulata et supra incurvo, minoribus oppositis lunulatis. Radices minutæ numerosissimæ; fasciculo vasorum centrali unico."

[1] Saporta, Fl. Foss. Portugal, 1894, p. 85, pl. xv, fig. 3; pl. xvi, fig. 18.
[2] Schenk, Palæontographica, Bd. xix, 1871, p. 221, pl. xxix, figs. 6, 7.
[3] Seward, Wealden Fl., pt. i, 1894, pp. 127, 128.
[4] Heer, Fl. Foss. Arct., Bd. iii, Ab. ii, 1874, p. 38, pl. xii, figs. 3-11.
[5] Newberry, Amer. Jour. Sci. (iii), vol. xli, 1891, p. 201, pl. xiv, fig. 9.

Four species were recognized thus early, of which the exact occurrences were not certainly known except in the case of *Tempskya Schimperi,* which came from the Wealden of England and Germany and which was described by Stokes and Webb[1] in 1824 as *Endogenites erosa.* This was referred to Sternberg's genus *Protopteris* by Unger[2] in 1845. Similar remains had previously been referred to *Porosus* by Cotta (1832) and also to the genus *Palmacites* of Brongniart by Corda (1845-1846).

Schenk[3] in 1871 with material from the Lower Cretaceous showed that Corda's view which had been based on fragments, that *Tempskya* represented the peripheral part of fern trunks with leaf bases and adventive roots, was not entirely accurate. From his more perfect material he concluded that there were several steles of various sizes, the whole imbedded in parenchyma and probably enclosed in a cortex. According to Schenk the smaller and more numerous steles consist of an axial bundle of scalariform elements surrounded by a sheath of sclerenchyma, while the larger show the fibrovascular elements arranged in a horseshoe-like curve surrounding delicate parenchymatous elements. Subsequently Hosius and von der Marck[4] described a species from the lower Senonian of Westphalia and Velenovsky[5] lumped a large number of occurrences of Wealden, Cenomanian, and Senonian forms under the new name *Tempskya varians.*

Schenk's smaller steles are now known to be adventitious roots of the normal fern type, the central radial bundle being diarc according to Seward but hexarc according to Solms-Laubach. The larger or true steles are also typically filicinean and were compared by Schenk with those of the Marattiaceæ.

[1] Stokes and Webb, Trans. Geol. Soc. Lond., 2d series, vol. i, 1824, p. 423, pl. xlvi, figs. 1, 2; pl. xlvii, figs. 5a, b.

[2] Unger, Synopsis Plantarum Fossilium, 1845, p. 107.

[3] Schenk, Palæontographica, Band xix, 1871, p. 259, pl. xlii, fig. 4; pl. xliii (separate p. 57, pl. xxi, fig. 4; pl. xxii).

[4] Hosius and v. d. Marck, Palæont., Band xxvi, 1880, p. 192, pl. xxxix, figs. 161-163.

[5] Velenovsky, Farne böhm. Kreidef., 1888, p. 23, pl. v, fig. 5; pl. vi, figs. 1-7.

They owe this comparison with the latter to a considerable extent to the presence of adventitious roots as in *Angiopteris* where these roots originate near the top of the stem and grow downward through the cortical tissue. Again in the late Paleozoic *Psaronius* stems there are a mass of closely packed roots separated from the true vascular region by a zone of sclerenchyma, the whole enclosed in a true cortex. In the latter some of the steles are cauline and some are common while in *Tempskya* they are apparently all common, and *Tempskya* differs from all other known forms in the singular interlacing course of the steles. Their course has, however, not as yet been made out with certainty.

The Potomac material while abundant is poorly preserved and is interesting chiefly as the first record of this singular type of fern from North America.

Seward[1] discussed the genus at length in 1894 and followed Feistmantel (1872) and Solms-Laubach (1891) in regarding *Tempskya* as a condition of preservation of fern stems rather than as a precise term for a distinct type. There can be no doubt but that the Maryland forms are a distinct type or that they are not generically different from the Wealden forms. They are not portions of fern stems above the stem apex, as Corda suggests, nor basal parts of stems as Stenzel suggests, neither have they lost their vascular cylinder during fossilization, nor are they rhizomes creeping among the felted roots of a *Protopteris* stem. The Maryland material is abundant and the stems are all nearly circular in cross-section. While the preservation is too poor for histological detail it is good enough to show that there never was a distinct central vascular cylinder, despite the fact that both Feistmantel and Velenovsky consider certain specimens of *Tempskya* as having such a cylinder of the *Protopteris* type. Unfortunately all of the Maryland material, and the European also according to Seward, is porous and imperfectly preserved.

Tempskya is common in Maryland and in the Wealden, and Velenovsky speaks of examining over 100 specimens from the Quader of Bohemia.

[1] Seward, Wealden Fl., pt. i, 1894, pp. 148-159.

Tempskya Whitei sp. nov.

Plates XXXVII, XXXVIII

Description.—Polystelic filicinean stems of large size. The steles numerous and small, anastomosing and giving rise to numerous petiolar strands. Entirely invested with a great mass of branching adventitious roots.

The latter are of various sizes and show a central axial vascular strand surrounded by a decayed zone representing phloem and this in turn surrounded by a sclerenchymatous zone. These roots are poorly preserved and it has been impossible to decide whether they are diarch as Seward has described them for *Tempskya Schimperi* from the English Wealden, or pentarch or hexarch as was asserted by Solms-Laubach. One of the best-preserved roots is shown in the exact center of the microphotograph, reproduced on pl. xxxviii, fig. 1, which shows portions of 2 steles, the lower of which is in the act of forking, while the periphery of a larger stele is shown at the left side above. Pl. xxxvii, fig. 2, shows a transverse section entirely across a small specimen and fig. 1 on the same plate shows a longitudinal section which cuts across several steles.

It has not been possible to secure sections and properly study these singular fossils in time to include the results in the present publication; further characterization and histological description, together with a discussion of their botanical affinity, are reserved for a special contribution. For the purposes of the present work they are included with a query in the order Marattiales, using that term in a broad sense so as to include the Paleozoic Psaronieæ.

As they appear to be specifically distinct from the numerous described European forms they have been named as a slight token of esteem in honor of Mr. David White of the U. S. Geological Survey.

These remains bear a superficial resemblance to palm wood, in fact they were, in the case of the English species, originally referred to *Palmacites* and to *Endogenites,* both properly appellative of fossil palm wood. In the Potomac area fragments of these trunks are often of considerable size, one being 39 cm. in length by 17 cm. in diameter. They are not uncommon and are considered by many as petrified palms, while others look upon them as fragments of bones of huge dinosaurs.

Occurrence.—PATAPSCO FORMATION. Valleys of Stony Run and Deep Run near Severn, Anne Arundel County, Patuxent Neck, Prince George's County, Maryland.

Collections.—Johns Hopkins University, Goucher College.

INCERTAE SEDIS

Genus SCLEROPTERIS Saporta

[Pal. Franc., tome i, 1873, p. 364]

This genus was established by Saporta for the reception of certain forms of supposed ferns of Jurassic age previously referred to *Loxopteris* Pomel, *Sphenopteris* Brongn., *Dichopteris* Zigno, and *Pachypteris* Brongn., but without completely absorbing any of these genera. He characterized it as follows: "Frons rigide coriacea bi-tripinnata, pinnis pinnatipartitis, pinnulis basi plus minusve constrictis in rachin angustissime alatam latere inferiori decurrentibus integris vel antice incisis lobulatisquē; nervatio immersa, sæpius imperspicua, ut manifesta fit, e nervulis paucioribus a basi ramosis latere dorsali pinnularum oblique prodeuntibus constans."

It seems probable that *Scleropteris,* as at present constituted, is a composite genus, certain species of which may be ferns while others, such as those formerly referred to *Pachypteris* Brongn., may well be cycadaceous.[1]

As developed in the Potomac beds it is represented by bi- or tripinnate coriaceous fronds with pinnatifid pinnæ more or less constricted and decurrent at the base, entire or incised on the anterior margin, with a flabellate venation immersed in the leaf substance. The genus is well developed in the middle and the Upper Jurassic, both in this country and Eurasia, and has several Lower Cretaceous representatives. These include, in addition to the following Potomac form, two species from the Lakota formation of eastern Wyoming, and a third from the Neo-

[1] See Krasser, Jahrb. k. k. geol. Reichs., Bd. xlv, 1895, pp. 39-49.

comian of Portugal. Heer described a species from the Kome beds of Greenland in 1874, but afterward transferred it to the genus *Dicksonia.*

SCLEROPTERIS ELLIPTICA Fontaine

Plate XXXIX, Figs. 1, 2

Scleropteris elliptica Fontaine, 1890, Mon. U. S. Geol. Survey, Vol. xv, 1889, p. 151, pl. xxviii, figs. 2, 4, 6; pl. xxix, fig. 1.

Scleropteris elliptica var. *longifolia* Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 152, pl. xxviii, fig. 7.

Scleropteris virginica Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 152, pl. xxviii, figs. 3, 5.

Ctenopteris integrifolia Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 158, pl. lxii, fig. 2; pl. lxv, fig. 3 (non Font., 1906).

Scleropteris elliptica Fontaine, 1906, in Ward, Mon. U. S. Geol. Survey, vol. xlviii, 1905, p. 511.

Scleropteris virginica Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 484.

Description.—Frond bipinnate or tripinnate, probably arborescent. Main rachis stout, its branches rather slender and straight. Pinnæ alternate or subopposite, broadly linear in general outline. Pinnules or segments lanceolate, becoming much reduced distad, directed upward; with an acute apex and a narrowed decurrent base which produces a winged rachis. Usually a single vein enters each pinnule, soon diverging in a flabellate manner into several which are simple or fork once or twice before their termination in the margin. In one specimen there appear to be several veins entering a pinnule, suggesting the forms constituting the genus *Ctenopteris.* The veins are all immersed and difficult to make out with certainty. Texture coriaceous. The pinnules vary greatly in size, reflecting the individual variation in the species and that due to position on a single plant. Thus their dimensions range from 0.5 cm. to 3.4 cm. in length, and from 1 mm. to 4 mm. in greatest width. Where the pinnules are more or less elongated and slender the veins approximate a parallel course.

This species, which is seen to contain three supposed species described by Prof. Fontaine, is not uncommon in the older Potomac, to which it is confined, not occurring in the Arundel formation or outside the Maryland-Virginia area.

Occurrence.—PATUXENT FORMATION. Fredericksburg, near Potomac Run, Dutch Gap, Kankeys, Chinkapin Hollow, near Telegraph Station (Lorton), and Cockpit Point (?), Virginia.

Collection.—U. S. National Museum.

Genus THINNFELDIA Ettingshausen

[Abh. k. k. geol. Reichsanstalt, Band i, Abth. iii, No. 3, 1852, p. 2]

The genus *Thinnfeldia* was proposed by Ettingshausen in 1852 with *Thinnfeldia rhomboidalis* as the type, for remains from the Lias of Steierdorf in Hungary. He characterized the genus in the following terms:

"Rami teretes vel subalati. Folia disticha, alterna oppositave, rhomboidea, ovalia vel lanceolata vel linearia, flabellatim vel pinnatim venosa."

After comparing his species, three in number, with *Odontopteris, Pachypteris, Albertia, Dammara, Ginkgo,* and *Phyllocladus,* Ettingshausen was induced to place *Thinnfeldia* with the conifers, from its resemblance to the existing *Phyllocladus.* In 1867 Schenk, on the basis of material from the Rhætic of Franconia, which showed epidermal and stomatal characters, referred *Thinnfeldia* to the cycads,[1] while Schimper, Saporta, Seward, and others refer it to the Filicales.

Raciborski[2] has furnished good evidence for the belief that some at least of the material from the European Jurassic is filicinean, as seems also to be the nature of the Potomac material, while the writer has shown[3] that the later American species which have been referred to this genus are in all probability gymnospermous.

Various authors have called attention to the difficulty of distinguishing *Thinnfeldia* from such genera as *Pachypteris* Brongniart *Dichopteris* Zigno, *Cycadopteris* Zigno, *Lomatopteris* Schimper, and while the con-

[1] Schenk, Die fossile Flora der Grenzschichten der Keupers und Lias Frankens, 1867, p. 105, pl. xxvii.

[2] Raciborski, Fl. Kopalna ogn. Glinek Krakowskich, 1894, see pl. xx, figs. 1, 2.

[3] Berry, Bull. Torrey Club, vol. xxx, 1903, pp. 438-445.

sensus of opinion considers these forms as ferns, such a reference, although probable, cannot be said to be founded upon well-authenticated evidence, in fact Kerner in a recent discussion considers them cycadaceous,[1] and Seward [2] makes the unwarranted suggestion of pteridospermic affinities.

Thinnfeldia may be defined as follows: Frond pinnate, bipinnate, or tripinnate. Pinnules varying much in size and shape, mostly oblong, ovate-lanceolate, or oblong-obovate, decurrent and mostly confluent at base, coriaceous. Rachis broad and occasionally forked dichotomously. Midvein of the pinnules dissolved before attaining the apex into many simple or dichotomous laterals, which go off at a very acute angle, diverging in ascending, usually several times dichotomous. Fruiting forms unknown.

The genus may be represented in the late Paleozoic, certainly there are Paleozoic forms which resemble it very closely. It is, however, especially characteristic of the older Mesozoic. The Potomac species are four in number, and are for the most part poorly defined fragments of rare occurrence, *Thinnfeldia Fontainei* Berry being of most frequent occurrence as well as the best preserved form.

Thinnfeldia Fontainei Berry

Plate XL, Figs. 4-7

Thinnfeldia variabilis Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 110, pl. xvii, figs. 3-7; pl. xviii, figs. 1-5 (non fig. 6 or Velenovsky, 1885. Fig. 6 is a *Cladophlebis* fragment of undeterminable specific affinity).

Thinnfeldia Fontainei Berry, 1903, Bull. Torrey Bot. Club, vol. xxx, p. 443

Thinnfeldia variabilis Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 502, 528, pl. cx, figs. 7, 8 (non Fontaine 1894, 1896, which are referred to *Cladophlebis virginiensis*).

Description.—" Frond bipinnate or tripinnate; rachises of the pinnæ stout, arborescent; pinnules lobed or toothed, with mostly ovate-obtuse lobes or teeth, short, varying much in size and nature according to posi-

[1] Kerner, Jahrb. k. k. geol. Reichs., Band xlv, 1896, p. 39.
[2] Seward, Fossil Plants, vol. ii, 1910, p. 538.

tion on the frond, passing in ascending, in the upper part of the pinnæ, through toothed and undulate pinnules into entire ones; lower pinnules attached by the rachis alone, and deeply cut into broadly ovate-obtuse lobes; up higher in the pinnæ, and on the frond they have ovate teeth and are attached by the middle of the much-narrowed base, and are slightly decurrent; towards the top the ultimate pinnæ pass into crenately lobed segments, and these into lobed and toothed pinnules, like those lower down; all are acute; leaf-substance thick and leathery; mid-nerve neuropteris-like, and vanishing before attaining the apex of the pinnules; lateral nerves occur in the lower portions of the pinnules mostly in nerve groups; all go off very obliquely and fork usually several times, very fine and closely placed, but distinct."—Fontaine, 1890.

This species is the only one of this genus in the Potomac flora which is reasonably well characterized. It has been recorded from the Patuxent formation near Potomac Run, Virginia, and from the Shasta beds of California, but in both cases the identifications were erroneous, and it appears to be confined to the Patapsco horizon where it is not common. It resembles considerably in its general facies the older Mesozoic species of *Thinnfeldia* from Europe.

Occurrence.—Patapsco Formation. Near Brooke (common), White House Bluff (rare), Virginia; Ft. Foote (rare), Maryland.

Collection.—U. S. National Museum.

Thinnfeldia granulata Fontaine

Plate XL, Figs. 1, 2

Thinnfeldia granulata Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 111, pl. xxvi, figs. 10-12; pl. xxvii, figs. 1-5, 8; pl. clxix, fig. 1.

Acaciæphyllum longifolium Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 279, pl. cxxxvii, fig. 6; pl. cxxxviii, figs. 1-3.

Acaciæphyllum spatulatum Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 280, pl. cxxxviii, figs. 4, 6-9.

Acaciæphyllum microphyllum Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 280, pl. cxxxviii, fig. 5.

(?) Acaciæphyllum variabile Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 281, pl. clxx, fig. 7.

Celastrophyllum proteoides Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 304, pl. cxlvi, fig. 5.

Acaciæphyllum microphyllum Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 486.

Description.—" Frond bipinnate or tripinnate; rachises comparatively stout; leaf-substance thick; pinnules varying in size and shape with their position on the pinnæ and frond; in shape they are ovate-elliptical to subrhombic, the lower ones irregularly cut into oblong to elliptical lobes; the lower surface of the pinnules has a very fine granulation between the nerves, which can be seen distinctly only by the help of a lens; nerves closely placed, very fine but distinct on the under surface of the pinnules, repeatedly branching and diverging flabellately."—Fontaine, 1890.

This species is rare at all the localities where it has been collected and is very poorly preserved. It includes the forms from the older Potomac which Professor Fontaine considered of a dicotyledonous nature under the name of *Acaciæphyllum,* but which are obviously identical with the type material of this species. A comparison of this author's pl. cxxxviii, fig. 5, of *Acaciæphyllum* with pl. clxix, fig. 1, of *Thinnfeldia,* will clearly show this. The present writer has carefully compared all of the available material, and there is not the slightest doubt but that the forms included in the foregoing synonymy are all fragments of the same species. The two specimens from the later Potomac at Federal Hill are retained and included with the earlier forms of *Acaciæphyllum* referred to this species, although they probably represent one of the *Celastrophyllum* species so common at this locality. Their preservation is such that nothing definite can be made out, and they are, therefore, queried as being doubtfully determined. Forms from the Neocomian of Japan which resemble the present species in a general way are described by Professor Yokoyama as *Glossozamites parvifolius* and *Adiantites lanceus,* and similar forms have been frequently referred to *Adiantites.*

Occurrence.—PATUXENT FORMATION. Dutch Gap, near Dutch Gap, near Potomac Run, Telegraph Station (Lorton), Virginia. PATAPSCO FORMATION. Federal Hill (?) (Baltimore), Maryland.

Collection.—U. S. National Museum.

Thinnfeldia rotundiloba Fontaine

Plate XL, Fig. 3

Thinnfeldia rotundiloba Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 111, pl. xxvii, figs. 6, 7.

Description.—" Frond bipinnate or tripinnate; principal rachis rather stout; pinnules with thick texture, alternate, broadly ovate in outline, obtuse, cut more or less deeply into subrhombic or broadly elliptical and rounded lobes; nerves numerous, closely placed, slender but distinct, repeatedly branching in the lower lobes, and diverging flabellately; mid-nerve in the terminal lobe dissolving in branches some distance below the summit, and in its lower portion sending off very obliquely nerve bundles or branches which fork one or more times."—Fontaine, 1890.

This fragmentary species is of little specific or other value. It represents a form of rare occurrence and is very probably not specifically distinct from *Thinnfeldia granulata.*

Occurrence.—Patuxent Formation. Fredericksburg, near Potomac Run, Virginia.

Collection.—U. S. National Museum.

Thinnfeldia marylandica Fontaine

Plate XL, Figs. 8, 9

Thinnfeldia marylandica Fontaine, 1906, in Ward, Mon. U. S. Geol. Survey, vol. xlviii, 1905, p. 541, pl. cxiv, figs. 8, 9.

Description.—" At the Arlington localities, and nowhere else, a number of fragments of a fern were found that seems to be a new species. While the portions of the pinnæ of this plant are not very rare, 16 in all, they are so fragmentary that it is difficult to make out its character. On the whole, it agrees best with the genus *Thinnfeldia,* so far as can be determined from the imprints. Still, it is quite possible that better specimens would show that it belongs to some other genus. The most complete specimen, Goucher College, No. 5450, shows no more than a portion of a detached ultimate pinna, or a lobed pinnule. This is represented in fig. 8. Fig. 9 gives two such fragments not so complete as that given in fig. 8. These two, however, are so placed as to indicate that they were once attached to a common rachis, not now preserved. The pinnæ or lobed pinnules partly overlap. The parts that are preserved appear to be the terminal ones of the pinna or pinnules, and they are not sufficiently well preserved to give their dimensions and shape. The nature of the incisions of the lamina, which represent either lobes or pinnules, can be made out and the nervation is remarkably distinct. This specimen is without number or locality label, but the Arlington material is so distinctive that there can be no doubt that it is from that locality.

"The lobes or pinnules are very obliquely incised and are oblong in form, with the free ends obtuse lancet shaped. The incisions visible are not cut down to the midrib, but indicate that lower down on the portions shown they may be so, constituting pinnules. The midnerve or rachis of the pinna is distinct and somewhat flexuous. On each side of this midnerve parent nerves depart at a very small angle to enter the pinnæ or lobes. The parent nerve forks at long intervals, the principal branch of each fork keeping near the middle of the pinna or lobe, while the other branch forks some distance up. These minor nerves are quite remote from one another and sharply defined, though not very strong.

"While this fern cannot be fully made out, it is clearly different from any previously found in the Potomac beds. It is confined to the Arlington localities."—Fontaine, 1906.

Any further discussion of such incomplete remains can serve no useful purpose.

Occurrence.—ARUNDEL FORMATION. Arlington, Maryland.

Collection.—Goucher College.

Order LYCOPODIALES

Family SELAGINELLACEAE

Genus SELAGINELLA Beauvois

[Prodr. Aetheog., 1805, p. 101]

The Paleozoic representatives of the order Lycopodiales (*Lepidodendron, Sigillaria,* etc.), as is well known, were dominant members of that flora with a large number of species and individuals. They were in general of a lofty arborescent habit, with a high structural organization. Mesozoic remains are extremely rare and ill defined, although several Cretaceous species have been described under the generic name *Selaginella.* None, however, come from as low a horizon as does the Maryland specimen.[1] The modern species are small in size and of wide geographical distribution, especially within the tropics, where they are larger and show greater specific differentiation than elsewhere. About five hundred existing species have been described. They are heterosporous and possess a ligule, as do their Paleozoic allies, and like *Lepidocarpon*[2] and *Miadesmia,*[3] among the latter, they are sometimes quasi-seedbearing.[4] The modern forms have doubtless been derived from Paleozoic forms which have always been herbaceous rather than from the complex arborecent types by reduction, one of the few herbaceous Paleozoic plants known, *Miadesmia membranacea,*[5] suggesting what such an ancestral type may have been like.

SELAGINELLA MARYLANDICA Fontaine

Plate XLI, Figs. 1, 2

Selaginella marylandica Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 553, pl. cxv, figs. 9, 10.

Description.—Fragmentary remains of dichotomously branching stems of sympodial habit with two laterally attached rows of minute leaves 1 and 1.5 mm. in length. Leaf substance firm, with a thick midrib. Leaves somewhat falcate, widest near the base, which is slightly cordate. Possibly the leaves were four-ranked, the other rows being obscured or present on the counterpart of the impression which was not collected.

[1] See Halle, Einige krautartige Lycopodiaceen Paläozoischen und Mesozoischen Alters, Arkv. für Botanik, Stockholm, 1907, Band vii, No. 5.
[2] Scott, Ann. of Botany, vol. xiv, 1900, pp. 713-717.
[3] Benson, Rept. Brit. Assn. Adv. Sci., Belfast, 1902, p. 808.
[4] Lyon, Bot. Gaz., vol. xxxii, 1901, p. 170.
[5] Bertrand, Ass. fr. Ad. Sc., 23e sess., Cæn, 1895, ii, p. 588.
Benson, Phil. Trans. Roy. Soc. Lond., vol. 199B, 1908, pp. 409-425, pls. xxxiii-xxxvii.

While the reference of this form to *Selaginella* is not conclusive it is certainly very suggestive of that genus in its superficial appearance, and no better disposition of it has suggested itself. Possibly future collections will fortunately disclose fruiting specimens which will conclusively settle the question. Heer[1] has described a doubtful species from the Cenomanian (Atane beds) of Greenland, and Velenovsky[2] another which is very similar to the Maryland form from the Perucer schichten of Bohemia.

Occurrence.—PATAPSCO FORMATION. Vinegar Hill, Maryland.

Collection.—Johns Hopkins University.

Order EQUISETALES

Family EQUISETACEAE

Genus EQUISETUM Linné

[Sp. Pl., 1753, p. 106]

Perennial rush-like plants with jointed stems, which are generally ridged and grooved, the ridges alternating at the joints. Much branched in the Potomac forms, the recent species often simple. Root stocks subterranean, often tuber-bearing. Leaves reduced to sheaths at the joints, the sheaths toothed. Spores (as far as known) all of one size and shape (isosporous). Sporangia borne on modified sporophylls (sporangiophores) which are aggregated to form a definite cone (strobilus).

These plants, which in the allied order Calamariales forms so dominant and imposing a group in the Paleozoic is almost entirely represented in Cretaceous formations by forms referable to the family Equisetaceæ. A number of Carboniferous species of small size, which are based upon impressions of cones or stems with leaf sheaths like those of the modern forms, have been referred to the genus *Equisetum* (or

[1] *Selaginella arctica* Heer, Fl. Foss. Arct., Band vi, Ab. ii, 1882, p. 39, pl. xiii, fig. 5.

[2] *Selaginella dichotoma* Velen., Farne böhm. Kreidef., 1888, p. 29, pl. ii, figs. 8-11.

Equisetites). Their internal structure is unknown, and as some of the Calamariaceæ had leaves united in sheaths the remains of foliage from the older rocks is not unequivocal. The cone impressions, however, are not so easily disposed of, and it seems quite possible that the later species form a continuous line of descent from some similar herbaceous Paleozoic stock which was plastic enough to adapt itself to varying subsequent conditions.

With the opening of the Mesozoic age forms clearly allied to the recent genus are common fossils. These are largely stem or pith casts (detached diaphragms and tubers are also fossilized) and are often of large size, i. e., from 12 to 15 cm. in diameter and 8 to 10 m. tall, quite as tall as the largest living species and not nearly so slender. It seems quite possible that some of these Triassic and Jurassic forms may have increased in diameter by the formation of secondary wood, as did so many of their Paleozoic allies.

The later Mesozoic species of *Equisetum* are much smaller than their Triassic and Jurassic ancestors, and are scarcely distinguishable from existing forms. These latter, commonly known as "horse tail," "mare's tail," or "scouring rushes," form a compact group of from twenty-five to thirty rather monotonously uniform species, growing usually in low and wet habitats and present on all the continents except Australia, although they are found as fossils in that region. They are present in tropical and arctic as well as in the temperate zones, and the majority are of small size, although one species, *Equisetum giganteum* Linné, which ranges from Cuba to Chile, is said to attain a height of about 8 m., but remains very slender and not over 2 or 3 cm. in diameter.

The Potomac forms are not important elements in the flora, although they are present in considerable abundance at some localities, nor are they at all well preserved. There are no apparent grounds for maintaining them as distinct from the rather widespread European forms of this age, and they are therefore identified with the latter, whose geographical ranges are quite comparable to that of such ubiquitous existing forms as *Equisetum arvense* Linné.

EQUISETUM BURCHARDTI (Dunker) Brongniart

Plate XLI, Figs. 3-6

Equisetites Burchardti Dunker, 1846, Monog. norddeutsch. Wealdenbild., p. 2, pl. v, fig. 7.
Carpolithus cordatus Dunker, 1846, *loc. cit.*, p. 22, pl. ii, figs. 7, 10.
Carpolithus Huttoni Dunker, 1846, *loc. cit.*, p. 22, pl. ii, fig. 8.
Carpolithus Lindleyanus Dunker, 1846, *loc. cit.*, p. 22, pl. ii, fig. 7.
Equisetum Burchardti Brongniart, 1849, Tableau, p. 107.
Equisetites Burchardti Unger, 1850, Gen. et Sp., p. 59.
Equisetites Burchardti Ettings., 1851, Haidinger Abh., vol. iv, Abth. 1, p. 65.
Equisetites Burchardti Ettings., 1852, Abh. k. geol. Reichs., Band i, Abth. iii, 1852, p. 10, pl. i, figs. 3, 4.
Equisetum Burchardti Schimper, 1869, Traité Pal. Végét, tome, i, p. 264; tome iii, 1874, p. 453.
Cycadinocarpus ? cordatus Schimper, 1870, Traité Pal. Végét., tome ii, p. 211.
Cycadinocarpus ? Huttoni Schimper, 1870, *loc. cit.*, p. 210.
Cycadinocarpus Lindleyanus Schimper, 1870, *loc. cit.*, p. 210.
Equisetum Burchardti Schenk, 1871, Palæont., Band xix, p. 205 (3), pl. xxii (i), figs. 1-5.
Equisetites Burchardti Renault, 1882, Cours bot. foss., tome ii, p. 151.
Equisetites Burchardti Saporta, 1890, Compt. Rend., tome cxi, p. 250.
Equisetum virginicum Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 63, pl. i, figs. 1-6, 8; pl. ii, figs. 1-3, 6, 7, 9.
Equisetum marylandicum Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 65, pl. ii, fig. 10.
Rhizome of Equisetum sp. ? Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 66, pl. clxx, fig. 8.
Equisetites Burchardti, Seward, 1894, Wealden Fl., pt. i, p. 27, pl. i, figs. 5, 6.
Equisetum Burchardti Saporta, 1897, Fl. Foss. Port., p. 66, pl. xv, fig. 7.
Equisetum virginicum Fontaine, 1899, in Ward, 19th Ann. Rept. U. S. Geol. Surv., pt. ii, p. 650 pl. clx, fig. 1.
Equisetum virginicum Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 483, 486, 519.
Equisetum marylandicum Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 517, 557, pl. cix, fig. 10.

Description.—"Equisetites caule tenni multiarticulato striato, striis subacutis, viii-x, æque distantibus, vaginis tumidis lanceolato-dentatis."—Dunker, 1846.

Stems branching freely, the branches slender or approaching the stems in size, ranging from 1.5 mm. to 8 mm. in diameter. Internodes .8 cm. to 2.2 cm. in length. Sheaths slightly swollen, 2 mm. to 10 mm.

in length, with ovate or lanceolate teeth with short, acute tips which may be somewhat obtuse in some specimens. Tubers abundant, two or more in number at the nodes, in shape oval, somewhat constricted at points of attachment, as preserved about 7 mm. by 8 mm. in diameter.

The preservation of all of the Potomac specimens is poor, and the great majority are partially or wholly decorticated and otherwise much maccrated, indicating prolonged submergence before fossilization. In neither of the specific forms established by Fontaine are there any constant characters which serve to distinglish them from the widespread *Equisetum Burchardti* of Europe, with which they are here identified. This species was described by Dunker from the Wealden of Hanover, along with its tubers in various stages of preservation. These he failed to recognize as such, describing them as various species of *Carpolithus*. Schenk in 1871 gave a much better diagnosis of this species and also pointed out the true nature of Dunker's various species of *Carpolithus*.

The species is common in the Wealden of England and has been recorded from the Barremian of Austria, the Valanginian or Lower Neocomian of Portugal, and the Lakota formation in the Hay Creek coal field of Wyoming. *Equisetum ushimarense* Yokoyama[1] from Japan is a closely allied if not identical form.

Occurrence.—PATUXENT FORMATION. Terra Cotta (obscure rhizome) and New Reservoir (common), District of Columbia; Dutch Gap, Cockpit Point, Telegraph Station (Lorton), Virginia. PATAPSCO FORMATION. Federal Hill (Baltimore), Maryland.

Collection.—U. S. National Museum.

EQUISETUM LYELLI Mantell

Plate XLI, Figs, 7, 8

Equisetum Lyelli Mantell, 1833, Geol. S. E. England, p. 217, fig. 52, 1-3 on p. 245.
Equisetites Lyelli Bronn, 1848, Index Pal., p. 464.
Equisetum Lyelli Brongniart, 1849, Tableau, p. 107.
Equisetum Lyelli Göppert, 1849, in Bronn, Geschichte der Natur, Band iii, p. 13.
Equisetites Lyelli Unger, 1850, Gen. et Sp., p. 60.
Equisetites Lyelli Morris, 1854, Brit. Foss., p. 8.

[1] Journ. Imp. Univ. Tokyo, vol. iii, 1890, p. 39, pl. xi, figs. 1-3.

Equisetum Lyelli Schimper, 1869, Traité Pal. Végét., tome i, p. 265; tome, iii, 1874, p. 453.
Equisetum Lyelli Schenk, 1871, Palæont., Band xix, 1871, p. 5 (207), pl. i, figs. 10-13.
Equisetites Lyelli Renault, 1882, Cours bot. foss., tome ii, p. 150.
Equisetum Lyelli Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 65, pl. i, fig. 7; pl. ii, figs. 4, 5.
Rhizome of Equisetum sp. ? Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 65, pl. ii, fig. 8.
Equisetum Lyelli Dawson, 1892, Trans. Roy. Soc. Can., vol. x, sec. iv, p. 83, fig. 1.
Equisetites Lyelli Seward, 1894, Wealden Fl., pt. i, p. 24, pl. i, fig. 4.
Equisetum Lyelli Fontaine, 1898, in Weed and Pirsson, 18th Ann. Rept. U. S. Geol. Surv., pt. iii, p. 481.
Equisetum Lyelli Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 301, 417, 514, pl. lxxii, figs. 12-14.
Equisetites Lyelli Neumann, 1907, Neues Jahrb. Beilage, Band xxiv, p. 77, pl. i, fig. 2.

Description.—" Caulis epigæus cylindricus articulatus ramosus, internodia 2 centim. longa, 10-13 millim. in diametro, rami 5 millim. in diametro, folia sterilia vaginata, vaginæ 1 centim. longæ, dentes lineares acuminati persistentes."—Schenk, 1871.

A somewhat larger species than the preceding, with stems .6 cm. to 1.5 cm. in diameter. Internodes 2 cm. to 2.5 cm. in length. Single branches are of frequent occurrence at the nodes in the foreign material, and it is probable that the smaller Potomac specimens represent detached branches. The sheaths are about a centimetre in length, with numerous linear acuminate teeth. Internodes finely striated.

The American remains are usually fragments of stems, and like those of the preceding species are generally very poorly preserved. Described originally from the Wealden of Pounceford, England, this species has been recognized at Fredericksburg, Dutch Gap, and Chinkapin Hollow (?) by Fontaine. Dawson found it in the Kootanie of Canada and Fontaine reports it from the same formation at Geyser, Montana. It has also been recorded recently from the Neocomian of Peru.[1]

Occurrence.—PATUXENT FORMATION. Springfield (?), Maryland; Fredericksburg, Chinkapin Hollow (?), Dutch Gap, Virginia.

Collection.—U. S. National Museum.

[1] Neumann, *loc. cit.*

Phylum SPERMATOPHYTA

Class CYCADOPHYTAE

Order BENNETTITALES

Family CYCADEOIDEACEAE

Genus CYCADEOIDEA Buckland

[Proc. Geol. Soc. Lond., vol. i, No. 8, 1827, pp. 80, 81]

Trunks usually low and more or less conical or ovoid in shape; generally simple; covered with a thick armor formed by the appendicular and reproductive organs, the former consisting of the persistent bases of the leaf-stalks surrounded by a dense mat of ramentum; trunk crowned with a large terminal vegetative bud often poorly preserved or obliterated by decay before fossilization; ramentum made up of very fern-like, multicellular hairs or scales, and extensively developed. Its resistant nature led to its ready petrifaction so that normally the fossil trunks show the ramental areas as prominent partitions separating the subrhombic angular cavities left by the leaf-stalks which decayed or were shed before fossilization. These leaf-scars are arranged in a more or less exact quincunx order, and usually in two sets of spirals, one dextral and the other sinistral, the one generally more emphasized than the other.

The generic separation and nomenclature of the fossil cycad trunks (so called) based on their external form and surface features is one beset with many difficulties, and a great variety of names have been proposed for their reception.[1] Following Professor Ward, the Maryland forms are all referréd to Buckland's genus *Cycadeoidea,* which has priority among the names proposed for tuberous armored types of cycad

[1] Such as *Clathraria* Schimper 1872, *Yatesia* Carruthers 1870, *Fittonia* Carr. 1870, *Platylepis* Sap. 1875, *Bucklandia* Presl 1825, *Mantellia* Brongn. 1828, *Tysonia* Font. 1889, *Bolbopodium* Sap. 1875, *Cylindropodium* Sap. 1875, *Palatylepis* Sap. 1875, *Clathropodium* Sap. 1875, *Cycadeomyelon* Sap. 1875, *Raumeria* Carr. 1870, *Williamsonia* Carr. 1870, *Crossozamia* Carr. 1870, etc., many of course being synonyms.

trunks. An alternative course largely followed abroad would be to consider them referable to the genus *Bennettites* of Carruthers. This is the view advocated by Seward[1] and adopted by Potonié in Engler and Prantls' *Naturlichen Pflanzenfamilien.*

Solms-Laubach[2] has already referred many of the species of *Bennettites* to *Cycadeoidea* restricting the former name to specimens showing lateral axillary fructifications. Seward[3] would use *Cycadeoidea* in a somewhat different sense, for all cycadean trunks, whether short and thick or tall and slender, which are covered with persistent leaf-bases,

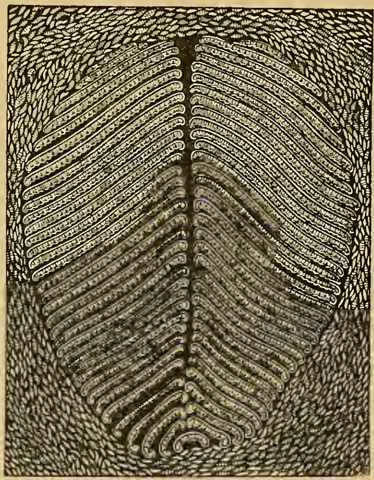

FIG. 5.—Transverse section of a partly emergent but still folded frond of Cycadeoidea ingens deeply embedded in ramentum, × 4 (after Wieland).

and which show no trace of lateral reproductive shoots such as characterize *Bennettites gibsonianus* Carruthers and allied forms, and which there is no reason for including in the family Cycadaceæ. It has been shown by Wieland[4] that fruition was the culminant event in the life of most, if not all, the trunks which he investigated, fruits not being produced

[1] Seward, Jurassic Flora, 1904, pt. ii, p. 44.
[2] Capellini and Solms-Laubach, 1891, Mém. R. Accad. Sci. Inst. Bologna (5), vol. ii, p. 161.
[3] Seward, *loc cit.*
[4] Wieland, American Fossil Cycads, 1906.

until vegetative maturity. It would follow, if the method just mentioned were pursued, that a *Bennettites* which was not mature enough to show indications of flowering would be a *Cycadeoidea,* or an accident of preservation might equally determine the question, an altogether undesirable state of affairs.[1]

It is very doubtful if specific determinations based upon external form and surface features have any real value aside from their practical utility, and it seems quite probable, as various writers have pointed out,

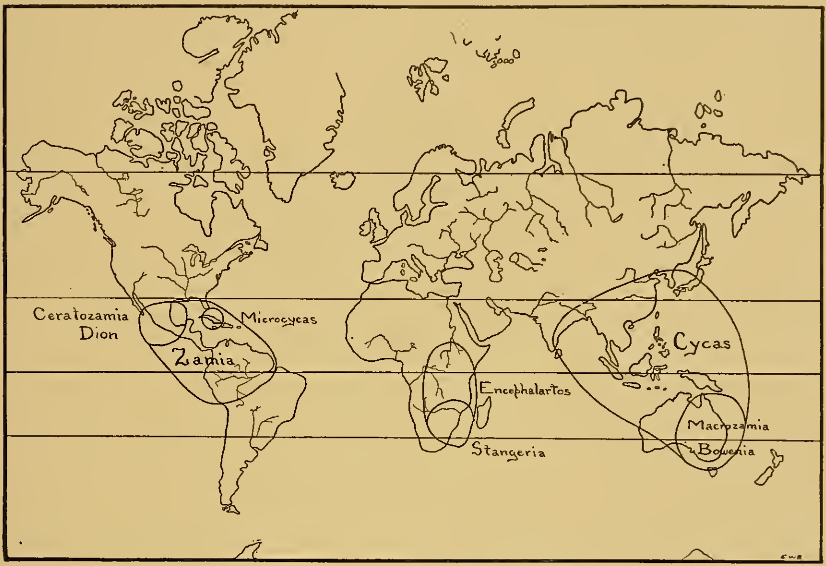

Fig. 6.—Sketch map of the world showing the approximate distribution of the existing cycads.

and as is fully admitted by Prof. Ward, that his determinations based on megascopic characters cannot be looked upon as having real specific value, but simply as the most expedient method of handling the immense amount of material which passed through his hands, the specific names affording convenient pegs on which to hang the morphological and structural details which will result from a study of their histological features. Nine species have been recognized by Prof. Ward in the

[1] See Wieland, Amer. Journ. Sci., vol. xxv, 1908, p. 97.

Maryland area, and these are here retained unaltered, although it is very probable, as already stated, that this is too large a number.

In view of the constantly increasing evidence of the abundance and extent of variation in the cycad-like plants during the Mesozoic, it has seemed proper to adopt the suggestion of Professor Nathorst[1] and consider them as representing a distinct class, the Cycadophytæ. Concerning their segregation within the class we know as yet too little to establish natural lines of cleavage. The genus *Cycadeoidea* is here retained in the larger group denominated the Bennettitales in contradistinction to the Cycadales, which term is reserved for forms resembling the modern types, as a matter of convenience and not as representing an altogether natural grouping.

The most interesting features of the Mesozoic cycadophytes are their fructifications and fruiting habits, for a knowledge of which we are indebted to Carruthers,[2] Solms-Laubach,[3] Lignier,[4] Nathorst,[5] and Wieland.[6] Among all of the five score or more species of existing cycads the distribution of which is shown on the accompanying sketch map (fig. 6) the fructifications are of a simple and rather uniform type. The staminate or pollen-producing organs have the form of a cone, the pollen sacs being attached in groups to the lower surfaces of the cone scales (sporophylls). In all but one of the nine existing genera into which these species are grouped the ovulate or seed-bearing fructification is also a cone, each scale (sporophyll) of which bears two seeds. In the genus *Cycas*, however, a far more primitive condition exists, the ovules being borne along the edges of carpellary leaves (sporophylls) which spring from the main axis exactly as do the foliage leaves, which they greatly resemble. This is by far the most archaic and fern-like method known among modern

[1] Nathorst, Beitr. z. Kennt. einiger Mesozoischen Cycadophyten, Kgl. Svenska Vetens.-Akad. Handl., Band xxxvi, No. 4, 1902.

[2] Carruthers, Trans. Linn. Soc. Lond., 1870, vol. xxvi, pp. 675-708, pl. liv-lxiii.

[3] Solms-Laubach, Ann. of Botany, 1891, vol. v, pp. 419-454, pls. xxv, xxvi.

[4] Lignier, Végét. Foss. de Normandie, Cæn, 1894.

[5] Nathorst, Kgl. Svenska Vetens-Akad. Handl., Band xlv, No. 4, 1909, *Ibid.*, Band xlvi, No. 4, 1911.

[6] Wieland, *loc. cit.*

seed plants, and the cycads still further emphasize this resemblance to ferns in their mode of fertilization, i. e., by means of ciliated motile sperms.

When we come to consider the method and organs of fructification of the Mesozoic Bennettitales (so called), instead of finding them of a simpler type, as we might expect, we find a much greater complexity, while on the other hand the vegetative structures are simpler than is the case in the existing cycads. The fructifications in the former as exemplified in the genus *Cycadeoidea* are long axillary bodies inserted

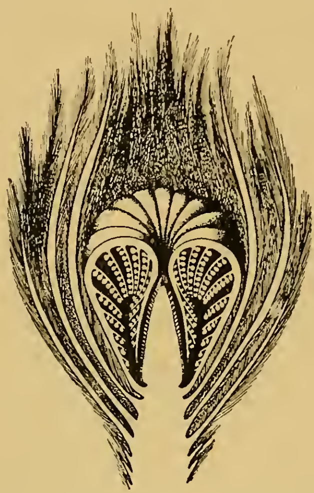

Fig. 7.—Restoration of an unexpanded bisporangiate strobilus with some of bracts removed, about one-half natural size. (After Wieland.)

in large numbers among the crowded leaf bases (see *Cycadeoidea marylandica*). About half their length is taken up by the peduncle or stalk on which spirally arranged bracts are borne, and these completely invest the essential organs (see fig. 7). Distad, this peduncle expands into a receptacle from the rim of which springs a whorl of staminate, compound, fern-like sporophylls on which the pollen is produced, not in simple anthers, but in compound pollen-sacs comparable with the synangia of the marattiaceous ferns. These Cycadeoidea "stamens" in their habit suggest a comparison with the ovulate fructification named by Renault

Cycadospadix milleryensis from the Permian of Autun, France.[1] The seed-bearing sporophylls of Renault's interpretation would then be morphologically the fertile leaflets of a single compound sporophyll. Within the whorl of "stamens" of the Cycadeoidea "flower," which were wilted or shed quite early, an ovoid or conical, ovulate cone was borne. The orthotropous ovules were situated at the ends of long slender pedicels, and the interstices were packed with sterile appendages (interseminal scales) which, with their expanded tips formed a protective envelope for the developing seeds, suggesting an angiospermous pericarp

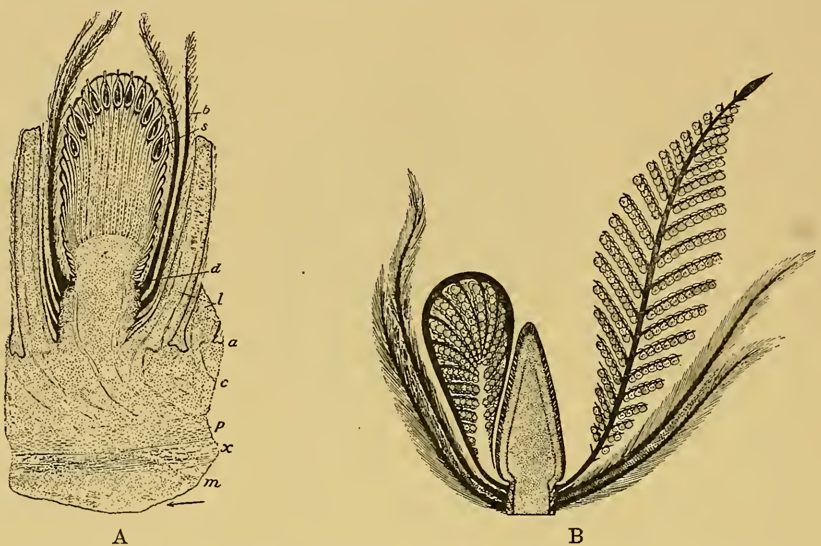

FIG. 8.—A. Radial longitudinal section of an ovulate strobilus of Cycadeoidea, somewhat reduced. (After Wieland.)
B. Semi-diagrammatic longitudinal section of a bisporangiate strobilus of Cycadeoidea, about one-fourth natural size. (After Wieland.)

as shown in fig. 8 in actual section at A, and semi-diagrammatically at B.

The gigantic "stamens," if they may be called stamens, which is a term of very doubtful propriety, have not been found unfolded, but as the American material is immature Wieland rightly supposes that they eventually opened out as shown in part in fig. 8, B.

[1] Renault, Bassin Houill, d'Autun, 1896, fasc. 4, pt. 2, p. 329, pl. 73, figs. 1-7.

Since these fructifications are obviously reduced lateral branches, the bracts at least, if not the staminate and ovulate appendages as well, representing leaves, it follows that the ancestral cycadophytes were more or less slender, unarmed, branching forms somewhat similar to the Triassic *Anomozamites* so admirably restored by Nathorst,[1] possibly with terminal instead of axillary fructifications, a not very essential difference, if, indeed, the fructifications are axillary in *Anomozamites.*

Detached and more or less imperfect cycadean fructifications of the same general character as those we have just been considering, and preserved as impressions, are common fossils in Mesozoic deposits the world over, and are usually referred to the genus *Williamsonia.* Although their true affinity was long ago suggested by the late Prof. Williamson,[2]

a b

FIG. 9.—Two views of the type of Williamsonia virginiensis, one-half natural size. (After Fontaine.)

their real nature has been the occasion of a great deal of argument. Williamsonias have been described by Ward[3] from the Maryland Potomac, but the specimens appear to be nothing but poorly preserved and distorted cone fragments of the coniferous genus *Abietites,* so that a figure of a true *Williamsonia* from the Virginia Potomac is introduced for comparison with Wieland's restorations. In habit the Williamsonias were probably borne on much longer peduncles, so that in those forms where they were axillary they projected considerably beyond the armor,

[1] Nathorst, *loc. cit.*, p. 13.
[2] Williamson, Trans. Geol. Soc. Lond., 1837, ser. 2, vol. v, pp. 223-242.
[3] Ward, Mon. U. S. Geol. Surv., No. xlviii, 1906, p. 554, pl. cxv, fig. 11.

others, like *Williamsonia gigas*, are known, in which the fructification appears to be terminal.

The discovery of the bi-sporangiate nature of *Cycadeoidea* inaugurated a renewed interest in the cycadophytes. Professor Nathorst has recently described Williamsonias which were unisexual,[1] and Wieland, Arber and Parkin, and others,[2] have advanced the theory that these Lower Cretaceous forms were not very different from the ancestors of the higher plants (Angiospermæ) represented in the existing flora by the order Ranales, entirely overlooking the wide difference in structure throughout the vegetative body, where the characters are much more conservative and furnish a much safer clue to filiation than do the reproductive parts, especially when of the indicated plasticity of those of the cycadophytes.

We may now proceed to the enumeration of species, brief descriptions of which are adapted from Prof. Ward's more voluminous treatment (*loc. cit.*).

CYCADEOIDEA MARYLANDICA (Fontaine) Capellini and Solms-Laubach

Plate XLII

Cycas sp., Tyson, 1860, First Report State Agric. Chem., Maryland, p. 42.

Bennettites sp., Carruthers, 1870, Trans. Linn. Soc., London, vol. xxvi, p. 708.

Cycadeoidea sp., Fontaine, 1879, Am. Journ. Sci., 3d ser., vol. xvii, p. 157.

Tysonia Marylandica Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 193, pl. clxxiv-clxxx.

Cycadeoidea Maryländica Capellini and Solms, 1892, Mém. Real. Accad. Sci. Inst., Bologna, ser. v, vol. ii, pp. 179, 180, 186.

Cycadeoidea Marylandica Ward, 1897, Proc. Biol. Soc., Washington, vol. xi, p. 9.

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[1] Nathorst, A. G., Ueber Williamsonia, Wielandia, Cycadocephalus und Weltrichia, Kgl. Svenska Vetens.-Akad. Handl., Band xlv, No. 4, 1909.

[2] Arber, E. A. N., and Parkin, J., On the Origin of Angiosperms, Journ. Linn. Soc. Lond., vol. xxxviii, 1907; The Relationship of the Angiosperms to the Gnetales, Annals of Botany, vol. xxii, 1908, pp. 489-515.

Scott, D. H., The Flowering Plants of the Mesozoic Age, in the Light of Recent Discoveries, Journ. Roy. Micr. Soc., 1907, pp. 129-141.

Wieland, G. R., The Williamsonias of the Mixteca Alta, Bot. Gazette, vol. xlviii, 1909, pp. 427-441.

Cycadeoidea Marylandica, Ward, 1906, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 416, pls. lxxxi, lxxxii, lxxxiii, figs. 1, 2, 4; pl. lxxxiv, figs. 1, 2; pl. lxxxvii, figs. ii, 3, 5, 6, 7; iii, 1, 4; iv, 4, 5, 12-14; v, 2, 3, 5-7, 17; pl. lxxxviii, pl. lxxxix, figs. ii, 3, 4, 7; iii, 2, 5, 8; 90, 91, 92.

Cycadeoidea Marylandica Wieland, 1906, American Fossil Cycads, fig. 1.

Description.—Trunks of medium or rather large size, almost always more or less laterally compressed so as to be elliptical in cross-section, conical in shape or slightly narrowed near the base, with a terminal bud set in a slight depression at the summit, simple, or in one specimen, apparently having one branch; mineral constitution very variable according to mode of preservation, but usually not hard, flinty, nor heavy and compact; 25 to 45 cm. high, 24 to 40 cm. in longer, and 12 to 26 cm. in shorter diameter, with a girth of from 70 cm. to 1 m.; organs constituting the armor proceeding at a right angle to the axis except above, where they are ascending, and near the base, where they are sometimes slightly descending; leaf scars arranged in two series of spiral rows crossing each other usually at a different angle to the axis of the trunk, the angle varying from 30° to 75°; scars usually subrhombic, i. e., with the lateral angles nearly equal and the vertical ones unequal, the lower more acute than the upper, the latter often reduced to a mere groove, or wanting entirely, and the two upper sides together forming an arch, or an irregular horizontal line; 15 to 25 mm. in breadth by 6 to 15 mm. in height; remains of the petioles usually present in the scars at different distances from the summit, often bearing evidence of having been disarticulated at a natural joint, sometimes indicating the existence of two such joints at different depths in the scars; vascular bundles rarely visible under an ordinary lens, but occasionally seen in the form of a row near the outer margin all round the leaf base with a few near the centre; ramentum walls usually with a more or less distinct line marking the junction of the parts belonging to adjacent petioles, sometimes with a distinct layer of less compact tissue between these, occasionally, but rarely, affected with pits or small bract scars, especially in the angles; reproductive organs usually abundant, often solid and protuding, generally more or less distinctly marked in the centre by the remains of the essential organs and surrounded by bract scars in several concentric rows, but often decayed in various degrees, leaving corresponding funnel-shaped cavities, commonly elliptical in cross-section, wider than high, very variable in size, the major axis 15 to 40 mm. and the minor 10 to 30 mm.; armor thin, 2 to 5 cm., usually joined to the internal parts by a clear line, but without measurable thickness, but sometimes very irregularly so joined, and occasionally showing a thin libro-cambium layer; woody zone 3 to 10 cm. thick, usually with two or three more or less distinct rings, the outer or parenchymatous zone thicker and firmer than the inner or fibrovascular zone; medulla usually homogeneous in structure, elliptical, the major axis 8 to 17 cm., the minor 3 to 9 cm.

This is historically the most important species of Maryland Potomac cycads, most of the original types found by Tyson belonging to it. It is also the most abundant species, and was the first species of cycad trunk from America to receive scientific mention. The plate is from an original daguerrotype sent to Sir Wm. Dawson, and by him to Carruthers, who mentioned it in a note to his paper On the Cycads from the Secondary Rocks of Great Britain (*loc. cit.*)

This was discovered by Tyson (*loc. cit.*) about 1860 between Baltimore and Washington, who collected in all perhaps 10 or 12 of these trunks. These excited much interest at the time, but did not receive scientific description for over 20 years, although Tyson sent pictures of them to various geologists, both in this country and abroad, and presented specimens to Professors Dawson and Marsh, and perhaps others.

The exact geological horizon in the Potomac Group has not been established with certainty for any except this one trunk, and for this reason the localities will not be given for the other species, since, as the specimens do not occur *in situ,* the point where they eroded out or were plowed up has little significance, since they have all come from the same circumscribed belt. It is quite possible that they are all of Patuxent age, and may have been reworked in later, even Pleistocene, deposits. The exact age of the trunks is of little biologic significance, since the frond impressions are present throughout the various formations of the Potomac Group, the absence of petrified trunks being due entirely to physical conditions of deposition.

Occurrence.—PATUXENT FORMATION. Link Gulch, near Arbutus, Baltimore County.

Collections.—Johns Hopkins University, Yale University, U. S. National Museum, Maryland Academy of Sciences, Goucher College of Baltimore, McGill University, and South Carolina College.

CYCADEOIDEA TYSONIANA Ward

Plate XLIII

Cycadeoidea Tysoniana Ward, 1897, Proc. Biol. Soc., Washington, vol. xi, p. 11.

Cycadeoidea Tysoniana Ward, 1906, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 432, pl. lxxxvii, figs. 1, 5; v, 4; pl. xciii.

Description.—Trunk medium sized or large, more or less compressed laterally; leaves slightly ascending; leaf scars arranged in spiral rows, 9 mm. high, 22 mm. wide, subrhombic, empty to some depth, petioles persistent at base, the vascular bundles arranged in one row near the exterior and a group near the centre, often persisting after the decay of the remaining substance; ramentum walls thin, often with a layer of spongy substance in the middle, wrinkled on the edges; reproductive organs few and small; armor 5 cm. thick; libro-cambium zone sometimes distinct, 3 mm. thick; woody zone 6 cm. to 8 cm. thick; consisting of a broad, parenchymatous layer 4 to 6 cm. thick, and a narrow inner vascular zone 1 cm. thick, the latter usually between open tissue without and within, its inner wall strongly marked with longitudinal grooves; medulla distinct and homogeneous, light and porous.

This species differs from *Cycadeoidea marylandica* in the larger leaf scars, thinner walls, thicker armor, and the great paucity of reproductive organs, and from *Cycadeoidea McGeeana* in the normal shape of the trunk and its greater size.

CYCADEOIDEA MCGEEANA Ward

Plate XLIV

Cycadeoidea McGeeana Ward, 1897, Proc. Biol. Soc., Washington, vol. xi, p. 12.

Cycadeoidea McGeeana Ward, 1906, Mon. U. S. Geol. Surv., xlviii, 1905, p. 434, pl. lxxxvii, figs. iii, 3, 10; iv, 15; v, 8, 9, 19, 20; pl. lxxxix, figs. ii, 1, 8; iii, 4, 9, 10; pl. xciv.

Description.—Trunks low and flat, with ample diameter, sometimes three times as thick as high, yellowish, brown, or nearly black, more or less porous and spongy, and of low specific gravity; leaves and reproductive branches set nearly at right angles to the axis; leaf scars arranged somewhat definitely in quincunx order and disposed in spiral rows around the trunk, small and uniform in shape, subrhombic with the vertical angles obtuse, the lateral ones acute, narrow-elongate, 6 cm. to 10 cm. in vertical by 16 mm. to 20 mm. in lateral dimensions, averaging 8 mm. by 20 mm., usually empty, by the disappearance of the leaf bases, at least to a considerable depth; ramentum walls thin, often less than 1 mm., with or without evident commissure, and with occasional punctuations; axes of inflorescence few and scattering, sometimes projecting, sometimes cavitous from the decay of the essential organs, surrounded by obtusely triangular or somewhat crescent-shaped bract scars; armor 4 cm. to 5 cm. thick; liber and cambium sometimes distinguishable; woody zone usually divided into two or three rings; medulla large, porous.

A very distinct species of low and squat trunks, some of them having almost the form of a car wheel, only a very small part of which can be due to vertical compression. The external organs, however, closely resemble those of *Cycadeoidea Tysoniana.*

Cycadeoidea Fontaineana Ward

Plate XLV

Cycadeoidea Fontaineana Ward, 1897, Proc. Biol. Soc., Washington, vol. xi, p. 13.

Cycadeoidea Fontaineana Ward, 1906, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 439, pl. lxxxvi; pl. lxxxvii, figs. i, 1; iii, 2, 6, 8; iv, 1, 7, 9; v, 1, 10, 11, 13, 14, 16, 18, 21; pl. lxxxix, figs. i, 1; iii, 1, 3, 6, 7, 11; pl. xcv; pl. xcvi; pl. xcvii; pl. xcviii.

Description.—Trunks small and low, usually much compressed or flattened vertically, light brown to whitish in color, often spongy or porous, and of low specific gravity; leaves and fruiting branches set nearly at right angles to the axis; leaf scars not obviously arranged in spiral rows, variable and irregular in shape, usually with four angles and four curved sides, often in the form of a cross, rarely subrhombic, small, 8 mm. to 12 mm. in vertical and 14 mm. to 25 mm. in lateral measurement, averaging 10 mm. by 19 mm.; ramentum walls thick, 4 mm. to 10 mm., usually without commissure or punctations; leaf bases rarely present; when so, spongy or porous, without visible bundles; terminal bud 6 cm. high, 65 mm. broad at the downwardly convex base, definitely bounded below, symmetrically conical above, consisting of a mass of densely matted bracts imbricated along a central axis; reproductive organs few and imperfectly defined, usually cavitous in the centre and sometimes surrounded by irregular-shaped bract scars; armor rather thin, 2 cm. to 4 cm.; liber and cambium obscure; woody axis divided into several rings, sometimes consisting of a loose, open structure separated by thin, firm plates, the inner face next the medulla definitely marked by the remains of vessels and medullary rays; medulla large, marked on the external surface by thin longitudinal ridges or lamellæ varying from 1 cm. to 3 cm. in length, the ends overlapping adjacent ones (*Cycadeomyelon* Saporta), internal parts coarse and porous or somewhat chambered.

This species resembles *Cycadeoidea McGeeana* in the general form of the trunks, but the external organs are very different, the most striking distinction being the very thick walls.

Cycadeoidea Goucheriana Ward

Plate XLVI

Cycadeoidea Goucheriana Ward, 1897, Proc. Biol. Soc., Washington, vol. xi, p. 14.

Cycadeoidea Goucheriana Ward, 1906, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 451, pl. lxxxvii, fig. i, 3; pl. lxxxix, fig. i, 3; pl. xcix.

Description.—Trunks large, cylindrico-conical with elliptical cross section, 30 cm. to 50 cm. high, 25 cm. to 50 cm. in diameter, light colored and of low specific gravity, somewhat chalky and friable; lower leaves somewhat deflexed, upper ones ascending the line between the two definite and encircling the trunk near the middle; leaf scars arranged in two sets of spiral rows, both having nearly the same angle to the axis, 45° or greater; scars variable in size and shape, chiefly subrhombic to nearly triangular, with curved or fluted sides, inner wall of the tubes marked by a raised line around it; scars averaging 11 mm. in vertical and 23 mm. in lateral measurement; leaf bases usually absent or only adhering to the bottom of the scars; ramentum walls thick, more or less divided into irregular laminæ or scales with fissures between them, their outer edges ragged; reproductive organs numerous, well marked, irregularly scattered over the surface, most abundant at the narrower sides, usually cavitous in the centre, sometimes solid and protuding, surrounded by concentrically arranged, crescent-shaped bract scars, sometimes well exposed and clearly distinguishable; armor 3 cm. to 5 cm. thick, separated from the wood by a definite line; woody zone 4 cm. thick, consisting of an outer parenchymatous ring 3 cm. thick, a thin ring of loose, open structure, and two thin plates separated by another ring of coarse cells divided by radial partitions, the inner walls of both plates marked with scars of the medullary rays, the pattern different in the two cases, the scars on the inner plate 13 mm. long, those on the outer longer and tapering upward; medulla large, elliptical, tapering upward, of a coarse homogeneous structure.

CYCADEOIDEA UHLERI Ward

Plate XLVII

Cycadeoidea Uhleri Ward, 1897, Proc. Biol. Soc., Washington, vol. xi, p. 14.
Cycadeoidea Uhleri Ward, 1906, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 454, pl. lxxxvii, fig. iv, 10; pl. c.

Description.—Trunks small, 28 cm. high, 20 cm. in diameter, 50 cm. to 60 cm. in girth at the thickest part, circular, or only slightly elliptical in cross-section, conical or somewhat cylindrical-conical in shape, contracted at the base, leaf scars definitely arranged in quincunx order and spiral rows around the trunk, one of these sets of rows ascending at an angle of 45° to the axis, the other at a much greater angle; subtriangular, the upper side arched and sometimes slightly grooved, lateral angles acute, inferior angle obtuse or rounded; scars uniform in size, 18 mm. wide and 9 mm. high; ramentum walls 4 mm. to 5 mm. thick, commissure distinct, the whole punctured with minute rhombic, triangular, or elliptical bract scars deeply penetrating the structures; leaf bases usually wanting, but sometimes nearly filling the cavities; vascular bundles few, arranged in a row near the upper side of the petiole, and others scattered over other parts; petioles all reflexed or pointing downward at a strong angle; reproductive organs numerous, situated directly over the leaf scars, i. e., axillary, elliptical in outline, 15 mm. wide, 10 mm. high, the centre occupied by the remains of the essential organs or by a circular cavity where these have disappeared; bract scars small and numerous, somewhat curved and arranged concentrically, also passing out into the ramentum walls; armor 3 cm. to 5 cm. thick; woody zone 15 mm. to 35 mm. thick, divided into two or three rings; medulla about 5 cm. in diameter, cylindrical or elliptical, according to the shape of the trunk; heterogeneous in composition, being traversed by dike-like plates of a hard substance dividing it into chambers, often wanting, leaving a hollow centre to the trunk.

Cycadeoidea Bibbinsi Ward

Plate XLVIII

Cycadeoidea Bibbinsi Ward, 1897, Proc. Biol. Soc., Washington, vol. xi, p. 15.

Cycadeoidea Bibbinsi Ward, 1906, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 456, pl. lxxxiii, fig. 3; pl. lxxxiv, fig. 3; pl. lxxxv; pl. lxxxvii, figs. i, 2, 4, 6, 7; ii, 1, 2, 4, 8, 9, 10, 11; iii, 5, 7; iv, 2, 3, 6, 8, 11; v, 12, 15; pl. lxxxix, figs. i, 5; ii, 2, 5, 6; pl. ci-civ.

Description.—Trunks large, 40 cm. to 60 cm. high, laterally compressed, girth of largest specimen 1 m., of next in size 88 cm., shorter axis of cross-section one-half to two-thirds of longer axis, contracted toward the summit, terminating in a conical bud 30 cm. high, or, where this is wanting, in a concave depression, thoroughly silicified throughout, heavy and solid, of a dark color; all the organs of the armor nearly at right angles to the axis of the trunk; leaf scars arranged spirally around the trunk in imperfect quincunical order, subrhombic, the lower angle much sharper than the upper, the latter sometimes reduced to a curve, 14 mm. high, 26 mm. wide; ramentum walls moderately thick, usually solid; vascular bundles of the petioles arranged in a row entirely around them and near the margin of a cross-section, also sometimes a few near the centre; spadices abundant, irregularly scattered over all parts of the surface, usually showing the marks left by the essential floral organs or a central cavity occupying their place, surrounded by curved or crescent-shaped pits concentrically arranged in several rows and set concave to the axis of the spadix, representing the involucral bracts; armor varying from 25 mm. to 75 mm. in thickness, this variation often great in different parts of the same specimen; cambium layer indistinct; liber zone not generally distinguishable from the wood; the latter in two or three zones, medullary rays faint; medulla well marked, homogeneous, usually spongy in appearance.

This species represents a type quite distinct from all the others, the cycadean trunks of Maryland being divisible, according to habit, into two classes, one of which would embrace all the forms included in the six species above described, and the other those that have been referred to this species. The fact that the rock in the latter is always firm, hard, and heavy, and usually dark colored, is not merely an accident of preservation, but results in some obscure way from the nature of the vegetable tissues. The trunks are generally larger and the leaf scars much larger, though they have nearly the same form and arrangement. The reproductive organs are more abundant and usually very regular and definite in their character.

This species, with *Cycadeoidea Fontaineana,* is scarcely less numerous than *Cycadeoidea marylandica,* these three being by far the most abundant of the Maryland trunks.

CYCADEOIDEA CLARKIANA Ward

Plate XLIX

Cycadeoidea Clarkiana Ward, 1906, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 472, pl. lxxxix, figs. i, 2, 4; pl. cvi.

Description.—Trunks rather large, tall and subcylindrical or barrel-shaped, laterally compressed, unbranched; rock rather hard, of a light-ash color and average specific gravity; organs of the armor horizontal or somewhat descending; rows of scars from left to right making an angle with the axis of 45°, those from right to left an angle of 80°; leaf scars subrhombic or irregular in shape and variable in size, 15 mm. to 18 mm. wide, 10 mm. to 15 mm. high; leaf bases present, sunk about 1 cm. below the surface, porous; vascular bundles not visible on the cross-sections, but distinct on the eroded surfaces; ramentum walls very thin and sharp edged, thickening below to 3 mm. to 5 mm. hard, destitute of markings or division line between the plates; reproductive organs obscure and reduced to pitted areas on the eroded surface; armor 3 cm. thick, the leaf bases passing insensibly into the woody axis; wood 2 cm. thick, in four layers or rings; outer layer 1 cm. thick, chiefly composed of the elements of vascular tissues passing upward and outward through it and curving over at the outer margin to enter the deflexed leaf bases; fibrous zone of three rings, the outer and inner consisting of loose, open tissue, largely decayed in the only specimen that shows them, leaving a fissure, the middle ring hard and firm, forming a plate surrounding the medulla, 5 mm. thick, its inner surface regularly marked with the scars of the medullary rays, which are elliptical in shape and disposed in alternating rows; medulla very large and prominent, elliptical in cross-section, thickest in the middle of the trunk to conform to its shape, which it chiefly determines, the shorter diameter varying from 9 cm. to 15 cm. and the longer from 14 cm. to 18 cm., coarse grained and homogeneous in structure, its surface where exposed handsomely marked by the ridges and flutings of the bases of the medullary rays rising out of it.

This is a very distinct species and the only one of the Maryland Potomac species that has the tall subcylindrical form.

Cycadeoidea Fisheræ Ward

Plate L

Cycadeoidea Fisheræ Ward, 1906, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 470, pl. lxxxvii, fig. iii, 9; pl. cv.

Description.—Trunks rather small, about 30 cm. high and 20 cm. in diameter, conical, unbranched; rock soft, light buff colored, of low specific gravity; leaf stalks strongly inclined, making an angle with the axis of the trunk of nearly 45°; rows of scars very distinct, spirally arranged around the trunk, those from left to right making an angle with the vertical axis of about 45°, those from right to left of about 30°, the latter much the more obvious and curving upward, so that the angle varies from 45° below to 25° above; leaf scars subrhombic, the two upper ones often forming a gentle arch, sometimes nearly a horizontal line, making the alveoli true triangles, the lower 2 cm., the upper 12 mm. wide, about 1 cm. high, diminishing toward the summit; leaf bases usually present, soft, shady, and fine grained; rarely reaching the surface, generally sunk to a depth of 5 mm., sometimes of 2 cm.; vascular bundles often visible, either as slight protuberances on the ends of those leaf bases that rise highest in the scars, or as small dots on those that lie deeper, or as a series of ridges running down into the scars where the central portion is deeper than the outer portion, the rows 0.5 mm. from the outer margin with occasional faint traces of more central bundles; ramentum walls when normal about 5 mm. thick, of a rather firm consistency, presenting a continuous sharp ridge in the direction of the rows of scars from right to left, without visible commissure; reproductive organs abundant, one in the axil of each leaf, small and doubtless mostly abortive, occupying wide triangular spaces between the leaf scars, causing the walls to appear abnormally thick; spadices always present and flush with the walls, elliptical or circular in cross-section, the larger ones 2 cm. wide and 1 cm. high, often much smaller; involucral scales abundant, occupying most of the space between the walls, concentrically arranged in groups of thin, crescent-shaped scars, which are always somewhat depressed and contain the bases of the scales; essential organs visible at the center of the best preserved spadices, but often wanting and represented by a cavity; armor 3 cm. thick; woody cylinder consisting of two layers or rings, the outer, or cortical parenchyma 2 cm. thick, open and loose in structure, the large vascular strands passing upward and outward through it to enter the leaf bases, where they suddenly arch over and assume the downward course of the leaves, the inner or fibrous zone, 5 mm. thick, very distinct from the outer, the strands rising from its outer surface and not penetrating it, its fibres being longitudinal; its inner walls showing the longitudinal rows of the alternating ovate scales of the medullary rays.

Genus DIOONITES Miquel

[Over de Rangschikking der fossiele cycadeæ; Tijdschr. v. d. Wissen. Naturk. Wetensch., Deel iv, 1851, p. 211]

The question of the proper generic reference of cycad fronds is a much mooted one, and considerable has been written as to the proper generic name for the fossils here referred to *Dioonites*. Nathorst (*loc. cit.*, p. 46) and Seward (*loc. cit.*, p. 75) have been foremost to question this reference, the former proposing the genus *Zamiophyllum* for fronds of this type from the Neocomian of Japan because the pinnæ are slightly narrowed towards the base and the latter advocating their reference to *Zamites*. Prof. Fontaine (1906, p. 246 *et seq.*) certainly makes out a strong case for their retention in Miquel's genus which was characterized as follows: "Frondes pinnatæ, rigidæ, crassæ. Foliola densa pantentissima suprema nunc subimbricata, lanceolata vel lineari-lanceolata, recta vel subfalcata, acuta vel acutiuscula, basi tola latitudine inserta, inferne retrorsum subdecurrentia, nervis cum margine parallelis æqualibus subtus, distinctioribus, cum sulculis stomatiferis alternantibus."

Bornemann in 1856 makes use of Miquel's genus, referring to it several additional species including the one so common in the Potomac Group, which Ettingshausen had previously referred to *Pterophyllum*. Schimper (1870) also adopts it and gives a somewhat unintelligible Latin diagnosis. The genus is also used by Schenk and Saporta. Fontaine in 1890, misled by Schimper's "*pro- et decurrentibus,*" gives a rather faulty generic diagnosis which is corrected in his later work (1906).

Dioonites may be distinguished from *Pterophyllum* by the insertion of the pinnæ on the plane of the upper surface of the rachis, and from *Zamites* by the decurrent pinnæ, for while they are slightly narrowed toward the base in some specimens they are attached by their whole width and run somewhat over and down the rachis, their insertion being somewhat lateral on the upper face of the rachis, the upper epidermis of the two being continuous. The angle of divergence of the pinnæ is of minor importance since it will obviously vary greatly in proceeding from the base to the apex of the frond.

It may be unfortunate that the name suggests a relationship to the modern genus *Dion* Lindley, but the time has passed when generic names have other functions than mere names, and the suggested relation to *Dion,* if it is suggested, is not wider of the mark than the implications of the term *Zamites.* The latter name is more properly retained for frond types in which the pinnæ are articulated to the rachis, often developing a prominent basal callosity and frequently found as detached fossils, which is not the usual method of occurrence of *Dioonites,* in which the pinnæ, as might be imagined from their structure, are markedly persistent.

The genus is a widespread and characteristic member of the Wealden and other Lower Cretaceous floras, and although Seward includes the Cenomanian *Pterophyllum saxonicum* of Reich in the synonymy of *Dioonites Buchianus* it is very doubtful if this species extends above the Lower Cretaceous. In its typical form it is a very prominent element in the oldest Potomac flora.

DIOONITES BUCHIANUS (Ettingshausen) Bornemann

Plates LI, LII

Pterophyllum Buchianum Ettingshausen, 1852, Abh. d. k. k. Geol. Reichsanst., Band i, Abth. iii, No. 2, p. 21, pl. i, fig. 1.

Dioonites Buchianus Bornemann, 1856, Org. Rest. d. Lettenkohlengruppe Thüringens, p. 57.

Dioonites Buchianus Schimper, 1870, Pal. Végét., tome ii, p. 149.

Pterophyllum Buchianum Schenk, 1871, Palæontographica, Bd. xix, 1869, p. 8, pl. iii, fig. 5.

Dioonites Buchianus Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 182, pl. lxviii, fig. 1; pl. lxix, figs. 1, 3; pl. lxx, figs. 2, 3; pl. lxxi, fig. 1; pl. lxxii, figs. 1, 1a, 2, 2a; pl. lxxiii, figs. 1-3, 3a, 3b; pl. lxxiv.

Zamiophyllum Buchianum Nathorst, 1890, Denks. Akad. Wiss., Wien, Band lvii, pp. 46, 49, pl. ii, figs. 1, 2; pl. iii; pl. v, fig. 2.

Zamiophyllum Buchianum Yokoyama, 1895, Journ. Coll. Sci., Imp. Univ., vol. vii, p. 223, pl. xx, fig. 1; pl. xxiii, fig. 6; pl. xxvii, figs. 5a, b; pl. xxviii, figs. 1, 2.

Zamites Buchianus Seward, 1895, Wealden Flora, pt. ii, p. 79, pl. iii, figs. 1-5; pl. iv; pl. viii, fig. 1.

Dioonites Buchianus Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 244, 479, 483, 486, 517, 534, 538, pl. lxvi, figs. 16, 17; pl. cvii, fig. 2; pl. cviii, fig. 1.

Dioonites Buchianus ? Knowlton, in Diller, Bull. Geol. Soc. Am., vol. xix, 1908, p. 386.

Description.—" P. fronde pinnata, pinnis circa 1-2 dm. longis, 4-7 mm. latis, alternis, linearibus, subremotis, subangulo acuto adnatis, nervis creberrimus, tenuissimis instructis; rhachide crassiuscula."—Ettingshausen, 1852.

Fronds very large, attaining probably the length of a metre or more; maximum width 25 cm. to 30 cm.; rachis stout, epidermis of the rachis and pinnæ thick and durable; leaves thick and leathery; pinnæ varying much in dimensions, distance, shape, and termination; linear-acute, sometimes closely placed, sometimes remote, those in the middle part of the frond the most commonly found, these diverge at an angle of 45°, those of the upper part become more and more oblique, until at the summit they occur in the prolongation of the rachis; the terminal pinnæ much shorter and narrower than those lower down; length varying, attaining in some cases 25 cm.; slightly narrowed to the base and attached by the whole width of the base, obliquely placed and decurrent; veins fine, not prominent, very closely packed, forking at the base, parallel, and terminating without convergence in the summits of the leaflets; some of the outer ones ending in the margins a little below the summit.

In the material collected in the vicinity of Dutch Gap Canal on the James River, Virginia, the leaf substance is often preserved on the impressions as a thick lignitic sheet. From such a specimen collected over 20 years ago by Prof. Fontaine, at the locality known as the Fishing Hut, above Dutch Gap Canal (U. S. N. M., No. 3773), pieces of the epidermis were suitably prepared for microscopic examination, and a number of interesting features were made out. Below a magnification of 100 diameters the outlines of the epidermal cells appear as rows of small, narrow-walled, almost square rectangles, the irregularly scattered stomata showing as cells of darker color. With a higher power (385 diameters) the outlines are still substantially rectangular, but the walls are seen to be not straight but irregularly waved or undulatory, as shown in the figure. This waving is less regular and less emphasized than in similar figures given by Schenk for the genus *Pterophyllum,* and seems to be more pronounced in the lateral and less marked in the transverse walls. The cells are small, about 7 microns (2/3 obj.) in diameter, and the walls are thin. The stomata are numerous and without regular arrangement, but the guard cells are all oriented alike and parallel, presumably to the long axis of the pinnule. This feature also differs from their arrangement in *Pterophyllum,* as shown by Schenk, where

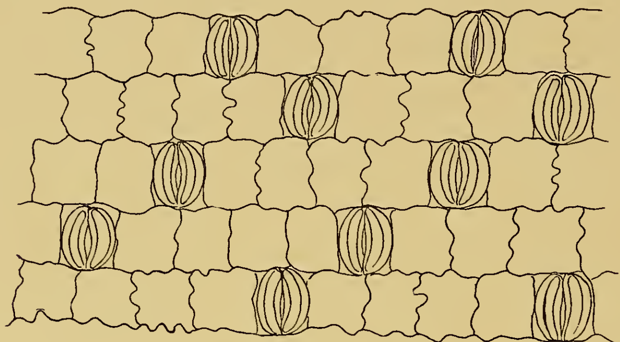

Fig. 10.—Cuticle of Dioonites Buchianus viewed from within, × 385.

they are less numerous and without parallel orientation. The guard cells are two in number and stout in form. Their upper surface is just at or slightly below the surface of the cuticle, and they are quite deep, becoming narrower inward. These features will enable observers to distinguish *Dioonites* from fragments of similar appearance like those of *Nageiopsis* in cases where the cuticle is preserved.

This fine plant is very abundant in the lower Potomac, along the James River in Virginia, the splendid specimens figured on pls. li and lii coming from Sailors' Tavern. The remains from Maryland, which have been identified as this species, are extremely poor and questionable, those so identified with a query by Fontaine from the locality on the Bewley estate being here omitted as undeterminable.

It is a widespread older Cretaceous type, first found in the Barremian Wernsdorfer schichten near Teschen in Austrian Silesia, and since found in great abundance at various localities in the Neocomian of Japan. It also occurs in the English Wealden, although Fontaine is of the opinion that most of the forms which Seward so identifies are incorrectly determined. Prof. Fontaine has also recorded this species from the Shasta and Horsetown beds of California, and from the Glen Rose beds of the Trinity Group of Texas.

Occurrence.—PATUXENT FORMATION. Cockpit Point, Telegraph Station (Lorton), Kankeys, Trents Reach, Dutch Gap and vicinity, Virginia; New Reservoir (?), District of Columbia. ARUNDEL FORMATION. Arlington (?), Maryland.

Collections.—U. S. National Museum, Goucher College.

Genus PODOZAMITES F. Braun

[In Münster, Beitr. Petref., Heft vi, 1843, p. 36]

This genus was proposed by Friedrich Braun for certain species formerly included in the genera *Zamia* Brongn. and *Zamites* Presl, which had pinnate, distant, alternate leaflets contracted basally and with parallel veins which converged at the base, and usually at the apex. *Zamites distans* of the latter author, a Rhætic and Liassic form, becomes the type. Braun's characterization is as follows: "Blätter gefiedert; Fiederblättchen abwechselnd fernstehend, durch zusammenziehung an der Basis gleichsam gefusst. Nerven von der Austrittstelle an bogig, in der Mitte fast grade und parallel zur Spitze der Fieder verlaufend." The genus at this time included six species, embracing besides *distans* and *lanceolata* four forms regarded by Braun as new species which, however, were not named or described. Schimper emended the genus in 1870,[1] listing ten species, four of which were of Lower Cretaceous age and the balance older. His diagnosis is as follows: "Folia magnitudine mediocri, rachi tenui. Foliola distantia, patentia, oblonga, ovato- et lineali-oblonga, apice obtuse acuminata vel rotundata, basin versus sensim angustata, subpedicellata, pedicello defluente articulato, decidua, nervis ex

[1] Pal. Végét., tome ii, 1870, p. 158.

infima basi dichotomis, dehinc simplicibus, erectis, parallelis, apicem versus convergentibus." Three score or more species have since been described, some of them coming from strata as late as the Tertiary. Post-Mesozoic forms which have been referred to this genus are of very doubtful propriety, however, since they probably represent fragmentary remains of monocotyledons in no wise related to the Mesozoic types.

The axis is usually slender and the leaflets are somewhat irregularly placed. They vary greatly in size and outline and are many veined, the veins not converging apically to any extent in extremely narrow-leafed forms. Leaflets usually found detached, and hence probably deciduous.

The genus is usually included in the Cycadaceæ, although some authors have been inclined to include it among the Araucarieæ.[1] It is wide-spread and more or less abundant type from the Triassic to the Upper Cretaceous, and may possibly include unallied forms, the character of the material, however, not admitting of as much precision in determinations as would be desirable.

Podozamites was not an especially important element in the flora of the Potomac Group, and what specimens have been found are fragmentary and poorly defined. They have been confused with both *Zamites* and *Nageiopsis* in the past, and are, it must be confessed, distinguishable with difficulty. Undue specific differentiation is undesirable, and it is very doubtful if the eleven species which Saporta (1894) recognizes from the Mesozoic of Portugal could be recognized a second time even by their describer.

Podozamites inæquilateralis (Fontaine) Berry

Plate LIII, Fig. 1

Nageiopsis obtusifolia Fontaine,[2] 1890, Monogr. U. S. Geol. Surv., vol. xv, 1889, p. 200, pl. lxxxv, fig. 7.

Nageiopsis inæquilateralis Fontaine, 1890, Monogr. U. S. Geol. Surv., vol. xv, 1889, p. 200, pl. lxxxv, fig. 6.

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[1] Seward, Jurassic Fl., pt. i, 1900, p. 241.

[2] The specific name *obtusifolia* cannot be used for a species of *Podozamites*, as there has been quasi use of this combination by Heer, Handl. Köngl. Sven. Vet. Akad. (Fl. Foss. Arct., Band iv, Abth. i), 1876, p. 39, pl. viii, fig. 6.

Nageiopsis montanensis Fontaine, 1906, in Ward, Monogr. U. S. Geol. Surv., vol. xlviii, 1905, p. 312, pl. lxxiii, fig. 7.

Nageiopsis obtusifolia Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 484.

Podozamites inæquilateralis Berry, 1910, Proc. U. S. Natl. Museum, vol. xxxviii, p. 194.

Description.—" Leaves short in proportion to width, very obtuse, attached by a short slightly twisted pedicel, broadly elliptical or oblong in shape, broadest near the base, slightly inequilateral at base; nerves forking once or twice near the base and then parallel to near the summit, where they are a little crowded together, the outer ones ending in the margins a little below the apex."—Fontaine, 1890.

The description of *N. inæquilateralis* is an alliteration of that of the preceding *N. obtusifolia.* It is based on a single specimen. Veins are twenty-two in number, much thicker than in *Nageiopsis,* and like those in *N. acuminata,* which has also been referred to *Podozamites.* They converge toward the tip of the leaf, which is missing in the specimen. Leaf pedicellate at base.

N. montanensis, from the Kootanie at Geyser, Montana, is based on a single detached leaflet with nineteen or twenty veins, convergent in the obtuse tip. There is absolutely no ground for including it in *Nageiopsis.* The *inæquilateralis* specimen comes from Kankeys, Virginia, and *obtusifolia* was found near Potomac Run and at Cockpit Point, Virginia.

These imperfect forms are suggestive of *Podozamites affinis* (Schenk) Schimper [1] of the Wernsdorfer schichten, but are not representative enough for accurate comparison.

It seems probable that *Podozamites ellipsoideus* Sap.[2] represents additional occurrences of this species in the Neocomian and Albian of Portugal, and that the forms from the Neocomian of Japan which Yokoyama [3] identifies with *Podozamites pusillus* Velen. are the Asiatic rep-

[1] Schenk, Palæont., Band xix, 1869, p. 13, pl. iii, fig. 8.

[2] Saporta, Fl. Foss., Portugal, 1894, pp. 87, 174, pl. xvi, fig. 31; pl. xxxii, figs. 8, 9; pl. xxxiii, fig. 5; pl. xxxv, fig. 12.

[3] Yokoyama, Mesozoic Plants from Kozuke, Kii, Awa and Tosa, Jour. Coll. Sci., Imp. Univ., Japan, vol. vii, 1895, p. 222, pl. xx, figs. 2, 3b, 4, 5, 7.

resentatives of this same form. It is doubtful if the Bohemian specimens are distinct.

Occurrence.—PATUXENT FORMATION. Kankeys, Cockpit Point, near Potomac Run, Virginia.

Collection.—U. S. National Museum.

PODOZAMITES SUBFALCATUS Fontaine

Plate LIII, Figs. 2, 3

Podozamites subfalcatus Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 179, pl. lxviii, fig. 6; pl. clxx, fig. 9.

Zamites ovalis Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889 (pars). p. 173.

Description.—"Leaves unknown; leaflets subfalcate, narrowly elliptical to strap-shaped, obtuse or subacute, gradually narrowed to the base so as to form a broad, short pedicel, thick and leathery; nerves slender, and not well disclosed, forking near the base, then nearly parallel to near the tips, where they converge."—Fontaine, 1890.

This species was based upon rare and detached fragments from the 72d milepost, near Brooke, and was compared by its describer with *P. ovatus* (Schenk) Schimp., and *P. affinis* (Schenk) Schimp. It is practically identical with the forms from the Cenomanian of Bohemia, which Velenovsky[1] refers to *Podozamites Eichwaldi* Schimp., and is not distinguishable from many of the fine specimens of this Jurassic species figured by Heer.[2]

Occurrence.—PATUXENT FORMATION. Telegraph Station (Lorton), Virginia. PATAPSCO FORMATION. Near Brooke, Virginia.

Collection.—U. S. National Museum.

PODOZAMITES ACUTIFOLIUS Fontaine

Plate LIII, Fig. 4

Podzamites acutifolius Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 181, pl. lxxx, fig. 6; pl. lxxxv, figs. 10, 15; pl. lxxxvii, fig. 1; pl. clxx, fig. 2.

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[1] Velenovsky, Gym. böhm. Kreidef., 1885, p. 11, pl. ii, figs. 9, 10, 23.

[2] Heer, Fl. Foss. Arct., Bd. iv, Abth. i, 1876, p. 36, pl. vi, fig. 22c; pl. vii, fig. 7e; pl. viii, figs. 1-4.

Nageiopsis acuminata Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 201, pl. lxxxv, fig. 11.

Podozamites acutifolius Fontaine, 1893, Proc. U. S. Nat. Museum, vol. xvi, p. 266, pl. lxxxvi, fig. 7.

Description.—Leaflets ovate-acuminate, widest toward the base, abruptly rounded to the short inequilateral pedicel. Sides straight, the whole outline suggesting a large leaf of the modern *Araucaria Bidwilli* and identical in size, outline, and venation with the usual type of leaves of *Dammarca Moorei* from New Caledonia. Veins about 20 in number, forked basally and converging conspicuously toward the apex. Length 3.5 cm. to 7 cm., greatest width 8 mm. to 17 mm.

The most complete and best specimen of this species is the one which formed the type of *Nageiopsis acuminata* of Fontaine, and although he says "nerves not seen," the venation is remarkably clear after twenty years, and shows conclusively that it cannot be referred to *Nageiopsis*. This species is also present in the Glen Rose beds of the Trinity in the Texas area.

Occurrence.—Patuxent Formation. Near Telegraph Station (Lorton), Dutch Gap, Virginia. Patapsco Formation. Deep Bottom, near Brooke, Virginia.

Collection.—U. S. National Museum.

Podozamites Knowltoni Berry

Plate LIII, Fig. 7

Zamites angustifolius Eichw., 1868, Lethæa rossica, tome ii, p. 39, pl. ii, fig. 7.

Podozamites angustifolius Schimper, 1870, Pal. Végét., tome ii, p. 160 (non Schenk, 1868).

Podozamites angustifolius Heer, 1876, Fl. Foss. Arct., Band iv, Abth. i, p. 36, pl. vii, figs. 8-11; pl. viii, figs. 2e, 5.

Podozamites angustifolius Heer, 1876, *Ibid.*, Abth. ii, p. 45, pl. xxvi, fig. 11.

Podozamites angustifolius Heer, 1878, *Ibid.*, Abth. ii, p. 22, pl. v, figs. 11b, 12.

Podozamites angustifolius Lesq., 1884, Cret. and Tert. Fl., p. 28.

Podozamites angustifolius Lesq., 1892, Mon. U. S. Geol. Survey, vol. xvii, p. 27, pl. i, fig. 4.

Podozamites angustifolius Newberry, 1896, Mon. U. S. Geol. Survey, vol. xxvi, 1895, p. 44, pl. xiii, figs. 1, 3, 4 (non fig. 2).

Podozamites angustifolius Moller, 1903, Kgl. Svensk. Vetensk. Akad. Handl., Bd., ix, pl. i, figs. 8-12, 17b.
Nageiopsis recurvata Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 552, pl. cxvi, fig. 2 (non Fontaine, 1890).
Zamites tenuinervis Fontaine, 1906, in Ward, Mon. U. S. Geol. Survey, vol. xlviii, 1905, p. 528.
Podozamites Knowltoni Berry, 1909, Bull. Torrey Club, vol. xxxvi, p. 247.

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

This species has a very wide range, both geological and geographical. It is common in the Jurassic of high latitudes in Russia (the type region), Siberia, Bornholm, and Spitzbergen. In the Lower and Upper Cretaceous indistinguishable remains are rather widely distributed. These occur in the Patapsco formation of the Potomac River valley, the Raritan formation of New Jersey, and the Dakota Group of Kansas. Whether or not they were specifically identical with the Jurassic forms cannot be proven, although they present no character aside from difference in geological horizon to warrant their separation.

Occurrence.—PATAPSCO FORMATION. Vinegar Hill, Fort Foote, Maryland; Mt. Vernon, Virginia.

Collection.—U. S. National Museum.

PODOZAMITES DISTANTINERVIS Fontaine

Plate LIII, Figs. 8, 9

Podozamites distantinervis Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 179, pl. lxxix, fig. 9; pl. lxxxii, fig. 4; pl. lxxxiii, figs. 1, 2, 6, 7; pl. lxxxiv, figs. 1, 2, 8, 10, 14, 15; pl. lxxxv, figs. 12, 16.
Podozamites pedicellatus Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 180, pl. lxxvi, fig. 1; pl. lxxviii, fig. 7; pl. lxxxii, fig. 5 (non Fontaine, in Ward, 1906).
Podozamites distantinervis Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 479, 516 (non pp. 165, 281, 573).

Description.—"Leaves comparatively large, pinnate; leaflets large, elongate-elliptical in form, varying a good deal in size, maximum width varying from 27 mm. to 40 mm., usually comparatively broad, full length not seen, but ranging from 11 cm. to over 14 cm., obtuse or subacute at tip, usually somewhat narrowed toward the base, and at the base rather abruptly rounded off into a short pedicel; nerves strong, quite remote, forking at or near the base, and then parallel to near the tip, where they converge and connive more or less."—Fontaine, 1890.

With the added amplification that the pedicel is somewhat variable in length, this species readily includes those forms named *P. pedicellatus* by Fontaine, which are otherwise identical with the type material.

This is the commonest species of *Podozamites* in the Potomac Group, where it is confined, however, to the earliest formation, the Patuxent. It is not uncommon at Fredericksburg, but most of the specimens are fragmentary, as might be expected in leaves of this size preserved in rather coarse deposits. In life this must have been a very handsome species, and it appears to be quite distinct from any that have been hitherto described. Professor Fontaine has recorded this species from Cape Lisburne, Alaska, but it does not occur there.[1] Possibly *Podozamites nervosa* Newberry (non-Schimper), described from the Kootanie of Montana, should be referred to this species, but in the absence of the base this cannot be demonstrated with certainty.

Occurrence.—PATUXENT FORMATION. Fredericksburg, Potomac Run, Dutch Gap (?), Virginia; 16th Street, District of Columbia.

Collection.—U. S. National Museum.

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

Plate LIII, Figs. 5, 6

Zamia lanceolata Lindley and Hutton, 1836, Foss. Fl., vol. iii, pl. cxciii.

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

Podozamites lanceolatus F. Braun, 1843, in Münster, Beitr. Petrefactenkunde, Band ii, pt. vi; p. 33.

Podozamites proximans Conrad, 1869, Amer. Jour. Sci. (ii), vol. xlvii, p. 361, tf.

Podozamites lanceolatus Schimper, 1870, Pal. Végét., tome ii, p. 160.

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[1] Knowlton, in Collier, Bull. U. S. Geol. Survey, No. 278, 1906, p. 29.

? *Podozamites minor* Heer, 1882, Fl. Foss. Arct., Bd. vi, Abth. ii, p. 44, pl. xvi, fig. 8.

Podozamites lanceolatus Velenovsky, 1885, Gymn. Böhm. Kreidef., p. 11, pl. ii, figs. 11-19, 24.

Podozamites lanceolatus Dawson, 1886, Trans. Roy. Soc., Can., vol. iii, sec. iv, p. 6, pl. i, fig. 3.

Podozamites distantinervis Font., 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 179 (pars).

Podozamites lanceolatus Lesq., 1892, Mon. U. S. Geol. Surv., vol. xvii, p. 28, pl. i, figs. 5, 6.

Podozamites angustifolius Newb., 1896, Mon. U. S. Geol. Surv., vol. xxvi, p. 44, pl. xiii, fig. 2 (non figs. 1, 3, 4).

Podozamites angustifolius Hollick, 1904, Bull. N. Y. Bot. Garden, vol. iii, p. 410, pl. lxxi, fig. 8.

Podozamites lanceolatus Penhallow, 1905, Summary Geol. Surv., Can., 1904, p. 9.

Podozamites lanceolatus Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, p. 110, pl. xxiv, figs. 17-20.

Podozamites pedicellatus Font., 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, p. 532, pl. cxiv, fig. 1 (non other references).

Podozamites distantinervis Font., 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 165, 281.

Zamia washingtoniana Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 503 (pars), pl. cxi, fig. 2 (non. fig. 1).

Podozamites lanceolatus Knowlton, 1907, Smith. Misc. Coll., vol. iv, pt. i; p. 120, pl. xiv, fig. 4.

Podozamites lanceolatus Hollick, 1907, Mon. U. S. Geol. Surv., vol. l, p. 35, pl. ii, fig. 1.

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 geological range, being recorded from the Jurassic upward to the Upper Cretaceous. The geographical range is equally great, embracing two continents, North America and Europe. It is quite probable that the species is composite but no certain grounds for segregation are apparent.

While some students may doubt the wisdom of correlating both Lower and Upper Cretaceous forms with a species which is essentially a Jurassic type, specific differentiation 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.

Forms indistinguishable from the type of this species occur in both the Patuxent and Patapsco formations of the Potomac Group, as well as in the Kootanie of Montana and British Columbia. As found in the Maryland-Virginia area the pinnules are always detached, lanceolate in outline, pointed at both ends and widest toward the base. Length about 11 cm.; greatest width about 12 mm.

Occurrence.—Patuxent Formation. Telegraph Station (Lorton), Virginia. Patapsco Formation. Ft. Foote, Maryland; Mt. Vernon, Virginia.

Collection.—U. S. National Museum.

Genus ZAMITES Brongniart

[Prodrome, 1828, p. 94]

The genus *Zamites* is strictly a form-genus for the reception of cycadean fronds which resemble in a general way those of recent Zamias. It has been used in a somewhat varying and rather vague sense by various authors since its proposal by Brongniart in 1828. Proposed at a time when but two types of modern cycad fronds, *Cycas* and *Zamia,* were recognized, it shows some of the characteristics of the modern genera *Zamia, Macrozamia, Ceratozamia,* etc. Afterwards Brongniart[3] abandoned his older use of the genus *Zamia* Linné as indicative of too definite a relation to the modern species which by that time had become segregated into a variety of genera and recharacterized *Zamites* as follows: "Ce genre est caractérisé par ses folioles parfaitement entières, non tronquées au sommet, mais aiguës ou arrondies, non rétrécies ou légèrement contractées à la base; à nervures parallèles entre elles et au

[1] Hollick, Mon. U. S. Geol. Surv., vol. 1, 1907, p. 35.
[2] Velenovsky, Gymn. Böhm. Kreidef., p. 11, pl. ii, figs. 11-19, 24, 1885.
[3] Brongniart, Tableau, 1849, p. 61.

bord de la foliole, et par conséquent convergentes vers le sommet; fines et égales entre elles, très rarement bifurquées lorsque la foliole est élargie dans sa partie moyenne." Braun's genera *Podozamites* and *Pterozamites* were included as subgenera.

Zamites has been redefined by various subsequent authors notably Bornemann,[1] Saporta,[2] Schimper,[3] Schenk,[4] Seward,[5] etc., and it will suffice in this connection to quote the definition of the latter author, which is as follows: "Frond pinnate, pinnæ more or less obliquely inclined to the rachis and attached to the upper surface, apices acuminate and tapering or obtusely rounded, the base may be abruptly rounded and marked with a callosity near the point of attachment, or the pinnæ may be slightly and gradually narrowed towards the base, margins entire; veins parallel, but slightly divergent in the apical portion of each pinna." While the foregoing characterization is quite general, greater precision seems undersirable in the present case.

The basal callosity, a feature emphasized in most definitions, is a character the determination of which is often exceedingly difficult in the best of fossil material, and, of course, impossible in fragments of pinnæ which lack the base. Although Fontaine and Ward have described seven species of *Zamites* from the Potomac Group, this proves to be much too large a number, only two species being recognized in the present work. These, while not common, are found at various horizons, always detached, however, and generally fragmentary, so that their distinctness from pinnæ of *Podozamites* is often determined with difficulty.

The genus has a recorded range from the Triassic to the Oligocene, with many species in the Mesozoic, and while all of the species are not congeneric botanically, they are all doubtless referable to the Cycadophytæ.

[1] Bornemann, Ueber organische Reste Lettenkohlen Gruppe Thüringens, 1856, p. 54.

[2] Saporta, Pl. jurass., tome ii, 1875, p. 84.

[3] Schimper, Pal. Végét., tome ii, 1870, p. 151.

[4] Schenk, in Zittel, Handbuch, 1890, p. 218.

[5] Seward, Wealden Fl., pt. ii, 1895, p. 75.

Zamites tenuinervis Fontaine

Plate LIV, Figs. 1-5

Zamites tenuinervis Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 171, pl. lxvii, fig. 1; pl. lxix, fig. 2; pl. lxx, fig. 1; pl. lxxv, fig. 3; pl. lxxvi, fig. 7; pl. lxxviii, fig. 6; pl. lxxxiv, fig. 7.
Zamites distantinervis Fontaine, 1890, *loc. cit.*, p. 172, pl. lxxxiii, fig. 4.
Zamites subfalcatus Fontaine, 1890, *loc. cit.*, p. 173, pl. lxxxiv, fig. 13; pl. lxxxv, fig. 3.
Zamites tenuinervis Fontaine, 1893, Proc. U. S. Nat. Museum, vol. xvi, p. 267, pl. xxxvii, figs. 3, 4; pl. xxxviii, figs. 1, 2.
Zamia washingtoniana Ward, 1895, 15th Ann. Rept. U. S. Geol. Survey, p. 350, pl. ii, fig. 6.
Zamites tenuinervis Penhallow, 1902, Trans. Roy. Soc., Can., series ii, vol. viii, sec. iv, p. 42.
Zamites tenuinervis Fontaine, 1906, in Ward, Mon. U. S. Geol. Survey, vol. xlviii, 1905, pp. 257, 548 (?), pl. lxviii, figs. 2, 3 (non p. 528).
Zamia washingtoniana Fontaine, 1906, in Ward, *loc. cit.*, p. 503 (pars), pl. cxi, fig. 1 (non fig. 2).
Podozamites distantinervis Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 573 (non balance of citations).

Description.—Pinnæ always found detached, very long and relatively narrow, somewhat falcate. Apex not preserved in the Maryland or Virginia material. In a specimen from the Glen Rose beds of Texas, identified as this species by Fontaine, an obtusely rounded tip with convergent veins is shown. Base inequilateral, narrowed, and abruptly rounded, somewhat variable. Length presumably 20 cm. or more, of the longest fragments preserved one is 15.5 cm. without showing the extreme base or any evidence of apical narrowing, while another rather obscure specimen, also lacking the extreme base or apex, is 20.5 cm. in length. Width from 1.2 cm. to 2.3 cm., averaging about 2 cm. Veins parallel throughout most of their length, numerous, forked at their extreme base. Texture coriaceous.

This species is rather common in the Potomac Group, being especially abundant in the Patuxent formation at Fredericksburg, Virginia, and in the Glen Rose beds of Texas. All of the specimens are detached and more or less fragmentary. Their distinctness from *Podozamites* is not conclusive, although a number seem to show evidence of a basal callosity, and altogether lack the contracted and more or less elongated peduncle of *Podozamites distantinervis* Fontaine, with which they are most closely comparable.

There is some variability with respect to closeness or remoteness of the veins and in the character of the base in the various specimens which the writer refers to this species but these variations are no greater than are shown among the specimens which the original describer referred to the type. For example, some of the specimens show a base which is slightly subcordate, while in the specimen which Ward made the type of *Zamia washingtoniana*, it is rather gradually narrowed, but no more so than in some of the Glen Rose specimens which Fontaine referred to *Zamites tenuinervis*. Again the typical forms of the latter have rather close-set fine veins, while the poorly preserved specimens with more remote veins but found associated with the others, were made the type of *Zamites distantinervis* Fontaine, although the veins are no more remote than in the Glen Rose specimens which the same author refers to *Zamites tenuinervis*. In reviewing all of the material it is seen that these minor variations and the variations in calibre of the veins due to the state of preservation are not of specific value, and it is found impossible to frame any definitions which will permit the segregation of these various forms.

The cone which Ward figures from the Patapsco formation as the cone of this species, while superficially suggesting a small *Zamia* cone, is undoubtedly a *Sequoia* cone and not that of a species of *Zamites*.

Zamites tenuinervis occurs in the Patuxent and Patapsco formations in the Maryland-Virginia area, but it is especially characteristic of the Patuxent. Elsewhere it occurs with considerable frequency in the Glen Rose beds of Texas. It is also reported from both the Knoxville and the Horsetown beds of California and from the Lower Cretaceous of the Queen Charlotte Islands. It shows a striking resemblance amounting almost to identity to *Zamites Carruthersi* Seward,[1] from the English Wealden.

A number of preparations were made for the purpose of observing the outlines of the epidermal cells and the stomata; but these all proved

[1] Seward, Wealden Fl., pt. ii, 1895, p. 86, pl. vi, figs. 2-4.

unsuccessful, because of the granular nature of the lignite due to the advanced stage of decay reached by the pinnules before preservation.

Occurrence.—Patuxent Formation. Fredericksburg, Kankeys, Dutch Gap, Virginia. Patapsco Formation. Mt. Vernon, Dumfries Landing, Widewater, Virginia; Gray's Hill, Vinegar Hill, Stump Neck. Maryland.

Collection.—U. S. National Museum.

Zamites crassinervis Fontaine

Plate LIV, Fig. 6

Zamites crassinervis Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 172, pl. lxix, fig. 4; pl. lxxxiii, fig. 3.

Zamites ovalis Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889 (pars), p. 173, pl. lxxxv, fig. 4; pl. clxx, fig. 3.

Zamites sp., Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 173, pl. lxxxiv, fig. 12.

Zamites crassinervis Penhallow, 1902, Trans. Roy. Soc., Can., series ii, vol. vii, sec. iv, p. 41.

Description.—"Leaves broadly elliptical, short, acute, abruptly narrowed at base and attached by a callosity; nerves simple or forking at the very base, very strong, distant, parallel to near the apex, where they are more crowded."—Fontaine, 1890.

This species is not well marked and is unimportant and rare. Were it not for the indications of a callosity the writer would be inclined to refer these forms to *Podozamites distantinervis* Fontaine, which they greatly suggest. It has been recorded by Penhallow from the Cretaceous of Alliford Bay, Queen Charlotte Islands, but little reliance can be placed in the identification.

Occurrence.—Patuxent Formation. Fredericksburg, Dutch Gap, Potomac Run, Kankeys, Virginia.

Collection.—U. S. National Museum.

Genus CTENOPSIS gen. nov.

Fronds pinnate, of large size. Pinnæ inserted latterly on a stout rachis, the angle of insertion dependent upon the proximal, distal or intermediate position of the pinnæ, linear in outline. Apex unknown, analogy would suggest that it was obtuse. Base slightly enlarged above and decurrent below, two adjacent segments subtending a rounded, parallel-sided sinus, the width of the sinus being about half that of a segment. Texture coriaceous. The veins branch from the rachis at regular intervals at acute, approximately parallel angles, bending outward almost immediately and usually forking, the subordinate veins running close together, and parallel. The members of a single pair are about 0.333 mm. apart, while the space between each pair is about 1 mm. Occasionally some of the veins fork again some distance from the rachis the branches running parallel with the remaining veins. The veins are slender and sharply defined when seen on specimens showing the lower surface of the fronds or on impressions of the lower surface, but they appear as a single flat band on impressions of the upper surface.

With the genera *Ctenis, Ctenidium, Ctenopteris, Ctenozamites* and *Ctenophyllum* already in the field it might seem unnecessary to propose a new genus for the fronds of this general type, and yet the Potomac species cannot be forced into any of these genera without unduly extending their limits. Described originally as a species of *Ctenophyllum* it differs from that genus in the character of the venation which is strictly simple and parallel in the latter. *Ctenophyllum* is moreover an older Mesozoic genus first known in the Triassic and culminating in the middle Jurassic. The type and the bulk of the species are late Triassic and none are known above the Oolite. The form in hand greatly resembles *Ctenis* in habit but the veins as far as observed do not anastomose as in that genus. The genera *Ctenidium* and *Ctenopteris* are quite different from the present genus in all of their characters, as is *Ctenozamites*. The two latter genera are bi- or tripinnate and the former has simple veins.

Ctenopsis may be looked upon as a gerontic type embracing some of the characters of both *Ctenis* and *Ctenophyllum* and representing one of the last authentic occurrences of this general type of cycad frond.

While the foregoing discussion was going through the press, Seward described a new frond genus from the Jurassic of Scotland as *Pseu-*

doctenis.[1] This is in many respects very close, if not identical, with *Ctenopsis*, and if the former can be shown to have the double vascular strands in the pinnules such as characterize the latter genus, the term *Ctenopsis* will possibly have to be abandoned.

CTENOPSIS LATIFOLIA (Fontaine)

Plate LV, Figs. 1, 2

Ctenophyllum latifolium Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 175, pl. lxviii, figs. 2, 3.
Podozamites grandifolius Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 180, pl. lxxxii, fig. 2; pl. lxxxiii, fig. 5 (non other references under this name).
? *Ctenophyllum latifolium* Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 255, pl. lxvii, fig. 10.

Description.—Frond very large and wide-spreading; length of pinnæ not disclosed, width in the same region of the frond variable, ranging from 27 mm. to 35 mm.; pinnules alternate, going off in the lower part of the leaf at a large angle, in the upper portion becoming much more oblique, attached by the entire width of the widened base, which is decurrent and meets the expanded base of the adjacent pinnules, forming a broad rounded sinus; those of the upper portion of the frond united more and more, all curved slightly upward toward the summit of the frond; tips of the pinnæ not seen; veins slender, going off obliquely at their insertion in the lower and middle portions of the lower pinnules, but nearly at right angles in the upper portions, and all turning strongly outward to enter the pinnules; the veins fork usually at their insertion; occasionally but rarely they fork farther from the rachis.

These magnificent cycad fronds are extremely rare, although it is by no means certain that the plant which bore them was equally rare in the earlier Potomac flora. A large part of the frond is said to have been

[1] Seward, The Jurassic Flora of Sutherland, Trans. Roy. Soc., Edinb., vol. xlvii, pt. iv, 1911, p. 691, pl. iv, figs. 62, 67, 69; pl. vii, figs. 11, 12, 17; pl. viii, fig. 32; pl. x, fig. 45. See particularly pl. vii, fig. 62, and pl. x, fig. 45, of *Pseudoctenis lathiensis* Seward.

uncovered in the quarry at Fredericksburg, and to have had the appearance and dimensions as shown in Professor Fontaine's Fig. 2, cited above. This was unfortunately completely broken up in getting it out, the best of the remaining fragments being that shown in fig. 1 of the present work. This shows the upper surface of the frond and emphasizes its coriaceous texture. As previously stated, the pairs of veins appear as a single flat vein in this specimen. Fig. 2 of the present work shows an impression of the under surface of a frond of somewhat smaller size and brings out clearly the slender, double veins of this species.

This same form has been recorded (*loc. cit.*) from the Horsetown beds in California but the identification is based on rather uncertain material which, however, may well be identical with the Virginia form.

The fragments from Virginia which were described by Professor Fontaine as *Podozamites grandifolius* are obviously referable to this species with which they are identical in size, texture, and in the peculiar double veins. They represent somewhat distorted fragments of detached pinnules. The supposed contracted base shown in the foregoing author's fig. 5 is entirely fanciful. Other remains subsequently referred to this species[1] are of doubtful value.

Occurrence.—PATUXENT FORMATION. Fredericksburg, Potomac Run, Virginia.

Collection.—U. S. National Museum.

Genus CTENOPTERIS Saporta

[Pal. Franc., t. i, 1873, p. 351 (Brongn. MSS.)]

This genus was established by Saporta in 1873 with the *Filicites cycadea* of Brongniart,[2] a Jurassic species, as the type. He characterized it as follows:

" Frons pinnata vel bi-tripinnata, pinnæ elongato-lineares pinnatipartitae basi exappendiculatae, pinnulae basi tota adnatae decurrentes inter se liberae versus apicem pinnarum plus minusve confluentes, brevi omnes

[1] Fontaine, Mon. U. S. Geol. Surv., vol. xlviii, 1906, p. 167, pl. xliv, fig. 1.
[2] Brongn., Hist., Végét. Foss., 1828, p. 387, pl. cxxix, figs. 2, 3.

costa exorientes simplices furcatique divergentes, nervo medio nullo, nervulis mediis dense quandoque fasciculatis; fructificatio ignota."

The Potomac species are bi- or tripinnate with broadly linear-lanceolate pinnæ of thick texture, with entire or toothed margins. The botanical position of this genus has never been definitely settled. Saporta has called attention to its resemblance to the *Odontopteris* forms of the Paleozoic and to the Oolitic genus *Dichopteris* of Zigno. Schimper makes it the basis for his filicinean genus *Cycadopteris*. Nathorst proposed the term *Ctenozamites* for remains of this sort and Seward originally referred the English Oolitic material to *Ptilozamites*. While Fontaine regarded the Potomac species as ferns it seems very probable in view of the general habit of the fronds and in the absence of the fructification characters that they are fronds of cycadophytes and they are so considered in the present work. As has been repeatedly pointed out, the modern cycad genus *Bowenia* furnishes an analogy among recent cycads and when we recall the probable diversity of the Mesozoic cycadophytes and their close relationship with the ferns, and particularly their filiation with forms with the fern-like foliage of the Paleozoic Pteridospermatophytes, to which group at least some of the Odontopterids belong, there can be little objection raised to such a reference on the basis of frond characters.

The genus *Ctenopteris* is mainly Jurassic, originating as far as the present records show in the Lias, and being especially well developed in the Oolites. Besides the three Potomac species to which the writer has reduced the six species of Fontaine, Saporta has described a Neocomian species from the Portuguese rocks and Penhallow another from the Cretaceous of Vancouver Island. In addition we have the closely allied cycadaceous genus *Ctenidium* Heer with two species in the Neocomian and Cenomanian of Portugal.

The Potomac species, which in many respects suggest the genus *Zamiopsis* of Fontaine, are confined to the Patuxent and Arundel formations and are abundant in the older deposits at Fredericksburg, Virginia.

CTENOPTERIS INSIGNIS Fontaine

Ctenopteris insignis Font., 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 156, pl. lxi, figs. 4, 5; pl. lxii, fig. 1; pl. lxiii, figs. 1, 2.

Ctenopteris virginiensis Font., 1890, *Ibid.*, p. 157, pl. lxii, fig. 4; pl. lxv, fig. 1; pl. lxvi, fig. 4.

Ctenopteris minor Font., 1890, *Ibid.*, pl. lxvii, fig. 3.

Ctenopteris insignis Font., 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 521, pl. cxii, fig. 7.

Zamiopsis insignis Font., 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 525, pl. cxiii, figs. 4, 5.

Description.—"Frond large, arborescent, bipinnate or tripinnate; principal rachis very strong, striate; ultimate pinnæ with strong, rigid rachises, alternate, terminating in a lobed segment, the pinnules passing into lobes more or less united toward the ends of the ultimate pinnæ; pinnules thick and leathery, those of the lower and middle portions of the pinnae attached by the entire base, slightly decurrent, separate, cut away obliquely above, alternate to subopposite, gradually diminishing towards the summit of the pinnæ in size and depth of toothing, not sensibly narrowed at base, oblong-acute, curved slightly forward, terminating in a large ovate to subtriangular acute tooth. The pinnules usually show two acute or spinous teeth on each side, a couple near the base, and a second couple near or at the summit of the pinnule, the associated members of the couples being opposite or subopposite. Sometimes there is an additional tooth on the posterior margin below the upper one, and sometimes the terminal tooth is enlarged to an oblong lobe, which is slightly notched; nerves several, departing separately from the principal rachis along the entire width of the base of the pinnule, the outermost ones once forking and curving outwards, the inner ones forking deeply several times and slightly diverging flabellately, the ultimate branches nearly or quite parallel, long, and slender."—Fontaine, 1890.

The only satisfactory specimens of this plant come from Fredericksburg, where it is not uncommon, but usually rather indistinctly preserved. The additional occurrences are based on small fragments.

Considerable variability is shown among the various forms but not enough to warrant specific distinctions. The specimen named *Ctenopteris minor* by Fontaine is simply a small form of the type as the latter author suspected. The marginal toothing is quite a variable feature on a single specimen of any size, and the form named *Ctenopteris virginiensis* by Fontaine shows a variation in the venation in the direction of the genus *Scleropteris,* the veins being apparently aggregated into two bundles at their insertion on the rachis, although this feature is far from clear on the specimens, the coriaceous nature of the pinnules rendering the venation indistinct and quite unlike the diagrammatical figures of these forms which were originally published.

Occurrence.—Patuxent Formation. Fredericksburg, and near Potomac Run, Virginia. Arundel Formation. Langdon, District of Columbia.

Collection.—U. S. National Museum.

Ctenopteris angustifolia Fontaine

Ctenopteris angustifolia Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 159, pl. lxv, fig. 2; pl. lxvii, fig. 4.

Ctenopteris angustifolia Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 510.

Description.—"Frond unknown; ultimate pinnæ long, with rather stout rachises, pinnules linear or narrowly oblong, in proportion to width quite long, slightly curved forwards, separate to the base, or united to form a wing on the rachis of the pinnæ, cut away obliquely on the upper side at base, and slightly decurrent on the lower side, attached by the entire base, terminated by from one to three acute spinous teeth, and having a varying number of the same placed irregularly on both margins. The nerves proceed from the rachis at different points along the entire base of the pinnules; the outer ones simple or forking once, the central ones forking several times, the ultimate branches being long, slender, and slightly diverging."—Fontaine, 1890.

This species which is based upon infrequent and insufficient material may simply be a variant of the common *Ctenopteris insignis* from which it shows but minor differences.

Occurrence.—PATUXENT FORMATION. Near Potomac Run, Chinkapin Hollow (?), Virginia.

Collection.—U. S. National Museum.

CTENOPTERIS LONGIFOLIA Fontaine

Ctenopteris longifolia Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 159, pl. lxvii, fig. 5.

Description.—" Frond unknown; rachis of the ultimate pinnæ very broad, but not apparently very woody; pinnules placed very remotely, opposite, going off obliquely, very long, linear, narrowed gradually and slightly towards the base and slightly decurrent, tips not seen; nerves not well made out, but apparently several, departing independently from the rachis and forking near the base; the branches, so far as seen, simple, and nearly parallel."—Fontaine, 1890.

This species was based upon the single specimen figured, which is the only one ever discovered, hence little can be added to the foregoing diagnosis. It seems probable that it is simply a variant of one of the other species of *Ctenopteris* which occur in the same layers, as for example *Ctenopteris angustifolia*.

Occurrence.—PATUXENT FORMATION. Fredericksburg, Virginia.

Collection.—U. S. National Museum.

Genus ZAMIOPSIS Fontaine

[Mon. U. S. Geol. Surv., vol. xv, 1890, p. 160]

This genus was established by Fontaine for certain supposed fern-like remains from the older Potomac which were characterized as follows:

" Fronds large, bipinnate to tripinnatifid; leaf-substance leathery and thick, covered with a dense, durable epidermis; rachises strong, rigid, and keeled on the lower surface, often with ridges or raised margins on the upper surface; penultimate pinnæ very long, ultimate pinnæ or pinnules usually closely placed, narrowed to the base, mostly linear-lanceolate or oblong-lanceolate, the lower ones generally cut obliquely into pinnules which are denticulate, but pass above into denticulate or spinous teeth and terminate in two or more spinous teeth; nerves of the pinnules and lobes mostly composed of a midnerve which goes off very obliquely and curves strongly outwards, sending off obliquely and alternately lateral branches, which are forked or simple and curve upwards towards the summit of the segment; in the lobes and teeth the lateral nerves go off very obliquely and fork once or twice, having very long ultimate branches; nerves, although fine, very distinct."

These plants are closely related to the genus *Ctenopteris* and possibly they should be included in that genus. They differ in having the pinnæ narrowed at the base, correlated with which the vascular strands are usually gathered into a single vein. Although Professor Fontaine compared these forms with the cycads he decided that the fern-like characters predominated. In the present treatment they are referred to the cycadophytes. The latter on *a priori* grounds would be expected to have included forms with branched fronds and other fern-like characters such as are possessed by *Zamiopsis* and *Ctenopteris*. It may be noted also that this is the habit in the modern genus *Bowenia:* That the toothed pinnules not only are present in a number of modern cycad genera, but are especially well developed in *Encephalartos:* And that the venation characters are very like those of the recent cycad-genus *Stangeria.*

With a single doubtful exception the genus is confined to the Patuxent formation, and with but a single doubtful occurrence it is confined to the Virginia area.

Zamiopsis dentata (Fontaine)

Plate LVI, Figs. 1, 2

Scleropteris dentata Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 153, pl. lxiii, figs. 3, 4.

Zamiopsis pinnatifida Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 161, pl. lxi, fig. 7; pl. lxii, fig. 5; pl. lxiv, fig. 2; pl. lxvii, fig. 2.

Zamiopsis insignis Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 162, pl. lxii, fig. 3; pl. lxiv, figs. 1, 3; pl. lxv, figs. 4-6; pl. lxvi, fig. 2; pl. lxvii, fig. 7.

Zamiopsis longipennis Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 164, pl. lxi, fig. 8.

Zamiopsis insignis Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 511 (?), 517 (non p. 525, pl. cxiii, figs. 4, 5, which is referred to *Ctenopteris dentata*).

Description.—Frond large, bipinnate or tripinnate, with keeled rachises. Pinnules ovate-lanceolate or somewhat falcate in outline, variously toothed or pinnatifid, depending upon their position on the frond, narrowed basally. The proximal ones are more or less pinnatifid, at times being merely toothed, again the basal divisions may be long and narrow, suggesting *Zamiopsis laciniata.* Ascending the frond the pinnules are less and less prominently toothed until they are of the type named by Professor Fontaine *Zamiopsis longipennis.* The ultimate form is that shown in some of the fragments which were named *Scleropteria dentata.* The character of the margin is very variable, all the above features being shown on a single frond. The midvein of the pinnules is very stout below, thinning rapidly and finally lost in repeated branching toward the apex. The laterals are long and slender, branching from the midrib at a very acute angle and after ascending, curving outward, giving off one or more branches at a small angle, all being approximately parallel to the margin. The texture is very coriaceous and the venation is not prominent.

No new material of this species at all comparable in extent with the type material has been collected in recent years and the latter is not well preserved at the present time because of its weathering. There are no adequate grounds for maintaining the several forms which the writer has combined to form this species, in fact their author suggested that his species *longipennis* might be an ultimate pinnule of *insignis* and that his species *pinnatifida* might also be a variety of this species, which is un-undoubtedly the case.

There is some question about the exact horizon as well as the identity of the specimens from Chinkapin Hollow referred to this species by Professor Fontaine in 1906. Most of the species from Chinkapin

Hollow appear to be Patapsco forms and it is possible that *Zamiopsis insignis* may have continued after the close of the Patuxent.

One feature worthy of comment is the venation. The laterals are not gathered together in systems with a main trunk to each segment of the pinnule as previously described and figured, but they branch more uniformly and fork less frequently and pursue approximately parallel courses, suggesting greatly the venation of the modern cycad-genus *Stangeria.*

Occurrence.—Patuxent Formation. Fredericksburg, Chinkapin Hollow (?), Virginia; New Reservoir (?), District of Columbia.

Collection.—U. S. National Museum.

Zamiopsis petiolata Fontaine

Zamiopsis petiolata Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 166, pl. lxvi, fig. 3.

Description.—" Frond bipinnate or tripinnate, principal rachis with a strong wing; primary pinna terminating abruptly in a large incised pinnule similar to those lower down; pinnules petiolate, attached by the midnerve, prolonged into a stout petiole, alternate, cut obliquely into oblong or subelliptical obtuse pinnules, in the lower part of the ultimate pinnae turned outwards. These graduate in the upper parts of the same into lobes and teeth of the same general character. The summit of the ultimate pinna is a broad oblong segment, ending in several shallow subacute teeth formed by the union of the lobes at the summit; the ultimate pinnæ in passing towards the summit of the penultimate ones diminish much in size, the pinnules and lobes passing finally into teeth; lateral nerves in each pinnule and lobe consisting of a nerve-bundle which goes off very obliquely from a point near the lower end of the pinnule or lobe, branching near the insertion, and curving out to enter the pinnule or lobe, the branches forking again once or twice, with the ultimate nerves very long and slender, owing to their deep forking." —Fontaine, 1890.

This rare plant represents a development of the *Zamiopsis dentata* type in the direction of greater subdivision of the pinnæ and the formation of a petiole. It is very doubtfully distinct from that type, with which it is also associated. It is not at all certain that the winged rachis is not a feature due to compression during fossilization.

Occurrence.—Patuxent Formation. Fredericksburg, Virginia.

Collection.—U. S. National Museum.

Zamiopsis laciniata Fontaine

Zamiopsis laciniata Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 164, pl. lxvi, figs. 1, 5-8.

Description.—"Frond very large and wide-spreading, probably arborescent; ultimate pinnæ alternate, the lower ones very long, rapidly diminishing in length and size in ascending towards the summit of the principal pinnæ, having a distinctly winged rachis, and terminating in a variously shaped segment formed of united pinnules or lobes, usually three in number; pinnules very variable in size and shape, mostly long, ribbon-shaped, slightly narrowed to the base and attached by the entire base, decurrent, and united to form a wing, cut very obliquely into a few lobes of varying depth, which are elongate-oblong or narrowly ovate in shape, and nearly always placed on the posterior margin of the pinnule. The lobes toward the summit of the pinnules pass sometimes into acute triangular teeth, which are turned outwards. The pinnules at the summit of the ultimate pinnæ pass into more or less united lobes, which vary a good deal in shape, being somewhat much narrowed and even wedge-shaped at base, and incised into a varying number of irregularly shaped teeth; nerves of the pinnules departing from a short mother nerve at the base of the pinnules, forming three branches, these diverging slightly in a flabellate manner; branches very long, slender, but distinct, outer branches simple or once or twice forked, the inner one forking several times and approaching the character of a midnerve; leaf-substance thick and leathery."—Fontaine, 1890.

This plant is of rare occurrence and combines the features of the genera *Ctenopteris* Saporta, *Ctenidium* Heer, and *Scleropteris* Saporta. It also suggests the latter author's genus *Stenopteris*. It is confined to the lowermost Potomac in the Virginia area and has not been discovered in Maryland.

The existing genus *Bowenia* has analogously divided fronds, while a number ef existing species of *Encephalartos* have similarly toothed pinnules.

Occurrence.—Patuxent Formation. Fredericksburg, Virginia.

Collection.—U. S. National Museum.

Genus NILSONIA Brongniart

[Ann. Sci. Nat., tome iv, 1825, p. 218]

This genus was founded by Brongniart for certain remains from the Rhætic of Sweden which had been recorded and figured by Nilsson in 1820 who regarded them as fern remains. In the Prodrome the diagnosis is as follows:

"Feuilles pinnées; pinnules rapprochées, oblongues, plus ou moins alongées, arrondies au sommet, adhérentes au rachis par toute la largeur de leur base, à nervures parallèles, dont quelques-unes sont beaucoup plus marquées." [1]

The genus was regarded by Brongniart as referable to the Cycadales, a view generally accepted by subsequent workers, although Schenk[2] in 1867, on the basis of supposed sori on some german specimens, referred it to the Filicales, in which he was at first followed by Schimper[3] and more recently by Solms-Laubach.[4]

The genus has also been ably discussed by Saporta, Nathorst, Seward, and others, Nathorst in particular having shown that the two kinds of veins supposed to occur together were due to slight folds in the lamina due to pressure, maceration, or the creep of the enclosing strata. He characterizes the veins as equal and simple, and emphasizes the insertion of the lamina on the upper surface of the rachis, suggesting that Schenk's supposed sori are fungal or stomatal in their nature.[5]

[1] Brongniart, Prodrome, 1828, p. 95.

[2] Schenk, Die fossile Flora Grenzschichten Keupers u. Lias Frankens, 1867, p. 124.

[3] Schimper, Pal. Végét., tome i, 1869, p. 488.

[4] Solms-Laubach, Fossil, Botany, 1891, p. 139.

[5] See Nathorst, Ueber die gattung Nilssonia Brongn., Kongl. Svenska Vet. Akad. Handl., Band xliii, 1909, No. 12.

The genus may be redefined in the following terms: Frond coriaceous, elongate-lanceolate in outline, entire or commonly more or less deeply pinnatifid by being split, usually to the rachis, into a number of more or less irregular segments which are contiguous, usually broad and truncate. Lamina attached to the upper surface of the rachis, the simple and parallel, equal, lateral veins running almost or quite to the median line. In material showing only the under surface of the fronds, the stout midrib is prominent and unsegmented specimens are scarcely distinguishable from *Tæniopteris* and allied forms, while the segmented varieties approach *Anomozamites* or even some species of *Pterophyllum* in appearance.

The genus *Nilsonia* appears in the Triassic and is particularly a Rhætic and Oolitic type. A number of undoubted species occur, however, in the Lower Cretaceous, no less than seven different species having been recorded from the Lakota, Kootanie, and Shasta deposits. The Neocomian of Japan furnishes two or three species, while the widespread *Nilsonia schaumburgensis* (Dunker) Nathorst, occurs very abundantly at a number of European Wealden localities. The Upper Cretaceous shows a species in the Atane beds of Greenland and one in the Cenomanian of Bohemia, while several supposed species have been recorded from Tertiary strata.

There are two species in the Potomac Group, a lanceolate unsegmented form variously described by Fontaine as *Angiopteridium* and *Sapindopsis* and the large and elegant form which this author describes as two species of *Platypterygium*. The latter term was proposed by Schimper, in 1880, as a subgenus of *Anomozamites* for very large forms of that type. It was subsequently used as a genus by Feistmantel and Fontaine, although this usage seems unwarranted, especially since the *Platypterygium* forms of *Anomozamites* are all confined to much older horizons, and the Potomac forms agree in all essential characters with *Nilsonia,* a relationship suggested by Seward, in 1900, ofter examining the material in the U. S. National Museum. As illustrated by Fontaine, the rachis is represented as very wide and the opposite segments are far apart. That the midrib was not wide and flat in life, but prominent below and not out of proportion to the size of the fronds is shown by a most casual examination of the considerably macerated and much flattened specimens, and is clearly indicated by the specimens photographically reproduced on the accompanying plates.

In collections from the Cretaceous of Japan, Stopes has been fortunate enough to obtain petrified material of the leaves of *Nilsonia orientalis* Heer which is described at length.[1] This species is one of the Tæniopteris-like species, Seward in his Wealden flora[2] having suggested that it was a *Tæniopteris*, and Nathorst[3] having proposed that the closely allied *Nilsonia tenuinervis* Nathorst would have its botanical affinity more clearly indicated by the name *Nilsoniopteris.*

It is interesting, therefore, to find that the internal anatomy of *Nilsonia orientalis* Heer is clearly gymnospermous rather than fern-like and exactly of the type which might be regarded as primitively cycadean.

NILSONIA OREGONENSIS (Fontaine) Berry

Angiopteridium strictinerve Fontaine, 1906, in Ward, Mon. U. S. Geol. Survey, vol. xlviii, 1905, pp. 240, 511, pl. lxvi, figs. 5-7; pl. cx, fig. 12 (non Font., 1890).

Sapindopsis oregonensis Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 268, pl. lxix, figs. 15-17.

Nilsonia oregonensis Berry, 1910, Proc. U. S. Natl. Mus., vol. xxxviii, p. 637.

Description.—Frond simple, unsegmented in all the specimens collected, lanceolate in outline, with equally pointed apex and base. Length apparently about 7 cm. to 15 cm. and greatest width, which is midway between the apex and the base, 1.2 cm. to 1.6 cm. Texture coriaceous. Rachis stout, prominent below. Lateral veins close and parallel, the great majority simple but an occasional vein forking dichotomously. Angle of divergence large, varying from 55° in the apical part of the frond to 85° in the median and basal portions.

[1] Stopes, Ann. of Botany, vol. xxiv, 1910, pp. 389-393, tf. 1, pl. xxvi.
[2] Seward, Wealden Fl., pt. i, 1894, p. 123.
[3] Nathorst, Kungl. Svenska Vetens Akad. Handl., Band xliii, 1909, p. 29.

This species is based upon considerable incomplete material from widely separated localities which afforded the basis for two different species of Fontaine, but which seem to be identical and markedly different from the types to which they were referred. The forms referred to *Angiopteridium strictinerve* are from Virginia and California while those described as a new species of *Sapindopsis,* which genus they do not resemble in the remotest degree, are from California. The former are quite different from the type of that species, being smaller and less elongate, with closer, mostly simple veins, and with the rachis prominent below and masked above by the lamina of the frond. The latter correspond with the others in outline and venation, differing in outline, venation, and in the character of the rachis from *Sapindopsis.*

The present species, which is confined to the Potomac Group and the Shasta of California, where it occurs in both the Knoxville and the Horsetown beds, is suggestive of the species from the Neocomian of Japan which Yokoyama[1] identifies as *Nilsonia Johnstrupi* Heer. It may also be compared with the rather widespread Wealden species *Nilsonia schaumburgensis* (Dunker) Nathorst, which has also been recorded from Japan and from the Kootanie of Montana.

Occurrence.—PATUXENT FORMATION (?). Chinkapin Hollow, Virginia.

Collection.—U. S. National Museum.

NILSONIA DENSINERVE (Fontaine) Berry

Plates LVII, LVIII

Platypterigium densinerve Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 169, pl. xxx, fig. 8; pl. xxxi, figs. 1-4; pl. xxxii, figs. 1, 2; pl. xxxiii, fig. 1; pl. xxxiv, fig. 1; pl. xxxv, figs. 1, 2.

Platypterigium Rogersianum Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 171, pl. xxxi, fig. 2; pl. xxxiii, fig. 2; pl. xxxiv, fig. 2.

Platypterygium densinerve Fontaine, 1906, in Ward, Mon. U. S. Geol. Survey, vol. xlviii, 1905, p. 521, pl. cxii, fig. 8.

Nilsonia densinerve Berry, 1910, Proc. U. S. Natl. Mus., vol. xxxviii, p. 638.

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[1] Yokoyama, Jour. Imp. Coll. Sci., Japan, vol. vii, 1895, p. 226, pl. xxv, figs. 1-4.

Description.---Fronds large, upwards of 50 cm. to 70 cm. in length by 15 cm. to 18 cm. in greatest width, averaging about 12 cm., either entire or more often irregularly divided into rectangular or subrhombic segments, at times somewhat rounded basally. Texture coriaceous. Rachis stout, prominent below, more or less flattened during fossilization. Laterals of small calibre, close, ½ to 1 mm. apart, parallel, invariably simple and nearly straight, diverging at an angle in the neighborhood of 90°.

This splendid species, presumably because of its large size, is represented only by fragmentary specimens, both the apex and the base being missing. It is not at all common and is confined entirely to the Patuxent and Arundel formations in the Maryland-Virginia area. The specimens show some individual variations in the degree of segmentation, and

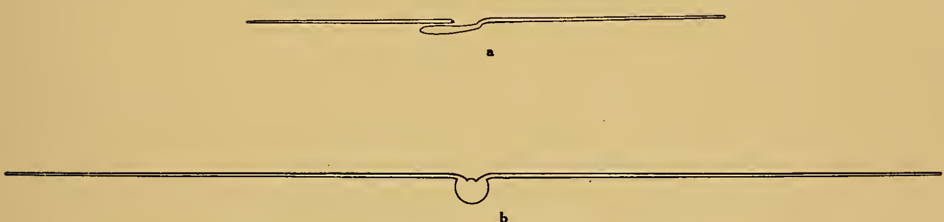

FIG. 11.—Cross-sections of fronds of Nilsonia densinerve. a—showing method of fossilization of specimen shown on pl. lvii, fig. 1, natural size. b—Diagrammatic cross-section of specimen shown on pl. lviii, fig. 1, natural size.

strength and position of the lateral veins, the forms which served as a basis for *Platypterygium Rogersianum* of Fontaine being more robust but somewhat smaller than the others with veins somewhat larger in size and less closely placed, but the limits of variation are, nevertheless, quite restricted.

There can be but little doubt of their all belonging to a single species. The accompanying plates, which illustrate in an admirable manner the variation in appearance and manner of preservation of these fronds, are photographs of three of Fontaine's figured specimens, which ones it will rest with the reader to discover among the figures cited (supra), the writer being wholly unable to determine. At first glance, the rachis appears to have been wide and ribbon-like, but this was not the case. The segments are inserted on the upper surface of the rachis in conformity with the generic diagnosis, and in one of the larger specimens (an impression on the reverse side of the specimen shown on pl. lvii), the lateral veins of opposite sides approach to within 1 mm. of each other, being separated by a slightly raised ridge. Below it is seen that the rachis is flattened, and during or since fossilization, small fragments of the inner margin of the segments overlying the rachis have flaked off, exposing more or less of the broadly flattened rachis below as is well shown on pl. lviii. Fig. 1 shows a diagrammatical cross-section of this frond.

In pl. lvii, fig. 2, the appearance is somewhat different, due entirely to the process of fossilization. The right hand segments are in place, attached to the upper raised line of the rachis, which during fossilization, possibly by the creep of the strata before lithification, was laid over toward the left and flattened, the left hand segments being detached and superimposed upon the flattened rachis. Text-fig. 11a is a diagrammatical cross-section across the base of this specimen.

Remains very suggestive of this species, but in a more fragmentary condition, have been described by Nathorst from an unknown, probably Neocomian, locality in Japan as *Macrotæniopteris* (?) *marginata*.[1]

Occurrence.—PATUXENT FORMATION. Fredericksburg, Virginia. ARUNDEL FORMATION. Langdon, District of Columbia.

Collection.—U. S. National Museum.

DICHOTOZAMITES gen. nov.

Fronds dichotomously compound. Rachis relatively slender, keeled. Pinnules slender, linear, acuminate, ascending, with a markedly decurrent base, attached laterally, alternate to opposite. Margins simple tending to be slightly inrolled dorsally. Venation consisting of a single midvein to each pinnule, prominent below and slightly sunken above,

[1] Nathorst, Beitr. z. Mesozoischen Fl. Japans, Denks. k. Akad. Wiss. Wien, Band lvii, 1890, p. 54, pl. vi, figs. 6, 6a.

which gives off at nearly right angles rather remote, short, simple secondary veins, which run direct to the margin.

This genus is based on the forms which Professor Fontaine referred to *Sequoia* and which he compared with *Cycadites* and certain existing species of *Podocarpus* as well as with the Triassic *Taxites falcatus* of Nathorst.

The distichous phyllotaxy is decidedly against the reference of these forms to the Coniferales, for while many conifers have a distichous habit the phyllotaxy is cyclic or spiral. The attachment of the pinnules is also against a reference to the Coniferales, as is also the venation. The dichotomous frond-habit, while wanting in modern cycads, is in a measure paralleled by the bipinnate fronds of *Bowenia* and by numerous bipinnate Mesozoic cycadophytes. Finally in a group derived from the Paleozoic pteridosperms, the majority of which had highly decompound fronds, some of which like *Odontopteris*, which is probably a member of this phylum, had a dichotomous habit (cf. *Odontopteris minor* Brongniart), it would be more than anomalous if all of the Mesozoic forms had the foliar characters of the modern cycads and none retained any of the foliar characters of their Paleozoic ancestors.

Dichotozamites cycadopsis (Fontaine)

Plate LXXVII, Figs. 2, 3

Sequoia cycadopsis Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 243, pl. cxii, figs. 9-11; pl. cxiii, figs. 1-3.

Sequoia cycadopsis Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 489, 533, pl. cix, fig. 11.

Description.—Frond dichotomously compound with a slender keeled rachis. Pinnules slender, linear, acuminate, markedly decurrent, slightly curved. They are attached to the rachis laterally and are ascending, subtending an angle of about 22°. Length variable, averaging about 3 cm. The length and angle vary with the position on the frond and the arrangement is rather open and varies from alternate to opposite.

Each pinnule has a midvein which is prominent below and sunken above. Secondaries branch from it at an angle of nearly 90°, and are rather remote, parallel, straight, and simple, running directly to the margin. The latter is entire and often slightly revolute giving the pinnules an acicular appearance. As preserved they range from 0.5 mm. to 1.75 mm. in width. The texture is coriaceous and the habit is strict and rigid.

This plant while not common is far from rare in the Patapsco formation to which it appears to be confined.[1] It is quite different from any fossil or recent plant known to the writer. It resembles somewhat the Jurassic *Stenopteris desmomera* Saporta[2] in form but it is decidedly different in venation. Superficial resemblances to various other described fossils might be pointed out, but they would be of slight value or interest.

Occurrence.—PATAPSCO FORMATION. Mt. Vernon, near Brooke, Virginia; Ft. Foote, Maryland.

Collection.—U. S. National Museum.

Genus CYCADEOSPERMUM Saporta

[Pl. Jurass., tome ii, 1875, p. 235]

This genus was founded by Saporta, in 1875, for the reception of certain Jurassic seeds or ovules believed to be those of cycads, the type species being *Cycadinocarpus hettangiensis* Schimper from the infra Lias of Hettange. It received the following characterization: "Semina e carpophyllis distracta post maturationem in strata pervagata nunc majora nunc plus minusve parvula, plerumque ovata ovatoque-oblonga haud raro compressione mutua angulosa extus lævia vel longitudinaliter striata costataque, basi semper rotundiore insertionis cicatrice notata apice autem plus minusve attenuata."

Three other species were described at the same time, embracing forms previously named *Cycadocarpus* by Saporta, *Carpolithes* by Schenk, and *Ulospermum* by Pomel.

[1] Through the kindness of Dr. Arthur Hollick I learn that this or a closely allied form is present in his Cretaceous material from Alaska.

[2] Saporta, Plantes jurassique, tome i, 1873, p. 292, Atlas, pl. xxxii, figs. 1, 2; pl. xxxiii, fig. 1.

When Professor Fontaine came to work up the Potomac flora he founded six new species of *Cycadeospermum* upon rather obscure remains of fruits or seeds from various localities in Virginia, and additional remains of a similar character have since been described by the same author from the Shasta formation of California, the Kootanie formation of Montana, the Triassic of Pennsylvania, and the Jurassic of Oregon. In the flora of the Dakota Group, Professor Lesquereux referred two additional species of rather doubtful value to this genus which has come to be looked upon as a convenient form-genus for the reception of fruits or seeds which suggest a cycadean affinity, but about which no certainty can exist, since they have thus far failed to show internal structure and are all found detached, although at times associated in the same deposits with cycad-like fronds, as is the case with the Potomac species which follow.

CYCADEOSPERMUM MARYLANDICUM sp. nov.

Plate LXXVII, Fig. 8

Description.—Fruits of medium size, 14 mm. to 15 mm. in length, 8 mm. to 9 mm. in width, and from 5 mm. to 6 mm. in thickness, ovate in outline, chalazal end broadly rounded, almost truncate, sides but slightly curved, approaching each other toward the micropylar end, which is not preserved in its entirety. Surface hard and shiny with faint longitudinal striæ especially toward the upper end. Sides with a trace of different tissue, apparently the remains of the outer slightly fleshy layer of the integument, which is also the cause of the striæ upon the surface of the testa.

This species is based upon a single rather well preserved specimen which comes from the blue charcoal clay of Coffins' Bank at Muirkirk. It is the most cycad-like of any of the fruits referred to this genus and is almost certainly the fruit of some one of the Maryland Potomac cycads. The entire outer integument was slightly fleshy and the inner one stony as in the modern members of this group. If the fossil be compared with well-dried seeds of a modern *Zamia* the resemblance is found to be very close.

Occurrence.—ARUNDEL FORMATION. Muirkirk, Prince George's County.

Collection.—U. S. National Museum.

CYCADEOSPERMUM OBOVATUM Fontaine

Cycadeospermum obovatum Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 270, pl. cxxxv, fig. 13.

Cycadeospermum obovatum Fontaine, 1906, in Ward, *Ibid.*, vol. xlviii, pp. 485, 520, 528, 545, pl. cvii, fig. 5.

Description.—Medium sized ovate-spatulate seed-like objects, 10 mm. to 12 mm. in length, by 6 mm. to 9 mm. in greatest width which is toward the obtusely rounded end; the opposite end is reduced to a narrow pointed neck. Surface smooth and shining, hard.

This species, which was based upon the specimens from near Potomac Run, Virginia, has been found at a number of additional localities in Virginia and Maryland. Its reference to this genus is of doubtful propriety and it is quite suggestive of the seeds of various modern members of the Taxaceæ, so that the inference is raised whether it might not be related to *Cephalotaxopsis* or *Nageiopsis* of the Potomac flora.

Occurrence.—ARUNDEL FORMATION. Langdon, District of Columbia; German's Iron Mine (?), Maryland. PATAPSCO FORMATION. Fort Foote, Maryland.

Collection.—U. S. National Museum.

CYCADEOSPERMUM ACUTUM Fontaine

Cycadeospermum acutum Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 270, pl. cxxxv, fig. 12.

Cycadeospermum acutum Fontaine, 1906, in Ward, *Ibid.*, vol. xlviii, 1905, pp. 480, 535.

Description.—Seed small, oval, obtusely rounded at one end and markedly acute at the other, about 7 mm. in length by 6 mm. in greatest breadth. Surface smooth and firm.

This species was based upon rare specimens from near Potomac Run, Virginia, and a single specimen was afterward recorded from Alum Rock in that State. The Maryland occurrence is based upon Fontaine's record of a single doubtful specimen, which the writer has been unable to find. The species is of doubtful value at best, and is included in the Maryland flora with some hesitation and for the sake of completeness.

Occurrence.—Patuxent Formation. Potomac Run, Alum Rock, Virginia. Arundel Formation. Muirkirk (?), Maryland.

Collection.—U. S. National Museum.

Cycadeospermum rotundatum Fontaine

Cycadeospermum rotundatum Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 271, pl. cxxxvi, fig. 12.

Cycadeospermum rotundatum Fontaine, 1893, Proc. U. S. Nat. Museum, vol. xvi, p. 279, pl. xliii, fig. 6.

Cycadeospermum rotundatum Fontaine, 1899, in Ward, 19th Ann. Rept. U. S. Geol. Survey, pt. ii, p. 667, pl. clxii, fig. 19.

Cycadeospermum rotundatum Fontaine, 1906, in Ward, Mon. U. S. Geol. Survey, vol. xlviii, 1905, pp. 280, 537.

Description.—Small, nearly orbicular nut-like seeds, about 7 mm. in diameter. Surface smooth and hard.

This species was based originally upon a single specimen found at Kankeys, Virginia, and afterward identified by the original describer from the Glen Rose beds of Texas and from the Oak Creek shales of the Black Hills, which now form a part of Darton's Fuson formation. It is also doubtfully recorded from the Kootanie formation at Great Falls, Montana.

While these widely removed remains are from nearly the same geological horizon and are identical in appearance, little certainty can be felt as to their actual identity and this for the reason that spherical seed-like remains, which it would be difficult to distinguish from this species, occur at a great variety of geological horizons and might appertain to plants of widely differing botanical affinities.

Occurrence.—Patuxent Formation. Kankeys, Virginia. Arundel Formation. Contee, Maryland.

Collection.—U. S. National Museum.

CYCADEOSPERMUM SPATULATUM Fontaine

Cycadeospermum spatulatum Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 271, pl. cxxxv, figs. 11, 21.
Cycadeospermum ellipticum Fontaine, 1890, *Ibid.*, fig. 19.
Cycadeospermum ellipticum Fontaine, 1906, in Ward, Mon. U. S. Geol. Survey, vol. xlviii, 1905, p. 520.

Description.—Seeds of considerable size, 15 mm. to 17 mm. in length by 12 mm. to 13 mm. in longest lateral diameter, nearly orbicular in outline, sometimes slightly truncated at one end and bluntly pointed at the other. Surface smooth and glossy. Apparently of a firm and durable consistency.

This species is based on a number of specimens from near Dutch Gap Canal on the James River, Virginia, and upon rare occurrences of similar objects at Fredericksburg, and near Potomac Run, in the same State, and two specimens from Langdon, in the District of Columbia.

Occurrence.—PATUXENT FORMATION. Fredericksburg, Dutch Gap, Potomac Run, Virginia. ARUNDEL FORMATION. Langdon, District of Columbia.

Collection.—U. S. National Museum.

CLASS GYMNOSPERMAE

Order GINKGOALES

Family GINKGOACEAE

Genus BAIERA Fr Braun

[Flora, Neue Reihe, Jahrg. 24, 1841, p. 33]

This genus was defined by Braun as follows: "Venæ primariæ frondis pluries dichotomæ; venæ secundaria ac venulæ in areas hexagonales elongatas irregulariter confluentes; Sporocarpia capsulæformia, ovalia pedunculata, ternata vel biternata." (1843, p. 20.)

The type was *Baiera dichotoma* from the Rhætic of Strullendorf, Bavaria. In Braun's contribution to Münsters Beiträge zur Petrefactenkunde, which is often cited as the original place of publication, as for example in Seward's Jurassic Flora, five species are referred to this genus, one other being from the Rhætic, and the balance from somewhat later, Jurassic horizons. Braun considered these forms referable to the ferns and compares them with the Marsiliaceæ. In this he was followed by Schimper (1869); and Schenk (1871), who include them in the family Neuropteridæ. Both authors, however, subsequently placed the genus in the Gymnospermæ (In Zittel's Handbuch, 1890), where they are commonly considered to belong at the present time as members of the order Ginkgoales (Pontonié, 1889, Saporta, 1879, Solms-Laubach, 1891, Zeiller, 1900, etc.). Certainly the sporophylls and fruits described by Schenk, Heer and Leuthardt, in some of the older Mesozoic forms are conclusive evidence of their gymnospermous nature, especially when considered in connection with the multipartite and undoubted true Ginkgoes of the later Jurassic and the well-known tendency of the leaves of the modern *Ginkgo* in localized situations (seedlings, shoots, and grafts), to revert to a very Baiera-like form.

Seward[1] states that it is not improbable that some of the species of *Baiera* are best compared with certain recent ferns such as *Actinopteris radiata* Link and *Schizæa dichotoma* Sw., or *Schizæa elegans* Sw., and in this connection (Wealden Fl., pt. ii, 1895, p. 5, pl. xiii, figs. 1, 2), he points out the considerable resemblance to *Baiera* shown by the fronds of *Macrozamia heteromera* Moore var. *Narrabri* and var. *glauca*, Australian cycads with peculiar repeatedly forked pinnæ. It is believed that such resemblances are purely fortuitous and in no way discredit the evidence furnished by fossil foliage, although it is not overlooked that some of the species referred to *Baiera* may not be related to those forms of *Baiera* whose botanical relations have been demonstrated. In all the species the leaves are repeatedly and dichotomously inciso-partite and are distinguished from *Ginkgo* by the shortness of the petiole, and by the greatly elongated and narrow linear segments in the ultimate divisions of which there is no further forking of the veins. In habit, the leaves appear to have been borne in tufts at or near the summit of short axillary branches, much as in the modern *Ginkgo,* but this habit

[1] Jurassic Fl., pt. i, 1900, p. 262.

has not been demonstrated for but a few of the fossil species of either *Baiera* or *Ginkgo.*

The staminate sporophylls are in lax strobili not very different from those of the modern *Ginkgo,* the micro-sporophylls are stalked and expand distally into from three to twelve sporangia which open by longitudinal slits. In Schenk's figures of *Baiera Münsteriana* Heer the sporangia are in clusters of six or seven, while in the excellent examples of *Baiera furcata* Heer figured by Leuthardt (1903), they are three or four in number, exactly as is sometimes the case in the modern Ginkgo.[1] The megasporangia (carpels) in *Baiera* were apparently always more than two in number (the usual number in *Ginkgo*[2]), and were borne on short branching stalks. It is worthy of mention in this connection, that some of the older Potomac forms described as species of *Carpolithus,* eg. *C. fasciculatus* Font., *C. ternatus* Font., *C. virginiensis* Font., etc., are possibly *Baiera* carpels.

The genus appears in the Permian of both Europe and America, and continues after the close of the Lower Cretaceous (Raritan formation of New Jersey, Atane beds of Greenland). It is very abundant in the Rhætic beds and continues to be a prominent element in Mesozoic floras throughout the Jurassic and well into the Lower Cretaceous, occurring most abundantly, perhaps, in the Jurassic.

BAIERA FOLIOSA Fontaine

Plate LIX

Baiera foliosa Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 213, pl. xciv, fig. 13.

Description.—" Leaves numerous, grouped in bundles or tufts at the summit of short, stout, annual growths, having their basal portions long, slender, and gradually narrowing into a pedicel; their upper por-

[1] Coulter records as many as three or four sporangia in occasional modern Ginkgo sporophylls although normally the sporangia are two in number. Morph. of Spermatophytes, vol. i, 1901, p. 38.

[2] Both Strasburger, Fujii, and Seward and Gowan record instances in which these shoots in the modern Ginkgo bear several ovules.

tions dichotomously divided into a small number of strap-shaped laciniæ, the ultimate ones being a little over 1 mm. wide; nerves slender, forking at long intervals, with branches parallel. This plant, evidently a true *Baiera,* is very rare, the specimens, few in number, being, with the exception of the one figured, found in small fragments. The leaves at the summit of the short twigs seem to have been very numerous and more slender than in the Jurassic Baieras."—Fontaine, 1890.

A single additional specimen, which in some respects is more complete than any of the earlier ones of this species, was collected some years ago by Mr. Bibbins, from the locality known as Sailors' Tavern on the James River. It shows a flattened shoot 3 cm. long, very thin proximad and gradually thickening to the rounded apex. As preserved in a much shrunken condition the apical portion of the twig is 8 mm. in the transverse diameter by about 3 mm. in thickness so that in life it could hardly have been less than 5 mm. in diameter. The leaves are arranged in a low spiral, each one inserted separately on a rounded subrhomboidal boss placed about 2 mm. apart. These bosses are more or less obliterated in the basal 11 mm. of the shoot. The leaves are thick and are covered with an epidermis of thick-walled cells. The petiole is lenticular in cross section, 1.5 mm. wide, appearing as flat on the impressions. It is 5 to 10 mm. in length to the height of the first subdivision. At this point the leaf splits into two or three major divisions which soon subdivide into slender, elongated segments, which are only about 0.5 mm. in diameter. Owing to the fragmentary nature of these ultimate segments their length cannot be determined. It is quite clear, however, that the present species is an undoubted gymnosperm and not a fern.

This species in its slender, graceful form, is very suggestive of the widespread *Baiera furcata* (L. & H.) F. Braun of the Jurassic. It resembles the ginkgoes in having the leaves borne on short shoots, but in the present species the leaves were not deciduous as they are in the modern *Ginkgo,* but were retained for several years as the specimen clearly indicates.

With the exception of its much smaller size the present species is very close to the Lakota leaves which Fontaine[1] identified as *Czekanowskia nervosa* Heer.[2] The latter are certainly referable to *Baiera* and not to *Czekanowskia* as are Heer's type specimens in all probability. The Potomac species may also be compared with the two small-leafed species described by Nathorst, from the lowermost Cretaceous or late Jurassic of Advent Bay, Spitzbergen, as *Baiera spetsbergensis*,[3] and *Baiera graminea*.[4] The method of arrangement of the leaves is unknown in these Arctic species, and their apparent resemblance to the Potomac species may be confined to the size and outline of the leaves.

It may also be compared with *Baiera Brauniana* (Dunker) Brongniart described by Dunker[5] from the Wealden of Germany as a *Jeanpaulia* and referred to *Baiera* by Brongniart.[6] This species is slightly larger than the Potomac species but it is otherwise very similar. It has been recently identified by Seward[7] from the Jurassic of northeastern Scotland, but it may be questioned whether the latter should not rather be compared with some of the described Jurassic species.

Occurrence.—PATUXENT FORMATION. Near Dutch Gap Canal and Sailors' Tavern, Virginia.

Collections.—U. S. National Museum, Johns Hopkins University.

Order CONIFERALES

Family TAXACEAE

Subfamily TAXEAE

Genus CEPHALOTAXOPSIS Fontaine

[Mon. U. S. Geol. Survey, vol. xv, 1890, p. 235]

The utility of a new generic designation for the Potomac forms included in this genus, is not altogether obvious with *Cephalotaxites* and

[1] Fontaine, in Ward, 19th Ann. Rept. U. S. Geol. Surv., pt. ii, 1899, p. 685, pl. clxix, figs. 1, 2.

[2] Heer, Cont. Fl. Foss., Portugal, 1881, p. 18, pl. xvii, figs. 5-8, 10, 11.

[3] Nathorst, Zur Mesozoische Flora Spitzbergens, Kgl. Svenska Vetens.-Akad. Handl., Band xxx, No. 1, 1897, p. 53, pl. iii, figs. 6-12.

[4] Nathorst, *Ibid.*, p. 54, pl. iii, fig. 13.

[5] Dunker, Monogr. Norddeutsch Wealdbild., 1846, p. 11, pl. v, figs. 2, 4.

[6] Brongniart, Tableau, 1849, p. 107.

[7] Seward, Trans. Roy. Soc. Edinb., vol. xlvii, pt. iv, 1911, p. 680, tf. 9b.

Taxites already in use, but as it is in the literature and differentiates an abundant type which is at least specifically distinct from the species usually referred to the two genera just mentioned, it is retained in the present publication. It may be characterized as follows:

Much branched stout limbs, apparently in a single plane, although it is impossible to determine to what extent this is due to pressure during fossilization. Leaves flat, linear-lanceolate, coriaceous and persistent, rather variable in size, mucronate tipped; base slightly decurrent and twisted; midrib broad and flat, bordered on either side below by a stomatal groove. The leaves are distichous in habit but the phyllotaxy was undoubtedly spiral as it is in so many other gymnosperms with the distichous habit, and is attested by the twisted leaf bases. No fruits have been found upon any of the abundant foliage specimens although certain associated species of *Carpolithus*[1] are mentioned by Professor Fontaine as the probable fruits of this genus, which are assumed to have been drupe-like with a bony seed after the manner of the existing species of *Podocarpus* and *Cephalotaxus*. This may well have been the case, the fact that no fruiting specimens occur in the abundant sterile material lends some support to this interpretation, since such fruits would stand far less chance of successful transportation by water and subsequent fossilization, than would the woody, buoyant cones of the majority of the conifers.

With the genus *Tumion* probably present in the Virginia Potomac, and with *Nageiopsis* representing the subfamily Podocarpeæ, the family Taxaceæ is abundantly represented in the Lower Cretaceous, and when the individual abundance is considered rather than the specific differentiation it must be admitted that this family furnishes an important element in the Potomac flora.

The existing distribution of the Taxaceæ is shown on the accompanying sketch map of the world (Fig. 12), the subfamily Taxeæ being represented by horizontal lining and the subfamily Podocarpeæ by vertical lining.

[1] eg. *C. fasciculatus*, *C. mucronatus*, *C. sessilis*, *C. ternatus*.

Heer[1] has described a leafy twig from the Patoot beds of Greenland (Senonian) bearing a large solitary drupe-like fruit which he calls *Cephalotaxites insignis,* an identification which Solms-Laubach[2] seems to consider probable. Bertrand[3] has described structural material of fruits allied to *Cephalotaxus* under the name of *Vesquia Tournaisii* from the Aachenian of Belgium and the present writer has described[4] similar fruits which are common in the Upper Cretaceous of the Southern Atlantic Coastal Plain.

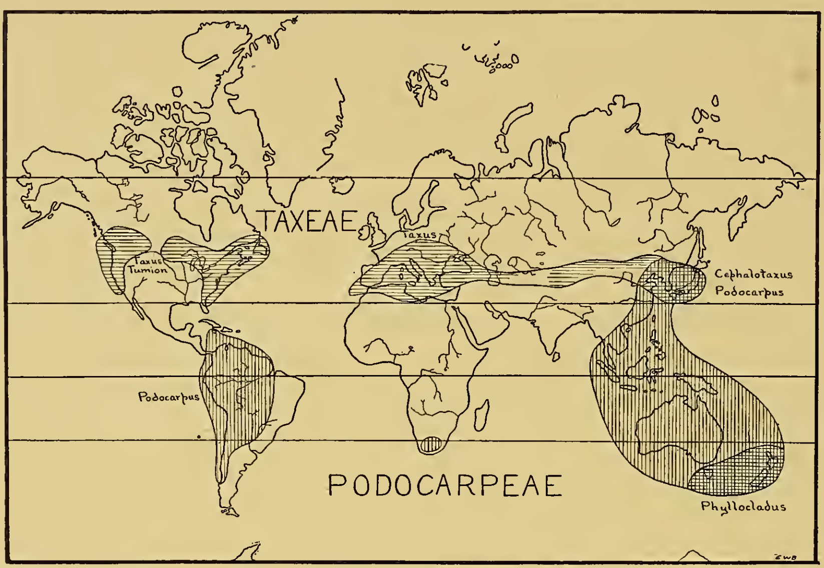

FIG. 12.—Sketch map of the world showing the approximate distribution of the existing Taxaceæ, horizontal lining = subfamily Taxeæ, vertical lining = subfamily Podocarpeæ.

The existing genus *Cephalotaxus* Sieb. and Zucc., contains four species confined to the Chinese-Japanese region. It was evidently much more widespread in former geologic times and to it should possibly be referred some of the leafy twigs included in the genus *Taxites* Bron-

[1] Heer, Fl. Foss. Arct., Bd. vii, 1883, p. 10, pl. liii, fig. 12.
[2] Solms-Laubach, Fossil Botany, 1891, p. 61.
[3] Bertrand, Bull. Soc. Bot. France, t. xxx, 1883, p. 293.
[4] Berry, Bull. Torrey Club, vol. xxxvii, 1910, p. 187.

gniart. Fruit of three species of *Cephalotaxus,* apparently identified corerctly, are described by Kinkelin[1] from the Pliocene deposits of Germany.

CEPHALOTAXOPSIS MAGNIFOLIA Fontaine

Plate LX, Fig. 1

Cephalotaxopsis magnifolia Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 236, pl. civ, figs. 4, 5; pl. cv, figs. 1, 2, 4; pl. cvi, figs. 1, 3; pl. cvii, figs. 1, 2, 4; pl. cviii, figs. 1, 3, 4.

Cephalotaxopsis ramosa Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 237, pl. civ, figs. 2, 3; pl. cvi, figs. 2, 4; pl. cvii, fig. 3; pl. cviii, fig. 2.

Cephalotaxopsis magnifolia Fontaine, 1894, in Diller and Stanton, Bull. Geol. Soc. Amer., vol. v, p. 450.

? *Cephalotaxopsis* sp., Fontaine, 1894, in Diller and Stanton, Bull. Geol. Soc., Amer., vol. v, p. 450.

Cephalotaxopsis magnifolia Fontaine, 1899, in Ward, 19th Ann. Rept. U. S. Geol. Survey, pt. ii, p. 686, pl. clxii, fig. 1b; pl. clxix, figs. 3, 4.

? *Cephalotaxopsis ramosa* Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 258 (?), pl. lxviii, figs. 5-7 (?) (non p. 311, pl. lxxiii, fig. 8, which is a species of *Oleandra*, or p. 547, which is *Nageiopsis angustifolia*).

? *Cephalotaxopsis ? rhytidodes* Ward, 1906, in Fontaine, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 258, pl. lxviii, fig. 8.

Cephalotaxopsis magnifolia Berry, 1911, Proc. U. S. Natl. Mus., vol. xl, p. 299.

Description.—Branches very stout, more or less branched, in some instances apparently in whorls through the suppression of the terminal bud and the development of the lateral shoots. Leaves distichous in habit, but probably with a spiral phyllotaxis, strikingly similar to those of the modern species of *Cephalotaxus,* linear-lanceolate in outline, rather abruptly rounded at the base and tapering gradually upward. Apex with a mucronate point. Length 2 cm. to 6 cm. averaging 4 cm. or 5 cm., and becoming regularly smaller distad and also smaller at the base of the new shoots. Width 3 mm. to 4 mm. Texture coriaceous. The midrib is broad and flat occupying about 1/17 of the diameter of the

[1] Engelh. and Kink., Abh. Senckenb. Naturf. Gesell., Bd. xxix, Hft. iii, 1908, p. 194, pl. xxiii, figs. 9, 13.

leaf. The epidermal cells are arranged in rows; they are small in size and thick-walled, quadrangular or slightly hexagonal in outline, ranging from proportions but slightly longer than wide to those in which the length is about 3 times the width. On the lower surface of the leaf on either side of the midrib, commencing one-fifth of the distance to the margin and occupying a width of one-fourth the distance to the margin are the stomatal grooves. They are deeply sunken and appear to have been floored with thin walled cells not well preserved. There is some evidence of the occurrence of a woolly scurf in these grooves but the preservation is such that this cannot be positively asserted. The

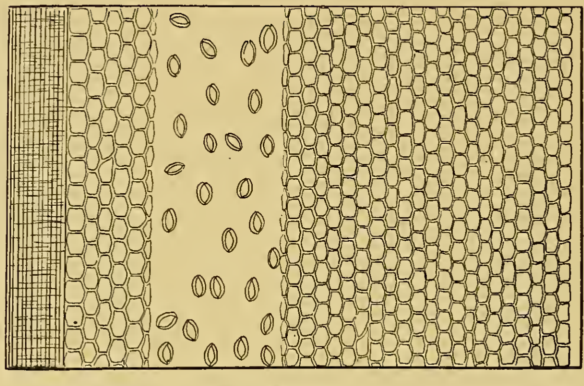

FIG. 13.—View showing the whole midrib and the cuticle of one-half the lamina of Cephalotaxopsis magnifolia, × 110.

stomata were comparatively large and irregularly scattered in the floor of the groove. They are without definite arrangement or orientation as the accompanying figure well shows. The guard cells are two in number, long, much curved and slender.

This species is exceedingly common in the Patuxent formation of Virginia to which it appears to be confined in the coastal plain. Although it has not yet been reported from the Kootanie formation of the Montana area, it is present in both the Lakota and Fuson formations of the Black Hills Rim and in both the Upper Knoxville and Horsetown beds of the Shasta of California. At no localities, however, is it as abundant as in the lowest Potomac of Virginia. It is strikingly like the modern *Cephalotaxus* in appearance and may also be compared with various fossil species of *Taxites*.

Occurrence.—PATUXENT FORMATION. Fredericksburg, near Dutch Gap, near Potomac Run, Virginia.

Collection.—U. S. National Museum.

CEPHALOTAXOPSIS BREVIFOLIA Fontaine

Plate LX, Fig. 2

Cephalotaxopsis brevifolia Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 238, pl. cv, fig. 3; pl. cvi, fig. 5; pl. cvii, fig. 5.
Cephalotaxopsis microphylla Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 238, pl. cviii, fig. 5; pl. cix, fig. 9.
Cephalotaxopsis brevifolia Berry, 1911, Proc. U. S. Natl. Mus., vol. xl, p. 300.

Description.—Ultimate branches alternate and rather slender. Leaves distichous in habit, narrowly lanceolate, 7 mm. to 21 mm. in length, averaging 10 mm. to 12 mm. Width 1 mm. to 3 mm., averaging about 2 mm. Apex and base almost equally acute, the base slightly less so. Texture coriaceous. Fontaine says of this species: "Midnerve slender." It is, on the contrary, extremely broad but flat and not prominent. In the specimen figured which is Fontaine's pl. cvi, fig. 5, the midrib occupies one-fifth of the maximum width of the leaf. This specimen exposes the upper surfaces of the leaves in consequence of which the midrib and stomatal bands are obscured. The photograph will also serve to emphasize the idealization and inaccuracy of the former figures of this plant.

This species, which may simply represent certain terminal or abortive shoots of the preceding, is not at all common and is confined to the Patuxent formation of Virginia. It may be profitably compared with some of the Mesozoic species of *Taxites*.

Occurrence.—PATUXENT FORMATION. Fredericksburg, near Dutch Gap, near Potomac Run, Virginia.

Collection.—U. S. National Museum.

Subfamily PODOCARPEAE

Genus NAGEIOPSIS Fontaine

[Mon. U. S. Geol. Surv., vol. xv, 1890, p. 194.]

This genus was founded by Fontaine in 1890 for forms apparently allied to the modern species which make up the *Nageia* section of the genus *Podocarpus*. He characterized it as follows:

"Trees or shrubs with leaves and branches spreading in one plane; leaves varying much in size and shape; those towards the base of the twigs sometimes smaller than those higher up, distichous mostly, or rarely subdistichous, opposite and persistent, attached by a short, slightly twisted footstalk, usually to the side of the twig, more rarely slightly within the margin on the upper or under surface of the stem, either attenuated towards the base or abruptly rounded off there, at their ends acute or subacute; nerves several, coalescing at base to form a footstalk, forking immediately at the base or a short distance above; then approximately parallel to near the tips of the leaves, where they are somewhat crowded together, but do not converge to a union, ending in or near the extremity."

The diagnostic characters which deserve emphasis are the branching habit, the persistent leaves and the parallel veins which do not converge to any great extent in the apex of the leaf. These all serve to distinguish the species of *Nageiopsis* from the cycadaceous fronds or leaflets with which they are most likely to be confused. The genus *Podozamites* for example, which is usually considered to be cycadean, although Seward suggests that it may be araucarian, is very similar in appearance; so similar in fact that Professor Fontaine included a number of *Podozamites* leaflets in his various species of *Nageiopsis*. But *Podozamites* is usually represented by detached leaves, hence it was deciduous in habit; the fronds are not known to branch, which habit is not only a distinguishing character but an argument against an araucarian affinity; finally, the veins converge, more or less, apically.

It has seemed wiser in considering detached and fragmentary leaves such as are those specimens which have been referred to *Nageiopsis* from the Shasta, Lakota, and Kootanie horizons to fully indicate their extremely doubtful character. A similar course is pursued in regard to the affinity of some of the fragmentary detached specimens of *Nageiopsis,* so called, from higher horizons in the Potomac Group. In cases where there is absolutely no evidence that they are so related they have been referred to *Podozamites* or *Zamites,* genera broad enough to include them without the implications and the contravention of the generic diagnosis which would be involved in retaining them in *Nageiopsis.*

Throughout the whole order Coniferales the phyllotaxy is as a rule spiral, more rarely it is cyclic in character. A true distichous or two-ranked arrangement is unknown, although a great many conifers with a spiral phyllotaxy are markedly distichous in habit, as for example, *Taxodium, Araucaria, Tumion, Taxus,* etc. It seems probable that *Nageiopsis* was no exception to the general rule; in fact some specimens show leaves inserted on all four sides of the stem. More often, however, the exact method of attachment is obscured, but the more or less twisted base argues strongly for a spiral phyllotaxy. A distichous habit is strongly emphasized in fossil impressions which have been subjected to more or less compression, just as in the case of pressed herbarium specimens.

There is a suggestion in some specimens of *Nageiopsis* that the base was markedly decurrent as in the modern *Araucaria Bidwilli.* This is furnished by the extraordinarily large size of some of the stems, which are irregularly expanded and contracted as if certain of the decurrent leaf bases had been spread out somewhat in the flattening which accompanied fossilization. This feature is especially well shown in the portion of the specimen of *Nageiopsis zamioides* previously figured.[1] The stem is broad at the base, giving off on either side sub-opposite leaves with apparently sheathing decurrent bases. Above their insertion the stem is considerably narrowed, passing to a portion obscurely preserved. Above this point it is at least twice as broad, contracting to form the narrow base of the right-hand leaf, while just above the main stem is continued as a much narrowed twig, the next leaf above, that on the left, having its base concealed behind the twig. In no instance is the

[1] Berry, Proc. U. S. Natl. Mus., vol. xxxviii, 1910, p. 191, fig. 1.

preservation as good as could be desired, so that the question cannot be definitely settled, but such examples, as that figured go a long way toward proving that at least some of the forms referred to *Nageiopsis* had strongly decurrent leaves and a spiral phyllotaxy. Similar features are shown in some of the specimens of *Nageiopsis angustifolia* and are indicated in the figures of this species on pl. lxiii.

Fourteen supposed species have been described from the Potomac Group, an additional one from the Kootanie, and Prof. Seward recognizes a species in the English Wealden and doubtfully records a representative from the inferior Oolite of Yorkshire. The genus is also possibly represented in the Neocomian of Japan by specimens which have been identified as *Podozamites,* but this is far from being demonstrable.

The Potomac forms, excluding those fragmentary species which are not here recognized as related to *Nageiopsis,* fall naturally into three species characterized respectively by the possession of very long, linear leaves, very narrow lanceolate leaves, and ovate-lanceolate leaves.

They are especially characteristic of the Patuxent formation, in fact the bulk of the unequivocal material comes from the single locality at Fredericksburg, Va. They evidently survived the close of the Patuxent, however, characteristic specimens of *Nageiopsis angustifolia* occurring in the lower beds at Federal Hill in Maryland. Their presence elsewhere in the Patapsco formation is probable, but the evidence is not wholly satisfactory.

Regarding the botanical affinity of *Nageiopsis* Professor Fontaine has repeatedly pointed out its striking resemblance to *Podocarpus.* While admitting this resemblance both Nathorst and Seward have suggested *Araucaria* for comparison.[1] Although there is, for example, considerable similarity between *Nageiopsis zamioides* and *Araucaria Bidwilli,* where in the genus *Araucaria* is there an analogue of *Nageiopsis longifolia?* In addition the Araucarieæ have their leaves much crowded and the phyllotaxy is spiral while in *Nageiopsis* the leaves are much more remote and the evidence for a spiral phyllotaxy is not

[1] This is probably the true affinity of Seward's Lower Oolite *Nageiopsis.*

conclusive. *Araucaria* has markedly decurrent leaves and this character also cannot be demonstrated for *Nageiopsis* although as the writer has elsewhere shown, there is some evidence for both this and the preceding character in some of the specimens. Taking into account all of the facts obtainable the reference of *Nageiopsis* to the Podocarpeæ seems reasonably well established, although the possibility of their relationship with the Araucarieæ should be kept in mind.

The existing species of *Podocarpus* comprise about two score forms and they are as dominant representatives of the Coniferales in the Southern Hemisphere as are the pines in the Northern. They extend northward to China and Japan through the East Indian region and have representatives in all three of the great Southern land masses. This peculiar distribution in itself may be considered as an indication of an extensive geological history, although the records of this history are not nearly as complete as they are for many other genera. To summarize briefly there are fifteen or more described species coming chiefly from the European Tertiary and one of these has been doubtfully recognized by Lesquereux in this country at Florissant, Col. The extra-American distribution includes Eocene species in England, Scotland, France, Italy and Australia; Oligocene species in France, Germany, Switzerland, Italy, Styria, Tyrol and Greece; Miocene species in France, Styria and Croatia; and Pliocene species in Italy. The descendants of *Nageiopsis* have not, however, been recognized in later American deposits.

The comparison of *Nageiopsis* with *Podocarpus* is more especially with the section *Nageia,* one of the four sections into which Eichler (in Engler and Prantl) divides *Podocarpus*. *Nageia,* formerly regarded as a distinct genus, has a broad form, numerous parallel veins and lacks a midrib, the latter being present in the other three sections of the genus. It may be questioned whether the reduction of Gaertner's genus to a section of *Podocarpus* L'Herit., as clearly expresses the natural facts as they would be emphasized by its retention as a distinct genus. *Nageia* has about a dozen species ranging from Japan southward to the East Indies and New Caledonia.

NAGEIOPSIS LONGIFOLIA Fontaine[1]

Plate LXI

Nageiopsis longifolia Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 195, pl. lxxv, fig. 1; pl. lxxvi, figs. 2-6; pl. lxxvii, figs. 1, 2; pl. lxxviii, figs. 1-5; pl. lxxix, fig. 7; pl. lxxxv, figs. 1, 2, 8, 9.

Nageiopsis crassicaulis Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 198, pl. lxxix, figs. 2, 6; pl. lxxxii, fig. 1; pl. lxxxiv, figs. 3, 9, 11.

Nageiopsis longifolia ? Font., 1894, in Diller and Stanton, Bull. Geol. Soc., Am., vol. v, p. 450.

Angiopteridium strictinerve Fontaine, 1894, in Diller and Stanton, *loc. cit.*

Nageiopsis longifolia ? Font., 1896, in Stanton, Bull. U. S. Geol. Surv., No. 133, p. 15.

Angiopteridium strictinerve Fontaine, 1896, in Stanton, *loc. cit.*

Nageiopsis longifolia Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 259, 311, 484, 491, 510, 528, 548, 557; pl. lxviii, figs. 9-12; pl. lxxiii, fig. 9 (non pl. xlv, figs. 1-5).

Nageiopsis longifolia ? Knowlton, 1908, in Diller, Bull. Geol. Soc., Am., vol. xix, p. 386.

Nageiopsis longifolia Berry, 1910, Proc. U. S. Natl. Mus., vol. xxxviii, p. 189.

Description.—Branching leafy twigs of large size, stout and thick, apparently branched in approximately one plane. Leaves linear-lanceolate, often slightly curved, somewhat inequilaterally narrowed into a short slightly twisted petiole; above, gradually narrowed to the acute or subacute tip. Length 8 to 20 cm.; width 5 mm. to 1.3 cm. The leaves are not crowded and usually appear opposite or sub-opposite as if inserted on the lateral margins of the stem although at times they seem to be attached to its upper or lower side. As previously remarked none of the material is conclusive in regard to the phyllotaxy. Veins 9 to 12 in number, usually 10, forking only at the base and running parallel until they abut against the leaf margin, about .7 mm. apart, somewhat coarser in calibre than in the other members of the genus, distinct on both surfaces of the lamina and apparently not immersed. Leaf substance not coriaceous.

[1] *Irites alaskana* Lesq. is made a synonym of this species in Monograph xlviii. According to the principles so often set forth by Prof. Ward this species should be renamed if *Irites alaskana* is included in it, since the latter was published 3 years before *Nageiopsis longifolia*. As the Alaska remains are not those of a *Nageiopsis* this name is omitted from the synonymy.

This species is quite distinct from its congeners and the great development of its evergreen foliage must have rendered it a most striking object in life.

Included under this species are the few and rather poor remains upon which Fontaine founded *Nageiopsis crassicaulis*. All but one of the specimens which that author so names are fragments of detached leaflets, somewhat shorter and broader than the typical leaves of *Nageiopsis longifolia,* but absolutely uncharacteristic and incapable of identification. The specimen with leaves attached is obviously a poorly preserved fragment of a twig of *Nageiopsis longifolia.*

This species occurs abundantly in characteristic and fine specimens at Fredericksburg. It has also been recorded from a large number of localities in Virginia and Maryland mostly as detached specimens generally with the base and apex missing so that the record of its range is somewhat unreliable, nor can it be otherwise from the nature of the material.

Professor Fontaine has recorded this species from Cape Lisburne, Alaska; from several Californian localities referred to the Upper, or Lower Cretaceous portion of the Shasta Group; from the Kootanie formation at Geyser, Montana; and from the Lakota formation in the western Black Hills at Barrett, Wyoming. Referring to these very briefly, it may be said that the Alaska locality is much older than any of the others and the fossils referred to this species, previously identified by Lesquereux as *Irites alaskana* Lesq., and *Baiera palmata* Heer, are entirely uncharacteristic and in the writer's judgment are in no wise related to *Nageiopsis*. The Shasta records are based entirely on small fragments which show only the middle portion of leaves and often lack the venation. The following quotation from Fontaine's report (1906, p. 259) sufficiently indicates their reliability: "The presence of *N. longifolia* in the flora of the Shasta formation cannot be positively determined from the specimens found."

The Kootanie record is likewise extremely doubtful and is based on five or six fragments from Geyser which are unattached and show neither bases nor tips. The specimens reported from the Lakota formation also are all fragmentary and uncharacteristic, and while we would expect to find this species in the West, the nature of the remains thus far collected scarcely justifies the identifications which have been based upon them, and as furnishing facts for stratigraphic correlation they are absolutely valueless.

Occurrence.—PATUXENT FORMATION. Fredericksburg, Potomac Run, Telegraph Station (Lorton), Cockpit Point, Kankeys, Dutch Gap, Virginia. ARUNDEL FORMATION. Langdon, District of Columbia. PATAPSCO FORMATION. Federal Hill (Baltimore), Vinegar Hill (?), Ft. Foote, Maryland; Mt. Vernon, Chinkapin Hollow (?) Brooke, Deep Bottom (?), Virginia.

Collection.—U. S. National Museum.

NAGEIOPSIS ZAMIOIDES Fontaine

Plate LXII, Figs. 1, 2; Plate LXIII

Nageiopsis zamioides Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 196, pl. lxxix, figs. 1, 3; pl. lxxx, figs. 1, 2, 4; pl. lxxxi, figs. 1-6.

Nageiopsis recurvata Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 197, pl. lxxv, fig. 2; pl. lxxix, fig. 4; pl. lxxx, fig. 3.

Nageiopsis decrescens Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 199, pl. lxxvii, fig. 3.

Nageiopsis ovata Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 199, pl. lxxvii, fig. 4; pl. lxxx, fig. 5.

Nageiopsis heterophylla Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 201, pl. lxxxiv, fig. 4; pl. lxxxvi, figs. 6, 7; pl. lxxxviii, figs. 2, 5.

Nageiopsis microphylla Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 201, pl. lxxxiv, fig. 6; pl. lxxxv, fig. 14; pl. lxxxvi, figs. 1-3, 5.

Nageiopsis cf. *N. heterophylla* Font., Seward, 1895, Wealden Flora, pt. ii, p. 211, pl. xii, fig. 3.

Nageiopsis zamioides Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol xlviii, 1905, pp. 510, 521, 528, 545.

Nageiopsis heterophylla Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 219 (?), 483, 520, 548, 561, pl. cxvii, fig. 6.

Nageiopsis microphylla Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv. vol. xlviii, 1905, p. 484.

Nageiopsis zamioides Berry, 1910, Proc. U. S. Natl. Mus., vol. xxxviii, p. 191, tf. 2.

Description.—Leaves ovate-lanceolate, proportionately shorter and wider than in *N. angustifolia* and much shorter and more rounded in outline than in *N. longifolia;* broadest toward the rounded base, the maximum width observed being 1.5 cm. although the average width is much less and may be put at 1 cm. or slightly less; very variable in size, tip generally acute although an occasional specimen may be obtuse. The greatest length observed is 8 cm. but the average length is much less than this and may be placed at 3 to 4 cm. Occasional twigs like the solitary specimen described as *N. decrescens* or the specimens referred to *N. microphylla* may be much smaller than the above. The latter are however of the same general shape while in the former case the fact that the larger leaves at the base of the specimen are replaced by very minute leaves indicates that the specimen is an abnormal twig. Veins fine in calibre, somewhat remote, generally 6 to 9 in number, forking at the base and diverging rapidly at first, then parallel until they abut upon the margin.

While it might seem at first sight that too great a variety of leaf forms had been lumped under this specific name the great variability of the leaves on single twigs should be kept in mind. The leaves in the type forms are commonly smallest toward the base of the twigs as they are also in the *N. ovata* forms. In *N. decrescens* the basal leaves are 100 per cent longer than are the succeeding leaves. In the forms described by Fontaine as *N. heterophylla* the leaves are especially variable, some being identical with those he called *N. microphylla* while others are like those he calls *N. decrescens,* other still simulating his *N. ovata* and *N. zamioides* with two or more of these types present on the same twig. Others referred by him to *N. zamioides* show an equally wide range of variation. Fig. 1 on pl. lxiii shows a figure of a small specimen labelled *N. zamioides* which has but five leaves and includes leaves easily referable to Fontaine's species *microphylla decrescens, ovata, heterophylla* and *zamioides* leaving only his *N. recurvata* to be accounted for. Since these latter are detached there is really no proof that they are correctly identified. They are, however, exactly like certain somewhat falcate leaves of *N. zamioides* found on twigs among normally straight leaves, so that there is little doubt but that the Virginia specimens are referable to this species. The form identified as *N. recurvata* from Vinegar

Hill, Md., is different from the others and is a *Podozamites* leaflet. Corroborate evidence is furnished by the similarity in venation characters and in the fact that all but one of the six so-called species, *N. decrescens,* are from the single limited exposure at Fredericksburg, and this was described from a nearby and probably synchronous outcrop and is really present at Fredericksburg attached to a twig labelled *N. heterophylla.* Four of them are again associated at the Dutch Gap locality. Again at Fredericksburg the typical forms of *zamioides* of Fontaine are very abundant while the variants which he described as separate species are represented in some cases by a single specimen, in others by but two or three specimens. A glance at the various figures in Fontaine's monograph and a perusal of the accompanying descriptions will be convincing, and this is only emphasized by a comparison of the specimens themselves.

Compare for example fig. 5 of *ovata* with fig. 3 of *zamioides* and it will be seen that they might have been drawn from the same specimen. This is likewise true when the single specimen of *N. decrescens* is compared with figs. 3 and 6 of *N. microphylla,* and similar comparisons can be made back and forth indefinitely.

Seward (Wealden Fl. pt. ii, p. 211, pl. xii, fig. 3, 1895) describes and figures a few small fragments from the English Wealden at Hastings and Ecclesbourne which he compares with *N. heterophylla* Fontaine.

The specimen figured shows well the branching habit and as near as can be judged is a species of *Nageiopsis.* Since, however, the name *N. heterophylla* Fontaine becomes a synonym of *N. zamioides* Fontaine the English fossils may be given the latter name without much question.

Occurrence.—PATUXENT FORMATION. Fredericksburg, Dutch Gap, Cockpit Point, Potomac Run, Virginia. ARUNDEL FORMATION. Bay View, Hobbs Iron Mine (?), Maryland; Langdon, District of Columbia. PATAPSCO FORMATION. Federal Hill (Baltimore), Vinegar Hill, Wellhams (?), Overlook Inn, Ft. Foote, Maryland; Chinkapin Hollow (?), Virginia.

Collection.—U. S. National Museum.

NAGEIOPSIS ANGUSTIFOLIA Fontaine

Plate LXIII, Figs. 3, 4

Nageiopsis angustifolia Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 202, pl. lxxxvi, figs. 8, 9; pl. lxxxvii, figs. 2-6; pl. lxxxviii, figs. 1, 3, 4, 6-8; pl. lxxxix, fig. 2.

Nageiopsis angustifolia Fontaine, 1899, in Ward, 19th Ann. Rept. U. S. Geol. Surv., pt. ii, 1899, p. 684, pl. clxviii, fig. 7.

Nageiopsis angustifolia Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 219, 491, 516, 528, 560, pl. cxvii, figs. 4, 5.

Cephalotaxopsis ramosa Font. ? 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 547.

Nageiopsis angustifolia Berry, 1910, Proc. U. S. Natl. Mus., vol. xxxviii, p. 190.

Description.—Much branched stems, of comparatively large calibre. Leaves variable in size, becoming smaller on ultimate twigs, but constant in their proportions; very long and narrow, linear-lanceolate, sometimes somewhat falcate, acute, averaging about 3 mm. in width in some instances only 1.5 mm. wide, greatest width observed 4 mm., length 2 to 7 cm., averaging about 5 cm.; veins of fine calibre, generally eight in number, sometimes observed to fork at the base. An abundant species suggestive of *Cephalotaxopsis* in general appearance.

Occurrence.—PATUXENT FORMATION. Fredericksburg, Dutch Gap, Potomac Run, Virginia; 16th St., District of Columbia. ARUNDEL FORMATION. Bay View, Md. PATAPSCO FORMATION. Federal Hill (Baltimore), Vinegar Hill (?), Wellhams, Ft. Washington, Ft. Foote, Maryland; Mt. Vernon, Brooke, Virginia.

Collection.—U. S. National Museum.

Family BRACHYPHYLLACEAE[1]

Genus BRACHYPHYLLUM Brongniart

[Prodrome, 1828, p. 109]

The genus *Brachyphyllum* was proposed by Brongniart in 1828 for conifers with short, fleshy, spirally arranged leaves attached by their

[1] Consistent with the avowed policy of the writer not to crowd the Lower Cretaceous flora into the confines of the Taxonomic bounds inherited from a study of the existing flora from which the former is separated by many millions of years, a new family is demanded for these peculiar Mesozoic types.

broad rhomboidal bases. The type species *Brachyphyllum mamillare* from the Lower Oolite was described but not figured and was placed under the heading *conifère doutense.* In 1849[1] the same author compared this genus with the existing genera *Arthrotaxis, Widdringtonia* and *Glyptostrobus.* Schimper in 1872[2] somewhat restricted the genus and also extended Brongniart's diagnosis. Saporta also[3] gives a rather well-illustrated account of *Brachyphyllum* figuring Brongniart's type and pointing out its doubtful botanical affinity. His diagnosis of the genus is as follows:

"Rami sparsim pinnati ramulis alternis erectiusculis cylindricis, sæpius rigidis; folia spiraliter inserta abbreviata vel brevissima basi late rhombæa insidentia, in statu juvenili etiam minime producta, cæterum conica mamillæformia, apice obtusissime intus recurva, plerumque carnosa vel saltem firma crasseque coriacea, dorso autem plus minusve carinata glandulaque sæpe notata, postea ætatis decursu in caulibus adultis dilatata depressaque, areas scutellasque convexiusculas regulariter rhombæas hexagonulasque puncto medio signatas efformantia; —strobili mediocres aut parvuli verosimiliter terminales, e squamis plurimis arcte imbricatis sursum lanceolatis aut rarius in apophysim incrassatis anticeque carinatis et post maturitatem sexus axin persistentibus constantes;—semina minutissima ala brevi superata inversa liberaque in quacumque squama 1-3;—amenta mascula ovata globosaque, parvula, ut videtur axillaria, basi involucrata postque pollinisationem caduca, e squamulis arcte imbricatis antice in appendicem lancealatum dilatatis composita."

Seward[4] regards *Brachyphyllum* as a purely provisional genus, the actual botanical position of which is very uncertain, and further states that it is quite probable that more than one family of conifers are included under this name. Comparisons have been made at various times with the modern subfamilies Araucarieæ, Taxodieæ, and Cupresseæ,

[1] Brongn., Tableau, 1849, p. 69.
[2] Schimp., Traité, Pal. Végét., 1870, tome ii, p. 334.
[3] Saporta, Pal. franc., 1884, tome iii, p. 310.
[4] Seward, Wealden Fl., pt. ii, 1895, p. 214.

especially with the Tasmanian genus *Arthrotaxis* of Don and the araucarian species *Araucaria imbricata.*

Brachyphyllum may be defined as a genus of arborescent conifers the twigs of which are thick and club-shaped, irregularly distichous in their mode of branching. The leaves are squamate, very short, thick, appressed, and densely crowded. Phyllotaxis spiral. In life the leaves must have been more or less fleshy, mutual pressure causing them to assume a pentagonal or hexagonal outline, with a dorsal, slightly projecting carina or boss becoming more or less obliterated with age. Leaf surface more or less striated, the striæ converging to the obtuse apical point (at least this is true of our American Cretaceous species). The leaf-scars on old branches are said to be rhomboidal and continuous, remotely suggestive of *Lepidodendron.*

A most remarkable species of this genus is *Brachyphyllum spinosum* Seward,[1] of the English Wealden, a large robust form whose lateral branches have become reduced to stout pointed spines about 3 cm. in length and 5 mm. in diameter at the base, where they are covered with reduced leaves, furnishing the only instance among the gymnosperms known to the writer where the branches are reduced to spines.

A variety of cones have been referred to *Brachyphyllum* usually upon the unreliable evidence of association in the same stratum. Even when cones are found in actual connection with the leafy twigs their preservation is such that positive evidence of botanical relationship is not available. Newberry[2] describes a large cylindrical cone with a length of 20 cm. and a diameter of 4 cm. and having spatulate scales, which he is quite positive is the cone of the *Brachyphyllum* so common in the upper part of the Raritan clays of New Jersey. As against these cones described by Newberry most cones referred to *Brachyphyllum* have been small and somewhat spheroidal in shape. Thus Zeiller describes branches of *Brachyphyllum* from the Lias of Madagascar which bore small ovoid cones with rhomboidal scales very suggestive of *Sequoia* and he seems to think it probable that some of

[1] Seward, Wealden Fl., pt. 11, 1895, p. 215, pl. xvii, figs. 1-6.

[2] Newberry, Mon. U. S. Geol. Surv., vol. xxvi, 1896, p. 51, pl. vii, figs. 3, 4. 6.

the forms of *Brachyphyllum* are referable to the Taxodieæ while others have an affinity with the Araucarieæ. Saporta[1] figures elliptical Walchia-like cones which he found associated with *Brachyphyllum jauberti, gracile,* and *moreauanum* in the French Jurassic, while Heer[2] describes and figures spherical cones with polygonal scales attached to twigs of his *Brachyphyllum insigne* from the Lower Oolite of Siberia, and other records of a very similar nature might be mentioned. Fontaine has recorded three obscure varieties of small cones from the Potomac beds along the James River in Virginia which he refers to *Brachyphyllum.*[3] They are very indefinite and poorly preserved and are all probably of a single species. They resemble somewhat the cones which Saporta refers to this genus and may be correctly identified, but this is doubtful. Finally Hollick and Jeffrey have rendered it extremely probable[4] that the widespread coniferous scales of the mid-Cretaceous referred to *Dammara* are related to *Brachyphyllum* and these authors have proved, at least in the species formerly known as *Dammara microlepis* Heer from Staten Island, a relation to twigs of the Brachyphyllum type, which relationship would seem to effectually disprove the identity of the cones described by Newberry.

Leafy branches and twigs very similar in appearance to those of *Brachyphyllum* in which, however, the leaves are less thick and more free and pointed are referred to the genus *Echinostrobus* which was founded by Schimper in 1872 for four or five Jurassic species of conifers, and it is to this Jurassic genus that Velenovsky refers two species from the Cenomanian of Bohemia,[5] although these latter are both practically identical with *Brachyphyllum macrocarpum* Newb. from the nearly homotaxial American horizons.

[1] Saporta, Plantes Jurassiques, tome iii, 1884, pp. 341, 349, 365, pl. clxv, figs. 1, 2; pl. clxvii, fig. 2; pl. clxxi, figs. 5-9.

[2] Heer, Fl. Foss. Arct., Bd. iv, Ab. ii, 1876, p. 75, pl. xiii, fig. 9.

[3] Fontaine, Mon. U. S. Geol. Surv., vol. xv, 1890, pp. 223, 224, pl. cxxxv, figs. 8, 9; pl. clxviii, fig. 2.

[4] Hollick and Jeffrey, Amer. Nat., vol. xl, 1906, p. 200.

[5] Velenovsky, Gym. böhm. Kreidef., 1885, p. 16, pl. vi, figs. 3, 6-8; Květena českého cenomanu, 1889, p. 9, pl. i, figs. 11-19; pl. ii, figs. 1, 2.

The geological range of *Brachyphyllum* like its geographical range is very great. The earliest recorded occurrence is that of a very doubtful species described by Feistmantel[1] from the Permo-Carboniferous of New South Wales (Newcastle beds). The genus reappears in the Upper Triassic, becoming prominent during the Jurassic and Lower Cretaceous, and dies out during the first half of the Upper Cretaceous.

Recently discovered structural material has enabled Hollick and Jeffrey[2] to show that in the Upper Cretaceous species *Brachyphyllum macrocarpum* Newb., the leaves are attached by practically the whole ventral surface, only the margins being free and these sometimes overlap. They refer this species to the subfamily Araucarieæ on the evidence of the branched leaf trace, the mucilaginous contents of the resin canals, the Araucarioxylon type of flattened and alternating bordered pits, the lateral pits of the ray cells, and the absence in the phlœm of regularly alternating rows of hard bast fibres. It would seem to the writer that while these characters show a certain relationship with the modern Araucaria stock there are constant differences which demand the reference of this species to a separate family particularly as forms conforming entirely to the Araucarian type in anatomy, vegetative, and reproductive structures, are present at this same horizon and also at much earlier horizons.

Brachyphyllum crassicaule Fontaine

Plate LXIV, Figs. 1-6

Brachyphyllum crassicaule Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1890, p. 221, pl. c, fig. 4; pl. cix, figs. 1-7; pl. cx, figs. 1-3; pl. cxi, figs. 6, 7; pl. cxii, figs. 6-8; pl. clxviii, fig. 9.
Brachyphyllum crassicaule Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 529, 557, pl. cxiii, fig. 6.
Brachyphyllum crassicaule Berry, 1911, Proc. U. S. Natl. Mus., vol. xl, p. 305.

Description.—"Trees with large branches, irregularly pinnate; on the penultimate twigs the ultimate branches lower and next to the main branch subdivide pinnately into branches; those higher are un-

[1] Feistmantel, Palæont., suppl. iii, 1878, p. 97, pl. vii, figs. 3-6; pl. xvii.
[2] *Loc. cit.*

branched and simple; ultimate branches vary in numbers and closeness, sometimes few and remote, and again crowded, contiguous, almost touching; towards the summit of the penultimate branches the ultimate ones become much crowded and grow gradually shorter, are cylindrical, and taper gradually to an obtuse point; leaf-scars of young leaves elliptical in shape, slightly prolonged in the direction of the axes of the stems, and such leaves seem to have been fleshy, slightly convex, and with a free tip slightly keeled in the upper half; with age the leaves become broader and more convex, being broadly elliptical, almost circular, and they leave similar scars after their fall; when crowded and dilated with age the leaves and leaf-scars are subrhombic or rhombic in shape; the surface of the leaves, which is very rarely preserved, shows fine tubercles or dots arranged in curving lines parallel to their margins and converging towards their tips; cones small, globular, or subelliptical in shape, attached laterally to the penultimate twigs, taking the place of ultimate branches; scales numerous, spirally arranged, touching, shape not made out, but probably with age rhombic and polygonal."—Fontaine, 1890.

This species is fairly common in Virginia in beds of both Patuxent and Patapsco age while in Maryland it occurs exclusively, as far as known, in deposits referred to the Patapsco formation.

All forms in this genus are much alike superficially as may be seen by comparing the figure reproduced on pl. lxiv of *B. mammillare* Brongniart, the type species from the European Lower Oolite, with the Potomac species, and these with the latest known American form, the widespread *B. macrocarpum* Newberry, which ranges from Greenland to Delaware, Alabama and Kansas and Wyoming and from the Raritan through the Magothy and Dakota to the Montana formation.

B. crassicaule is very similar to the European *B. obesum* Heer [1] with which Seward [2] unites it tentatively. This latter species is found in the English Wealden and in the Urgonian and Aptian of Portugal. One of Saporta's figures of this species is reproduced on pl. lxv, fig. 3, and it will be seen that the European and American forms are very similar;

[1] Heer, Contrib. Fl. Foss., Port., 1881, p. 20, pl. 17, figs. 1-4.

[2] Seward, Wealden Fl., pt. ii, 1895, p. 218, pl. xvii, fig. 9; pl. xx, figs. 1, 2, 4.

however, since this similarity runs through all the members of this genus and these two species are so widely removed geographically it has seemed best to maintain their distinctness. *B. obesiforme* Saporta[1] from beds of Albian age in Portugal is also very similar to the forms under discussion. This species in its more slender specimens approaches very close to certain forms from the Upper Cretaceous of the Southern Coastal Plain (Tuscaloosa formation of Alabama, Eutaw formation of Georgia), which the writer has referred to the usually somewhat larger, more striate-leafed form *Brachyphyllum macrocarpum* Newb.

Occurrence.—PATUXENT FORMATION. Trents Reach and near Dutch Gap, Virginia. PATAPSCO FORMATION. Ft. Foote, Federal Hill, near Glymont, Stump Neck, Maryland; near Widewater, near Brooke, Dumfries Landing, Virginia.

Collections.—U. S. National Museum, Maryland Academy of Sciences, Johns Hopkins University.

BRACHYPHYLLUM PARCERAMOSUM Fontaine

Plate LXV, Figs. 4, 5

Brachyphyllum parceramosum Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 223, pl. cx, fig. 4.

Brachyphyllum texense Fontaine, 1893, Proc. U. S. Natl. Mus., vol. xvi, p. 269, pl. xxxviii, figs. 3-5; pl. xxxix, figs. 1, 1a.

Brachyphyllum parceramosum Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 517, 538.

Brachyphyllum parceramosum Berry, 1911, Proc. U. S. Natl. Mus., vol. xl, p. 306.

Description.—"Twigs branching sparingly and dichotomously; leaves and leaf-scars elliptical to subrhombic, with the longer dimensions in the direction of the length of the twigs; leaves convex, spirally arranged, showing a keel in their upper portions, closely appressed, contiguous, prolonged very slightly at the tips, branches cylindrical, of the same thickness throughout; so far as can be seen about 4 mm. in diameter." —Fontaine, 1890.

[1] Saporta, Fl. Foss., Port., 1894, p. 176, pl. xxxi, figs. 12, 13; pl. xxxiii, fig. 4; pl. xxxiv, fig. 8.

This form which is of rare occurrence is possibly not specifically distinct from *B. crassicaule* Font., which in turn is very closely allied to various European forms. It may be distinguished, however, from the preceding species by its slender branches which rarely fork and then in an apparently dichotomous manner (this is only apparent, however, and not real dichotomy) and by its more regular, pointed, slightly keeled leaves. The specimens from Glen Rose, Texas, described as new by Prof. Fontaine are not distinguishable from the Maryland and Virginia specimens of *B. parceramosum.*

B. parceramosum is retained as a distinct species because of the inconclusive nature of the material and because it occurs in beds of somewhat greater age than *B. crassicaule,* and because in habit it more nearly resembles the less branched Jurassic types rather than the more regularly and pinnately branched Cretaceous types; the later type culminating in the type of *Brachyphyllum macrocarpum* of the Upper Cretaceous. The great similarity among all of the species in this genus, when studied as poorly preserved impressions, tends to enforce caution on the student who would unite under one name forms which appear to be similar but which are widely separated either geologically or geographically. The European representative of *B. parceramosum* is *B. obesiforme elongatum* Sap. which occurs in the Albian of Portugal.

Occurrence.—PATUXENT FORMATION. Telegraph Station (Lorton), Virginia; New Reservoir, D. C. ARUNDEL FORMATION. Arlington, Maryland.

Collection.—U. S. National Museum.

Family ARAUCARIACEAE

Genus ARAUCARITES Presl

[In Sternb., Fl. Vorwelt, fasc. ii, 1833, p. 203]

This genus is characterized in the following terms by its describer:

“Strobilus ovalis, rotundato-obtusus, squamis densissimis Rami sparsi, subdichotomi. Folia imbricata, parva, crassiuscula. Strobilus unius speciei hucusque notus multo minor illis specierum viventium, attamen similitudo præsertim cum strobilo juveni Araucariæ brasilianæ negari non protest."

Schimper[1] restricts the term to foliage remains, referring the cones and cone-scales described as *Araucarites* previous to his time to the genus *Araucaria* to which many of them are undoubtedly related. Subsequent workers have used the genus *Araucarites* entirely as a form-genus for remains of foliage, cones and cone-scales which seem to be more nearly related to the Araucarieæ than to any other existing subfamily of the Coniferales, a relation which because of the inconclusive nature of the remains cannot be demonstrated. As such a form-genus *Araucarites* has proved to be a most convenient repository for single seeded cone-scales and large spherical cones as well as for impressions of foliage resembling that of the modern araucarias. Many species have been described, ranging in age from the Permian through the Tertiary. These are especially abundant in the Jurassic and Cretaceous.

Fontaine took up this genus in Monograph xv for two classes of remains from the Virginia Potomac. These embraced an obscure cone from the lower Potomac (Patuxent) named *Araucarites virginicus,* with which he subsequently correlated other remains from higher horizons (Patapsco) which turn out to be those of *Pinus vernonensis,* and detached cone-scales named *Araucarites aquiensis* which are found to be characteristic remains in the later Potomac or Patapsco deposits, and as such possess a quite considerable stratigraphic value.

Professor Fontaine has described three species of *Araucaria* based on the remains of foliage from the Potomac Group. These are omitted from the present work because of their extremely indefinite character. The first is *Araucaria podocarpoides*[2] described from the Patapsco formation at Brooke, Va., which resembles somewhat the foliage in the *Colymbea* section of *Araucaria.* This was based upon a single indistinct fragment which in all probability is a poorly preserved twig of *Nageiopsis zamioides.*

[1] Schimper, Pal. Végét., tome ii, 1870, p. 252.

[2] Fontaine, Mon. U. S. Geol. Surv., vol. xv, 1890, p. 249, pl. lxxxvi, fig. 4.

The second, *Araucaria obtusifolia*,[1] was based on a tiny specimen of undeterminable affinities from the Patuxent formation at Trents Reach, Va. The third, *Araucaria zamioides*,[2] was based on similar scant and indefinite material from the Patuxent formation at Potomac Run, Va., which its author states may represent a small species of Zamia-like cycad. While there are no reasons for a denial of the presence of Araucaria foliage in the Potomac flora (in fact there are strong reasons for predicting its presence), the foregoing species do not afford reliable data on this point.

Many remains of cones and cone-scales have been described from various Mesozoic horizons as species of *Araucaria* or *Araucarites*, but it seems scarcely worth while to enumerate them in the present connection since none resemble the present species at all closely.

ARAUCARITES AQUIENSIS Fontaine

Araucarites aquiensis Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 264, pl. cxxxiii, figs. 8-12.

Araucarites aquiensis Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 489, 514, 528.

Description.—" Scales of the cones varying considerably in size and shape, attaining the maximum dimensions in length of 5 cm. and in width across the top of 3 cm. with the minimum of 3.5 cm. by 1.5 cm.; scales probably closely appressed and imbricated, wedge-shaped, and narrowed at base into a sort of foot-stalk, thickened at the summit, and rounded on the upper margin, with a depressed transverse furrow, very deciduous, and always found scattered singly and sparingly in the clay."—Fontaine, 1890.

These scales were described originally from the Brooke area where they are not uncommon. The writer has collected similar scales at a number of localities within the Patapsco terrane but can add little to the foregoing description. No positive evidence of a single seed is observable on any of the specimens either old or new, although their form is suggestive of such a habit. They were compared by their describer with

[1] *Ibid.*, pl. lxxxv, fig. 13.

[2] *Ibid.*, p. 250, pl. cxxi, fig. 1.

the modern genera *Abies* and *Dammara,* largely because of their obviously deciduous habit. While they are retained in the genus *Araucarites* they are probably more nearly related to *Dammara* than to *Araucaria,* since they more closely resemble both the Upper Cretaceous and the modern *Dammara* cone-scales, and we know that the Upper Cretaceous species of *Araucaria* already had cone-scales very like those of the modern members of that genus and quite different from the scales under discussion.[1]

The present species is confined to the Patapsco formation and is apparently a type fossil for this horizon.

The Lakota formation of the Black Hills region has furnished two species of cone-scales, *Araucarites wyomingensis* Fontaine and *Araucarites cuneatus* Ward, both of which are smaller and thicker than the present species.

Occurrence.—PATAPSCO FORMATION. Ft. Foote (common), Prince George's County, Maryland; near Brooke, R. F. & P. cut at Aquia Creek, near Widewater, Mt. Vernon, Chinkapin Hollow (?), Virginia.

Collection.—U. S. National Museum.

ARAUCARITES PATAPSCOENSIS sp. nov.

Plate LXXVII, Figs. 5, 5a

Description.—Deciduous cone-scales broadly rhomboidal in outline, rounded above and with nearly straight lateral margins below. As preserved, 2.6 cm. in length by 3.3 cm. in greatest width, which is about midway between the apex and the base, 6 mm. in width at the base. The single incomplete specimen upon which this description is based shows the under (dorsal) surface of a rather large scale which at first sight appears to have subtended three or four seeds. A careful comparison with the cone-scales of the existing species of the genus *Araucaria* leads to the conclusion that the organization of this Lower Cretaceous cone-scale was essentially like that which obtains in the modern species of Araucaria, among which the most similar are the cone-scales of *Araucaria Bidwilli* Hooker, a native of Australia. The cone-scales were

[1] See Berry, Bull. Torrey Club, vol. xxxv, 1908, p. 258, pl. xvi.

single-seeded as indicated on the diagrammatic sketch that accompanies the figure of this species and the seeds were large and truncate-spatulate in outline. It is assumed from the analogy furnished by *Araucaria Jeffreyi* Berry [1] from the lower part of the Upper Cretaceous that a more or less prominent ligule served to enclose the seed. The lateral margins of the scales are winged, but the wings are stiff and ligneous and it is the flutings of these wings due to drying which causes the scales to appear to have borne more than a single, medianly located seed. This appearance can be exactly matched in modern Araucaria cone-scales. The distal margin of the scale has disappeared in the fossil so that this part of the diagram together with the central spur must be regarded as hypothetical.

It seems evident, that the cones of the ancestral forms of the Araucarieæ had already, as early as the Lower Cretaceous, acquired the habit and morphology which distinguish the modern members of this somewhat isolated family.

Occurrence.—PATAPSCO FORMATION. Widewater, Virginia.

Collection.—Johns Hopkins University.

Family PINACEAE

Subfamily ABIETEAE

Genus PINUS Linné

[Sp. Pl., 1753, p. 1000]

Modern members of this genus are the dominant conifers of the northern hemisphere with about seventy species usually forming vast forest areas. There are considerable differences of opinion at the present time among morphologists as to the relative antiquity of the various members of the order Coniferales, the older view that the Abieteæ were a highly specialized and relatively modern type being questioned by Jeffrey and others. It would seem, however, that the old view not only has the fossil record exclusively in its favor but many morphological arguments to substantiate it.

[1] Berry, Bull. Torrey Bot. Club, vol. xxxv, 1908, p. 258, pl. xvi.

A very large number, perhaps as many as two hundred, fossil species of Pinus have been described, ranging in age from the Jurassic upward. The Jurassic has furnished pine-like leaves, as well as the remains of cones, which have formed the foundation of several species. While these records are for the most part not entirely unequivocal, Fliche and Zeiller[1] in a recent communication are positive of the identity of the cone which they describe from the French Portlandian. From horizons homotaxial with the Potomac Group, a number of forms have been recorded. These include six species described by Heer from leaves in the Kome beds, three species from the Kootanie, one from the Lakota of the Black Hills, and one from the Trinity of Texas. Strata of Albian age in Europe are remarkable for the number, variety and excellent preservation of cones of *Pinus,* about a dozen species being known from England, Belgium, and France. The Upper Cretaceous records are frequent and conclusive, including the evidence of wood with structure preserved, and the genus becomes thoroughly cosmopolitan during the Tertiary period. The definite remains of *Pinus* in the Potomac Group are those of both cones and seeds constituting the following single species, the cones of which sometimes crowd the strata of the Patapsco formation. In addition, both the older and the younger Potomac contain leaf remains which have been described by Professor Fontaine as species of *Leptostrobus* and *Laricopsis.* These are obviously not related to *Leptostrobus* or the modern *Larix,* and are included by the present writer in the form-genus *Abietites,* since the latter type of cones in the English Wealden material (*Pinites*) are borne on branches bearing long leaves like those named as above by Professor Fontaine.

Pinus vernonensis Ward

Plate LXVI

Seed of Pinus ? sp., ? Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 272, pl. clxx, fig. 4.

Pinus vernonensis Ward, 1906, in Fontaine, Mon. U. S. Geol. Survey, vol. xlviii, 1905, p. 497, pl. cix, figs. 4-6.

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[1] Fliche and Zeiller, Bull. Soc. Géol. France (iv), t. iv, 1904, p. 804.

Pinus schista Ward, 1906, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 531, pl. cxii, figs. 13-15.
Araucarites virginicus Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 572, pl. cxix, fig. 8 (non Fontaine, 1890).
Pinus vernonensis Berry, 1911, Proc. U. S. Natl. Mus., vol. xl, p. 316.

Description.—Cones elongate, conical, somewhat variable in size, averaging about 7 cm. in length by 1.8 cm. in diameter. Axis stout, 2 mm. to 3 mm. in diameter. Cone-scales triangular, relatively thin, thickened apically to form a rhomboidal boss with an elevated transverse ridge. A central umbilicus may represent the area of attachment of a short spine which had been worn away before fossilization. Length about 1.5 cm., greatest width about 0.8 cm. to 1.0 cm., thickness 1 mm. to 2 mm.

The arrangement of the scales is a close spiral and in all of the cones collected or seen, numbering several score, none was found expanded, all having the scales closely appressed. This may indicate fossilization before maturity, since numbers of the cones retain their seeds, which is remarkable if the cones were shed in a ripe state. The seeds seem to be mature, however, and it is probable that the cones in this species had reached nearly or quite their full size when they were blown into some Lower Cretaceous stream and carried out and buried in the Patapsco estuaries. Each cone-scale subtends two seeds which are typically those of *Pinus*. The seeds are elliptical, 3 mm. to 5 mm. long with straight wings 5 mm. to 15 mm. high and not over 7 mm. wide, sides rather straight though somewhat curved on the outside, obtusely rounded apically.

The single seed from Federal Hill represents the maximum of size as given above and is also rather more pointed than the specimens from the other localities. It was doubtfully described by Fontaine in his first monograph. More recently Professor Ward discovered seeds of *Pinus* at Mount Vernon, Virginia, and at Ft. Foote, Maryland. The former were described as *Pinus vernonensis* which now becomes the name of all the Pinus-like remains from the Patapsco formation. The latter specimens were described as a distinct species, *Pinus schista,* because the wings are somewhat split. As the latter are identical with the more complete remains from the other bank of the Potomac and as the different specimens are split to a varying degree and one specimen is not split at all, it is quite obvious that the splitting is due entirely to trituration before fossilization.

Recently the writer discovered abundant lignified cones associated with these seeds near Widewater, Virginia, and these cones were found in a number of instances to still contain some of their seeds which proved to be identical in every respect with the seeds previously described from the Patapsco formation. Having become familiar with the cones which bore the pine seeds it was found that the single cone described by Fontaine (*loc. cit.*), from Cecil County, Maryland, as identical with *Araucarites virginicus* was in reality a pine cone identical in every respect with the cones from near Widewater, Virginia.

The seeds of *Pinus vernonensis* may be compared with those figured by Seward,[1] from the Wealden of Bernissart, Belgium, as *Pinites*, cf. *Solmsi*.

In the National Museum collections a number of specimens of *Widdringtonites ramosus* are labelled *Pinus vernonensis* in Professor Fontaine's handwriting but there is no record in print of supposed foliage of this species, although there is a possibility that some of the following forms of *Abietites* may have such a relationship.

Occurrence.—Patapsco Formation. Mt. Vernon (seeds), near Widewater (cones and seeds), Virginia; Federal Hill (Baltimore) (seed), Ft. Foote, Prince George's County (seeds), Muddy Creek, Cecil County (cone), near Wellhams, Anne Arundel County (seeds), Maryland.

Collections.—U. S. National Museum, Johns Hopkins University.

Genus ABIETITES Hisinger

[Lethæa suecica, 1837, p. 110]

Since its establishment by Hisinger in 1837 this genus has been a convenient and perhaps useful repository for fossils whose real or fancied affinities were thought to suggest the modern Abieteæ. They

[1] Seward, La. Fl. Weal. de Bernissart, Mém. Musée Roy. d'Hist. Nat. de Belgique, Année 1900, p. 28, pl. iv, fig. 77.

have ranged in age from the Keuper to the Pliocene, the bulk coming from the Cretaceous, and consisting of obscure impressions of foliage and cones, none of which have any real biological value or present any definite clue to their true relationship. Professor Fontaine has included in this genus fossils from the Triassic of North Carolina and various indefinite remains from the Trinity Group of Texas, the Shasta Group of California, the Lakota formation of the Black Hills, and the Potomac Group of Maryland and Virginia. The latter he segregated into four species all of which were based upon obscure cone-impressions and none of which possess much specific value. When it is remembered what diverse appearances may be assumed by a single species of cone irrespective of individual variation and due to different stages of maceration before preservation, to differences in the matrix, and to differences in the direction and force of compression, it seems very probable that we are dealing with a single species of cone or at least not more than two, instead of the four which are in the literature relating to the Potomac formations.

Similar forms from the English Wealden are described by Carruthers, Gardner, and Seward and referred to the comprehensive genus *Pinites* of Endlicher (1847). They are in all probability congeneric if not specifically identical with *Abietites macrocarpus* Fontaine, whose generic and specific name is here retained since the writer wishes to avoid all unnecessary changes and Endlicher's *Pinites* is antedated anyway by the *Pinites* of Witham, 1833. In the French Neocomian also, cones of this character are abundant, Cornuel (Bull. Soc. Géol. Fr. (ii), t. xxiii, 1866, pp. 658-673, pl. xii) describing five species from beds of this age and referring them to *Pinus*. His *Pinus submarginata* is especially suggestive of *Abietites macrocarpus* Fontaine, as are also some of the species of *Pinus* described by Coemans[1] from the Lower Cretaceous of Belgium and by Carruthers,[2] from the Gault of England. Finally the foliage from the Potomac beds which has been referred to *Leptostrobus* and *Laricopsis* is neither *Leptostrobus* nor related to *Larix*, and since such

[1] Coemans, E., Mém. Acad. Roy. Belg., tome xxxvi, 1867.
[2] Carruthers, W., Geol. Mag., vol. iii, 1866, pp. 534-546, pl. xx, xxi.

foliage in the English Wealden is in organic union with cones of the *Abietites macrocarpus* type,[1] it seems eminently proper in the treatment of the American material to associate this type of foliage with the corresponding type of cone.

Abietites macrocarpus Fontaine

Plate LXVII, Figs. 1-4

Abietites macrocarpus Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 262, pl. cxxxii, fig. 7.

Abietites ellipticus Font., 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 263, pl. cxxxii, figs. 8, 9; pl. cxxxiii, figs. 2-4; pl. clxviii, fig. 8.

Abietites angusticarpus Font., 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 263, pl. cxxxiii, fig. 1.

Abietites californicus Fontaine, 1894, in Diller and Stanton, Bull. Geol. Soc., Am., vol. v, 1894, p. 450 (nomen nudum).

Abietites angusticarpus Font., 1899, 19th Ann. Rept. U. S. Geol. Surv., pt. ii, p. 671, pl. clxiii, fig. 14.

Abietites angusticarpus Font., 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 528, 538, 556, 572, pl. cxiv, fig. 10.

Williamsonia ? Bibbinsi Ward, 1906, in Fontaine, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 554, pl. cxv, fig. 11.

Abietites ellipticus Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 260, pl. lxviii, fig. 14.

Abietites macrocarpus Font., 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 261, 547, pl. lxviii, figs. 15, 16; pl. cxv, figs. 2, 3.

Abietites macrocarpus Berry, 1911, Proc. U. S. Natl. Mus., vol. xl, p. 313.

Description.—Large, stout cones, with a stout axis and numerous long, thin, imbricated, appressed scales. The various specimens vary considerably in length and appearance, and all are much macerated and poorly preserved. The author is unable to find good characters for the separation of the forms included in the foregoing synonymy, the supposed *Williamsonia* being nothing but a cone fragment vertically compressed as Prof. Ward surmised.

Described originally from Fredericksburg and Dutch Gap, Virginia, it has since been identified in the Horsetown beds of California and the Fuson formation of the Black Hills, while a very similar cone-

[1] Seward, Wealden Fl., pt. ii, 1895, p. 197, pl. xviii, figs. 2, 3; pl. xix, see especially pl. xviii, fig. 2.

fragment has been described from the Trinity Group of Texas as *Abietites Linkii* (Roemer) Dunker.

These cones are comparable with a number of previously described species and they are especially close to *Pinites Solmsi* Seward from the English Wealden as the latter author has already pointed out. From the foliage preserved with the English cones, which is identical with what Professor Fontaine referred to as *Leptostrobus,* it is possible that the latter type of foliage was borne by the tree which furnished the cones described above.

Occurrence.—PATUXENT FORMATION. Broad Creek, Maryland; Fredericksburg, Dutch Gap, Virginia. ARUNDEL FORMATION. Arlington, near Lansdowne, Maryland. PATAPSCO FORMATION. Vinegar Hill (common), Ft. Foote, Maryland.

Collections.—U. S. National Museum, Johns Hopkins University.

ABIETITES MARYLANDICUS Fontaine

Plate LXVII, Figs. 5, 6

Abietites marylandicus Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 549, pl. cxv, figs. 4, 5.
Abietites marylandicus Berry, 1911, Proc. U. S. Natl. Mus., vol. xl, p. 314.

Description.—Obscure impression of a narrowly oblong cone about 15 mm. wide and about 4 cm. long, covered with closely placed, transversely elongated rhomboidal scars. The very stout peduncle might be taken to indicate a stout cone with thin scales of which only the basal portions were retained in the fossil. The relation of this cone to the preceding species is altogether doubtful, it is retained in this genus since the preservation is so vague that any effort to determine its true affinity would be futile.

In some respects it suggests the staminate cone of a cycad and it may also be compared with cones of the coniferous genus *Geinitzia* which are characteristic forms in the Albian, Cenomanian and Senonian. There is also the possibility that the present material represents the poorly preserved cones of *Pinus vernonensis* Ward which is so common at certain localities of this age. The specimen represented in fig. 5 is especially suggestive of such a relationship.

Occurrence.—Patapsco Formation. Vinegar Hill, Maryland

Collection.—U. S. National Museum.

Abietites longifolius (Fontaine), Berry

Plate LXVII, Fig. 7

Leptostrobus longifolius Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 228, pl. ci, figs. 2, 3; pl. cii, figs. 1-4; pl. ciii, figs. 6-12; pl. civ, fig. 6.

Leptostrobus longifolius Fontaine, 1899, in Ward, 19th Ann. Rept. U. S. Geol. Survey, pt. ii, p. 671, pl. clxiii, fig. 15; pl. clxv, fig. 3.

Leptostrobus longifolius Fontaine, 1906, in Ward, Mon. U. S. Geol. Survey, vol. xlviii, 1905, pp. 281, 481, 482, 491, 506, 528, 551, 557, pl. cx, fig. 11; pl. cxvi, fig. 1.

Abietites longifolius Berry, 1911, Proc. U. S. Natl. Mus., vol. xl, p. 315.

Description.—Leaves long and narrow, needle-like, 10 to 15 cm. in length, aggregated in bundles. Bundles apparently borne on short shoots with many leaves in each bundle. No satisfactory venation can be made out. Fontaine describes a various number of veins in these forms but as nearly as can be determined these are simply folds due to compression or the angles of the leaf.

This species has a considerable geologic as well as geographic range having been recorded from the Kootanie formation of British Columbia and the Fuson formation of the Black Hills. In the Potomac Group it is of frequent occurrence and individually common being found in the oldest as well as the youngest beds. The remains are always poorly preserved and were evidently much macerated before fossilization. They are closely comparable with *Pinites Solmsi* Seward of the Wealden and with *Pinus Peterseni* Heer from the Kome beds of Greenland.

They may also be compared with the genus *Prepinus* proposed by Professor Jeffrey for certain structural material from the Upper Cretaceous. The type species of the latter genus came from the Raritan formation of Staten Island, New York, and is described as showing centripetal xylem, although this feature is not clear in the figures of this species or in the slides kindly furnished the writer by Professor Jeffrey. A single additional species has more recently been described by Stopes[1] from the Upper Cretaceous of Japan and this latter is said to lack centripetal xylem, a feature in any case of considerably less theoretic importance than is assigned to it by Professor Jeffrey. Still more recently the latter author has described another species from the Magothy formation of Marthas Vineyard.[2]

The genus *Leptostrobus* was proposed by Heer[3] in 1876 for certain Siberian Jurassic cones, although in 1880 remains of foliage were also correlated with these cones.[4] Five species in all were described. The age of the containing beds is Oolitic.

Subsequently this generic name was utilized by Ward and Fontaine for a considerable number of American Jurassic and Cretaceous species based on an assortment of probably unrelated vegetative twigs, supposed cones, and seeds or fruits.

Occurrence.—PATUXENT FORMATION. Fredericksburg, Potomac Run and Dutch Gap, Virginia. PATAPSCO FORMATION. Brooke, 72-mile post Mt. Vernon and Hell Hole, Virginia; Ft. Foote, Vinegar Hill (very common), and Federal Hill (Baltimore), Maryland.

Collection.—U. S. National Museum.

ABIETITES FOLIOSUS (Fontaine) Berry

Leptostrobus foliosus Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 230, pl. ci, fig. 4; pl. ciii, fig. 5; pl. civ, fig. 1.

Laricopsis longifolia Fontaine, 1890, *Ibid.*, p. 233, pl. cii, figs. 7, 8; pl. ciii, figs. 2, 3; pl. clxv, fig. 4; pl. clxviii, figs. 5, 6.

(?) Laricopsis longifolia Fontaine, 1893, Proc. U. S. Nat. Museum, vol. xvi, p. 268, pl. xxxvi, fig. 9.

Leptostrobus foliosus Fontaine, 1906, in Ward, Mon. U. S. Geol. Survey, vol. xlviii, 1905, p. 482.

Laricopsis longifolia Fontaine, 1906, *Ibid.*, p. 312, pl. lxxiii, figs. 11, 14.

Abietites foliosus Berry, Proc. U. S. Natl. Mus., vol. xl, p. 314.

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[1] Stopes, Annals of Bot., vol. xxiv, 1910, pp. 395-402, pls. xxvii, xxviii.

[2] Jeffrey, Proc. Bost. Soc. Nat. Hist., vol. xxxiv, 1910, pp. 333-338, pl. xxxiii.

[3] Heer, Fl. Foss. Arct., Band iv, Abt. ii, 1876, p. 72.

[4] Heer, *Ibid.*, Band vi, Abth. i, 1880, p. 23.

Description.—Leaves long and slender, .5 to 1.0 mm. in width, full length not seen, at least several centimeters, much crowded, seen to be in bundles where the preservation is fairly good.

This is clearly distinct from the preceding species and less common. It is not fully characterized because of the poorness of preservation as evinced by the fact that the leaves are detached in a majority of the specimens collected. The forms which were the basis for *Laricopsis longifolia* Fontaine have been united with this species since they are indistinguishable and probably identical in character.

This species occurs at the oldest and youngest horizons in the Virginia Potomac and it has also been recorded from the Kootanie formation of Montana. The fragment from the Trinity beds of Texas which Professor Fontaine identifies with such certainty is, in the writer's judgment, absolutely untrustworthy.

Occurrence.—PATUXENT FORMATION. Dutch Gap and immediate vicinity, Virginia. PATAPSCO FORMATION. Brooke, Virginia.

Collection.—U. S. National Museum.

Genus LARICOPSIS Fontaine

[Mon. U. S. Geol. Survey, vol. xv, 1890, p. 232]

This genus received the following diagnosis by its describer:

"Trees or shrubs, with the penultimate twigs sending off alternately in the same plane ultimate branches; leaves thin, narrow, and thread-like, attached by the entire base either in bundles at the same point on the stem or scattered singly on its surface, both on the same stem, very deciduous, the leaf-bundles leaving small scars. Nerves not made out with certainty, but apparently one for each leaf.

"This genus is nearer to *Larix* than to any other known plant, and the the resemblance is sufficiently great to render it possible that it may be the ancestor of this genus. It should be noted that the young shoots of *Larix* often have the leaves scattered singly as they occur in this genus, and it is probable that the immature portions of *Larix* approach the ancestral forms more nearly than the mature portions do. In these specimens also the leaves appear most often to be attached laterally to the stems as now preserved, while no doubt they were originally scattered around the stem. This appearance, as in the case of *Leptostrobus,* is doubtless due to the accidents of preservation. No nerves could be made out with certainty. The leaves are very narrow, being sometimes like hairs."

The unsatisfactory nature of the material upon which this genus is founded renders any extended comment superfluous. As here understood it includes but a single species which is confined to the Patuxent formation of Virginia. That there is any relation to the modern genus *Larix* is doubtful and it seems probable that *Laricopsis* will eventually be correlated with those Cretaceous remains here referred to the genus *Abietites.* The fancied resemblance to *Larix* was based on the grouping of the slender leaves and their deciduous nature, although the criteria for determining such a habit in the case of much macerated coniferous fossils are not altogether obvious to the writer.

LARICOPSIS ANGUSTIFOLIA Fontaine

Laricopsis angustifolia Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 233, pl. cii, figs. 9, 10; pl. ciii, figs. 1, 4.
Laricopsis brevifolia Fontaine, 1890, *Ibid.*, p. 234, pl. cii, figs. 5, 6.

Description.—Twigs slender. Leaves slender, scattered singly or in fascicles, thin and flat, ranging in length from 1 cm. to 3 cm.

Obviously the variation among the different examples of these rare twigs is not sufficient to serve as a basis for two species as described by Fontaine, and as the remains come from identical outcrops they are here considered as slight variants of a single species; the apparent minute differences noted by their original describer being due to differences of preservation. They are an altogether negligible element in the Potomac flora at best.

Occurrence.—PATUXENT FORMATION. Dutch Gap and Trents Reach, Virginia.

Collection.—U. S. National Museum.

Genus CEDRUS Miller

[Gard. Dict., ed. iii, 1737]

The modern cedars number three species of northern Africa, southern Asia, the Himalayas, and the Orient. Evidence that the genus was much more widespread in the past is furnished by a considerable amount of fossil evidence. Cedars undoubtedly made their appearance at least as far back as the Lower Cretaceous, no less than three species founded upon cones occurring in the Albian of England, Belgium, and France. These records are substantiated by the association of the cones in the latter country with fossil wood showing structure and described as various species of *Cedroxylon* by Fliche[1] and Lignier.[2] Fossil wood is also described by the former author from the somewhat older Barremian deposits of France (Haute-Marne[3]), while Schenk and Nathorst refer two of Cramer's species of *Pinites* from the Upper Jurassic of Spitzbergen to Cedroxylon.[4]

The genus has not been previously recorded from America. The toxonomy of Mesozoic cones is in such a deplorably tangled state that it is difficult or altogether impossible to infer the true affinities of a large number of the various species of *Pinites, Abietites, Strobilites, Conites,* etc.

CEDRUS LEEI (Fontaine) Berry

Plate LXXVII, Figs. 4, 4a

Cedar cone Bibbins, Johns Hopkins Univ. Circ., vol. xv, 1895, p. 19, fig. F.
Pinites Leei Fontaine, 1906, in Ward, Mon. U. S. Geol. Survey, vol. xlviii, 1905, p. 570, pl. cxix, figs. 6, 7.

Description.—Cone small (possibly unripe), 4 cm. long by 2 x 1.5 cm. in diameter, considerably distorted by the movement of the enclosing clay so that the scales on one side appear thin, while the reversed movement gives those on the opposite side the appearance of being tipped by

[1] Fliche, Études sur la Flore Fossile de l'Argonne, 1896, p. 134, pl. xv, figs. 1, 2.

[2] Lignier, Mém. Soc. Linn. Normandie, tome xxii, 1907, p. 263, pl. xviii, figs. 15-17; pl. xxi, fig. 66; pl. xxii, fig. 72; pl. xxiii, fig. 87.

[3] Fliche, Bull. Soc. Sci. Nancy, 1900, p. 16, pl. ii, fig. 1.

[4] Nathorst, Kgl. Svensk. Vetensk.-Akad. Handl., Bd. xxx, 1897, p. 42.

a short and wide umbo almost sufficiently developed to suggest the genus *Sequoia,* but due entirely to the pressure and the movement of the matrix in a direction toward the base of the cone as can be readily seen by the intermediate scales.

Scales in a close spiral, imbricated, rather thin, perhaps, .5 mm. in thickness, strongly striated longitudinally, very broad, the distance around the cone being occupied by slightly over 3 scales; and, as the circumference of the fossil is 5.7 cm. it would make each fully developed scale about 1.7 cm. in width, broadly rounded apically and apparently slightly thicker at the tip than elsewhere, exposed for a height of about 3 mm.

This species is based upon a single specimen, which is so admirably preserved, however, that in a footnote to the original description Professor Ward raises the question whether it may not be a Pleistocene cone of *Abies* or *Picea,* preserved in some Quaternary pocket of the Potomac surface. Mr. Bibbins who obtained it from Mr. John W. Lee, the original discoverer, is positive that it comes from Potomac strata, and the condition of the specimen tends to substantiate this view since it is thoroughly altered to a jet. *Picea* does not have such wide scales and those of *Abies* are deciduous.

Professor Fontaine referred this cone to the genus *Pinites,* presumably the *Pinites* of Endlicher 1847 since it resembles somewhat the English Wealden forms which were referred to that genus by Carruthers, Gardner, and Seward. The genus *Pinites,* which is used by Seward in his Wealden Flora in much the same way that the writer uses *Abietites* for imperfect cones which resemble those of *Abies* or the Strobus section of *Pinus,* is somewhat misleading in the present case since the cone in question is to all appearances referable to *Cedrus,* the modern species of which have long since been segregated from the old genus *Pinus.*

The genus *Cedrus* is represented in the Cretaceous by at least three species of Albian age from various European localities, those from France being associated with wood of the *Cedroxylon* type. Except for its smaller size, which may be due to immaturity, the Potomac cone is very close to those of these European species and to those of the modern species of *Cedrus.*

The *Cedrus lotharingica* which Cornuel (Bull. Soc. Géol. Fr. (iii), t. x, 1882, p. 262, pl. vii, figs. 2, 3) describes from the lower Gault of Houpette (Meuse), France, is strikingly similar to the Potomac form. This species was afterward united by Fliche *loc. cit.* with the larger but otherwise similar cones which are widespread in the Albian of France and England under the name of *Cedrus oblonga* (L. and H.).

Occurrence.—ARUNDEL FORMATION. Union Tunnel, near Aisquith St., 35 feet below the surface, Baltimore, Maryland.

Collection.—Johns Hopkins University.

Genus CUPRESSINOXYLON[1] Goeppert

[Mon. Foss. Conif., 1850, p. 196]

This rather comprehensive genus is defined as follows by its original describer:

"Truncorum structura fere Cupressinearum viventium. Trunci ipsi e cortice, ligno et medulla magis minusve centrali formati. Corticis pars fibrosa cellulis quadrangulis periphericis, lignum e stratis concentricis angustis distinctis, strati zona exteriore plerumque angusta e cellulis pachytichis compressa, interiore multo latiore e vasis leptotichis formata, medulla e ipsa cellulis paucioribus pachytichis composita. Cellulæ ligni prosenchymatosæ, porosæ ductibus resiniferis simplicibus interjectis. Pori rotundi in simplici, in truncis annosioribus quoque duplici interdum tri vel quadruplici serie in eodem plano horizontali justapositi, in iis plerumque tantum cellularum parietibus, qui sibi oppositi et radiorum medullarium paralleli sunt vel in parietibus radiis medullaribus obversis interdum nonnulli vel etiam plurimi tamen minores in omnibus inveniuntur. Radii medullares similares minores simplici cellularum parenchymatosarum porosarum serie. Parietes earum superiores et inferiores poris minutis, laterales majoribus instructi. Ductus resiniferi plerumque simplices cellulis elongatis subquadrangulis superpositis formati inter ligni cellulas imprimus angustiores inveniuntur."

[1] This generic name is spelled in various ways, the present usage being that of Goeppert which not only has priority but is etymologically correct, the root being derived from the subfamily name Cupressineæ.

Goeppert's work was ably supplemented by that of Kraus, who points out that the usual specific characters used by students of vascular anatomy such as the breadth of the annual ring, width of the cell-lumina, thickness of the cell-wall, number of rows of pits on the radial walls of the tracheids, height of the medullary rays and their frequency, can only be used with the most extreme caution on account of the individual variation of these parts in different parts of the same plant or on different individuals of the same species.[1] Krause's diagnosis of *Cupressinoxylon* as given by Schimper[2] is as follows:

"Lignum stratis concentricis distinctis, angustis; cellulis prosenchymatosis porosis, poris magnis, rotundis, uni-vel pluriserialibus, opposítis; cellulis resiniferis creberrimis, ductibus resiniferis nullis, radiis medullaribus simplicibus."

More modern studies have emphasized the uncertainties of vascular anatomy as indicative of exact relationship.[3]

A large number of species, so-called, have been described, Schimper in 1870 listing 41,[4] and many more have been described since Schimper's list was prepared. These range in age from the Lower Cretaceous to the Pliocene.

The fossil wood and lignite of the Potomac beds was made the subject of a monograph by Knowlton in 1889[5] which remains our only source of knowledge of the anatomy of the Potomac plants. A chapter is devoted to the very interesting historical development of the study of fossil wood which strangely enough, considering its abundance, is not mentioned by any of the ancients, the first authentic record being that of Albertus Magnus about the middle of the 13th century.[6]

Both lignite and petrified wood, either silicified or ferruginized, are

[1] See Solms-Laubach, Fossil Botany, 1891, pp. 81-83.

[2] Schimper, Pal. Végét., tome ii, 1870, p. 374.

[3] Gothan, Zur Anatomie lebender und fossiler Gymnospermen-Hölzer, Abh. k. preuss. geol. Landes, N. F., Heft xliv, 1905, pp. 101-103.

[4] Schimper, *loc. cit.*, pp. 374-377.

[5] Knowlton, Bull. U. S. Geol. Survey, No. 56, 1889.

[6] Beati Alberti Magni de Mineralibus Tractatus I, Caput VII, Opera, Lugduni, 1651, vol. ii, p. 216.

common at most horizons in the Potomac beds, but very little effort has been devoted to their collection or study. The lignites as far as they have been examined are coniferous but so much distorted by pressure and by decay before fossilization as to be of but little scientific value. The silicified materials while in a somewhat better state of preservation leave much to be desired. Of a large number of such sections in the hands of the writer only a very few are sufficiently well preserved to be determinable. The ease with which fragments of silicified wood may be reworked from formation to formation also minimizes their stratigraphic and phylohistorical value. The following two species have been described from the Maryland area by Knowlton.[1]

CUPRESSINOXYLON WARDI Knowlton

Plate LXVIII, Figs. 1-6, Plate LXIX, Figs. 7, 8

Cupressinoxylon Wardi Knowlton, 1889, Bull. U. S. Geol. Survey, No. 56, p. 48, pl. iv, figs. 1-4; pl. v, figs. 1, 2.

Description.—"Annual ring distinct, moderately broad; tracheids medium in size, the radial walls bearing one, rarely two, rows of bordered pits; medullary rays two cells broad and from one to thirty-five cells high; resin ducts simple, not numerous.

"This species is represented by specimens from the localities which have been designed by the letters A and B, respectively.

"A. Several small fragments collected by W J McGee in a cut on the Washington Branch of the Baltimore and Ohio Railroad about half way between Montello and Rives Station, D. C. The largest piece is only 8 cm. long, 6 cm. wide, and 1 cm. thick, and the others are much smaller. They are all very poorly preserved, and the structure can be made out only in a few favored spots.

"B. A small piece, hardly 5 cm. square, collected by Lester F. Ward from Freestone Cut, on the Neabsco Creek, Virginia. Like the other specimens this is very badly preserved, and the structure has entirely disappeared in many places.

[1] Knowlton, 1889, *loc. cit.*

"*Microscopic analysis.*—Transverse section: The fragments are all too small and too poorly preserved to show the annual rings to the naked eye, but under the microscope they are observed to be tolerably distinct. The ring of fall wood consists of from three to six or eight compressed cells in each radial row. The spring wood contains some very large cells, with a diameter in some instances of .062 mm. The number of cells in each row of tracheids varies according to the width of the annual ring, there being frequently as many as one hundred. Large intercellular spaces occur particularly where additional rows of tracheids have been introduced.

"*Radial section.*—In this section the tracheids are shown to be provided with one row; or, in some rare instances, with two longitudinal rows of bordered pits. They occupy the center of the cell and are close together, almost touching in some cases. The larger have a diameter of .020 mm., and the smaller a diameter of .015 mm. The medullary rays consist of typical parenchymatous tissue. The individual cells are short, covering the width of from four to eight tracheids. I have not been able to detect markings on the walls of the rays, but this may be on account of the poor state of preservation of the specimens. The resin ducts are not numerous. They are of nearly the same size and shape as the tracheids, and in fact look very much like tracheids with transverse partitions. They are almost always empty.

"*Tangential section.*—The tracheids are not provided with pits on the tangential walls, or at least none have been detected. The medullary rays in many cases are two cells broad, and, as above indicated, from one to thirty-five cells high. The individual cells of the rays have a diameter of from .017 mm. to .030 mm."—Knowlton, 1889.

Additional and somewhat better preserved material enables the writer to add one or two features to the foregoing description. It may be noted that the so-called annual ring is not distinct in the present section, where, over a distance of 2 cm., there is but a single zone of smaller cells. This is only three or four cells wide and not at all regular. It undoubtedly denotes a slackening of vitality but hardly merits the term of fall wood. The radial rows of tracheids are somewhat irregular and those of the same age are often quite variable in size. The bordered pits were not observed except in a single row and are not especially close together. In the radial section the ray pores can occasionally be made out. They are small and circular and not more than two were observed in the width of a wood cell.

There is great variability in the rays, which may consist of a single or but two cells, or a ray may be made up of twenty or thirty cells in a single row, or a high ray may be double at either end or merely in the middle, or small rays only 4 or 5 cells high may be double throughout.

Occurrence.—Patuxent Formation. Clifton (Baltimore), Maryland; Near Montello, District of Columbia, Neabsco Creek, Virginia.

Collections.—U. S. National Museum, Johns Hopkins University.

Cupressinoxylon McGeei Knowlton

Plate LXIX, Figs. 1-6

Cupressinoxylon McGeei Knowlton, 1889, Bull. U. S. Geol. Survey, No. 56, p. 46, pl. ii, fig. 5; pl. iii, figs. 1-5.

Description.—"Annual ring very distinct, from 2 mm. to 4.5 mm. broad; tracheids remarkably large, thick walled, closely covered with from one to three rows of large bordered pits on the radial walls and a few scattered ones on the tangential walls; medullary rays simple, from 2 to 49 cells high, covered on the lateral walls with numerous oblong pores; resin ducts simple, numerous, composed of a chain of thin walled cells.

"The type of this species was collected by W J McGee of the U. S. Geological Survey, from excavations made for the new reservoir of the water-works extension, Washington, D. C. It had originally a length of nearly forty feet and a diameter of almost two feet. It was somewhat flattened by pressure, the shorter diameter being considerably less than the longer. The trunk was exposed at a depth of about twenty feet below the surface, and must have belonged originally to a tree of large size. To the naked eye the annual rings are very indistinct. The medullary rays, however, are easily observed and are seen to pursue a very tortuous course, due, in part at least, to the dislocation caused by the pressure to which it had been subjected. The bark was not preserved in any of the pieces examined.

"*Microscopic analysis.*—Transverse section: This section shows the tracheids to be arranged in strict radial rows, and also indicates their great size. The annual ring, as above stated, is broad, consisting in some cases of as many as fifty or sixty of the larger and from ten to sixteen of the smaller, thick-walled cells. The larger cells are mostly quadrangular in outline and have a diameter in some instances of .080 mm., the average being about .068 mm. The cells of the fall wood have very thick walls and are much flattened. Intercellular spaces are frequently observed, particularly where additional rows of tracheids have been intercalated (pl. lxix, fig. 1). The medullary rays are moderately numerous.

"*Radial section.*—The large size of the tracheids is very clearly shown in this section, most of which is made up of summer wood. The tracheids in the fall wood are, of course, much smaller and are covered with but a single row of pits. The bordered pits are very close together on the summer wood and are always in two and in some exceptionally large cells in three rows. They are also very large, the outer circle having a diameter of from .020 mm. to .025 mm., and the inner of from .005 mm. to .008 mm. The walls of the medullary rays are marked by large oval pores, from one to three of which occupy the width of a single wood cell. These pores are about .015 mm. in length and .010 mm. in the short diameter. The resin ducts consist of a chain of short, small, thin-walled cells, which now contain a small quantity of granular matter, representing probably the drops of resin. The individual cells have a length of from .12 mm. to .25 mm., and a diameter of about .05 mm., slightly less, it will be observed, than the tracheids among which they run.

"*Tangential section.*—The medullary rays are always simple; that is, they consist of but a single row of cells, which varies from 2 to 49 cells in height. The tracheids are provided on the tangential walls with a few scattered bordered pits. These have a diameter of from .016 mm. to .021 mm."—Knowlton, 1889.

It is of interest to note that Gothan[1] has described wood extremely close to, if not identical with this species from the supposed Upper Jurassic (Portlandian ?) of King Charles Land.

Occurrence.—Patuxent Formation. New Reservoir, District of Columbia.

Collection.—U. S. National Museum.

Subfamily CUPRESSINEAE

Genus FRENELOPSIS Schenk

[Palæontographica, Band xix, 1869, p. 13]

Shrubs or trees with cylindrical jointed monopodial stems and branches, the latter of which may be alternate, apparently in a single plane, or whorled, often of large size, stems up to 5 cm. in diameter having been found in the Virginia area. Leaves much reduced, somewhat variable in outline, in general triangular with a broad base and an acute apex, squamiform, appressed, one to four in number at the nodes, decussate. Internodes variable in length but longer in the apparently annual shoots which were more or less deciduous and functioned as leaves, since the fine longitudinal striæ with which their surface is ornamented turn out in certain of the species which have been examined microscopically to be rows of stomata. These stomata have been described for *Frenelopsis Hoheneggeri* by Zeiller[2] and for *Frenelopsis bohemica* by Velenovsky.[3] They consist in the foregoing species of four cells although sometimes five or even six may be present. They are symmetrically arranged, the opening between them being in the form of a narrow-rayed star. According to the former author they ally these forms with the existing species of *Callitris* and *Libocedrus* and effectually disprove Heer's contention that this curious genus is a member of the Gnetales allied to *Ephedra.*

[1] Gothan, Die Fossilen Hölzer von König-Karls-Land, Kgl. Svenska Vetens.-Akad. Handl., Band xlii, No. 10, 1907.

[2] Zeiller, Obs. sur quelques cuticules fossiles, Ann. sci. nat., 6e sér., Bot., t. xiii, p. 231, pl. xi, 1882; Eléments de Paléobotanique, 1900, p. 274, fig. 196.

[3] Velenovsky, Ueber einige neue Pflanzenformen der böhemischen Kreideformation, Sitz. k. böhm. Gesel. Wiss. Prag., 1888, p. 590, figs. 1-3, 10.

The epidermis is made up of small rectangular thick walled cells and is very coriaceous, as are apparently the cortical tissues, which serves to account for the preservation of the twigs in such abundance where the materials have been much macerated as at Plaster Bluff on the Little Missouri River, Arkansas.

This genus was founded by Schenk upon abundant material from the *Wernsdorferschichten,* with *Thuites Hoheneggeri* of Ettings, as the type and only species. This was, he says, the most abundant fossil in those beds in which it occurs, and it received a careful and elaborate treatment at his hands. This species has subsequently been recognized in the Kome beds of Greenland, the Trinity of the Texas region, the Raritan and Magothy formations of New Jersey and the Turonian of Bagnols, France. In 1880 Hosius and van der Marck described a rather illy-defined species, *F. Königii,* from the Senonian of Westphalia[1] and the next year Heer[2] described an additional species, *F. occidentalis* from Portugal which Saporta has shown[3] ranges from the Urgonian of Cercal through the Albian of Nazareth into the Cenomanian of Alcantara and Padrão. The latter author also describes an additional species, *F. leptoclada*[4] which is confined to the Lower Cretaceous of Portugal (Neocomian-Aptian).

In 1889 Velenovsky described the Bohemian form *F. bohemica* from the Cenomanian of that country (*loc. cit.*) and the next year Fontaine described the two species from the Potomac Group (*loc. cit.*) the same author three years later founding a third species, *F. varians* upon material from the Trinity Group of Texas.[5] Newberry in 1896 described the ninth species *F. gracilis*[6] which is a very abundant type in the Raritan and Magothy formations of the Coastal Plain and which has recently been shown by Hollick and Jeffrey to be referable to a distinct genus.

[1] Palæont., vol. xxvi, 1880, pp. 132, 181, pl. xxxvii, fig. 148.

[2] Cont. Foss. Fl. Port., 1881, p. 21, pl. xii, figs. 3b, 4-7.

[3] Fl. Foss. Port., 1894, pp. 139, 199, 214, pl. xxvi, fig. 16; pl. xxxvi, figs. 1, 2; pl. xxxviii, figs. 2, 3; pl. xxxix, fig. 20.

[4] *Loc cit.*, pp. 109, 113, pl. xix, fig. 18; pl. xxi, figs. 9-11.

[5] Proc. U. S. Natl. Mus., vol. xvi, 1893, p. 273, pl. xl, figs. 1, 2; pl. xli, figs. 1-3a.

[6] Fl. Amboy Clays, 1896, p. 59, pl. xii, figs. 1-3a.

Although fruiting specimens have not been found, the position of the genus in the Cupressineæ based as it is upon similarity in habit, form, and stomatal characters, is not disputed at the present time although formerly Heer argued for an affinity with *Ephedra.*

Named originally for its resemblance to the living species of *Frenela* of the Australian region, we find the latest treatment of the modern Cupressineæ, that by Eichler in Engler and Prantl's Naturlichen Pflanzenfamilien (1889), makes *Frenela* a subgenus of *Callitris* Vent., the latter being divided into four subgenera as follows:

Octoclinis F. v. Müll. (*Frenela* Bentham) with eight scales to the cones and a single species inhabiting Australia.

Hexaclinis (*Frenela* Mirbel) with six scales, 3 large and 3 small, and nine species of Australia and New Caledonia.

Pachylepis Brongn. (*Widdringtonia* Endl.) with thick woody cones of four subequal scales and having three or four species of South Africa and Madagascar.

Eucallitris Brongn. (*Tetraclinis*) with four scales to the cones and a single species of Northern Africa.

However admirable this arrangement may be when only the living species are considered, it will not answer for the fossil forms and paleobotanists quite rightly maintain the various genera *Frenelites, Widdringtonia, Widdringtonites, Callitris,* etc., ranging in age from the older Mesozoic through the Tertiary and abundantly fortified by fruiting specimens. Fossil fruits of still other species and perhaps genera occur in the late Tertiaries of Australia, the weight of the evidence showing that this type was considerably more varied in the past, the existing forms being isolated remnants of a once almost world-wide distribution.

Within the Potomac Group *Frenelopsis ramosissima* ranges from the bottom to the top while *F. parceramosa* appears to be confined to the later beds serving by its resemblance to *F. Hoheneggeri* to connect them with the overlying Raritan formation.

The genus is not recorded from the English Wealden although certain poorly preserved remains which fail to show joints or leaves but seem to be similar in habit are described by Seward as a new genus and species, *Becklesia anomala*.[1] These, as their author points out, show considerable resemblance to some of the more poorly preserved specimens of *Frenelopsis Hoheneggeri* figured by Schenk from the *Wernsdorfer schichten*.

Nathorst in a recent paper upon some fossil plants collected by Felix from the Neocomian of Tlaxiaco, Mexico,[2] establishes a new genus for somewhat similar remains which he calls *Pseudofrenelopsis* on the ground that the specimens are not truly jointed. To this genus he would refer Fontaine's species and in this he is followed by Seward (*loc. cit.* p. 181). It is difficult to see the basis for Nathorst's proposals since the Mexican remains appear to differ from those found in Maryland, Virginia, or Texas, and since these latter are all jointed and therefore exhibit the characters of true species of *Frenelopsis* according to Nathorst's own definition.

FRENELOPSIS RAMOSISSIMA Fontaine

Plates LXXI, LXXII

Frenelopsis ramosissima Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 215, pls. xcv-xcix; pl. c, figs. 1-3; pl. ci, fig. 1.

Frenelopsis ramosissima Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 504, 512, pl. cxi, fig. 8.

Frenelopsis ramosissima Berry, 1910, Botanical Gaz., vol. l, pp. 305-309, tf. 1, 2.

Description.—Stems sometimes of large size, the branches sometimes alternate but usually crowded in whorls at the nodes with three to five branches to the whorl. Internodes usually short, as are the ultimate branches. Jointing not visible in the larger stems. Epidermis durable, longitudinally striated. Leaves in whorls of three at the nodes, decussate in outline, acute, closely appressed, becoming somewhat variable on the larger stems. Clusters of abortive branches or buds occur and are figured by Fontaine.

[1] Seward, Wealden Fl., pt. i, 1894, p. 179, pl. xiv.

[2] Nathorst, Pflanzenreste aus dem Neocom von Tlaxiaco in Beitr. z. Geol. u. Palæont. d. Repub. Mexico, von J. Felix u. H. Lenk, ii Theil, Leipzig, 1893, pp. 51-54 (see p. 52, figs. 6-9).

The epidermal cells are very small, the largest not exceeding 0.025 mm. in diameter, and the average being about half this size. They are roughly rectangular in shape and have very thick walls. Their most curious feature, one not observed in any other species of this genus, is the presence of minute, usually curved, spinelike outgrowths of large numbers of the epidermal cells. These protuberances vary in prominence

FIG. 14.—View of a preparation of the epidermis of Frenelopsis ramosissima.

from blunt papillæ of various heights to pointed spines 0.025 mm. in length. These are not present on all of the epidermal cells, and some preparations of the epidermis are apparently entirely smooth. Fig. 14 shows a characteristic bit of the epidermis dotted with these spines. Some of the spines, probably all of them, have a central cavity opening into the interior of the epidermal cell, which they surmount, as is shown in one of the individual spines figured. The second and third single spines figured show irregular cavities toward the apex which are apparently cut off from the cell cavity, and the third spine figured gives a good idea of the papillose character of those adjacent cells in which these processes are not prominently developed.

In the area included in fig. 14 are three of the curious stomatal openings which apparently characterize the genus *Frenelopsis*. These are circular in outline and about 0.03 mm. in diameter. They are very numerous, but whether they are localized on certain portions of the branches which perform the functions of leaves in this genus, or whether they are uniformly distributed on the annual shoots, could not be determined. They consist of five or six guard cells arranged around the central stomatal opening. These cells are much thinner-walled than the epidermal cells. In form they are relatively slender distad and broad proximad. As viewed through the microscope, they are darker colored around the stomatal opening and peripherally they are lighter. Since structural material is not available, their exact attitude is made out with difficulty. Their outer centrally directed ends come into focus at about the same time as do the outer ends of the longer spinelike processes, or very soon after, while their inner broad ends are visible after the epidermal cells have gone out of focus; hence it is obvious that they are inclined toward each other and project outward for a considerable distance from beneath the surrounding epidermal cells.

In their more essential characters they agree with the stomata as described by Zeiller for *F. Hoheneggeri* and by Velenovsky for *F. bohemica.* Just what were the physiological factors responsible for the great reduction of the leaves and the assumption of the photosynthetic processes by the branches in *Frenelopsis* it is difficult to imagine. Such features are usually associated with peculiarities of climate and habitat, and suggest strong insolation and lack of humidity; but such conditions are not suggested by the other members of the flora associated with *Frenelopsis,* since with the Potomac species are found large numbers of ferns, many of them apparently tree ferns with decompound fronds a meter or more across, and large numbers of cycads of various genera and large size; while in the latest beds in which *F. ramosissima* occurs there are considerable numbers of dicotyledonous leaves, some of which are allied with genera which in the modern flora are confined to tropical areas where the humidity is high and the rainfall heavy.

It is possible that these peculiar features in the Cretaceous species of *Frenelopsis* were inherited from Triassic ancestors which acquired them during these portions of the Triassic when the climate was extremely arid, as we know it was from physical as well as paleontological criteria.

This species, which is exceedingly abundant in the oldest Potomac at Fredericksburg, Virginia, occurs sparingly at higher horizons both in that State and in Maryland. It may be distinguished from the following species and from *Frenelopsis Hoheneggeri* by the short branches, their crowded habit, and the short internodes. The latter species is described as having the leaves in pairs and opposite while in *F. ramosissima* they are in whorls of three, but this can have but little significance since in the living forms the leaves normally in threes occur singly, in pairs, or in fours. The following species often shows but a single leaf at the nodes while *F. leptoclada* Sap. has the leaves either opposite or in fours.

Perhaps the most nearly related species is *Frenelopsis occidentalis* Heer of the Barremian, Albian and Cenomanian of Portugal, but this is abundantly distinct, in fact the majority of species of this genus taken as a whole constitute a group of forms closely related to the type species with which some of them may even be identical, while *F. ramosissima* stands by itself as a markedly distinct type.

Occurrence.—Patuxent Formation. Fredericksburg, Virginia. Patapsco Formation. Federal Hill (Baltimore), Maryland; Chinkapin Hollow, Hell Hole (?), Virginia.

Collections.—U. S. National Museum, Johns Hopkins University.

Frenelopsis parceramosa Fontaine

Plate LXX, Figs. 1-5

Frenelopsis parceramosa Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 218, pl. cxi, figs. 1-5; pl. cxii, figs. 1-5; pl. clxviii, fig. 1.

Frenelopsis parceramosa Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 544, 584.

Description.—Branches larger in size than in the preceding species, more remote and much longer, but with the same short internodes, constricted at the nodes. Epidermis persistent, the longitudinal rows of tubercles produced by the stomata more prominent than in the preceding. Leaves very short and broadly triangular, closely appressed, often entirely suppressed and never more than a single one observed at a node. Ultimate branches not only deciduous but prone to break up at the joints so that the materials preserved are usually poor. The branches could not have been very woody since in the fossils they are generally pressed flat and ribbon-like. Fontaine speaks of them as succulent, which may or may not have been the case, the mere fact of their being flattened is hardly an argument in favor of such a condition.

This species more closely resembles *F. Hoheneggeri* in its long cylindrical branches, differing in its shorter internodes and in the number of leaves. Both are variable characters, however, since on single specimens so identified by Heer from the Kome beds we find a variation of length of the internodes of from 1 cm. to 2.2 cm. and among the various fragments figured some internodes are only 3 or 4 mm. in length while others are 2.4 cm. and a large number are about 1 cm.

Frenelopsis parceramosa is also closely related if not identical with *F. varians* described by Fontaine from the Trinity Group of Texas and Arkansas and also shows considerable resemblance to the European species of this genus. Its occurrence in Virginia is very local and but few specimens have been found in Maryland.

Occurrence.—PATUXENT FORMATION. Trents Reach, Virginia. ARUNDEL FORMATION. Hanover, Howard Brown estate (?), Maryland.

Collection.—U. S. National Museum.

Genus WIDDRINGTONITES Endlicher

[Synop. Conif., 1847, p. 271]

The genus *Widdringtonites* was established in 1847 by Endlicher with *Thuites gramineus* Sternberg[1] from the Tertiary of Perutz, Bohemia,

[1] Sternberg, Fl. Vorwelt, Tentamen, 1825, p. xxxviii, pl. xxxv, fig. 4.

as the type. This he named *Widdringtonites Ungeri* including in its synonymy *Juniperites baccifera* Unger, *Thuia graminea* Brongn., and *Muscites Stolzii* Sternberg. Three additional species were listed, one from the Cretaceous, one from the Wealden, and one from the Lias. His characterization of the genus was as follows: "Folia spiraliter inserta, pleraque squamæformia adpressa. Strobilus globosus, valvatus."

There are perhaps a score of species referred to this genus at the present time ranging in age from the Triassic to the Miocene. It has

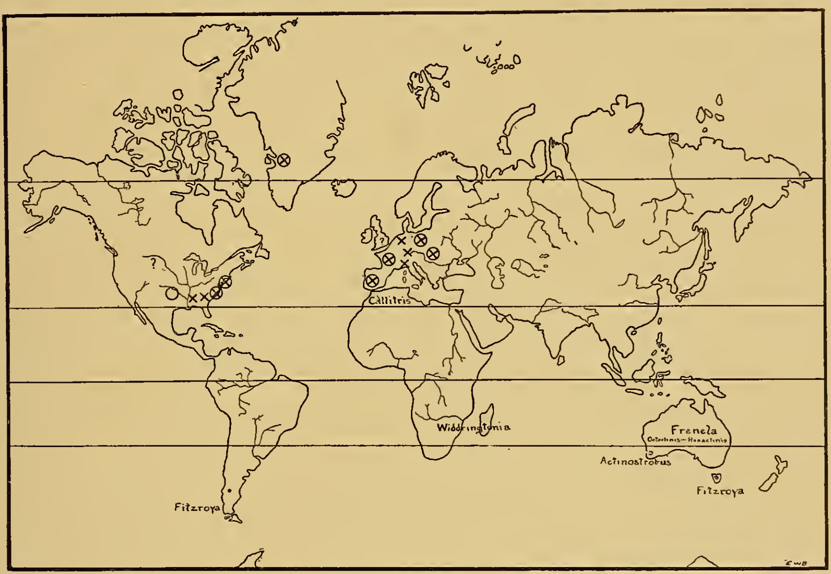

Fig. 15.—Sketch map of the world showing the segregation of the existing Actinostrobinæ and the Mesozoic occurrences of Frenelopsis and Widdringtonites. Circles indicate Frenelopsis and crosses indicate Widdringtonites.

been commonly used for foliar specimens which resembled the living forms but which lacked the certainty furnished by associated cones. These are known, however, in a large number of species, many of which, especially those of Tertiary age, are now referred directly to the genus *Widdringtonia.*

Although fruiting specimens of *Widdringtonites ramosus* (Font.) are unknown, its immediate successor *Widdringtonites Reichii* (Ettings.) Heer of the Raritan and Magothy formations has, in the European material, furnished abundant four-valved cones which induce Velenovsky and Krasser to advocate its reference to *Widdringtonia*. *Widdringtonites subtilis* Heer which is common in the later Cretaceous of the Coastal Plain has also furnished somewhat poorly preserved cones of this type in material collected by the writer in South Carolina, and well preserved attached cones in material from the Tuscaloosa formation in Alabama.

There can be but little doubt of the actual genetic relationship between these Mesozoic conifers and the existing species of *Callitris, Widdringtonia,* and *Frenela* which Eichler lumps into the single genus *Callitris* Vent. At the present time they constitute a restricted group confined to the Australian region on the one hand (*Frenela*) and to northern Africa (*Eucallitris*) and southern Africa and Madagascar (*Widdringtonia*) on the other. In former geological periods they were much more abundant as is partially shown by the accompanying sketch map, which, however, is designed to show only their reported range in the Mesozoic and does not include the quite numerous Cenozoic records. It will be seen that *Frenelopsis* is recorded in America from Greenland to Texas and *Widdringtonites* from Greenland to Alabama. Abroad both types occur abundantly in central and western Europe. Like so many other types of plants which were widespread in Mesozoic times they became during the Tertiary more and more restricted in their range until today they are not found at all in the western hemisphere and are confined to the limited areas indicated on the accompanying sketch map. (Fig. 15.)

Referring only to Cretaceous species of *Widdringtonites* we find four in the Neocomian, one in the Barremian, one in the Albian, three in the Cenomanian and one in the Senonian. The corresponding occurrences of the allied species of *Frenelopsis* are discussed under that genus.

WIDDRINGTONITES RAMOSUS (Fontaine) Berry

Plate LXXIII, Figs. 1-6

Taxodium (Glyptostrobus) ramosum Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 251, pl. cxxiii, figs. 2, 3; pl. cxxiv, fig. 2; pl. cxxvii, fig. 1; pl. cxxxii, fig. 1; pl. clxvi, fig. 1.

Taxodium (Glyptostrobus) brookense Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 254, pl. cxxii, fig. 1; pl. cxxiv, figs. 3-9; pl. cxxxi, fig. 5; pl. clxv, figs. 1-3; pl. clxvi, figs. 4, 7; pl. clxvii, fig. 3.

Taxodium (Glyptostrobus) brookense angustifolium Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 256, pl. clxvii, fig. 1.

Glyptostrobus brookensis Ward, 1895, 15th Ann. Rept. U. S. Geol. Surv., p. 359.

Glyptostrobus brookense angustifolium Knowlton, 1898, Bull. U. S. Geol. Surv., No. 152, p. 112.

Glyptostrobus brookensis Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 481, 489, 495, pl. cx, fig. 1 (non pp. 483, 486, 520 which are referred to *Arthrotaxopsis expansa* Font.).

Glyptostrobus ramosus Ward, 1906, in Fontaine, Mon. U. S. Geol. Surv., vol. xlviii, 1906, pp. 281 (?), 489, 544.

Glyptostrobus brookensis angustifolius Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 489, pl. cviii, fig. 4.

Arthrotaxopsis expansa Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 547 (non balance of original citation).

Widdringtonites ramosus Berry, 1911, Proc. U. S. Natl. Mus., vol. xl, p. 302.

Description.—"The principal stems seen are moderately stout and very rigid, the secondary ones mostly slender and rigid, the ultimate ones usually very long, slender, and unbranched, widespreading, often very delicate and thread-like, going off at an angle of about 45°, but from distortion due to pressure frequently appearing fastigiate and irregularly grouped; leaves on the oldest stems elongate-linear, acute, close appressed, on the younger stems all very narrowly oblong, or narrowly elliptical, acute to obtuse, very closely appressed, not distinctly visible without the help of a lens in many cases, all spirally arranged; the facial leaves usually acute, the lateral ones usually more obtuse and sometimes slightly divergent at the tips and incurved; midnerves slender and thread-like."—Fontaine, 1890.

Since nowhere in the Potomac Group are cones or scales found which indicate the presence of *Glyptostrobus* it seems desirable to refer these species and variety of Prof. Fontaine's to the genus *Widdringtonites* because of their extremely close resemblance to *Widdringtonites Reichii* (Ettings.) Heer, which is so widespread and characteristic a form in the Cenomanian of both the Old and New World. In fact it may be eventually desirable to reduce this Patapsco species to the synonymy of the latter, to which it is at least very closely allied. The variety *angustifolium* Fontaine is not distinguishable from the type and is based on specimens slightly more slender than the average, but readily matched in the material which that author refers to the type species. *Glyptostrobus ramosus* (Font.) Ward is clearly identical with the other forms of Fontaine's which are included in this species and comes from the same outcrops with the exception of certain material from the Kootanie at Great Falls, Montana which Prof. Fontaine has identified as *Glyptostrobus ramosus* but which is in all probability *Glyptostrobus grœlandicus* Heer and not identical with the Potomac species, although detached twigs of the two may and do show considerable similarity.

The material from the Fuson formation of eastern Wyoming which Fontaine referred to his *Glyptostrobus brookensis,* a synonym of *Widdringtonites ramosus,* is clearly identical with *Sphenolepis Kurriana* (Dunker) Schenk which occurs in the same beds with it and quite different from the species under discussion.

Widdringtonites ramosus is a characteristic species of the Patapsco formation both in Maryland and Virginia and occurs in considerable abundance at numerous localities. It is undoubtedly the ancestor of *Widdringtonites Reichii* (Ettings.) Heer of the Raritan and Magothy formations.

Stomata of the same general type as those described by the writer in *Frenelopsis ramosissima* (see *supra*), but confined to certain areas on the tiny crowded leaves, are described by Caspary for *Widdringtonites oblongifolius* Goeppert and Meng., a Tertiary relative of these Lower Cretaceous forms.[1]

Occurrence.—PATAPSCO FORMATION. Ft. Foote and Overlook Inn Road, Stump Neck, near Wellhams, Vinegar Hill, Maryland; Mt. Vernon, Hell Hole, White House Bluff, near Brooke, 72-mile post, Virginia.

Collection.—U. S. National Museum.

[1] Abhandl. k. Preuss. Geol. Landes., neue folge, Heft iv, 1907, p. 66: Atlas, pl. ix, see especially fig. 53c.

Subfamily TAXODIEAE

Genus SPHENOLEPIS Schenk

[Palæontographica, Band xix, 1871, p. 243]

The generic name *Sphenolepidium* was proposed by Heer as a substitute for *Sphenolepis* Schenk (1871) as the latter had been previously used in the animal kingdom. In his treatment of these plants in Zittel's Handbuch Schenk adopts Heer's generic name which had meanwhile come into general use. As however, all modern nomenclatorial codes, both zoological and botanical, do not regard the use of a name in the one kingdom as prohibiting its use in the other we must return to Schenk's original usage.

Sphenolepis may be defined as follows: Branches and twigs alternate. Phyllotaxy spiral. Leaves decurrent, more or less imbricated, acute, more or less appressed, especially on the older branches. Cones small, oblong or spherical, borne on short lateral branches. Cone-scales persistent, leathery, somewhat divergent at maturity, in habit suggesting *Sequoia*. The number and position of the seeds is altogether uncertain.

Although Solms-Laubach considers[1] that these forms cannot be precisely located in any of the existing subfamilies of Conifers most authors refer them to the Taxodieæ comparing them with the existing species of *Sequoia* and *Arthrotaxis,* especially the latter, with which as regards the cones the leaf form and arrangement and the general habit there is the closest similarity, amounting almost to an actual demonstration of relationship.

The genus appears in beds of Rhætic age both in Europe and South America. In North America one species has been recorded from the Oregon Jurassic, and Saporta has described a species from the Upper Jurassic of Portugal. Species of this genus are widespread and characteristic of the Wealden and Lower Cretaceous and constitute a very abundant element in the flora of the Potomac Group, where they are represented by remains of both foliage and cones. As has been frequently pointed out the genus may be composite since the difficulty of separation

[1] Solms-Laubach, Fossil Botany, 1891, p. 71.

of fossilized fragments of different conifers with a similar vegetative habit is almost unsurmountable and very similar twigs are often referred to *Sequoia.*

SPHENOLEPIS KURRIANA (Dunker) Schenk [1]

Plate LXXIV, Figs. 2, 3

Thuites (Cupressites ?) Kurrianus Dunker, 1846, Mon. Norddeutsch. Weald.-bild., p. 20, pl. vii, fig. 8.
Widdringtonites Kurrianus Endlicher, 1847, Synopsis, p. 272.
Brachyphyllum Kurrianum Brongniart, 1849, Tableau, p. 107.
Brachyphyllum Germari Brongniart, 1849, Tableau, p. 107.
Widdringtonites Kurrianus Göppert, 1850, Foss. Conif., p. 176.
Thuites Germari Unger, 1850, Gen. et Sp., p. 348.[2]
Widdringtonites Kurrianus Unger, 1850, *Ibid.*, p. 342.
Widdringtonites Kurrianus Ettings., 1851, Abh. k. k. geol. Reichs., Band i, Abth. iii, p. 25.
Widdringtonites Haidingeri Ettingshausen, 1851, *Ibid.*, p. 26, pl. ii, fig. 1.
Araucarites Dunkeri Ettingshausen, 1851, *Ibid.* (pars), p. 27, pl. ii, figs. 2-10.
Widdringtonites Kurrianus Hildebrand, 1861, Verbreit. Conif., 1861, p. 296.
Widdringtonites Haidingeri Hildebrand, 1861, *Ibid.*, p. 296.
Widdringtonites Kurrianus Schimp., 1870, Pal. Végét., tome ii, p. 329.
Sphenolepis Kurriana Schenk, 1871, Palæont., Band xix, p. 243, pl. xxxvii, figs. 5-8; pl. xxxviii, fig. 1 (non fig. 2 which is an *Onychiopsis*).
Sphenolepis Kurriana Schimper, Pal. Végét., Atlas, 1874, pl. cx, fig. 26.
Sphenolepidium Kurrianum Heer, 1881, Contrib. Fl. Foss. Port., p. 19, pl. xii, fig. 1b; pl. xiii, figs. 1b, 8b; pl. xviii, figs. 1-8.
Sphenolepidium Kurrianum Schenk, 1884, in Zittel, Handbuch, p. 304, fig. 210.
Sphenolepis Kurriana Hosius and v. d. Marck, 1885, Palæont., Band xxvi, p. 216, pl. xliv, fig. 209.
Sphenolepidium Kurrianum Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 260, pl. cxxvi, figs. 1, 5, 6; pl. cxxviii, figs. 1, 7; pl. cxxix, figs. 1, 4, 6, 8; pl. cxxx, fig. 11; pl. cxxxi, fig. 4; pl. clxvii, fig. 2.

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[1] The following are included in the synonymy of this species by Seward *(loc. cit.)*: *Muscites imbricatus* Roember, Verstein., 1839, p. 9, pl. xvii, fig. 1c (this is doubtful and would change the specific name if recognized); *Araucarites hamatus* Trautschold, Nouv. Mém. Soc. Nat. Moscou, tome xiii, 1870, p. 225, pl. xxi, fig. 3; and *Thuites Choffati* Heer, *loc. cit.*, 1881, p. 11, pl. x, fig. 8.

[2] Since it would involve a change in the specific name of this well-known species, *Thuites Germari* Dunker, Mon. Norddeutsch. Weald.-Bild., p. 19, 1846, is omitted from the synonymy as being of uncertain value.

Sphenolepidium parceramosum Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 257, pl. cxxix, fig. 7; pl. cxxx, fig. 8; pl. cxxxi, fig. 2.

Arthrotaxopsis grandis Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 240 (pars).

Sphenolepidium virginicum Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 259, pl. cxxv, fig. 4; pl. clxvi, fig. 6.

Arthrotaxopsis expansa Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 241 (pars), pl. cxxxv, figs. 15, 18, 22.

Taxodium (Glyptostrobus) expansum Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 252, pl. cxxiii, fig. 1.

Taxodium (Glyptostrobus) denticulatum Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 253, pl. cxxiv, fig. 1.

Taxodium (Glyptostrobus) fastigiatum Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 253, pl. cxxv, figs. 1, 3.

Sphenolepidium Kurrianum Saporta, 1894, Fl. Foss. Port., pp. 115, 139, pl. xxii, figs. 3-5; pl. xxvii, fig. 15.

Sphenolepidium Kurrianum Seward, 1895, Wealden Fl., pt. ii, p. 200, pl. xvii, figs. 7, 8; pl. xviii, fig. 1.

Glyptostrobus fastigiatus Ward, 1895, 15th Ann. Rept. U. S. Geol. Surv., p. 380.

Sphenolepidium Kurrianum Kerner, 1896, Jahrb. k. k. geol. Reichs., Band xlv, Heft i, p. 51, pl. iv, fig. 2.

Sphenolepidium Kurrianum Fontaine, 1899, in Ward, 19th Ann. Rept. U. S. Geol. Surv., pt. ii, p. 681, pl. clxvi, figs. 12, 13.

Sphenolepidium parceramosum Fontaine, 1899, in Ward, 19th Ann. Rept. U. S. Geol. Surv., pt. ii, p. 682, pl. clxiii, fig. 11b; pl. clxviii, figs. 1-3.

Glyptostrobus brookensis Fontaine, 1899, in Ward, 19th Ann. Rept. U. S. Geol. Surv., pt. ii, p. 682, pl. clxv, fig. 4; pl. clxviii, fig. 4.

Sphenolepidium Kurrianum Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 484, 489, 519, 538, 543.

Sphenolepidium parceramosum Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 484, 538, 548.

Sphenolepidium virginicum Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 481, 484, 517.

Glyptostrobus expansus Ward, 1906, in Fontaine, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 543.

Sphenolepis Kurriana Berry, 1911, Proc. U. S. Natl. Mus., vol. xl, p. 291.

Description.—"Thuites ramulis erectis irregulariter pinnatis, compressiusculis utrimque subcarinatis, foliolis crassiusculis imbricatis irregulariter dispositis elongatis subflexuosis apice acutis dorso carinatis subdistantibus."—Dunker, 1846.

In habit the twigs are alternate, branching copiously, more or less crowded, with a tendency toward a fastigiate arrangement in numerous specimens. Leaves thick, keeled dorsally, ovate in outline, often broadly so, acuminate, often slightly recurved, rather crowded and more or less appressed but larger than and much more divergent than those of the genera *Arthrotaxopsis* or the Lower Cretaceous species of *Widdringtonites.* Phyllotaxy spiral. Cones small, globose or oblate spheroidal; scales few in number, short and thick, truncate distally, becoming more or less divergent with age.

This species is very common at a large number of Lower Cretaceous horizons in both Europe and America and it has also been recorded from the Cenomanian in Portugal, Saxony, and Austria (Lesina). It is present in the Neocomian of Portugal and Westphalia and doubtfully in beds of this age in Russia. It is present in the Wealden of England and Germany, the latter being the type locality. It is also recorded from the Barremian of Portugal and is probably present in the Kome beds of Greenland. In this country it is recorded from the Kootanie of Montana and the Fuson formation of the Black Hills. It is a very abundant form in the Potomac Group and occurs at numerous localities ranging in age from the oldest or Patuxent beds to the youngest or Patapsco beds, a range similar to but somewhat less in time than that ascribed to it in Portugal, where Saporta recognizes it from the Neocomian to the Cenomanian. Some of the numerous specimens from the Kome beds of Greenland, which Heer described first as *Widdringtonites gracilis*[1] and afterwards as *Cyparissidium gracile,*[2] are probably identical with *Sphenolepis Kurriana* (Dunker) Schenk although the cones ascribed to the former differ from those of the latter. Heer notes the resemblance between the remains of foliage of *Cyparissidium, Widdringtonites, Glyptostrobus, Arthrotaxis,* and *Sequoia.*

Araucarites hamatus Trautschold which Seward (*loc. cit.*) doubtfully includes in the synonymy is here excluded. There is some suggestion of *Sphenolepis* in Trautschold's figures but not enough for certainty. These figures are, however, almost identical with the coniferous twigs

[1] Heer, Fl. Foss. Arct., Band i, 1868, p. 83, pl. xliii, figs. 1e, f, g, 3c.

[2] Heer, *Ibid.*, Band iii, Abth. ii, 1874, p. 74, pl. xvii, figs. 5b, c; pl. xix; pl. xx, fig. 1e; pl. xxi, figs. 9b, 10d.

from Glen Rose, Texas, which Fontaine describes as *Sequoia pagiophylloides* sp. nov.

The species may be a composite one, its wide geographical and geological range offers some basis for such a suspicion, but the materials available for study do not furnish reliable data for its segregation.

Occurrence.—Patuxent Formation. New Reservoir, Ivy City, District of Columbia; Fredericksburg, Potomac Run, Trents Reach, Dutch Gap, Telegraph Station (Lorton), Cockpit Point, Kankeys, Virginia. Arundel Formation. Bay View, Arlington, Maryland. Patapsco Formation. Federal Hill (Baltimore), Vinegar Hill, Maryland; near Brooke, 72-mile post, Mt. Vernon, Hell Hole, Virginia.

Collections.—U. S. National Museum, Johns Hopkins University.

Sphenolepis Sternbergiana (Dunker) Schenk

Plate LXXV, Figs. 1, 2

Muscites Sternbergianus Dunker, 1846, Mon. Norddeutsch. Weald.-Bild., p. 20, pl. vii, fig. 10.

Juniperites Sternbergianus Brongniart, 1849, Tableau, p. 108.

Muscites Sternbergianus Unger, 1850, Gen. et Sp., p. 42.

Araucarites Dunkeri Ettingshausen, 1851, Abh. k. k. geol. Reichs., Band i, Abth. iii, p. 27, pl. ii, figs. 2, 3, 7, 8 (pars).

Araucarites curvifolius Ettingshausen, 1851, *Ibid.*, p. 28, pl. ii, figs. 11, 13, 14, 17-21.

Araucarites Dunkeri Hildebrand, 1861, Verbreit. Conif., p. 276.

Widdringtonites Dunkeri Schimper, 1870, Pal. Végét., tome ii, p. 329.

Widdringtonites curvifolius Schimper, 1870, *Ibid.*

Sphenolepis Sternbergiana Schenk, 1871, Palæont., Band xix, p. 243, pl. xxxvii, figs. 3, 4; pl. xxxviii, figs. 3-13.

Sequoia gracilis Heer, 1873, Fl. Foss. Arct., Bd. iii, Ab. ii, p. 80, pl. xviii, fig. 1c; pl. xxii, figs. 1-10.

Sphenolepis Sternbergiana Schimper, 1874, Pal. Végét., tome iii, p. 575, Atlas, pl. cx, fig. 27.

Sphenolepidium Sternbergianum Heer, 1881, Contrib. Fl. Foss. Port., p. 19, pl. xiii, figs. 1a, 2-8; pl. xiv.

Sphenolepis Sternbergiana Hosius and v. d. Marck, 1885, Palæont., Band xxvi, p. 215, pl. xliv, figs. 206-208.

Sphenolepidium Sternbergianum Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 261, pl. cxxi, figs. 8, 10, 11; pl. cxxx, fig. 9.

Sphenolepidium Sternbergianum densifolium Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 261, pl. cxviii, fig. 7; pl. cxxi, figs. 5, 7, 9; pl. cxxv, fig. 2; pl. cxxix, fig. 3; pl. cxxx, fig. 1; pl. cxxxi, figs. 1, 3; pl. cxxxii, fig. 4.

Sequoia gracilis Fontaine, 1890, *loc. cit.* (non 1899), p. 247, pl. cxxvi, figs. 3, 4.
Sphenolepidium Sternbergianum densifolium Fontaine, 1893, Proc. U. S. Natl. Mus., vol. xvi, p. 268, pl. xxxvi, fig. 10.
Sphenolepidium Sternbergianum Saporta, 1894, Fl. Foss. Port., pp. 114, 139, 193, pl. xxii, figs. 1, 2; pl. xxvii, fig. 14; pl. xxxiii, fig. 13.
Sphenolepidium Sternbergianum Seward, 1895, Wealden Fl., pt. ii, p. 205, pl. xvi, figs. 4-6.
Sphenolepidium Sternbergianum Ward, 1895, 15th Ann. Rept. U. S. Geol. Surv., p. 359, pl. iii, fig. 1.
Sphenolepidium Sternbergianum Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 264, pl. lxix, fig. 7.
Sphenolepidium Sternbergianum densifolium Fontaine, 1906, in Ward, *loc. cit.*, vol. xlviii, 1905, pp. 480, 481, 484, 486, 491, 507, 511, 515, 524, 528, 544, 546, 555, 573, pl. cix, figs. 8, 9; pl. cxii, figs. 1, 10 (non fig. 11 which is referred to *Arthrotaxopsis expansa* Font.); pl. cxv, fig. 1.
Sequoia gracilis Knowlton, 1907, Smith. Misc. Coll., vol. iv, pt. i, p. 126.
Sequoia gracilis ? Hollick, 1907, Mon. U. S. Geol. Surv., vol. l, p. 43, pl. iii, fig. 14.
Sphenolepidium Sternbergianum Knowlton, 1908, in Diller, Bull. Geol. Soc. Am., vol. xix, p. 386.
Sphenolepis Sternbergiana Berry, 1911, Proc. U. S. Natl. Mus., vol. xl, p. 293.

Description.—"Muscites caule virgato subflexuoso, foliis bifariis imbricatis patentibus ovatolanceolatis subfalcatis."—Dunker, 1846.

The branches are somewhat more remote than in *Sphenolepis Kurriana,* with relatively shorter twigs. Leaves ovate, decurrent, keeled, with a broad base and acuminate apex, often divergent and falcate, in other specimens appressed. In general the leaves are much more crowded and divergent than in the preceding species. Cones not collected in connection with the American material except in the case of some poorly preserved specimens from Mt. Vernon figured by Ward (1895 *loc. cit.*) which may be immature, although they suggest the preceding species rather than this one. Cones are described by Schenk from the German Wealden and are also figured by Seward from the English Wealden. The cones are small, oblate-spheroidal in shape, with few, stout, truncated scales which become more or less divergent with maturity. Ward (*loc. cit.*) reports specimens of the foliage of this species with attached staminate catkins similar to those described by Fontaine as "Male aments" from various Virginia localities, where they were not attached to recognizable twigs.

This species was described by Dunker in 1846 as a species of *Muscites,* Brongniart in 1849 substituting *Juniperites* as a more appropriate generic name, one subsequently changed to *Araucarites* by Ettingshausen. Schimper referred this species to *Widdringtonites,* but since 1871 it has been rather consistently referred to as *Sphenolepis,* or *Sphenolepidium Sternbergianum;* although the difficulty of dealing satisfactorily with various detached coniferous twigs of similar habit is no small one, not only from their similar appearance in various unallied species but also because of their resistance of decay and retention of their leaves when reduced to fragments, so that they are often the most abundant remains in coarse sediments.

Sphenolepis Sternbergiana has an equally wide range, both geographic and geologic, as has the preceding species. It is common in the Wealden of England and Germany and is recorded by Saporta from the Neocomian, Barremian, and Albian of Portugal, a range similar to that which it shows in the Maryland-Virginia area. It is probably represented in the Kome beds of Greenland by *Sequoia gracilis* Heer while the latter author's *Glyptostrobus groenlandicus*[1] and *Sequoia fastigiata* from these beds also suggest this species. It is recorded from the Glen Rose (Trinity) beds of Texas and from the Horsetown beds of the Pacific Coast. The form from the Upper Cretaceous of Marthas Vineyard which Hollick has identified as *Sequoia gracilis* Heer is also similar enough to be suggestive. The present species is very abundant in the Potomac Group ranging from the bottom to the top.

The specimens of *Sphenolepis Sternbergiana* from the Wealden of Ecclesbourne in possession of the writer, are much stouter than the American conifer usually identified as this species and resemble rather closely what in America goes by the name of *Sequoia ambigua* Heer, a resemblance already commented on by Seward (Wealden Fl. pt. ii, p. 206, 1895); since, however, the preservation is poor, too much importance cannot be attached to a resemblance which may be purely superficial, although in the opinion of the writer it seems probable that some

[1] Heer, Fl. Foss. Arct., Band iii, Abth. ii, p. 76, pl. xvii, fig. 9; pl. xx, figs. 9, 10.

at least of the Wealden twigs identified as *Sphenolepis Sternbergiana* may really be those of *Sequoia ambigua,* which in this country we have no difficulty in distinguishing from *Sphenolepis.*

Occurrence.—PATUXENT FORMATION. Fredericksburg, Telegraph Station (Lorton), Potomac Run, Alum Rock, Cockpit Point, Woodbridge, Virginia. ARUNDEL FORMATION. Langdon, District of Columbia; Hanover, Tip Top, Soper Hall, Maryland. PATAPSCO FORMATION. Grays Hill, Ft. Foote, Stump Neck, Maryland; Mt. Vernon, White House Bluff, Hell Hole, Chinkapin Hollow, 72-mile post, Dumfries Landing, near Widewater, Aquia Creek, Virginia.

Collections.—U. S. National Museum, Johns Hopkins University.

Genus ARTHROTAXOPSIS Fontaine

[Mon. U. S. Geol. Survey, vol. xv, 1890, p. 239]

The genus *Arthrotaxopsis* named from its resemblance to the modern genus *Arthrotaxis* Don of the subfamily Taxodieæ which has three species confined to Tasmania, is characterized in the following terms by its describer:

"Trees or shrubs, copiously branching, with principal stems or branches proportionally strong, cylindrical, rigid, sending off thickly placed, long, slender, cord-like, ultimate twigs, all in the same plane and spreading widely; the ultimate twigs leave the penultimate ones under a very acute angle and show a tendency to a fastigiate grouping; cones mostly broadly oblong, rarely globular, obtuse and rounded at base and apex, average dimensions 10 mm. by 14 mm. attached singly on the summit of short lateral branches and placed on the lower portions of the leafy stems and branches, the twig with its cone representing the branching leafy twigs which occur higher up; scales of the cones woody, thick, wedge-shaped in the basal portions, expanded at the free ends, and probably shield-shaped, numerous, spirally placed, attached at a large angle, the middle ones being nearly or quite at a right angle with the axis, close appressed, opening with age; seed under each scale one, elliptical in shape, smooth and bony in texture, average dimensions 1 mm. by 2.5 mm; leafy branches ending abruptly in an ultimate twig similar to those sent off pinnately and alternately lower down; leaves very thin and scale-like, elliptical, rhombic, or oblong, with varying age changing their shape, the rhombic forms representing the oldest and most crowded leaves, slightly keeled on the back, spirally arranged."

The only qualification that it is necessary to make in the foregoing description is that referring to a single, smooth, bony seed under each cone-scale. The present writer has been entirely unable to verify this feature in any of the material some of which, however, suggests such a seed habit. The cones are of small size and comparable to the cones usually referred to *Sequoia, i. e.,* with wedge-shaped peltate scales. The material is all poorly preserved and the leafy twigs have evidently suffered greatly from decay before fossilization.

The genus may be distinguished from *Arthrotaxites* Unger,[1] *Echinostrobus* Schimper,[2] and *Cyparissidium* Heer,[3] all of which have very similar leafy twigs, by the characters of the cones, which are quite different. The first two are Jurassic while the last extends from the Rhætic to the Upper Cretaceous. As a rule the twigs of *Arthrotaxopsis* are more elongated and slender than those of these other genera, indicating beyond doubt a pendulous habit.

As originally described *Arthrotaxopsis* contained four species. Two of these prove to be identical with the species described below while the third was composite and included specimens of both *Sphenolepis Kurriana* (Dunker) Schenk and *Sequoia ambigua* Heer.

Arthrotaxopsis expansa Fontaine

Plate LXXIV, Fig. 1

Arthrotaxopsis expansa Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 241, pl. cxiii, figs. 5, 6; pl. cxv, fig. 2; pl. cxvii, fig. 6 (non pl. cxxxv, figs. 15, 18, 22 which are referred to *Sphenolepis Kurriana* (Dunker) Schenk).

Taxodium expansum Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 252, pl. cxxiii, fig. 1.

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[1] Unger, Bot. Zeit., 1849, Nr. 19.

[2] Schimper, Pal. Végét., tome ii, 1870, p. 330.

[3] Heer, Fl. Foss. Arct., Bd. iii, Abth. ii, 1874, p. 74.

Arthrotaxopsis expansa Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 504, 520, 546, 571 (non pp. 533, 535, 538, 555, 573, pl. cix, figs. 12, 13 which are referred to *Sequoia ambigua* Heer, and p. 547 which is referred to *Widdringtonites ramosus* (Font.) Berry).
Glyptostrobus expansus Ward, 1906, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 543.
Sphenolepidium Sternbergianum densifolium Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 524 (pars), pl. cxii, fig. 11 (non figs. 1, 10).
Glyptostrobus brookensis Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 483, 486, 520 (non other citations).
Arthrotaxopsis expansa Berry, 1911, Proc. U. S. Natl. Mus., vol. xl, p. 297.

Description.—Branches and twigs elongated and extremely slender, widely spreading and sparingly branched, showing a tendency as preserved to be in a single plane although it cannot be determined to what extent this reflects the original habit of the plant. Leaves spirally arranged, thick, keeled, acute, showing a tendency to become obtuse and less appressed, especially on the older twigs.

As here delimited this species is confined to the older Potomac although it is very similar to those forms from the Patapsco formation which are described as *Widdringtonites ramosus* (Fontaine) Berry, the latter being more copiously branched, less spreading, and with more acute leaves which frequently become more or less elongated. These differences may or may not be of specific value. As preserved the two plants differ decidedly in aspect but this is due largely to the spreading habit of the present species, and is approached in some of the coniferous twigs from Mt. Vernon which are referred to *Widdringtonites.*

The relation to *Arthrotaxis* implied by the name is not certain and the present species is retained in the genus to which it was referred by Professor Fontaine, more from a desire to avoid changes which do not appear to be justified by the meager evidence at hand than from any conviction of relationship. For the same reason it was not transferred to *Widdringtonites* although it seemed desirable in the case of *Widdringtonites ramosus* to make such a change and bring the latter in association with the Upper Cretaceous species of that genus with which there is such a close agreement.

Following Seward's suggestion,[1] the cones that Fontaine referred to this species are considered to belong to *Sphenolepis Kurriana* (Dunker) Schenk, as are also some of the leafy twigs which Fontaine identified as *Arthrotaxopsis,* and a number of the recorded occurrences of the latter have also been found to belong to *Sequoia ambigua* Heer.

The present is another of the several species which may be compared with the foliage from the Lower Cretaceous of Greenland which Professor Heer referred to *Cyparissidium.*

Occurrence.—PATUXENT FORMATION. Roadside near Potomac Run, Telegraph Station (Lorton), Trents Reach, Cockpit Point, Dutch Gap, Virginia; Springfield (?), Maryland. ARUNDEL FORMATION. Langdon (common), District of Columbia; Tip Top (?), Maryland.

Collection.—U. S. National Museum.

ARTHROTAXOPSIS GRANDIS Fontaine

Plate LXXVI, Plate LXXVII, Fig. 6

Arthrotaxopsis grandis Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 240 (pars), pl. cxiv, figs. 1-3; pl. cxvi, figs. 1-4; pl. cxxxv, fig. 10.

Arthrotaxopsis tenuicaulis Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 241, pl. cxiv, figs. 4, 5; pl. cxv, fig. 4; pl. cxvi, fig. 6; pl. cxvii, fig. 2.

Arthrotaxopsis pachyphylla Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 242, pl. cxv, figs. 1, 3; pl. cxvii, figs. 1, 3-5.

Arthrotaxopsis tenuicaulis Fontaine, 1899, in Ward, 19th Ann. Rept. U. S. Geol. Survey, pt. ii, p. 674, pl. clxiv.

Arthrotaxopsis grandis Fontaine, 1906, in Ward, Mon. U. S. Geol. Survey, vol. xlviii, 1905, p. 546.

Arthrotaxopsis tenuicaulis Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 516, 520, 538, 546, 571.

Arthrotaxopsis grandis Berry, 1911, Proc. U. S. Natl. Mus., vol. xl, p. 296.

Description.—Leafy twigs elongate and slender, especially the distal ones which are extremely attenuated and unbranched or sometimes dichotomously branched. Main branches alternate, much branched, apparently in a single plane. Distal twigs crowded, somewhat fastigiate. Leaves usually thin, closely appressed, elliptical to rhombic in shape, slightly keeled, acute. Phyllotaxy spiral. Cones small, ovoid,

[1] Seward, Wealden Fl., pt. ii, 1895, p. 201.

5 mm. to 10 mm. in diameter and 1 cm. to 1.5 cm. in length, made up of a small number of relatively thick, wedge-shaped, peltate scales, becoming somewhat spreading with age.

This species may be distinguished from *Sphenolepis Kurriana* (Dunker) Schenk with which it was confused by Professor Fontaine by the method of branching and by its longer and more slender twigs as well as by the usually more spreading leaves of *Sphenolepis*. The material which constituted the species *tenuicaulis* and *pachyphylla* of Fontaine is not separable from that of the type. It comes from the same beds and differs merely in the condition of preservation and relative positions of the twigs upon the branch. Under *Arthrotaxopsis grandis* was also included originally certain material from near Brooke, Virginia, which is referable to *Sphenolepis*. Both the foliage and the cones are common in the Patuxent and Arundel formations and, so far as known, they do not extend above the top of the latter. Very ambiguous material from the Hay Creek beds of the Fuson formation in Wyoming are referred to this species by Fontaine.

Occurrence.—PATUXENT FORMATION. Springfield, Fort Worthington (Baltimore), Maryland; Dutch Gap and Fredericksburg, Virginia; 16th St., District of Columbia. ARUNDEL FORMATION. Tip Top, Arlington, Bay View (cones and foliage common), Maryland; Langdon, District of Columbia.

Collections.—U. S. National Museum, Johns Hopkins University.

Genus SEQUOIA Endlicher

[Synop. Conif., 1847, p. 197]

" Flores in diversis ramulis monoici. Staminig. Amenta axillaria globosa, subspicata, perulata. Stamina plurima, axi inserta; filamenta brevissime filiformia, in connective squamulam late ovatum, verticalem producta, antheræ loculis duobus, connectivi basi continuis, discretis, parallelis, postice longitudinaliter bivalvibus. Seminif. Amenta. . . . . Strobilus subglobosus, squamis coriaceo lignosis, suborbicularibus, ungue brevi excentrico peltatis, lamina rugosa margine involuta, medio breviter mucronata, persistentibus. Semina subquavis squama 5-7, infra ejusdem marginem superiorem libere pendula, tuberculis minutishilo orbiculari inserta, elliptica, compressa, integumento subcrustaceo utrinkue in alam membranaceum rigidam, latiusculam, basi ad hilum emarginatam, apice versus micropylen deorsum spectantem sensim angustatam producto. Albumen carnosum.

"Abores Californicæ, giganteæ. Rami alterni, teretes, foliis abbreviatis anguste lanceolatis longe adnato decurrentibus vestiti; ramulorum foliis linearibus, alternis distiche lineari-subfalcatis, obtusiusculis v. acutis, rigide coriaceis, persistentibus, supra lucidis, sulco longitudinali exaratis, subtus nervo valido, et utrinque juxta nervum stomatum fasciis albidis notatis. Semmæ terminales perulatæ, perulis ad innovationes persistentibus. Amenta staminigera in ramulis axillaribus brevissimis solitaria, sæpe spicam foliatam referentia. Strobili in ramulis brevibus, perulis imbricatis tectis ad innovationes solitarii, nucis Avellanæ magnitudine, squamis in rhachi persistentibus."—Endlicher, 1847.

What appears to be the earliest authentic record of a Sequoia is furnished by the cones found in the Portlandian of France.[1] Ranging through the succeeding Lower Cretaceous deposits about a dozen species are known. The localities include Maryland, Virginia, California, Montana, Wyoming, and Texas; and outside the United States, British Columbia, Greenland, Mexico, Spitzbergen, Portugal, Belgium, Germany, Switzerland, England, and Russia. Wood of the Sequoia type of structure is also known from the Lower Cretaceous of this country and Europe. In the Upper Cretaceous species of Sequoia become still more abundant and they apparently extend their range and specific differentiation throughout the greater portion of the succeeding Tertiary period; some of the forms, represented by foliage, cones and wood, being almost identical with the modern red wood *Sequoia sempervirens* (Lamb.) Endl., while others appear to be ancestral to the modern big tree of California *Sequoia washingtoniana* (Winsl.) Sudworth. The climatic changes of the Pleistocene seem to have inaugurated the extinction of this type which had previously become restricted in America by the

[1] Fliche and Zeiller, Bull. Soc. géol. France (iv) tome iv, 1904, p. 798, pl. xix, figs. 4, 5.

extensive development of the plains type of country which was too arid for their continued existence. Both the *sempervirens* and the *washingtoniana* type are present in the Pliocene of Europe at a large number of localities as well as three or four additional species represented by twigs, cones, seeds, and wood.

In the present flora the redwood is common in the coast range from Oregon southward to Monterey County, California, while the big tree is confined to the west slopes of the Sierras from southern Placer County to Tulare County, California.

SEQUOIA REICHENBACHI (Geinitz) Heer[1]

Plate LXXVII, Fig. 7

Araucarites Reichenbachi Geinitz, 1842, Charakteristik d. Schichten u. Petrefacten sachs.-böhm. Kreide, Heft iii, p. 98, pl. xxiv, fig. 4.

Cryptomeria primæva Corda, 1846, in Reuss, Versteinerungen böhm. Kreidef., Abth. ii, p. 89, pl. xlviii, figs. 1-11.

Pinus exogyra Corda, 1846, in Reuss, *Ibid.*, p. 91, pl. xlviii, figs. 16-18.

Geinitzia cretacea Endlicher, 1847, Synop. Conif., p. 281.

Pinites exogyrus Endlicher, 1847, *Ibid.*, p. 284.

Araucaria Reichenbachi Debey, 1849, Entwurf. z. e. Geogn.-Geogenst. Darst. d. Gegend v. Aachen (Nachträge), p. 63.

Cryptomerites primævus Brongniart, 1849, Tableau, p. 74.

Geinitzia cretacea Unger, 1850, Gen. et Sp. Plant, Foss., p. 353.

Piceites exogyrus Göppert, 1850, Mon. Foss. Conif., p. 208.

Cycadopsis cryptomerioides Miquel, 1853, Verh. Geol. Kaart. v. Nederl. Deel i, p. 42 (10), pl. iii.

Araucarites adpressus v. d. Marck, 1863, Palæont., Band xi, p. 80, pl. xiii, figs. 10, 11.

Cunninghamites Sternbergii Ettingshausen,[2] 1867 (nec syn.), Sitzb. k. Akad. Wiss. Wien, Bd. liv, Abth. i, p. 246, pl. 1, figs. 4-6.

Sequoia Reichenbachi Heer, 1868, Fl. Foss. Arct., Band i, p. 83, pl. xliii, figs. 1d, 2b, 5a.

Sequoia Reichenbachi Heer, 1869, Kreidefl. v. Quedlinburg, p. 9, pl. i, fig. 2 (Neue Denks. schweiz. Gesell. Naturw., Bd. xxiv).

Sequoia Reichenbachi Heer, 1872, Fl. v. Moletein in Mähren, p. 7, pl. i, figs. 1-9 (Neue Denks. schweiz. Gesell. Naturw., Bd. xxiii, Mém. ii).

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[1] The following three citations, involving a change in the specific name of this well-known form are here omitted as being too uncertain: *Conites familiaris* Sternb., *Bergeria minuta* Presl, and *Sedites ? Rabenhorstii* Gein.

[2] Included doubtfully by Heer and positively by Ward (very questionable).

Sequoia Reichenbachi Lesquereux, 1874, Cret. Fl., p. 51, pl. i, figs. 10, 10a, 10b.

Sequoia Reichenbachi Heer, 1874, Fl. Foss. Arct., Bd. iii, Ab. ii, pp. 77, 101, 126, pl. xii, figs. 7c, d; pl. xx, figs. 1-8; pl. xxviii, fig. 2; pl. xxxiv, fig. 1; pl. xxxvi, figs. 1-8; pl. xxxvii, figs. 1, 2.

Sequoia Reichenbachi Schenk, 1875, Palæont., Band xxiii, p. 168, pl. xxix, figs. 6, 7.

Abietites dubius Lesquereux, 1878, Tert. Fl., p. 81, pl. vi, figs. 20, 21, 21a.

Sequoia Reichenbachi Hosius and v. d. Marck, 1880, Palæont., Band xxvi, pp. 132, 179, pl. xxxvii, figs. 145, 146.

Sequoia Reichenbachi Heer, 1882, Fl. Foss. Arct., Bd. vi, Abth. ii, p. 52, pl. xxviii, fig. 7.

Sequoia Reichenbachi Dawson, 1882, Trans. Roy. Soc. Can., p. 21.

Sequoia Reichenbachi Velenovsky, 1885, Gymn. böhm. Kreidef., p. 19, pl. viii, figs. 8, 9; pl. ix, fig. 5, 5a, 6a, 7a, 10a, 12, 12a, 13, 14.

Sequoia ? sp., Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 248, pl. cxvi, fig. 7; pl. cxxxii, figs. 2, 5, 6.

Sequoia sp., Font., 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 248, pl. cxxxii, fig. 10.

Sequoia Reichenbachi Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 243, pl. cxviii, figs. 1, 4; pl. cxix, figs. 1-5; pl. cxx, figs. 7, 8; pl. cxxii, fig. 2; pl. clxvii, figs. 5.

Sequoia Reichenbachi longifolia Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 244, pl. cxvii, fig. 8.

Sequoia densifolia Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 246, pl. cxxi, fig. 4.

Sequoia Couttsiæ Hollick, 1892, Trans. N. Y. Acad. Sci., vol. xii, p. 30, pl. i, fig. 5 (non Heer).

Sequoia Reichenbachi Hollick, 1892, Trans. N. Y. Acad. Sci., vol. xii, p. 30, pl. i, fig. 18.

Sequoia Reichenbachi Lesquereux, 1892, Mon. U. S. Geol. Surv., vol. xvii, p. 35, pl. ii, fig. 4.

Sequoia Reichenbachi Nathorst, 1893, in Felix and Lenk, Beitr. Geol. u. Pal. Mex., ii Theil, i Heft, p. 52, figs. 4, 5.

Sequoia Reichenbachi Smith, 1894, Geol. Coastal Plain in Ala., p. 348.

Sequoia Reichenbachi Newberry, 1896, Mon. U. S. Geol. Survey, vol. xxvi, 1895, p. 49, pl. ix, fig. 19.

Sequoia Reichenbachi Krasser, 1896, Kreidefl. v. Kunstadt in Mahren, Palæont. Oest. Ung. u. d. Orients, Bd. x, p. 124.

Sequoia Reichenbachi Fontaine, 1899, in Ward, 19th Ann. Rept. U. S. Geol. Surv., pt. ii, p. 674, pl. clxv, figs. 1, 2; pl. clxvi, fig. 1.

Sequoia Reichenbachi Knowlton, 1899, Mon. U. S. Geol. Survey, vol. xxxii, p. 657.

Sequoia Reichenbachi Ward, 1899, 19th Ann. Rept. U. S. Geol. Survey, table facing p. 712.

Sequoia Reichenbachi Berry, 1903, Bull. N. Y. Bot. Gard., vol. iii, p. 59, pl. xlviii, figs. 15-18, 20.

Sequoia Reichenbachi Berry, 1904, Bull. Torrey Club, vol. xxxi, p. 69, pl. iv, fig. 8.
Sequoia Reichenbachi Knowlton, 1905, in Stanton and Martin, Bull. Geol. Soc. Amer., vol. xvi, p. 408.
Sequoia Reichenbachi Berry, 1905, Bull. Torrey Club, vol. xxxii, p. 44, pl. i, fig. 3.
Sequoia Reichenbachi Berry, 1906, *Ibid.*, vol. xxxiii, 1906, p. 165.
Sequoia Reichenbachi Berry, 1906, Rept. State Geol. (N. J.), for 1905, p. 139.
Sequoia Reichenbachi Hollick, 1906, Mon. U. S. Geol. Survey, vol. l, p. 42, pl. ii, fig. 40; pl. iii, figs. 4, 5.
Sequoia Reichenbachi Fontaine, 1906, in Ward, Mon. U. S. Geol. Survey, vol. xlviii, 1905, pp. 177, 263, 281, 544, pl. xlv, figs. 7, 8; pl. lxix, figs. 4, 5.
Sequoia ? inferna Ward, 1906, in Fontaine, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 507.
Sequoia Reichenbachi Knowlton, 1907, Smith. Misc. Coll., vol. iv, pt. i, p. 126, pl. xii, figs. 7, 8.
Sequoia Reichenbachi Berry, 1910, Bull. Torrey Club, vol. xxxvii, p. 20.
Sequoia Reichenbachi Berry, 1911, Proc. U. S. Natl. Mus., vol. xl, p. 308.

Description.—" S. ramis elongatis, foliis decurrentibus, patentibus, falcato-incurvis, rigidis, acuminatis."—Heer, 1869.

This is one of the most wide-ranging fossil plants, both geologically and geographically, that is known, and it seems very probable that it is of a composite character, the well-known difficulty of distinguishing between coniferous twigs of this character prohibiting any satisfactory segregation. Described originally as a species of *Araucarites* certain of these remains from the Staten Island Cretaceous have shown by their vascular structure that they are related to the Araucarieæ, while on the other hand a large number of exactly similar remains of leaf-bearing twigs bore cones which are unquestionably those of a *Sequoia.* Twigs of this sort are abundant throughout the Potomac Group occurring also in the Fuson formation of the Black Hills, the Kootanie of Montana, the Shasta of California, the Kome beds of Greenland, and the Neocomian of Central Mexico. Abroad they have been reported from the Upper Jurassic (?) of Portugal, the Neocomian of Belgium, the Barremian of Silesia, and the Albian of Switzerland. Similar remains have also been described from a large number of horizons in the Upper Cretaceous, both in this country and abroad.

The slight variations from specimen to specimen and the varying conditions of preservation in the twigs of this species throughout the Potomac, together with the detached and more or less macerated cones furnished the basis for six species and varieties of Fontaine and Ward, but these are obviously not specifically distinct from one another.

Occurrence.—PATUXENT FORMATION. Fredericksburg, Telegraph Station (Lorton), Dutch Gap, Virginia; Springfield, Maryland. ARUNDEL FORMATION. Reynolds Ore Pit, Maryland. PATAPSCO FORMATION. Near Brooke, Virginia.

Collection.—U. S. National Museum.

SEQUOIA RIGIDA Heer

Plate LXXVIII, Fig. 8

Sequoia rigida Heer, 1873, Fl. Foss. Arct., Band iii, Abth. ii, pp. 80, 91, 102, 128, pl. xxii, figs. 5g, 11a; pl. xxv, fig. 6; pl. xxvii, figs. 8-14; pl. xxxviii, figs. 9a, 10.

Sequoia rigida Schenk, 1875, Palæont., Band xxiii, p. 168, pl. xxix, figs. 8, 9.

Sequoia rigida Heer, 1882, Fl. Foss. Arct., Band vi, Abth. ii, p. 52, pl. vii, figs. 10-12; pl. viii, fig. 7; pl. xxi, fig. 1c; pl. xxiv, fig. 3b.

Sequoia rigida Heer, 1883, Fl. Foss. Arct., Band vii, p. 13, pl. liii, figs. 5-7.

Sequoia subulata Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 245, pl. cxvii, fig. 7; pl. cxviii, figs. 5, 6 (non Heer).

Sequoia rigida Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 246, pl. cxviii, fig. 3; pl. cxxi, fig. 2; pl. cxxvi, fig. 2; pl. cxxx, fig. 3.

Sequoia rigida Knowlton, 1905, in Stanton and Martin, Bull. Geol. Soc. Amer. vol. xvi, p. 408.

Sequoia rigida Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 219.

Sequoia subulata Fontaine, 1906, in Ward, *Ibid.*, pp. 486, 571.

Sequoia rigida Berry, 1911, Proc. U. S. Natl. Mus., vol. xl, p. 309.

Description.—" S. foliis coriaceis, rigidis, linearibus, apice acuminatis, patentibus, rectis, uninerviis, transversim subtilissime regulosis, basi non angustatis, adnato-longe decurrentibus."—Heer, 1873.

This species was described by Heer from the Kome beds of Greenland although he subsequently pointed out that it was more abundant in the Atane beds. He compared it with *Sequoia Woodwardii* (Carr.) Schimp., of the Upper Greensand of England and with *Sequoia pectinata* Heer of the Senonian of Germany. It is also recorded from the Gosau beds of Europe and from the Upper Cretaceous of Alaska as well as from the Potomac of Virginia, the Kootanie of Montana, and the Shasta of California. The specific identity of these Upper and Lower Cretaceous forms may well be doubted but no clear line of demarcation can be drawn between them at the present time. It is quite possible that the Potomac forms are merely variants of the abundant *Sequoia Reichenbachi* since they fail to show the transverse rugosity (a feature of the preservation merely) described by Heer, and also appear to be somewhat less decurrent and at times less finely pointed than the type material. A variety described by Saporta from the Albian of Portugal as var. *lusitanica*[1] is scarcely to be distinguished from the Potomac specimens.

The Potomac specimens which Professor Fontaine identified as *Sequoia subulata* Heer are here referred to *Sequoia rigida* Heer with which they are obviously identical, in fact it seems probable that the type material of *Sequoia subulata* cannot be distinguished from this species. There are differences in some of the specimens which Heer has identified with his *Sequoia subulata*, so that it seems best not to unite the two species at the present time.

Occurrence.—PATUXENT FORMATION. Near Potomac Run, near Telegraph Station (Lorton), Virginia; Springfield, Prince George's County, Maryland.

Collection.—U. S. National Museum.

SEQUOIA DELICATULA Fontaine

Sequoia delicatula Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 247, pl. cxxi, fig. 3.

Sequoia delicatula Berry, 1911, Proc. U. S. Natl. Mus., vol. xl, p. 310.

Description.—" Principal twigs slender, penultimate and ultimate ones all in one plane, minute, short, closely placed, alternate and pinnate

[1] Saporta, Fl. Foss. Portugal, 1894, p. 177, pl. xxxiii, figs. 7-12.

in arrangement; leaves very small, narrowly linear, acute or acuminate, widest at base, decurrent, and mostly crowded; midnerve slender but distinct."—Fontaine, 1890.

Fontaine says of this species: "This plant is a good deal like *S. subulata*, but the leaves are proportionately wider and not so falcate, while the ultimate branches are placed at more uniform intervals." It may be doubted whether it is really distinct from the abundant *Sequoia Reichenbachi* since it was extremely rare at the single Virginia locality from which it was originally collected and it has not been met with in any of the subsequent collections. It is not especially well marked and is of little significance although it has seemed best to keep it distinct at the present time.

Occurrence.—Patuxent Formation. Near Dutch Gap. Virginia.

Collection.—U. S. National Museum.

Sequoia ambigua Heer

Plate LXXVIII, Figs. 1-7

Sequoia ambigua Heer, 1874, Fl. Foss. Arct., Band iii, Abth. ii, pp. 78, 91, pl. xxi, figs. 1-11; pl. xxv, fig. 5.

Sequoia ambigua Heer, 1882, *Ibid.*, Band vi, Abth. ii, pp. 17, 52, pl. i, fig. 3.

Sequoia ambigua Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1880, p. 245, pl. cxviii, fig. 2; pl. cxx, figs. 1-6; pl. cxxvii, fig. 5; pl. cxxxii, fig. 3.

Sequoia ambigua White, 1890, Am. Journ. Sci., vol. xxxix, p. 97, pl. ii, figs. 2, 3

Sphenolepidium recurvifolium Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 258, pl. cxxvii, fig. 2; pl. cxxx, figs. 2, 7.

Sphenolepidium dentifolium Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 258, pl. cxxviii, figs. 2-6; pl. cxxix, fig. 5; pl. cxxx, figs. 4-6, 10.

Sequoia ambigua Nathorst, 1893, in Felix and Lenk, Beitr. z. Geol. u. Pälæont. Repub. Mexico, ii Theil, 1 Heft, p. 51, figs. 1-3.

Sequoia ambigua Hollick, 1895, Bull. Geol. Soc. Am., vol. vii, p. 13.

Sequoia gracilis Fontaine, 1899, in Ward, 19th Ann. Rept. U. S. Geol. Surv., pt. ii, p. 675, pl. clxvi, fig. 2 (non Heer).

Sequoia ambigua Uhler, 1901, Trans. Md. Acad. Sci., vol. i (1892), p. 207.

Sequoia ambigua Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 272, 281, 538, 555, pl. lxix, fig. 6; pl. cx, fig. 13.

Sphenolepidium dentifolium Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 484, 528, 538, 546, 555.
Arthrotaxopsis expansa Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xv, 1889, pp. 533, 535, 538, 555, 573, pl. cix, figs. 12, 13 (non pp. 504, 520, 547, 571).
Sequoia ambigua Hollick, 1907, Mon. U. S. Geol. Surv., vol. l, p. 41, pl. iii, figs. 7, 8.
Sequoia ambigua Knowlton, 1907, Smith. Misc. Coll., vol. iv, pt. i, 1907, p. 126.
Sequoia ambigua Berry, 1910, Bull. Torrey Club, vol. xxxvii, p. 20.
Sequoia ambigua Berry, 1911, Proc. U. S. Natl. Mus., vol. xl, p. 310.

Description.—" S. ramis elongatis, foliis omnino tectis, ramulis alternis, gracilibus, foliis decurrentibus, brevibus, crassiusculis, falcato-incurvis, apice acuminatis, uninerviis, strobilis globosis, squamis peltatis, planiusculis."—Heer, 1874.

Remains of the foliage of this species are distinguishable from those of contemporaneous conifers, which occur in the beds with them, by the relatively short and very stout, acuminate, falcate or recurved, decurrent leaves.

The cones are spherical and consist of relatively few short scales with longitudinally striated peduncles and suddenly expanded, quadrangular, peltate, umbilicate tips. These cones are abundant in the Lower Cretaceous of Maryland occurring usually as detached ferruginized mud-casts. They vary considerably in size and this has resulted in their having been referred to two species and genera, the smaller having been identified by Professor Fontaine as *Arthrotaxopsis expansa* while the larger were referred to *Sequoia ambigua*. As Prof. Ward pointed out in Monograph XLVIII they show no differences except in size, and even this feature has rather narrow limits of variation with every gradation present. The writer has carefully compared a large suite of specimens and many wax casts of the scales and finds them absolutely identical in every respect, the relative proportions of the scales from the smallest and the largest cones giving the same ratios of length, width, and height.

As recorded in the literature cited above *Sequoia ambigua* is widely distributed geographically and it has an equally great geological range.

Described originally from the Kome beds (Barremian) of Greenland by Professor Heer this author soon afterward recorded it from the Upper Cretaceous Atane beds of that country. It has been recorded by Nathorst from the Neocomian of Mexico and it is present in the Kootanie formation of Montana. It is a member of the Shasta flora of the Pacific coast (Horsetown beds) and is probably represented in the Fuson formation of eastern Wyoming by what Prof. Fontaine calls *Sequoia gracilis.* In the Upper Cretaceous, remains in every way identical with these Lower Cretaceous occurrences are present in the Magothy formation at Gay Head and at a number of localities in Maryland as well as in the Tuscaloosa formation of Alabama.

In the Potomac Group this species ranges from the base of the Patuxent, through the Arundel to the top of the Patapsco in considerable abundance. Seward (Wealden Fl. pt. ii, 1895, p. 206) comments on the resemblance between *Sequoia ambigua* Heer and the widespread remains of *Sphenolepis Sternbergiana* (Dunker) Schenk, a resemblance strikingly shown in some Wealden specimens of the latter from Ecclesbourne recently received by the writer. However, their preservation is not of the best and the English specimens seem to show slight differences from the type of this species in the direction of what in America is identified as *Sequoia ambigua.* No changes in nomenclature are proposed, however, since it seems probable that *Sphenolepis Sternbergiana* in North America is properly identified and distinct from *Sequoia ambigua,* which is more open and stouter and which may be present in the English Wealden in some at least of the coniferous twigs identified as *Sphenolepis Sternbergiana.*

Occurrence.—Patuxent Formation. Fredericksburg, Dutch Gap, Cockpit Point, Potomac Run, Telegraph Station (Lorton), Virginia. Arundel Formation. Soper Hall, Riverdale, Arlington, Muirkirk, Schoolhouse Hill (Hanover), Maryland. Patapsco Formation. Federal Hill (Baltimore), Locust (Poplar) Point, Fort Foote, Maryland.

Collections.—U. S. National Museum, Johns Hopkins University.

CLASS ANGIOSPERMAE

Subclass MONOCOTYLEDONAE

Order NAIADALES

Family ALISMACEAE

Genus ALISMAPHYLLUM gen nov.

The present genus is proposed for monocotyledonous leaves of unknown generic affinity but obviously referable to the family Alismaceæ. The type species is *Sagittaria Victor-Masoni* Ward based on a single specimen from the Patapsco formation at Mt. Vernon, Virginia. It was compared by its describer with the exisiting *Sagittaria latifolia* Willd., but it would be equally at home in other genera, as for example *Echinodorus* or *Lophotocarpus* to mention but two such. The venation is of the type of this family and the auricles suggest various species of *Sagittaria,* although when auricled the ears in the mature leaves are usually much more extended than in the fossil leaf. Since, however, there is considerable variation in this respect, some species having lanceolate leaves and others like *Sagittaria rigida* Pursh having linear, lanceolate, elliptical and hastate leaves, this character is not of importance. It is believed, however, to be of distinct advantage in cases where certainty is impossible, not to carry the generic lines of the present too far back into the past. The genus *Alismacites* of Saporta [1] is not available since it was proposed for forms with a distinctly stated relationship to the modern genus *Alisma.*

A considerable number of fossil species from a large number of horizons have been described as species of *Alisma, Alismacites* and *Sagittaria,* the oldest being the leaves and seeds from the Neocomian of Portugal which Saporta names *Alismacites primævus.* [2]

The existing Alismaceæ number about 70 species segregated into 10 or 12 genera and all are aquatic or marsh plants of herbaceous stature

[1] Saporta, Ann. Sci. Nat. Bot. (iv), tome xvii, 1862, p. 228.

[2] Saporta, Fl. Foss. Portugal, 1894, p. 96, pl. xv, fig. 31; pl. xvi, fig. 13a.

and wide distribution, representatives being present on all the continents. They seem equally at home in the tropics and in the less cold parts of the temperate zone and with favorable edaphic conditions seem to be but little influenced by those of temperature

Alismaphyllum Victor-Masoni (Ward)

Plate LXXIX, Fig. 5

Sagittaria Victor-Masoni Ward, 1895, Fifteenth Ann. Rept. U. S. Geol. Survey, p. 354, pl. iii, fig. 5.

Sagittaria Victor-Masoni Fontaine, 1906, in Ward, Mon. U. S. Geol. Survey, vol. xlviii, 1905, p. 491.

Description.—Leaf ovate in outline tapering upward and presumably acutely pointed, auriculate below. Auricles relatively short, wide and rounded, margin entire. Petiole and midrib stout. Secondaries four to six in number, from the top of the petiole, one or two on each side reflexed and supplying the auricles, the two inner on each side curving upward, the outer following the margin for a considerable distance, how far it is not possible to ascertain since both of the lateral margins are inrolled in the single known specimen of this species. The finer venation is unfortunately not preserved.

This species is clearly referable to the family Alismaceæ and while it shows a number of characters which ally it with the modern genus *Sagittaria* it is equally close to other modern and closely related genera as has just been pointed out, so that its reference to a genus which while denoting its general botanical affinity does not carry implications of identity with any of the existing genera of this family is clearly demanded.

The species is obviously distinct from any previously described fossil forms but is unfortunately based on the single specimen figured so that a more complete diagnosis is impossible.

Occurrence.—Patapsco Formation. White House Bluff, Virginia.

Collection.—U. S. National Museum.

Order GRAMINALES

Family CYPERACEAE

Genus CYPERACITES Schimper

[Pal. Végét., tome ii, 1870, p. 412]

This genus was proposed by Schimper for those fossil remains including fragments of rhizomes, culms, leaves, inflorescences, fruits, etc., whose reference to the family Cyperaceæ seems justified, but which cannot be satisfactorily compared with any of the existing genera of that family.

It is strictly a form genus and was designed to replace the genus *Cyperites* of Heer since the latter name as originally proposed by Lindley and Hutton was applied to carboniferous leaves of *Sigillaria*. Schimper in 1870 (*loc. cit.*) listed 33 species of *Cyperacites* and about as many more have been described since that date, nearly all coming from Tertiary strata. Some doubtful remains of parallel-veined leaves from the Upper Cretaceous have, however, been referred to this genus. The Lower Cretaceous records are similar to those of the Upper Cretaceous and are very indefinite in character; they include certain vague material recorded by Dawson[1] from the Kootanie of British Columbia and two types of leaves recorded by Heer[2] from the Kome beds of Greenland.

The following species from the Patapsco formation of Maryland, while it leaves much to be desired, is of considerable interest, since it is by far the oldest known sedge which has been preserved with sufficient of its parts to render its reference to this family certain. While remains of sedges and grasses showing flowers or fruits are not unknown in the fossil state all have come from comparatively recent deposits, that is to say, late Eocene or younger.

The family Cyperaceæ in the existing flora is a large one with several thousand species distributed among about 70 genera, of which the ubiquitous genus *Carex* is by far the largest. The species are chiefly temperate in habitat but many of them have a very wide range.

[1] Dawson, Trans. Roy. Soc. Can., vol. x, sec. iv, 1892, p. 91, tf. 16.
[2] Heer, Fl. Foss. Arct., Band iii, 1874, p. 86, pl. xii, fig. 4b; pl. xxiv, fig. 4.

CYPERACITES POTOMACENSIS sp. nov.

Plate LXXIX, Fig. 6

Description.—Plants of small size, with slender, somewhat flabellate, linear leaves. Culm slender, apparently flat, preserved for a length of 2.2 cm. (apical part missing) and bearing 1.6 cm. from the base, a single fruiting head, the subtending bract being apparently reduced to a small scale. Head oblong conical, about 5 mm. in length and 2 mm. in width as preserved with a short peduncle about 1 mm. in length. Achenes relatively few in number, apparently angular, much flattened. The associated leaves are flat and slender, about 1/3 of a millimeter in width.

This species is based upon the specimen figured and its counterpart, comprising the culm with the attached fruits and the more or less broken remains of four leaves, apparently belonging to the same individual as does the culm. It was evidently a small and delicate form and not a young plant since the achenes must have been nearly or quite mature to have left such sharp impressions in the clay. The preservation is such that no details can be made out but it is clearly referable to the sedges and might be matched by a number of modern species of *Carex*. As previously mentioned it is of considerable interest in that it furnishes conclusive evidence of the existence of this supposed modern family of Monocotyledonæ at an age as remote as the late Lower Cretaceous and it is of further interest, even preserved as poorly as it is, in representing a fruiting specimen of these comparatively rare types.

Occurrence.—PATAPSCO FORMATION. Near Wellhams, Anne Arundel County, Maryland.

Collection.—Johns Hopkins University.

Order XYRIDALES (?)

Genus PLANTAGINOPSIS Fontaine

[In Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1906, p. 560]

PLANTAGINOPSIS MARYLANDICA Fontaine

Plate LXXIX, Figs. 1-4; Plate LXXX

Plantaginopsis marylandica Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 561, pl. cxvii, fig. 7; pl. cxviii, figs. 1, 2.
Celastrophyllum marylandicum Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 559, pl. cxvi, fig. 7.

Description.—Leaves elongate linear-lanceolate, 10 to 18 cm. in length by about 2.5 cm. in width at the broadest part which is toward the apex, from which point they narrow gradually to the broad sheathing base. The latter is about 5 mm. wide with the margins approximately parallel and is the part usually preserved, the upper and more delicate part of the leaf lamina having usually been completely macerated or torn away before fossilization. Margins entire basally for 1/3 the length of the leaf, and for even a greater distance, passing distad into slight serrations which gradually grade into large, shallow, rather rounded, dentate teeth. Apex not clearly made out but apparently rounded. Venation indistinct; basally there are several approximately parallel veins of rather fine calibre, higher up in the lamina these branch in a straggling manner and apparently send short branches into the teeth. Several specimens of the capitate fruit (inflorescence ?) are preserved in intimate association but not in actual connection with the leaves. These fruits are elliptical in shape, as preserved they are about 2.5 cm. x 1.2 cm., the surface covered with more or less circular bosses of small size about 1 mm. in diameter, somewhat suggestive of the berry-like fruits of the Araceæ.

Five specimens in all have been found and a sixth from the same locality has received the name *Celastrophyllum marylandicum.* This latter shows the venation of the upper part of the leaf, but not at all clearly, nor are the veins as prominent as the published figure would indicate. It has the same narrow outline, broad entire base, large irregular teeth and is undoubtedly referable to this same species another leaf of which is preserved alongside of it on the same piece of clay. There is no obvious relation to *Celastrophyllum* the absence of a definite midrib at once removing that genus from consideration. The plant evidently was stemless from a rootstock as the larger specimen figured would indicate and was evidently a semi-aquatic marsh plant comparable with *Eriocaulon*, Fontaine's comparison with *Plantago* emphasized by the name being particularly unfortunate.

Occurrence.—PATAPSCO FORMATION. Federal Hill (Baltimore), Maryland.

Collections.—U. S. National Museum, Goucher College.

Subclass DICOTYLEDONAE

Order SALICALES

Family SALICACEAE

Genus POPULUS Linné

[Sp. Pl., 1753, p. 1034]

Trees with narrow lanceolate to broadly orbicular, alternate, stipulate, generally long petiolate leaves. Margins sometimes entire but usually toothed in various ways. Venation pinnate in the modern and in a large number of the fossil species, the secondaries being approximately parallel and the basal pair not of sufficiently disproportionate size to be termed primaries. In numerous fossil species, however, especially those from the Arctic regions and from the earlier American deposits, the basal secondaries are prominent and curved upward, warranting the use of the term palmate in describing them. Fruit a 2 to 4 valved capsule, the enclosed seeds with a conspicuous long coma of white silky hairs, both fruit and seeds occurring as fossils under especially favorable conditions of preservation.

The genus *Populus* is an important one for the paleobotanist with over 150 described species, the oldest of which, the celebrated *Populus* *primæva* of Heer [1] from the Kome beds (Barremian) of Greenland, still remaining one of the oldest known dicotyledons of undisputed identity.

Two other species described by Heer from the Arctic Tertiary, *Populus Zaddachi* and *Populus arctica* have the further distinction of having been found fossil in latitude 81° 46′ on the north shore of Grinnell Land.

The Potomac species comes next after *Populus primæva* in point of age. With the dawn of the Upper Cretaceous a number of species appear including four in the Atane beds of Greenland, ten in the Dakota sandstone and four or five in the Raritan, Tuscaloosa and Magothy formations. The first European species appear to be of Senonian age. After the close of the Cretaceous the genus expanded suddenly, especially in America, over a score of species being known from the Fort Union beds and many from the Arctic Tertiary. It remained cosmopolitan in the northern hemisphere throughout the Tertiary and Recent periods, and several of the existing species, which number in all about 25 forms, are present in the Pleistocene deposits of both America and Europe.

POPULUS POTOMACENSIS Ward

Plate LXXXI, Figs. 1-1e

Populus potomacensis Ward, 1895, 15th Ann. Rept. U. S. Geol. Survey, p. 356, pl. iv, figs. 1-3.
Populus auriculata Ward, 1895, 15th Ann. Rept. U. S. Geol. Surv., p. 356, pl. iv, fig. 4.
Populophyllum menispermoides Ward, 1906, in Fontaine, Mon. U. S. Geol. Survey, vol. xlviii, 1905, p. 498 (pars), pl. cx, fig. 2 (non figs. 3, 4).
Populus auriculata Ward, 1906, in Fontaine, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 499, pl. cx, fig. 5.
Populus potomacensis Ward, 1906, in Fontaine, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 500.

Description.—Leaves of small size, orbicular to ovate in general outline, with an obtusely pointed apex and a broad, deeply cordate base. 2 cm. to 5.5 cm. in length by 2.2 cm. to 4 cm. in greatest width, which

[1] Heer, Fl. Foss. Arct., Band iii, Abth. ii, 1874, p. 88, pl. xxiv, fig. 6.

is in the basal half of the leaf. Margin crenulate, entire in the basal sinus. Petiole stout. Midrib of medium calibre. Primaries 3 to 7 in number decreasing in calibre outward, inserted at the apex of the petiole, curving upward, camptodrome.

This characteristic and handsome little species is abundant in the Mt. Vernon clays to which locality it is thus far confined. It shows considerable variation in the amount of elongation, some specimens being relatively narrow with a consequently more pointed apex and more acute basal sinus, but there can be scarcely any doubt that the forms figured were all borne by the same tree, although they constituted a part of three different species of Professor Ward, as enumerated above. The outlines of *Populus* leaves in general vary considerably in the same species and on the same tree. The venation on the other hand is more conservative, and it is on the basis of these well-known facts that the present treatment is based.

Occurrence.—Patapsco Formation. Mt. Vernon and White House Bluff, Virginia.

Collection.—U. S. National Museum.

Genus POPULOPHYLLUM Fontaine

[Mon. U. S. Geol. Survey, vol. xv, 1890, p. 311]

This genus named to indicate a supposed but altogether doubtful relationship with the genus *Populus* is characterized as follows by its describer:

"Leaves rotundate; petiole thick and apparently somewhat succulent; nerves tending to a radiate grouping from the summit of the petiole; midnerve not much surpassing in strength the nerves which go off on each side of it."

As here understood the genus embraces two species, one with an entire or slightly undulating margin and the other with a coarsely dentate margin. It may be doubted whether the two are congeneric, the former certainly shows but the slightest affinity with *Populus* and suggests the genus *Chondrophyllum*. Similar remains from the Lower Cretaceous of Portugal are referred by Saporta to the genera *Menispermites* and *Aristolochia*.

POPULOPHYLLUM MINUTUM Ward

Plate LXXXI, Fig. 2

Populophyllum minutum Ward, 1906, in Fontaine, Mon. U. S. Geol. Survey, vol. xlviii, 1905, pp. 499, 532, pl. cvii, fig. 9; pl. cviii, fig. 11.

Description.—Leaf nearly orbicular in outline; small in size, being about 1.5 cm. in length and width. Margin coarsely dentate, becoming entire toward the base which is not at all cordate or auriculate, but rounded truncate or cuneate. Venation palmate; primaries three to five in number from the summit of the petiole, the midrib being much the strongest. The lateral primaries are fine in calibre, they fork and anastomose some distance from the margin sending very delicate branches into the broad blunt teeth.

As Professor Ward remarks (*loc. cit.*), this leaf is suggestive of the Vitaceæ and recalls *Cissites crispus* Velen. from the Bohemian Cenomanian and the forms which Newberry described under the same name from the New Jersey Raritan. It is abundantly distinct from all of these, however, and were the present author describing it *de novo*, it would be referred to *Populus*. As the case stands it may remain in *Populophyllum* which sufficiently indicates its probable affinity and does not necessitate a change in nomenclature.

More representative specimens of this species occur on the southern bank of the Potomac at Mt. Vernon, the fragments from Ft. Foote being not entirely satisfactory, suggesting the possibility that they might be small and somewhat anomalous leaves of *Celastrophyllum acutidens* Font., which is so abundant at this locality. They appear, however, to be identical with the Mt. Vernon material.

Entirely characteristic leaves of this species occur in the Maryland Patapsco deposits near Wellhams. These are identical in appearance with those from Mt. Vernon, Virginia, except for a somewhat narrowed base coupled with which character the outer lateral primaries have migrated upward slightly and become basal secondaries.

Occurrence.—PATAPSCO FORMATION. Ft. Foote, Prince George's County, near Wellhams, Anne Arundel County, Maryland; Mt. Vernon, Virginia.

Collection.—U. S. National Museum.

POPULOPHYLLUM RENIFORME Fontaine

Plate LXXXI, Figs. 3-6

Populophyllum reniforme Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 311, pl. clv, fig. 9; pl. clvi, fig. 3.

Populophyllum hederæforme Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 311, pl. clxvi, fig. 3.

Proteæphyllum reniforme Ward, 1895, 15th Ann. Rept. U. S. Geol. Survey, p. 360, pl. iv, figs. 5, 6 (non Font.).

Populophyllum menispermoides Ward, 1906, in Fontaine, Mon. U. S. Geol. Survey, vol. xlviii, 1905, p. 498, pl. cx, figs. 3, 4 (non fig. 2 which is *Populus potomacensis* Ward).

Description.—Leaves of small or medium size, orbicular or reniform in outline, 3 cm. to 7 cm. in length by 3 cm. to 7 cm. in greatest width which is about half way between the apex and the base. Margin entire or slightly undulate. Petiole very stout, of considerable length. Venation palmate, camptodrome. Primaries 4 to 7 from the top of the petiole, usually 7 in number, very fine in calibre and often invisible, the midrib slightly more prominent than the lateral primaries; these soon fork and anastomose in broad arches sending off branches which form similar secondary and tertiary arches. Basal sinus shallow with the basal auricles of the leaf lamina uniformly rounded, ranging to forms in which the sinus is narrow and as much as 2 cm. deep with the auricles of the lamina somewhat angular.

This curious species is especially common, although usually in a fragmentary condition, in the Patapsco beds in the vicinity of Aquia Creek, Virginia. It is scarcely related to *Populus* and by its thick petiole and fine venation is suggestive of an aquatic plant. Mention has already been made (*supra*) of its resemblance to some of the forms referred to the genus *Chondrophyllum* but this gives no better clue to its botanical affinity. In Portugal Saporta has described similar remains from the Albian beds of Buarcos under the names *Menispermites cerci-*

difolius[1] and *Aristolochia Daveauana.*[2] The latter form is undoubtedly congeneric with the Patapsco species but it is extremely doubtful if *Aristolochia* is even as near an expression of its generic affinities as *Populophyllum.* The present species should also be compared with the Kome plant which Heer described as *Protorhipis cordata*[3] which is obviously not a *Protorhipis* and is closely related to this Patapsco species.

Occurrence.—PATAPSCO FORMATION. Mt. Vernon, 72-mile post near Brooke, White House Bluff, near Widewater, just north of Aquia Creek on the R. F. & P. R. R. and just south of Aquia Creek on the R. F. & P. R. R. (common), Virginia; near Wellhams, Anne Arundel County, Maryland.

Collections.—U. S. National Museum, Johns Hopkins University.

Order RANALES

Family NYMPHAEACEAE

Genus NELUMBITES gen. nov.

The Potomac forms referred to this genus have hitherto been referred to *Menispermites* a comprehensive genus belonging to the allied family Menispermaceæ of this order.

The oldest species of *Nelumbo*-like leaves heretofore known include the small leafed *Nelumbo primæva* Berry[4] from the Magothy formation of New Jersey and Maryland which should probably be referred to this genus and the large leafed *Nelumbo Kempii* Hollick[5] from the same formation in New Jersey and on Long Island and Marthas Vineyard. Small leafed forms also occur at higher horizons in the Montana Group and in the Laramie or Shoshone Groups of the West. Still other and mostly larger species are referred to the allied genus *Nelumbium* of Jussieu.

[1] Saporta, Fl. Foss. Portugal, 1894, p. 191, pl. xxxv, fig. 7.
[2] Saporta, *Ibid.*, p. 183, pl. xxxv, fig. 10.
[3] Heer, Fl. Foss. Arct., Band vi, Abth. ii, 1880, p. 10, pl. iii, fig. 11.
[4] Bull. N. Y. Bot. Garden, vol. iii, 1903, p. 75, pl. xliii, fig. 1.
[5] Mon. U. S. Geol. Surv., vol. l, 1907, p. 61, pl. xiii, figs. 1-4; pl. xiv, figs. 1, 2; pl. xv; pl. xvi, figs. 1-6.

While the Potomac species have the characteristic peltate leaves they are not radially symmetrical as are the later species but have the petiole attached nearer to one margin giving them an appearance much like that of a number of supposed species of *Menispermites*. The venation is, however, nearer that of *Nelumbo* and its allies, the secondaries being prominent on the lower surface, obsolete on the upper surface, and forking after the manner of the Nymphæaceæ. If these leaves were not floating it is surprising that a petiole stout enough to hold the leaf erect is not found fossil, unless the leaf normally abscissed from the apex instead of the base of the petiole. It is hoped that sooner or later specimens will be found showing whether or not the stomata were confined to the upper surface and thus confirming or disproving the assumption here made that they were aquatic in habit.

The author has followed Fontaine in keeping the two following species separate, although they are very similar except as to size and the resulting calibre of venation, and it would have done little violence to the facts to have united them in a single species. They are characteristic forms of the Patapsco formation and quite abundant at certain outcrops. The existing species of *Nelumbo* are two in number, both large aquatic perennials, one North American and the other Asiatic and Australian. It has seemed better to establish a new genus for the reception of these older Cretaceous forms, which while expressing their proper affinities does not unduly extend our conception of the modern genus.

It is interesting to note in this connection that Saporta[1] has reported two species of *Nelumbium* from the supposed Albian of Portugal, but as these are not fully defined and unfigured their relation to the following American species is unknown.

Nelumbites virginiensis (Fontaine) Berry.

Plate LXXXII, Figs. 3-5

Menispermites virginiensis Fontaine, 1890, Mon. U. S. Geol. Surv., 1889, vol. xv, p. 321, pl. clxi, figs. 1-2.

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[1] Saporta, Comptes rendus, tome cxix. 1894, pp. 835-837.

Menispermites virginiensis Ward, 1895, 15th Ann. Rept. U. S. Geol. Surv., p. 360, pl. iv, fig. 8 (non fig. 7).
Menispermites virginiensis Fontaine, 1906, in Ward, Mon. U. S. Geol. Survey, vol. xlviii, 1905, pp. 504, 528, 534, 557.

Description.—The type of this species from near Brooke, Va., is a fragment of a large leaf about 15 cm. in diameter. The preservation is such that its peltate character cannot be made out with certainty the specimen having the appearance of having a deeply auriculate overlapping base, but this is probably due to maceration or folding, as the additional specimens since found which resemble it very closely are distinctly peltate.

General outline orbicular, about 10 cm. in diameter; leaf substance thick; margin inclined to be undulate or obscurely crenulate. Point of attachment to the petiole about 1/3 of the diameter distant from the margin. Veins radiate, somewhat flexuous, stout, nine or ten in number, dichotomously forking.

This species is very suggestive of certain Dakota Group forms which Lesquereux described as species of *Menispermites*, e. g., *M. grandis* and *M. cyclophyllum*. Poorly preserved remains have been found at a number of localities in Virginia and Maryland in beds of Patapsco age, and its resemblance to *N. primæva* Berry from the Magothy formation suggests an ancestral relationship.

Occurrence.—PATAPSCO FORMATION. Ft. Foote (?), Federal Hill (Baltimore), Overlook Inn Road, Maryland; Mt. Vernon, Hell Hole, 72-mile post, Brooke, Virginia.

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

NELUMBITES TENUINERVIS (Fontaine) Berry

Plate LXXXII, Figs. 1, 2

Menispermites tenuinervis Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 322, pl. clxii, fig. 8.
Menispermites virginiensis Ward, 1895, 15th Ann. Rept. U. S. Geol. Surv., p. 360, pl. iv, fig. 7 (non fig. 8).
Menispermites tenuinervis Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 496, 557, pl. cix, figs. 2, 3.

Description.—The type of this species was a small, thick, orbicular leaf with obscure venation from Federal Hill which the describer compared with a *Lemna*. The same author has identified this species in more recent collections and it is from these that the present description is drawn since the original type presents no distinctive characteristics.

Leaves peltate, considerably smaller than those of the preceding species, not over 7 cm. in maximum diameter, orbicular in outline, the transverse somewhat greater than the longitudinal diameter. Margin entire or obscurely undulate. As might be expected from the comparative size, the veins are finer and the leaf substance is thinner than in *N. virginiensis*. Veins radiating from the eccentric point of attachment of the petiole, about seven in number, thin and somewhat flexuous, forking and forming transverse loops parallel with the margin. These loops send off almost rectangular branches forming a secondary series of loops parallel with the margin. Similarly a third and smaller series may be present. Veins obsolete on the upper surface of the leaf but prominent below.

This species is not strikingly different from the preceding, its specific characters possibly being due entirely to its smaller size, although the attachment to the petiole is nearer the margin, the transverse diameter is proportionately greater, and there is a more definitely marked midrib than in *N. virginiensis*.

Occurrence.—PATAPSCO FORMATION. Federal Hill (Baltimore), Maryland; Mt. Vernon, Aquia Creek, White House Bluff, Virginia.

Collection.—U. S. National Museum.

Family MENISPERMACEAE

Genus MENISPERMITES Lesquereux

[U. S. Geol. Surv. Terr., vol. vi, 1874, p. 94]

The genus *Menispermites* was erected by Lesquereux in 1874 for the reception of four species of leaves from the Dakota sandstone of the West, which he had previously referred to *Dombeyopsis, Acer* or *Acerites,* and *Populites*. His diagnosis was as follows:

"Leaves large, coriaceous or subcoriaceous, broadly deltoid, more or less distinctly three-lobed, with obtuse divisions, and borders entire or undulate; nervation palmately 3 to 5 nerved, from a peltate or subpeltate, truncate or subcordate base; primary veins craspedodrome, their points joining the borders of the lobes, but their divisions following along them by a series of curves upon each other, or of multiple festoons, as seen in the leaves of the present *Menispermum canadense* especially. The divergence from this last type is marked in one species only, whose nervation agrees with that of *Menispermum* (*Cocculus*) *carolinum*," etc.

The craspedodrome character of the venation or the lobate character of the lamina cannot be insisted upon since Lesquereux and others have referred a number of camptodrome and entire forms to this genus. Later exploration in the Dakota sandstone enabled Lesquereux and others to characterize five additional species from this horizon, one of which has been reported from the Coastal Plain. Heer has described two species from the Atane beds of Greenland, one of which extends southward to the Raritan of New Jersey. This species in all but its more pointed apex closely resembles the following Patapsco species. Three other species have been described from the Atlantic Coastal Plain and several are known from the Upper Cretaceous of the West, while Saporta has described a single species from the Albian of Portugal. Fontaine records this genus from the Shasta flora of the Pacific coast but the remains are altogether uncharacteristic. The species from the Potomac Group which were formerly referred to this genus by Fontaine are discussed under the genus *Nelumbites* in the present work.

MENISPERMITES POTOMACENSIS sp. nov.

Plate XCIII, Figs. 3, 4

Description.—Leaves of relatively medium or small size, orbicular in general outline. Length 6 cm. to 9 cm. Greatest width 5 cm. to 8 cm. at a point about half way between the apex and the base. Margin entire, more or less undulate. Apex rounded. Base rounded, ultimately slightly decurrent and possibly inclined to cordate in some specimens.

Venation palmate from at or near the base. Midrib slender, somewhat flexuous. Lateral primaries three to five pairs, spreading at acute angles, ultimately camptodrome by curving inward to join secondary branches of the next within primary.

This species is very close to the later species which have been referred to *Menispermites* but it is clearly distinct from any of these. It is also separated by well-marked characters from the Potomac species of *Nelumbites* which resemble it in a general way.

Occurrence.—PATAPSCO FORMATION. Stump Neck, Maryland; Widewater, Virginia.

Collection.—Johns Hopkins University.

Order SAPINDALES

Family SAPINDACEAE

Genus SAPINDOPSIS Fontaine

[Mon. U. S. Geol. Survey, vol. xv, 1890, p. 296]

"Leaves pinnate, both odd pinnate and abruptly pinnate; terminal leaves usually more or less united at base; upper pairs of leaves decurrent, forming a wing on the common stem, the wing lessening in width on the pairs in descending; leaves mostly opposite in pairs, sometimes subopposite; the lowest pairs lack the wing, and are sometimes short-petioled; leaves thick, with dense and often glossy epidermis, elliptical or lancet-shaped, with a strong prominent midrib, which extends with slight diminution to the tip of the leaf; lateral nerves going off at a large angle, and uniting more or less completely near the margin to form a series of arches; the lateral or primary nerves, as seen on the lower side of the leaves, strong and prominent, but on the upper side, owing to the thickness of the leaves, generally indistinct; the ultimate reticulation is strong, and forms a series of rather large, irregular, polygonal meshes."—Fontaine, 1890.

This curious genus forms an important element in the flora of the Patapsco formation to which it is strictly confined with the single exception that *S. variabilis* has been recorded in the nearly homotaxial Fuson formation of Wyoming. No specimens of *Sapindopsis* are known from either the Patuxent or Arundel formations or their equivalents in other parts of North America. It is true that Professor Fontaine described *Sapindopsis cordata* from Fredericksburg, Virginia, but this material, which is very poor, is obviously not related to this genus, while the record of *Sapindopsis elliptica* from Fredericksburg by the same author is based upon the remains of *Rogersia longifolia* Fontaine. The genus is notably absent from the fossiliferous Patapsco beds at Federal Hill, Md., but when present at a locality it usually occurs in the greatest abundance, as at Fort Foote, Maryland, or in the vicinity of Brooke, Virginia, where hundreds of specimens often of great perfection have been collected.

In modification of the diagnosis quoted above, it may be said that the vast majority of the leaves are abruptly pinnate and the terminal leaflets while usually confluent and decurrent are sometimes petiolate, *Sapindopis magnifolia* in particular furnishing many individuals lacking the decurrently winged rachis.

The most closely related plants to *Sapindopsis* in the modern flora are the various genera of American tropical Sapindaceæ. Among these the genus *Matayba* Aubl. approaches very near to the Cretaceous form. *Matayba* embraces species with both opposite and alternate leaflets having either entire or dentate margins. The rachis lacks definite alæ but it is somewhat flattened with a vestigial wing on each side in the form of a raised line which is wider at the point of origin of the leaflets and decurrent to the next lower leaflets. So many other genera of the Sapindaceæ have markedly alate rachises that the presumption is strong that this genus or its ancestors were at some time similarly provided. The most similar species seems to be *Matayba apetala* (Macf.) Radlk., in which the leaflets are usually more numerous than in *Sapindopsis* although some specimens show but 3 pairs, those with 4 pairs are common; they are sometimes subopposite and as many as 7 pairs are met with. The venation is exactly like that of the fossils as is the texture of the leaves and their limits of variation. Another closely related species is *Matayba Domingensis* Radlk., also a native of the West Indies.

It is exceedingly satisfactory to be able to establish upon a somewhat firmer basis Professor Fontaine's choice of the term *Sapindopsis* for these Potomac plants. They are so abundant in their occurrence, so striking in appearance, their strict habit and glossy texture giving them every appearance of some fern-like plant as for example the common *Acrostichum aureum* of the tropics, that their original describer deserves great credit for having correctly determined their modern affinities.

SAPINDOPSIS VARIABILIS Fontaine

Plates LXXXIII, LXXXIV, LXXXV

Sapindopsis variabilis Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 298, pl. cli, fig. 1; pl. clii, figs. 1, 4; pl. cliii, fig. 3; pl. cliv, figs. 2-4; pl. clv, figs. 2-5.

Sapindopsis parvifolia Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 300, pl. cliv, fig. 6.

Sapindopsis variabilis Fontaine, 1899, in Ward, 19th Ann. Rept. U. S. Geol. Survey, pt. ii, p. 690, pl. clxix, fig. 9.

Sapindopsis variabilis Fontaine, 1906, in Ward, Mon. U. S. Geol. Survey., vol. xlviii, 1905, pp. 481, 482, 489, 532, pl. cxiv, fig. 2.

Eucalyptus rosieriana Ward, 1906, in Fontaine, Mon. U. S. Geol Surv., vol. xlviii, 1905, p. 530, pl. cxiii, figs. 9, 10.

Ficus myricoides Ward, 1906, in Fontaine, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 531, pl. cxii, fig. 12 (non Hollick, 1896).

Rogersia angustifolia Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 491, 510 (non p. 521).

Sapindopsis variabilis Berry, 1910, Proc. U. S. Natl. Mus., vol. xxxviii, p. 641.

Description.—Leaves odd pinnate, sometimes abruptly pinnate, with three pairs of lateral leaflets, which may be opposite although usually there is a tendency toward a subopposite arrangement, markedly so in several specimens. Leaflets normally lanceolate, individuals of the same leaf about of a size, usually markedly decurrent, but variable in this respect. The proximal leaflets are always less decurrent than the pair next above and in some cases even have short petioles. The upper leaflets are remarkably variable, sometimes with an abnormal decurrent wing which joins the inner lamina of the next lower pair of leaflets, at other times the rachis entirely lacks a wing. The leaf may be terminated abruptly by a pair of leaflets variously coalesced or the three apical leaflets may be variously united, their lamina may be almost symmetrical or markedly inequilateral, their margins showing a tendency toward undulation and occasionally a leaflet is divided into a basal and an apical part by a sharp constriction on one side near the middle of the blade. Ranging in size from the small forms upon which Fontaine founded his species *S. parvifolia* and which are 1.6 cm. long and 0.4 cm. wide to forms which approach *S. magnifolia* in size and are 10 cm. long and 1.5 cm. wide. The average dimensions of a large number of specimens are, however, 6 cm. to 7 cm. long by 1 cm. to 1.3 cm. wide.

Leaves thick with smooth surface. Rachis and midrib stout. Venation more prominent than in the other species but still very faint, with the exception of the secondaries which while fine are more conspicuous than in the other species. Secondaries forming a wide angle with the midrib, nearly straight for 2/3 of the distance to the margin where they bend sharply upward and join the secondary next above by a but slightly curved arch. As the secondaries are numerous and almost uniformly spaced the venation has much the appearance of a *Eucalyptus* except that the marginal hem is much broader than in that genus.

This species is exceedingly abundant at various localities in the Patapsco formation and is by far the most characteristic species of that formation, although it has not been detected at certain other undoubted Patapsco horizons. It is the only species of the genus which has been recorded outside of the Maryland-Virginia area, occurring in the Fuson formation along Oak Creek, Wyoming, where it is the most abundant species found just as it is at White House Bluff, Brooke, and Aquia Creek, Virginia, and at Ft. Foote, Maryland.

It is an exceedingly variable form in all its details, and as during maceration the most variable apical portion is the last to be destroyed, this variability is emphasized in fragmentary material such as that usually found at Fort Foote. When well preserved it furnishes most striking specimens as may be seen from the specimens reproduced photographically. In life its rigid pinnate leaves and strict appearance must have made it a very striking member of the Patapsco flora.

Occurrence.—PATAPSCO FORMATION. Fort Foote, Maryland; Aquia Creek, near Widewater, Chinkapin Hollow (?), near Brooke, White House Bluff, Mt. Vernon, 72-mile post, Virginia.

Collections.—U. S. National Museum, Johns Hopkins University.

SAPINDOPSIS MAGNIFOLIA Fontaine

Plate LXXXVI; Plate LXXXVII, Fig. 1; Plate LXXXVIII

Sapindopsis magnifolia Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 297, pl. cli, figs. 2, 3; pl. clii, figs. 2, 3; pl. cliii, fig. 2; pl. cliv, figs. 1, 5; pl. clv, fig. 6.

? *Aralia dubia* Font., 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 314, pl. clvii, figs. 1, 7 (non Schimper, 1874).

Sapindopsis obtusifolia Font., 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 301, pl. clvi, fig. 13; pl. clix, figs. 3-6.

Ficophyllum eucalyptoides Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 294, pl. clxiv, figs. 1, 2.

Sapindopsis tenuinervis Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 301, pl. cliii, fig. 1.

? *Aralia Fontainei* Knowlton, 1898, Bull. U. S. Geol. Surv., No. 152, p. 37.

Sapindopsis magnifolia, Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 481, 482, 528.

Sapindopsis tenuinervis Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 489, 528.

Ficophyllum eucalyptoides Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 489.

Sapindopsis magnifolia Berry, 1910, Proc. U. S. Natl. Mus., vol. xxxviii, p. 642.

Description.—Leaves commonly odd-pinnate, although occasional abruptly pinnate forms occur, of considerable size, but somewhat variable however, in this respect. Leaflets 3 pairs, comparatively large, lanceolate, tapering almost equally toward apex and base, the latter inequilateral except in terminal leaflets, pointed, often lacking apical portions, length increasing proximad, averaging about 10 cm., longest seen 14 cm. (estimated), shortest 5 cm., width varying from 1.1 cm. to 3.2 cm., inequilateral, since the outer half of the lamina is broader than the inner half and is markedly decurrent. This feature is least emphasized in the basal leaves which may even have a considerable petiole, but becomes increasingly pronounced distad, the terminal leaflets often forming a bilobate or trilobate whole with the outer margins broadly decurrent and joining the lamina of the leaflet next below at the point of juncture of its inner margin with the rachis. Certain specimens show all of the leaflets petiolate, a feature largely emphasized in the specimen figured from Stump Neck showing three terminal leaflets with petioles 3 to 4 cm. in length. The leaflets in this species are much oftener petiolate and lacking in the winged rachis than in *S. variabilis* in this particular closely resembling the modern *Matayba apetala* in which the rachial wings are vestigial. Leaf substance thick and leathery, epidermis firm and glossy. Leaflets commonly subopposite, often markedly so, forming an acute angle with the rachis. Midribs stout and prominent below. Secondaries slender, only seen on the under surface of the leaflets and even then made out with difficulty, 8 to 10 pairs, branching from the midrib at a rather wide angle especially in the central part of the leaf; the angle is more acute basally, curving upward ultimately to join a short branch of the secondary next above. Tertiaries fine, forming lax subrhombic areolæ where visible.

This species is very common at certain localities within the Patapsco formation as for example at Stump Neck in Charles County, although at other outcrops of this same formation it has not been detected. This is notably the case in the Federal Hill deposits from which large collections have been made without disclosing a single specimen. Evidently the species was local in its distribution which is emphasized by its total absence in any other Lower Cretaceous deposit either here or abroad.

The grounds for the separation of this species from *S. variabilis* are slight since both are variable and the larger forms of the latter are quite as large as the smaller forms of *S. magnifolia*. In the Potomac they are found in association at all the localities where either occur and the smaller species is usually the most common as if *S. magnifolia* represented the occasional more robust forms of that species. On the other hand the latter has not been detected in the abundant remains of *S. variabilis* found at Oak Creek, Wyoming, and there is commonly considerable disparity in size between the two. There are certain other differences which appear to be constant. These are the thicker, relatively longer leaflets of *S. magnifolia* with less numerous and somewhat more ascending secondaries which are not connected distad by relatively flat arches. The writer includes under this species the *S. tenuinervis* of Fontaine recorded from the localities near Brooke, Virginia, and from Fort Foote, Maryland. The only apparent ground for its erection was a fancied difference in venation based chiefly on a more slender midrib and more remote leaflets, both characters which are seen to be variable and altogether unreliable as soon as any number of specimens are compared.

The specimens from Deep Bottom, Virginia, which formed the basis for the species *Aralia dubia* Fontaine (*Aralia Fontainei* Knowlton) are doubtfully included under this species since they seem to represent a macerated and distorted specimen of the terminal leaflets of a *Sapindopsis.* There is absolutely no ground for retaining it in *Aralia.*

Occurrence.—Patapsco Formation. Near Brooke, near Widewater, Deep Bottom (?), 72-mile post, near 72-mile post, Aquia Creek, White House Bluff, Virginia,[1] Ft. Foote, Stump Neck, Maryland.

Collections.—U. S. National Museum, Johns Hopkins University.

Sapindopsis brevifolia Fontaine

Plate LXXXVII, Figs. 2-5

Sapindopsis brevifolia Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 300, pl. cliii, fig. 4; pl. clv, figs. 1, 7; pl. clxiii, fig. 3.

Sapindopsis brevifolia Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 481, 482, 528.

Sapindopsis brevifolia Berry, 1910, Proc. U. S. Natl. Mus., vol. xxxviii, p. 644.

Description.—Leaves odd-pinnate, the terminal leaflet considerably larger than the lateral leaflets of which but two pairs are known. These are opposite. Leaflets somewhat crowded so that their margins often overlap, with subacute tips, varying in length from 2 cm. to 5 cm. and in width from 0.8 cm. to 1.6 cm., averaging about 3 cm. long by 1.3 cm. wide. Inequilateral toward the base and showing considerable variation in decurrence even among the few specimens known, in some the rachis is conspicuously winged while in others the leaflets are all petioled, the

[1] Table on p. 586, Mon. xlviii, gives Colchester road as an additional locality, which is not mentioned in the text.

whole having the aspect of some member of the Leguminoseæ. Midribs stout, secondaries ascending, camptodrome, seen with difficulty, since the leaf texture is coriaceous. This is a poorly marked species of infrequent occurrence at the same localities where the other species of this genus occur and may simply represent a variant of *S. variabilis.*

Occurrence.—PATAPSCO FORMATION. Fort Foote, Maryland; near Brooke, 72-mile post, Aquia Creek, Virginia.

Collections.—U. S. National Museum, Johns Hopkins University.

Family CELASTRACEAE

Genus CELASTROPHYLLUM Goeppert

[Die Tertiarflora auf der Insel Java, 1854, p. 52]

The family Celastraceæ is a most important one for the paleobotanist embracing a large number of forms, many of which are definitely referred to living genera such as *Celastrus, Pterocelastrus,* and *Euonymus.* In a large number of cases, however, it is impossible to exactly locate the fossil leaf within the family so that the genera *Celastrinites* Sap. and *Celastrophyllum* Göpp. have been used for a large number of leaf-forms, while the genus *Celastrinanthium* Conwentz has been proposed for the flowers, which occur in the Baltic amber.

The genus *Celastrophyllum* was proposed by Gœppert in 1854 to include four species from the Tertiary of the island of Java, although a number of authors like Fontaine follow Schimper in crediting the genus to Ettingshausen who wrote considerable about it, including his well-known and beautifully illustrated memoir on the venation of the Celastrineæ.[1]

It may be briefly defined as follows: Leaves simple, mostly small, elliptical in outline, with entire or toothed margins; secondaried branching at a wide angle, numerous, parallel, connected by arches near their extremities. In the species with toothed margins short subsidiary veins from these arches enter the marginal teeth.

[1] Denks. k. Akad. Wiss., Wien, vol. xiii, p. 43.

The most ancient horizon recorded for this genus is that of the Potomac Group, Professors Fontaine and Ward having described no less than thirteen species from strata of that age in Maryland and Virginia. This proves to be altogether too large a number, however, as a critical examination of the material shows that the three forms *C. arcinerve* Fontaine, *C. marylandicum* Fontaine, and *C. proteoides* Fontaine are not referable to *Celastrophyllum* at all. *C. tenuinerve* and *C. obovatum* of Fontaine are included in that author's *C. latifolium* while *C. obtusidens* Fontaine and *C. pulchrum* Ward are included in *C. acutidens* Fontaine. The genus is not present in the older Potomac, *i. e.,* the Patuxent or Arundel formations, but is present in considerable force in the Patapsco formation with four species in Maryland and three additional species in Virginia, one of the latter being identical with a form from the New Jersey Raritan. The latter formation has nine recorded species and embracing the largest leaves which have been referred to this genus. The Dakota Group also has several species as has the Cenomanian and Senonian of Greenland and Europe. A large display of these forms is also made in the Paleocene of Europe from which Saporta and Marion have described the well preserved remains of seven species of *Celastrophyllum* and four species of the allied *Celastrinites.*

Few species have been described from strata younger than Eocene, the more modern leaves of this type being more readily correlated with the various living genera of this family.

The living descendants of the American fossil forms are probably to be found among those species which inhabit the American tropics or those which took refuge in the mountains of eastern Asia after the retreat of the Pleistocene glaciers.

Celastrophyllum denticulatum Fontaine

Plate XC, Figs. 1, 2

Celastrophyllum denticulatum Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 306, pl. clxix, fig. 10; pl. clxxii, fig. 7.

Description.—Leaves small, 2 to 4 cm. in length by 1.25 cm. in breadth, ovate in outline, with an acute apex and a broad, slightly decurrent base. Margin with small, shallow, dentate teeth. Midrib slender. Secondaries numerous, parallel, branching from the midrib at an angle of about 40°, their ultimate disposition not made out.

This species is very rare in the Federal Hill collections and is readily distinguished from the other species of this genus by its general outline and by its marginal characters.

Occurrence.—PATAPSCO FORMATION. Federal Hill (Baltimore), Maryland.

Collection.—U. S. National Museum.

CELASTROPHYLLUM PARVIFOLIUM (Fontaine) Berry

Saliciphyllum parvifolium Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 303, pl. clxxii, fig. 5.
Saliciphyllum ellipticum Fontaine, 1890, *Ibid.*, p. 303 (pars).
Celastrophyllum brookense Fontaine, 1890, *Ibid.*, p. 305, pl. clviii, fig. 8; pl. clix, fig. 7.
Celastrophyllum brookense Fontaine, 1906, in Ward, *Ibid.*, vol. xlviii, 1905, p. 505, pl. cx, fig. 10.

Description.—Leaves of variable size, 2.5 cm. to 12 cm. (?) in length by 1.3 cm. to 5.5 cm. in greatest width which is about half way between the apex and the base. Outline broadly elliptical, with apex and base somewhat abruptly and about equally acute. Margin entire. Petiole and midrib stout. Secondaries about 5 or 6 pairs, branching from the midrib at a rather wide angle (over 45°) and rather straight in their course, camptodrome. Leaf texture coriaceous.

This species which is of somewhat doubtful botanical affinity is based on uncommon and rather fragmentary remains confined to the Patapsco formation.

Occurrence.—PATAPSCO FORMATION. Near Wellhams, Anne Arundel County, Federal Hill (Baltimore), Maryland; 72-mile post and Hell Hole, Virginia.

Collection.—U. S. National Museum.

CELASTROPHYLLUM LATIFOLIUM Fontaine

Plate XC, Figs. 6-9

Celastrophyllum latifolium Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 306, pl. clxxii, figs. 3, 6; pl. clxxiii, fig. 13.

Celastrophyllum tenuinerve Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 306, pl. clxxii, fig. 2.

Celastrophyllum obovatum Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 307, pl. clxxii, figs. 9, 10.

Celastrophyllum latifolium Fontaine, 1906, in Ward, Mon. U. S. Geol. Survey, vol. xlviii, 1905, p. 559, pl. cxvi, fig. 6.

Proteæphyllum Uhleri Fontaine, 1906, in Ward, 1905, Mon. U. S. Geol. Survey, vol. xlviii, 1905, p. 564, pl. cxviii, fig. 5.

Celastrophyllum obovatum Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 550, 560, pl. cxv, fig. 6; pl. cxvii, figs. 2, 3.

Description.—Leaves of delicate texture, obovate to nearly orbicular in outline, with a broadly rounded tip and a somewhat decurrent base, length 3 cm. to 6 cm., greatest width 2.2 cm. to 4.5 cm., widest about half way between the base and apex, margin entire. Midrib and secondary venation delicate. Secondaries numerous, approximately parallel, branching from the midrib at a usually acute angle, the lower pairs long and curved upward parallel with the leaf margins, camptodrome. There is considerable minor variation in the venation characters of these leaves and as the delicate secondaries tend to be obliterated in all except the basal part of the leaves where they are more ascending, specimens in this state of preservation appear to have a palmate venation.

This species, which is rather common in the collections from Federal Hill, shows considerable variation in size and appearance and is the least satisfactorily determined *Celastrophyllum* from the Potomac Group suggesting the genus *Chondrophyllum* rather than *Celastrophyllum*. This variation is really one of the distinguishing characters of the species as here defined. A single specimen has been collected from the Vinegar Hill locality. A single specimen from Federal Hill, slightly shorter and wider than the average with consequently more obtusely branching secondaries, was made the basis for the species *Proteæphyllum Uhleri* Fontaine, although it is not allied with that genus and is clearly a slight variant of the present species.

Occurrence.—PATAPSCO FORMATION. Federal Hill (Baltimore), Vinegar Hill, Maryland.

Collections.—U. S. National Museum, Goucher College.

CELASTROPHYLLUM ACUTIDENS Fontaine

Plate LXXXIX

Celastrophyllum acutidens Font., 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 305, pl. clvi, fig. 8.

Celastrophyllum obtusidens Font., 1890, *Ibid.*, 1889, p. 305, pl. clvi, fig. 5.

Myrica brookensis Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 310, pl. cl, fig. 11; pl. clvi, fig. 10.

Celastrophyllum pulchrum Ward, 1899, 19th Ann. Rept. U. S. Geol. Surv., pt. ii, 1899, p. 706, pl. clxxi, figs. 3, 4.

Myrica brookensis Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 513, pl. cviii, fig. 8.

Celastrophyllum acutidens Font., 1906, in Ward, *Ibid.*, vol. xlviii, 1905, p. 529, pl. cxiii, figs. 7, 8.

Description.—Leaves ovate-elliptical in outline, varying considerably in size and relative proportions, ranging from 2.5 cm. to 6 cm. in length and from 1.5 cm. to 4 cm. in width. Margin irregularly toothed, crenate-dentate or shallowly rounded, directed slightly forward and obsolete toward the base of the leaf. Petiole comparatively long and very stout. Midrib also stout, more or less flexuous, diminishing rapidly toward the apex of the leaf. Secondaries generally in four or five alternate pairs, diverging at an angle of about 45° and running with a slight upward curve and somewhat irregularly three-fourths of the distance to the margin where they turn sharply upward to join a lateral fork of the secondary next above, sending off tertiary lateral branches which loop along the margin and from which branches enter the marginal teeth. Characteristic of the type of venation usually ascribed to *Celastrophyllum*.

These leaves are all more or less fragmentary, usually lacking the apex or base, or portions of the margin, as if they had been submerged a considerable time before fossilization. They are also rather contorted and fractured by the settling or creep of the arenaceous clay matrix.

This is one of the characteristic species of the Patapsco formation and is very abundant at the Fort Foote locality but has not been found elsewhere in Maryland. From Virginia it is recorded in beds of this age at the 72-mile post near Brooke, near Widewater and White House Bluff. The same species also occurs at Evan's quarry in the Black Hills at a horizon which Prof. Ward places low down in the Dakota Group but which may be more properly included in the Fuson formation

They find their counterpart in the European Cretaceous in the forms described by Saporta from the Albian of Buarcos in Portugal as *Myrsinophyllum revisendum.*[1]

Occurrence.—PATAPSCO FORMATION. Ft. Foote, Prince George's County, Maryland; White House Bluff, near Brooke, Widewater, Chinkapin Hollow, Virginia.

Collections.—U. S. National Museum, Johns Hopkins University.

CELASTROPHYLLUM BRITTONIANUM Hollick

Plate XC, Fig. 3

Celastrophyllum Brittonianum Hollick, 1896, in Newberry, Mon. U. S. Geol. Survey, vol. xxvi, 1895, p. 105, pl. xlii, figs. 37, 38, 46, 47.

Celastrophyllum Brittonianum Ward, 1896, 15th Ann. Rept. U. S. Geol. Survey, 1895, pp. 349, 358, 377, 378, 379.

Celastrophyllum Brittonianum Ward, 1906, in Fontaine, Mon. U. S. Geol. Survey, vol. xlviii, 1905, p. 493, pl. cvii, fig. 7.

Description.—Leaves small, 4 cm. to 5 cm. in length by 1.2 cm. to 2.1 cm. in maximum width, which is at or above the middle. Outline ovate-lanceolate, varying toward spatulate in some specimens, with an acute apex and a cuneate or somewhat decurrent base. Margins entire below, denticulate above. Midrib mediumly stout. Secondaries numerous, branching from the midrib at angles of about 45 degrees, very thin but prominent, somewhat irregular, eventually camptodrome.

This species was described originally from the Raritan formation of New Jersey, where it is not uncommon, although the exact horizon from which it was collected is not known. It occurs also in the lower part of the Tuscaloosa formation in western Alabama. Its unmistakable presence in the Patapsco formation is of considerable interest since very few forms are known to pass from the Lower into the Upper Cretaceous. While it

[1] Saporta, Fl. Foss. Portugal, 1894, p. 186, pl. xxxiv, fig. 10.

resembles *Celastrophyllum albædomus* Ward the two species are readily distinguishable.

Occurrence.—PATAPSCO FORMATION. Mt. Vernon, Virginia.

Collection.—U. S. National Museum.

CELASTROPHYLLUM HUNTERI Ward

Plate XC, Figs. 5, 10, 11

Celastrophyllum Hunteri Ward, 1896, 15th Ann. Rept. U. S. Geol. Survey, 1895, p. 358, pl. iv, fig. 9.

Celastrophyllum Hunteri Fontaine, 1906, in Ward, Mon. U. S. Geol. Survey, vol. xlviii, 1905, p. 494, pl. cviii, fig. 6.

Celastrophyllum (?) *saliciforme* Ward, 1906, in Fontaine, in Ward, Mon. U. S. Geol. Survey, vol. xlviii, 1905, p. 494, pl. cviii, fig. 7.

Description.—Leaves linear-lanceolate in outline, 7 cm. to 10 cm. in length by 0.8 cm. to 2.0 cm. in maximum width, which is in the middle part of the leaf. Apex and base about equally pointed. Margin finely and sharply dentate. Midrib mediumly stout becoming thin distad, curved. Secondaries numerous, thin, branching from the midrib at angles of about 45 degrees, more or less forked, eventually camptodrome (not craspedodrome as stated by Professor Ward).

This species is somewhat variable in its relative proportions, the most slender specimen found having been the basis for a distinct specific name. It is similar to *Celastrophyllum albædomus* Ward, differing chiefly in its much greater elongation. The broader forms suggest *Celastrophyllum angustifolium* Newberry of the Raritan formation.

Occurrence.—PATAPSCO FORMATION. White House Bluff, Mt. Vernon, Virginia.

Collection.—U. S. National Museum.

CELASTROPHYLLUM ALBÆDOMUS Ward

Plate XC, Fig. 4

Celastrophyllum albædomus Ward, 1906, in Fontaine, Mon. U. S. Geol. Survey, vol. xlviii, 1905, p. 489 (footnote), pl. cviii, fig. 3.

Description.—"Leaf ovate-lanceolate, rounded at the base and apex, unequal-sided, crenate-toothed, 4 cm. long exclusive of the petiole, which is wanting, 16 mm. wide at the middle; midrib strong and straight, secondary nerves camptodrome, delicate, curving forward, forking and anastomosing midway between the midrib and the margin, the branches forming festoons along the margins."—Ward, 1906.

This species shows some points of resemblance to *Celastrophyllum acutidens* Fontaine, which is, however, a coarser and more ovate leaf with much larger and more irregular teeth. It also is much like *Celastrophyllum Hunteri* Ward, a relatively narrow and more elongated leaf. It is very similar to *Celastrophyllum Brittonianum* Hollick, differing in being widest below instead of above the middle, in having more prominent marginal teeth which are crenate instead of denticulate, and in the less numerous, more ascending, and earlier forked secondaries. Like the latter species it survives into the Upper Cretaceous Tuscaloosa formation of Western Alabama.

Occurrence.—Patapsco Formation. White House Bluff, Virginia.

Collection.—U. S. National Museum.

Order RHAMNALES

Family VITACEAE

Genus CISSITES Heer

[Phyll. Crét. d. Nebraska, 1866, p. 19]

This genus was instituted by Heer in 1866 for the species *Cissites insignis* from the Dakota Group, a tri-lobate, tri-veined leaf with sublobate lobes, which presented various points of affinity with the genus *Cissus* of Linné. Subsequent authors included a variety of leaves in this genus some of which are more or less suggestive of *Sassafras, Platanus,* etc.

The genus makes its appearance in the Patapsco formation of Maryland and in the Albian of Portugal and is largely developed in later Cretaceous deposits, Lesquereux enumerating no less than seventeen species from the Dakota Group of the West, one of which succeeded in migrating as far as the southern part of South America according to Kurtz.[1] *Cissites* is much less prominent in the Raritan formation. It

[1] Kurtz, Revista Mus. La Plata, vol. x, 1902, p. 54.

is present in the Cenomanian of Europe and Greenland but is replaced after the Eocene by somewhat similar forms referred to modern allied genera such as *Cissus, Vitis,* etc.

CISSITES PARVIFOLIUS (Fontaine) Berry

Plates XCI, XCII

Vitiphyllum parvifolium Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 309, pl. clxxii, figs. 11, 12.
Vitiphyllum multifidum Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 309, pl. clxxiii, figs. 1-9.
Cissites obstusilobus Saporta, 1894, Fl. Foss. Port., 1894, p. 190, pl. xxxiv, figs. 12, 13 (non Lesquereux, 1892).
Vitiphyllum multifidum Ward, 1896, 16th Ann. Rept. U. S. Geol. Surv., pt. i, p. 539, pl. cvii, figs. 2-5.
Vitiphyllum parvifolium Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 558.
Vitiphyllum multifidum Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 553, 565, pl. cxix, figs. 2-5.

Description.—Leaves comparatively small but somewhat variable in size, the largest specimens indicating leaves about 6 cm. long by 7 cm. wide. Outline somewhat variable, in general orbicular with base varying from truncate or slightly decurrent to deeply cordate. Divided by deep narrow sinuses into three main lobes and these in turn subdivided into subordinate lobes, all terminating in shallow lobes or broadly rounded crenations. Petioles stout sending off three or more rather straight primaries from their tips, the central and main laterals being the stoutest, the presence of additional primaries being occasioned by the degree of subdivision of the lateral leaf lobes. Secondaries branching from the primaries at an acute angle and running to the tips of the subordinate lobes giving off acutely branched tertiaries which run to the tips of the lobules or teeth.

This is the most common form at Federal Hill, several hundred specimens, often exceedingly well preserved, being contained in the various collections which have been made. Prof. Fontaine established a new genus for its reception which he called *Vitiphyllum* although he recognized its resemblance to *Cissus*. There is really no ground for the maintenance of such a separate genus since the leaves are obviously allied to various species generally referred to *Cissites,* in fact this Potomac species was described as a new species in that genus by Saporta in his description of the fossil plants of Portugal, although the name he used had already been used two years earlier by Lesquereux for a different species. That it is identical with the Potomac plant may be seen by a comparison of one of Saporta's figures reproduced on pl. xci with the figures of the Federal Hill plant on the same plate.

Prof. Fontaine differentiated two species from Federal Hill, the more common *multifidum* and the very small and rather rare *parvifolium,* the latter being simply small leaves of the former. The same author described a third species from Potomac Run, Va. (*Vitiphyllum crassifolium loc. cit.,* 1889, p. 308, pl. cl. figs. 9, 10), based on what he took to be the middle lobe of a leaf of this species but which is so incomplete as to be altogether worthless as evidence of the existence of this type in Virginia in beds older than the Patapsco formation. Leaves of the same general plan as *Cissites parvifolius* are present in succeeding formations where they attain a considerably larger size, thus some of the Raritan forms which Newberry referred to *Cissites formosus* Heer are very suggestive of the Federal Hill plant. A closely allied species called by Velenovsky *Cissus vitifolia* has also been described from the Cenomanian of Bohemia.

Occurrence.—Patapsco Formation. Federal Hill (Baltimore), very common, near Wellhams (?), Vinegar Hill (?), Maryland.

Collections.—U. S. National Museum, Johns Hopkins University, Goucher College.

Order THYMELEALES

Family LAURACEAE

Genus SASSAFRAS Nees and Eberm

[Handb. Med. Pharm. Bot., Bd. ii, 1831, p. 418]

This genus is characterized as follows by Schimper[1]: "Folia plus minus ovato-orbiculata, brevissime acuminata, vel triloba, triplinervia,

[1] Schimp., Pal. Végét., t. ii, 1872, p. 834.

nervis lateralibus suprabasilaribus haud exacte oppositis, subangulo acuto orientibus, ultra medium folium productis, extus ramosis, ramis camptodromis; nervis secundariis longe a primariis lateralibus remotis, subangulo aperto emissis, parum numerosis, Camptodromis, nervis tertiariis e nervo mediano et e latere anteriore nervorum lateralium subangulo recto emissis, arcuato-transversis. Bacca pedicello apice incrassato carnosoque imposita, basi perianthii sexpartiti laciniis cincta."

Like all genera which are monotypic in the existing flora Sassafras has a most interesting geological history. The most ancient forms are the following three species of late Lower Cretaceous age from the Maryland-Virginia area and a fourth species described by Saporta[1] from the Albian of Portugal. The Upper Cretaceous shows an extensive development of Sassafras-like forms in Europe, Greenland, and America; the Dakota Group in particular having a large number of species. Although reduced in variety of forms the genus remains cosmopolitan throughout the Tertiary, *Sassafras Ferretianum* Massal. which is common in the late Pliocene in France and Italy being almost indistinguishable from the single modern species which is confined to eastern North America.

SASSAFRAS BILOBATUM Fontaine

Plate XCIII, Fig. 1

Sassafras bilobatum Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 290, pl. clvi, fig. 12; pl. clxiv, fig. 4.
Sassafras bilobatum Berry, 1902, Bot. Gaz., vol. xxxiv, p. 435.
? *Sassafras bilobatum* Fontaine, 1906, in Ward, Mon. U. S. Geol. Survey, vol. xlviii, 1905, p. 506, pl. cxi, fig. 5.

Description.—" Leaf-substance moderately thick; leaf rather large, elliptical-shaped at base, cut into a rather long lateral lobe, ovate in shape, which is turned away from the midrib, having the opposite side of the leaf gently rounded off; terminal lobe much larger, ovate in shape; midnerve strong, sending off on the right-hand side from near the base and into the lateral lobe a strong nerve, and on the left-hand side from a little higher a smaller one, which curves upward, following the margin

[1] Saporta, Fl. Foss. Portugal, 1894, p. 182, pl. xxxi, fig. 7.

of the leaf for some distance; the midnerve above the base at different points sends off minor nerves, which curve upwards and fork; ultimate nervation not seen."—Fontaine, 1890.

While the outline of this leaf does not exactly conform to any modern bilobed Sassafras leaf known to the writer, it is nearer the latter than it is to any other leaf. The right-angled sinus with straight sides and running to a point is also a feature not seen in the modern leaf. In the latter, when the sinus runs to a point it is narrow and deep; and when it forms a right angle it is curved and the resulting lobe is generally obtuse and but slightly produced. We have characters which ally this ancient leaf to *Sassafras* in the decurrent base; the subopposite primaries, as they usually are in the bilobed leaves of the existing Sassafras: the position of the secondaries; and especially in the secondary running to the sinus, a feature we would hardly expect to find in so primitive a leaf. We would consider the bilobed leaf as a more ancient type than the trilobed form, and removed from the ancestral simple leaf by a series beginning with leaves with but a slight depression marking the position of the future sinus, and a slightly produced obtuse lobe, through forms partially paralleled in the modern leaf, in which these features were more and more emphasized. Just why the leaf became lobed is largely conjectural. The primaries form a more acute angle with the midrib than do the secondaries, especially in the simple leaves; they are the first and largest arteries branching from the midrib; in the growing leaf they are carried upward, while new laterals are added toward the tip of the blade. It may be that the diagonal position of the leaves in the bud causes pressure at that particular lateral part near the tip of the primary, causing more or less atrophy of that part of the blade. This tendency once inaugurated the rest is simple, for those portions of the leaf at the tips of the primaries would have nearly all their leaf-forming energy expended in increasing the length of the lobes; possibly especially good environment was a factor in the original location, as witness the great development of the lateral portions of the leaf blade in the five-lobed forms occurring in rich soil. The Potomac species under discussion bears some resemblance to certain species referred to *Sterculia,* as well as to the asymmetrical terminal leaflets of some compound leaves, but we are probably justified in considering it a true *Sassafras*—the first that can be identified as such with any degree of certainty. As pointed out by Fontaine in the fragment of this leaf figured (by him), the opposite primary is considerably stouter than its fellow which runs to the lobe which is preserved, lending color to the supposition that this species was also trilobed.

This species is rare and with the exception of the material from near Brooke, Virginia, it has not been recorded except for a single extremely doubtful fragment reported from the synchronous beds along the Potomac River.

Occurrence.—PATAPSCO FORMATION. Near Brooke and Hell Hole (?), Virginia.

Collection.—U. S. National Museum.

SASSAFRAS PARVIFOLIUM Fontaine

Plate XCIII, Fig. 2; Plate XCIV, Fig. 2

Sassafras parvifolium Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 289, pl. cxxxix, fig. 7.

Sassafras cretaceum var. *heterolobum* Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 289, pl. clii, fig. 5; pl. clix, fig. 8; pl. clxiv, fig. 5.

Sassafras parvifolium Berry, 1902, Bot. Gaz., vol. xxxiv, p. 434.

Sassafras cretaceum var. *heterolobum* Berry, 1902, Bot. Gaz., vol. xxxiv, p. 435.

Description.—Leaves somewhat variable in shape, comparatively small in size, elliptical in general outline, trilobate; the lobes rather short and obtusely pointed or broadly rounded, separated by usually shallow more or less rounded sinuses which do not extend more than half the distance to the base. Length 3 cm. to 9 cm. Width across the lobes 3.25 cm. to 8 cm. Base cuneate, decurrent. Midrib stout. Lateral primaries subopposite, supra-basilar. Secondaries more or less remote, ascending, camptodrome.

This is a rather rare but well-marked species very suggestive of, and possibly ancestral to, the Upper Cretaceous *Sassafras cretaceum* Newberry, as a variety of which Fontaine described one of the Virginia specimens. As pointed out by the writer in 1902, the Federal Hill material is simply a small form of the same species.

This late Lower Cretaceous species may be duplicated by many of the leaves of the still existing species of *Sassafras*. It is also closely comparable with a number of other described fossil species, as for example, some of the forms which have been referred to *Aralia grœnlandica* Heer in which subordinate lateral primaries are not developed and the lobes are full and rounded and not straight margined (cf. Heer, Fl. Foss. Arct., Band vi, Abth. ii, pl. xxxviii, fig. 3). The present species is also extremely close to *Sassafras arctica* described by Heer[1] from the Atane beds of Greenland as well as to what Ward[2] identifies as *Sassafras mudgii* from the supposed Dakota sandstone of the Black Hills region and from the Cheyenne sandstone of southern Kansas.

Occurrence.—Patapsco Formation. Federal Hill (Baltimore), Stump Neck, Maryland; near Brooke, Virginia.

Collections.—U. S. National Museum, Johns Hopkins University.

Sassafras potomacensis sp. nov.

Plate XCIV, Fig. 1

Description.—Leaves of relatively small size, palmately trilobate. 9 cm. in length by 7 cm. in width from tip to tip of the lateral lobes. Sinuses mediumly open, rounded, not extending more than half way to the base. Lobes narrowly conical, pointed. Base cuneate. Primaries three, diverging from the extreme base of the leaf or just above it. Secondaries mostly concealed, a single one can be made out on the right running from the midrib to the sinus in a manner quite characteristic of the existing Sassafras. Texture thin but coriaceous.

This species is based upon rather poor material from several localities of Patapsco age. It is clearly different from any described species and while not positively determinable as a species of *Sassafras*, it agrees in its general facies with the various species commonly referred to this

[1] Heer, Fl. Foss. Arct., Band iii, Abth. ii, 1874, p. 109, pl. xxxi, figs. 3a, b.

[2] Ward, 19th Ann. Rept. U. S. Geol. Surv., pt. ii, 1899, p. 705, pl. clxx, figs. 4, 5; pl. clxxi, fig. 1.

genus from the Upper Cretaceous, and it may also be matched by some of the variant leaves of the existing Sassafras. It is rather smaller but otherwise very close to *Sassafras acutilobum* Lesq., especially the forms from the Raritan formation which Newberry[1] identified as this species.

It may also be compared with *Sassafras protophyllum,* a somewhat smaller but otherwise very similar form described by Saporta from the Albian of Portugal.

Occurrence.—PATAPSCO FORMATION. Widewater, Dumfries Landing, Virginia.

Collection.—Johns Hopkins University

Order UMBELLALES

Genus ARALIAEPHYLLUM Fontaine

[Mon. U. S. Geol. Survey, vol. xv, 1890, p. 316]

This genus is defined as follows by its describer:

"Leaves more or less fan-shaped, divided more or less deeply into three principal lobes, the middle or terminal one subrhombic or elliptical in outline, rapidly narrowed to an acute tip, and separated from the lateral lobes by broad sinuses rounded at the bottom; the lateral lobes divided into two minor lobes, one being larger than the other; the larger one ovate, sometimes inequilateral, and turned upwards; the outer or small one is ovate, and turned outwards; the primary nerves three, radiately diverging from the same or nearly the same point at the base of the leaf, going to the summit of each primary lobe; from the two lateral primaries a strong branch goes off a short distance above the base on the lower side and extends to the summit of the outer smaller lobes; all the primaries are strong, and send off on each side branches which curve up and anastomose; ultimate reticulation not seen."

While the specific differentiation within the genus is somewhat different in the present treatment, the foregoing diagnosis will answer in the

[1] Newberry, Mon. U. S. Geol. Surv., vol. xxvi, 1896, p. 87, pl. xxv, figs. 1-10; pl. xxvi, figs. 2-6.

present connection. One feature should be emphasized, however, and that is the variability in lobing which these leaves show. They are primarily palmately trilobate in character, but show a considerable range in variability in the development of subordinate lobes on any or all of the principal lobes. The point of insertion of the secondaries and the character of the apices, whether obtusely rounded or acutely pointed, are also very variable characters. Their coriaceous texture should also be referred to.

This variability in lobation in *Araliæphyllum* finds an analogy in the like variation among the leaves of the modern *Sassafras* as pointed out by the writer in 1902.[1] *Sassafras* is predominantly entire or trilobate but individual leaves can be found showing every stage of incipient lobation up to leaves with five or even six lobes which are strikingly similar to the leaves of *Araliæphyllum* (compare the plates of the latter with *loc. cit.* figs. 2-4).

In the original treatment of the genus four species were recognized. These have here been reduced to two species with which have been united certain forms described by Fontaine as *Aceriphyllum, Platanophyllum,* and *Hederæphyllum.* The material is all rather fragmentary and is strictly confined to the Patapsco formation.

With regard to the botanical affinity of these forms, like so many of the Lower Cretaceous dicotyledones, little can be said of a decisive nature. They are comprehensive types and unite the foliar characters of leaves which in the Upper Cretaceous are referred to *Aralia, Sassafras, Platanus,* and *Cissites.* As the genus *Aralia* is used by paleobotanists it would naturally include the following forms, although there is a distinct advantage in the present case in keeping them separate as constituting the genus *Araliæphyllum* which indicates without undue definiteness their supposed affinity with the modern Araliaceæ.

One of the species, *Araliæphyllum crassinerve* (Fontaine), shows considerable resemblance to the Raritan form *Aralia Newberryi* Berry and was doubtless ancestral to it.

[1] Berry, Bot. Gazette, vol. xxxiv, 1902, pp. 426-450.

The genus *Araliæphyllum* of Fontaine must not be confused with *Araliophyllum,* a name proposed by Debey in manuscript for certain Upper Cretaceous leaves from Aachen in Rhenish Prussia and published by Schimper in 1874.[1]

ARALIÆPHYLLUM CRASSINERVE (Fontaine) Berry

Plate XCV, Figs. 1-3

Platanophyllum crassinerve Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 316, pl. clviii, fig. 5.
Araliæphyllum obtusilobum Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 317, pl. clxiii, figs. 1, 4; pl. clxiv, fig. 3.
Araliæphyllum acutilobum Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 318, pl. clxiii, fig. 2.

Description.—Leaves of medium or small size ranging from 6 cm. to 10 cm. in length by from 5 cm. to 10.5 cm. in greatest width, orbicular in general outline. Primarily palmately trilobate, usually with a subordinate lobe on the outside of each lateral lobe, occasionally two such lobes are developed and sometimes the apical lobe is also sublobate. Texture coriaceous. Lobes usually broadly ovate in outline with generally rounded (occasionally acute) tips. Sinuses rounded, the main ones rather narrow and extending about half way to the base of the leaf. Subordinate sinuses shallower and more open. Petiole, preserved for a length of 3 cm. in one specimen, stout, as is also the midrib. Lateral primaries two in number (one on each side), coarse in calibre, branching from the midrib at or near its base at angles of about 30° and running to the tips of the main lateral lobes. On the outside a short distance above their point of insertion they give off rather stout laterals which run to the tips of the principal subordinate lateral lobes. The true secondaries are numerous in all of the lobes; they are comparatively fine in character and camptodrome. The base of the leaf is cuneate in outline and slightly decurrent on the petiole. In some of the broader leaves the base approaches a truncate outline.

As constituting this species the writer has combined *Platanophyllum crassinerve, Araliæphyllum obtusilobum* and *Araliæphyllum acutilobum*

[1] Schimper, Pal. Végét., t. iii, 1874, p. 38.

of Fontaine, the first and the last based on very sparse material of a fragmentary character which as nearly as it admits of comparison is identical with the type material of the second, in fact Professor Fontaine states that the last two may be identical, a point upon which there can be but little doubt.

The remains of these leaves are fairly common at various outcrops of Patapsco age near both banks of the Potomac River but have not been found either to the northward in Maryland or to the southward in Virginia. They undoubtedly represent the ancestral form of *Aralia Newberryi* Berry, a common Upper Cretaceous species which extends from the Raritan through the Magothy formation, and they may be compared more particularly with various forms of this species figured by the writer[1] from Cliffwood Bluff, New Jersey. The present species does not differ greatly from the next, such differences as are observable being discussed under the latter.

Occurrence.—PATAPSCO FORMATION. Deep Bottom, near Brooke, Virginia; near Glymont, Stump Neck, Maryland.

Collections.—U. S. National Museum, Maryland Academy of Science.

ARALIÆPHYLLUM MAGNIFOLIUM Fontaine

Plate XCVI, Figs. 1-5

Araliœphyllum magnifolium Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 318, pl. clix, figs. 9, 10.

Araliœphyllum aceroides Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 319, pl. clvi, fig. 11; pl. clxii, fig. 2.

Aceriphyllum aralioides Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 321, pl. clxiii, fig. 8.

Hederœphyllum angulatum Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 324, pl. clxii, fig. 1.

Description.—Leaves usually of large size, ovate to orbicular in general outline, ranging from 8 cm. to 17 cm. in length by from 8 cm. to 18 cm. in greatest width, usually longer than wide. Palmately trilobate with subordinate lobes developed exactly as in the preceding species, but to a less degree and frequently not at all. Lobes broadly ovate in

[1] Berry, Bull. N. Y. Bot. Garden, vol. iii, 1903, p. 93, pl. xliv.

outline and acutely (but not narrowly) pointed. Sinuses narrow and rounded, the main ones extending half way to the base or somewhat less, the subordinate ones extremely shallow. Texture coriaceous. Petiole stout, as is the usually curved midrib. Lateral primaries two in number, stout, basal or subbasal, sending off a stout branch on the outside which is camptodrome in cases where the lateral lobe is entire and running to the apex of the subordinate lobe when the latter is present. True secondaries numerous, not coarse, camptodrome. Base of the leaf broadly cuneate or truncate, slightly decurrent.

This species differs from the preceding in its uniformly larger size and consequent coarseness of texture and venation; in its usually more elongate form and less sublobation; in its truncate base and broader, more acute lobes.

As the synonymy shows, the writer has united *Araliæphyllum magnifolium* and *Araliæphyllum aceroides* of Fontaine which show absolutely no distinctive characters except that the material is in the one case more fragmentery than in the other. With these it has been found necessary to unite the genus *Accriphyllum* of Fontaine founded upon a single specimen (as nearly as can be made out from the U. S. National Museum collection) which is identical with the remains just cited. Professor Fontaine compares it with *Araliæphyllum* and gives as its only diagnostic character the lack of subordinate lobes, which as we have seen is of minor importance in the present genus. Finally *Hederæphyllum angulatum* Fontaine is also found to be identical with the foregoing. It was based upon a single incomplete specimen, the only one ever discovered, and was compared by its original describer with *Araliæphyllum*, with which it undoubtedly naturally belongs.

The present species is less common than the preceding and, like it, is thus far restricted to the vicinity of the Potomac River, occurring in beds of Patapsco age in both Virginia and Maryland. Because of its large size it is usually found in a fragmentary condition.

Occurrence.—PATAPSCO FORMATION. Near Brooke, 72-mile post, Virginia; Stump Neck, Charles County, Maryland.

Collection.—U. S. National Museum.

INCERTAE SEDIS

Genus HEDERAEPHYLLUM Fontaine

[Mon. U. S. Geol. Survey, vol. xv, 1890, p. 323]

This genus received the following brief diagnosis by its describer: "Leaves of rather small size, rotundate in form, with nerves radiating from the base of the leaf, the middle one being the strongest; petioles long and moderately strong; leaf substance thick."

While the foregoing would apply to a score of genera of dicotyledonous leaves it is difficult to frame a proper diagnosis for such fragmentary remains which are described in more detail under the single species. A second species was described by Fontaine which proved upon careful comparison to be referable to *Araliæphyllum.*

The remains constitute an unimportant element in the flora of the Patapsco formation and show no especial affinity with the modern species of *Hedera,* the supposed resemblance to which was the occasion for the name given to them.

HEDERÆPHYLLUM DENTATUM (Fontaine) Berry

Proteæphyllum dentatum Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 286, pl. clvi, fig. 7; pl. clxxii, figs. 1, 4; pl. clxxiii, figs. 12, 14.
Hederæphyllum crenulatum Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 324, pl. clxii, fig. 3.
Proteæphyllum dentatum Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 563, pl. cxviii, figs. 3, 4.

Description.—Leaves ovate to orbicular in general outline, 5 cm. to 6 cm. in length by 2 cm. to 6 cm. in greatest width. Apex obtusely rounded. Base usually subcordate. Margin varying from crenulate to dentate. Petiole stout. Midrib slender and but slightly differentiated. Primaries slender, four to six in number, diverging at narrow angles from the apex of the petiole, somewhat flexuous and sooner or later anastomosing by their dichotomous forking to produce large elongate subrhombic meshes. Secondaries few, ultimately craspedodrome. Texture coriaceous.

This species in the condition of numerous imperfect and illy-defined fragments is common in the Federal Hill beds and occurs sparingly near Brooke, Virginia. As here recognized it embraces certain apparently identical forms which were the basis for *Proteæphyllum dentatum* Fontaine, but which have no observable characters in common with the species of that genus. They may be compared with various supposed, but not true, species of *Protorhipis.*

Occurrence.—Patapsco Formation. Federal Hill (Baltimore), Maryland; near Brooke, Virginia.

Collection.—U. S. National Museum.

Genus PROTEAEPHYLLUM Fontaine

[Mon. U. S. Geol. Survey, vol. xv, 1890, p. 281]

This genus was established by Fontaine in 1890 for certain remains of supposed primitive angiosperms and eight species, so-called, were included in it. Since that date the same author has described several additional species, also of nominal value. The original discussion which is reproduced in the present connection for the sake of completeness is as follows:

"I group under this head a number of leaves with a very archaic type of nervation that occur in the Potomac flora. In their nervation, and in many cases in the form of the leaves, they bear a greater resemblance to species of Protea than any other plants. The main points that characterize them are the absence of any pronounced difference in the size of the primary nerves, the great slenderness of these, the lax and irregular reticulation formed, and the uniformly strong ultimate nerves, which gives a reticulation that reminds one of ferns. Indeed, I was for some time in doubt whether some of these leaves were really angiosperms and not ferns. There are two types of these leaves, that differ only in the presence or the absence of a distinct midrib; when the midrib is present the leaves assume an elliptical form; when it is absent, they tend to take an orbicular shape. We might perhaps divide the genus into two subgenera according to this distinction, giving one the name *rotundatum* and the other the appellation *elongatum.*

"The genus may be described as follows: Leaves orbicular or elongate in form; in the case of the former, no midrib present; in the case of the latter, a thick, vaguely defined, and apparently somewhat succulent midrib exists; petioles proportionally very thick and apparently succulent; nervation of the primary order very slender, and with little or no difference in the strength of the primary nerves; reticulation of all orders lax, irregular in shape, and varying in the size of the meshes; ultimate nerves strong, all of equal strength and fern-like. These leaves form an important portion of the angiosperms that occur with a predominant flora of Jurassic type, as at Fredericksburg, and they give a very ancient look to the angiospermous element of the flora."

Any discussion of *Proteœphyllum* must take into account the history of the genus *Protorhipis* since the American species have been referred to that genus by Ward and since similar leaves from foreign localities have also been unhesitatingly so identified.

The genus *Protorhipis* was founded by Andrae in 1853 for certain large Liassic forms from Banat in Hungary.[1] Subsequently Zigno[2] described a species from the Oolite of Italy in 1865, Nathorst two additional species from the Rhætic of Sweden[3] in 1878, Heer in 1880 a species from the Oolite of Siberia,[4] and in 1882 a species from the Barremian of Kome,[5] Greenland. Saporta in 1894 described another Barremian species[6] this time coming from Portugal and another poorly characterized species from the Rhætic of Sweden.[7] Seward records[8] a species from the Wealden of Bernissart, Belgium, and recently Knowlton has described still another species from the Kootanie of Montana.[9] Intimately involved with the foregoing is the genus *Hausmannia* of

[1] Andrae, Foss. fl. Siebenburgens u. d. Banates, Abh. k. k. geol. Reichs., Bd. ii, Ab. iii, 1853, p. 35, pl. viii, fig. 1.

[2] Zigno, Fl. Foss. Oolith., i, 1865, p. 180, pl. ix, figs. 2, 2a.

[3] Nathorst, Fl. v. Bjuf., i, 1878, p. 42; ii, 1879, p. 57, pl. xi, figs. 2, 4.

[4] Heer, Fl. Foss. Arct., Bd. vi, Ab. i, 1880, p. 8, pl. i, fig. 4a.

[5] Heer, *Ibid.*, Ab. ii, 1880, p. 10, pl. iii, fig. 11.

[6] Saporta, Fl. Foss. Portugal, 1894, p. 144, pl. xxii, figs. 9-11; pl. xxvi, figs. 17, 18; pl. xxvii, figs. 1-5.

[7] Saporta, *Ibid.*, p. 143, pl. xxii, figs. 14, 14a.

[8] Seward, Mém. Mus. d'Hist. Nat. Belg., tome i, 1900, p. 18, pl. iii, fig. 34.

[9] Knowlton, Smith. Misc. Coll. (Quart.), vol. 1, pt. i, 1907, p. 114, pl. xii, figs. 3, 4.

Dunker[1] based in the first instance on German Wealden material. A number of species of *Hausmannia* have been subsequently described including a number of Bornholm specimens which are exactly similar to the type of *Protorhipis* but which Bartholin named *Hausmannia forchhammeri.*[2] In reviewing this work Zeiller describes[3] and figures additional material from the type locality for *Protorhipis* in Banat, Hungary, and shows that the type of the genus was polymorphous and closely related to the living genus *Dipteris.* This view is adopted by Möller in 1902 in his revision of the Bornholm flora,[4] and by Richter,[5] who has still more recently elaborately gone over the whole ground anew. This being the case *Hausmannia* has priority, having been published seven years before *Protorhipis,* although both Seward and Knowlton favor the retention of the latter as a purely form-genus.

Regarding the systematic position of *Protorhipis,* it was originally referred to the ferns by Andræ who compared his species with the exisiting genus *Platycerium.* Other students compared these forms with the modern genus *Dipteris* and both Bartholin and Zeiller found fructified material of the latter type. However, Saporta in his review of the subject makes these forms conspicuous members of his Proangiosperms and Ward two years later[6] not only follows Saporta's view but refers the genus bodily to the Dicotyledonæ, including with it the Potomac forms *Proteœphyllum reniforme* Fontaine, *P. orbiculare* Fontaine and *Populophyllum reniforme* Fontaine. These latter are in no wise related to the true forms of *Protorhipis* (*Hausmannia*) which are undoubted ferns of the *Dipteris* type, although they are somewhat similar to *Protorhipis Choffati* Saporta from the Portuguese Barremian and *Protorhipis cordata* Heer from the Kome beds, neither of which can be compared with *Protorhipis* (sens stricto). The same may be said of *Protorhipis*

[1] Dunker, Mon. Norddeutsch. Weald., 1846, p. 12, pl. v, fig. 1.

[2] Bartholin, Nogle i den Bornholmske Juraform forkommende Planteforsteninger, 1894, pp. 17, 48, pl. xi, figs. 4-6; pl. xii, figs. 1, 2.

[3] Zeiller, Rev. Gén. Botan., t. ix, 1897, p. 51, pl. xxi, figs. 1-5.

[4] Möller, Kgl. Fysiogr. Sällsk. Handl., xiii, 1902, p. 48.

[5] Richter, Beitr. Fl. unteren Kreide Quedlinburgs, Teil i, 1906.

[6] Ward, 16th Ann. Rept. U. S. Geol. Survey, pt. i, 1896, p. 535.

asarifolia Zigno and *Protorhipis reniformis* Heer which do not appear to be related to the Cretaceous forms just mentioned nor to the true *Protorhipis* but apparently represent detached scales of some *Zamiostrobus* or similar object as has been suggested by Nathorst and others.

This long discussion terminates at about the point where it started except that it appears clear that *Proteæphyllum* is not a fern of the *Protorhipis* type. An additional species recently described by Fontaine from the Californian Shasta does not help any since the latter is absolutely undeterminable and uncharacteristic.[1]

There are a number of somewhat similar foliar, stipular, or bracteate objects described by Saporta from the Cretaceous (Albian) of Portugal with which the reniform Potomac species may be compared, such as *Braseniopsis venulosa*,[2] *B. villarsioides*,[3] *and Adoxa prætavia*,[4] but these comparisons are worth little. The only possible view of their botanical relationship is that they are either angiospermous or filicinean. They may represent aquatic forms of either type or juvenile forms of the fronds of some dimorphic Lower Cretaceous fern. With regard to the ovate forms of *Proteæphyllum* with a midrib these may also be angiospermous or they may be related to *Ficophyllum* and *Rogersia*, which may be early representatives of the Gnetales. They suggest, rather remotely it is true, the two specimens from the Stonesfield slates of England which are described and figured by Seward as simply *Phyllites* sp.[5] Probably it would have been better in the first instance to have described these Potomac forms as *Phyllites* instead of making them the basis of six different species of angiosperms, but as they are in the literature and the name does not carry any implications of relationship, it has seemed best to retain it, reducing, however, the six nominal species to the two which are actually present in nature. Their true affinity remains

[1] Font., in Ward, Mon. U. S. Geol. Survey, vol. xlviii, 1906, p. 267, pl. lxix, fig. 11.

[2] Saporta, Fl. Foss. Portugal, 1894, p. 192, pl. xxxiv, figs. 1-4.

[3] *Ibid.*, p. 195, pl. xxxv, fig. 9.

[4] *Ibid.*, p. 187, pl. xxxiv, fig. 5.

[5] Seward, Jurassic Fl., pt. ii, 1904, p. 152, pl. xi, figs. 5, 6.

unknown, for while they may be compared with a number of modern plants, they present no characters entitled to any great weight, certainly they do not furnish adequate evidence of their angiospermous nature, although they may well be the remote representatives of this type since there are no grounds, theoretical or otherwise, to deny the existence of angiosperms at such a relatively late date in the Mesozoic.

The genus *Proteæphyllum* of Fontaine must not be confused with *Protophyllum* Lesquereux (Cret. Fl., 1874, p. 100) or *Proteophyllum* Velenovsky (Květena českého cenomanu, 1889, p. 18). Saporta has referred a number of Portuguese Lower Cretaceous forms to the latter genus, which is supposed to be related to the existing Proteaceæ.

PROTEÆPHYLLUM RENIFORME Fontaine

Proteæphyllum reniforme Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 282, pl. cxxxix, fig. 3; pl. clvi, fig. 4; pl. clx, figs. 1, 2 (non Ward, 1895 or 1896, or Fontaine in Ward, 1906).

Proteæphyllum orbiculare Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 283, pl. cxxxix, fig. 4.

Phyllites pachyphyllus Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 325, pl. cxlix, fig. 2.

Description.—Leaves of medium size, reniform to orbicular in outline, with entire margin, and coriaceous in texture. Length 3 cm. to 6 cm., width 4 cm. to 10 cm. Petiole wide and flat, preserved for a length of 2 cm. in some specimens and at times as much as 5 mm. in width. Primaries numerous, thin, diverging from the top of the petiole, anastomosing irregularly and in a lax manner.

No material shedding any new light on this singular form has been collected and its affinity remains unknown. The forms described as the species *reniforme, orbiculare,* and *pachyphyllus* are obviously identical and the records from post-Patuxent horizons prove to be based upon decidedly different leaves in no wise related to this species.

Occurrence.—PATUXENT FORMATION. Fredericksburg, near Dutch Gap, Virginia.

Collection.—U. S. National Museum.

PROTEÆPHYLLUM OVATUM Fontaine

Proteœphyllum ovatum Font., 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 285, pl. cxli, fig. 1 (non Fontaine in Ward, 1906, p. 510).
Proteœphyllum ellipticum Font., 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 285, pl. cxlii, figs. 1, 2.
Proteœphyllum tenuinerve Font., 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 286, pl. cl, fig. 13; pl. clvi, fig. 2.

Description.—"Leaves of medium (and large) size, ovate-acute, with the tip bent to one side, abruptly rounded at base, and subcordate; midnerve very thick and apparently somewhat succulent; primary nerves very slender, going off nearly opposite in pairs, basal pair leaving at a very large angle and curving strongly around approximately parallel to margin, those higher up leaving at more and more acute angles, curving gently until near the margin of the leaf, and then bending strongly upwards, gradually approaching the margin, sending off slender branches, which anastomose to form large, lax, and mostly irregular quadrangular primary meshes; ultimate meshes variable in size, distinctly defined, and formed chiefly by the meeting of the nerves under large angles."—Fontaine, 1890.

No new material which can be referred to this protean species has been collected and its botanical affinity remains in doubt.

Occurrence.—PATUXENT FORMATION. Fredericksburg, near Dutch Gap, near Potomac Run, Virginia.

Collection.—U. S. National Museum.

Genus ROGERSIA Fontaine

[Mon. U. S. Geol. Surv., vol. xv, 1890, p. 287]

The present genus was characterized in the following terms by its describer:

"Leaves long, narrow, and willow-like, wedge-shaped at base, acute, with a very strong midnerve and very slender primary nerves; these go off very obliquely and diverge very slowly from the midrib, running for a long distance nearly parallel with the margins of the leaves; they anastomose with branches sent off from other nerves of like grade higher up to form very long, irregularly shaped, and lax meshes; ultimate reticulation oblong, subrhombic, of quite uniform dimensions. This genus is named for Prof. W. B. Rogers, who first called attention to the plants of the Potomac formation and studied its geology."—Fontaine, 1890.

What has been said in the case of *Proteæphyllum* and *Ficophyllum* applies equally well to the present genus, which may be angiospermous, but is more likely referable to the Gnetales, a problem which cannot be solved until fruiting or structural material is discovered.

ROGERSIA LONGIFOLIA Fontaine

Rogersia longifolia Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 287, pl. cxxxix, fig. 6; pl. cxliv, fig. 2; pl. cl, fig. 1; pl. clix, figs. 1, 2.
Sapindopsis elliptica Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 297, pl. cxlvii, fig. 3 (non Font., 1906).
Rogersia longifolia Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 538 (non pp. 511, 523, pl. cxii, fig. 9).

Description.—"Leaves narrowly elliptical, gradually narrowed to the base and apex, with wedge-shaped base, acute, very long in proportion to width; midrib comparatively very stout; primary nerves very slender, going off very obliquely, proceeding upwards for some distance nearly parallel with the margin, but gradually approaching it; primary nerves sending off very obliquely secondary nerves, which anastomose with their neighbors to form elongate, subrhombic, and irregular meshes, which have their maximum dimensions turned upwards and slightly outwards; primary meshes filled with pretty sharply defined ultimate meshes, polygonal in shape, and varying in the number of sides from four to six." —Fontaine, 1890.

No new facts regarding these peculiar forms have been obtained.

Occurrence.—PATUXENT FORMATION. Fredericksburg, near Dutch Gap, Kankeys, Virginia. ARUNDEL FORMATION. Arlington (?), Maryland.

Collection.—U. S. National Museum.

ROGERSIA ANGUSTIFOLIA Fontaine

Rogersia angustifolia Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 288, pl. cxliii, fig. 2; pl. cxlix, figs. 4, 8; pl. cl, figs. 2-7.

Saliciphyllum longifolium Fontaine, 1890, Mon. U. S. Geol. Surv., vol. xv, 1889, p. 302, pl. cl, fig. 12.

Rogersia angustifolia Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 521 (non pp. 491, 510).

Description.—" Leaves narrow, small, very elongate-oblong, narrowed gradually to the base and apex, subacute, sometimes curved ensiform; midnerve proportionally very strong, with a thick petiole; lateral or primary nerves very slender, going off at an acute angle and arching up towards the summit, forming more or less persistent nerves approximately parallel with the margin, and having a flexuous course. They send off very obliquely slender lateral nerves, which anastomose with the adjacent ones, and form irregular, elongate, polygonal meshes, with their longer dimensions directed upwards. The latter, by splitting up into ultimate nerves, form an irregular, lax, ultimate network."—Fontaine, 1890.

No new material which can be referred to this species has been collected.

Occurrence.—PATUXENT FORMATION. Fredericksburg, Potomac Run, Virginia. ARUNDEL FORMATION. Langdon (?), District of Columbia; Bay View, Maryland.

Collection.—U. S. National Museum.

ROGERSIA ANGUSTIFOLIA PARVA Fontaine

Rogersia angustifolia parva Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, p. 523, pl. cxi, fig. 9.

Description.—" At this locality five specimens of a dicotyledon were found that indicate a smaller and narrower leaf than the normal *Rogersia angustifolia*. In fact, the leaves are so narrow that they suggest *Cephalotaxopsis magnifolia.* The nervation, however, although vaguely shown, is that of a dicotyledon, and the leaf substance is thinner than that of a Cephalotaxopsis. This may be a new genus, but the amount of material is too small and the preservation too imperfect to permit the establishment of its full character. It may provisionally be regarded as a variety of *Rogersia angustifolia,* which it resembles in all determinable points except size."—Fontaine, 1906.

It seems very probable that this supposed variety of *Rogersia angustifolia* is based upon detached leaves of *Cephalotaxopsis,* but as the writer has not been able to entirely satisfy himself on this point the variety is retained for the present.

Occurrence.—ARUNDEL FORMATION. Langdon, District of Columbia.

Collection.—U. S. National Museum.

Genus FICOPHYLLUM Fontaine

[Mon. U. S. Geol. Survey, vol. xv, 1890, p. 290]

This genus was founded by Fontaine in 1890 for certain netted-veined leaves which are present in considerable abundance in the Patuxent formation at Fredericksburg and less commonly at a few other synchronous outcrops in Virginia. The specimens are all fragmentary and the preservation is poor so that it is difficult to arrive at any definite conclusions regarding their true nature.

For the sake of completeness the original discussion is quoted in full:

"Leaves elliptical in outline, subacute, gradually narrowed at base, with the lamina of the leaf more or less decurrent along the petiole; midnerve and petiole extremely thick proportionally; lateral or primary nerves proportionally and in most of the forms absolutely slender, extremely irregular in arrangement, forming a lax reticulation of very archaic type. Ultimate reticulation strongly marked and fern-like.

"This genus is an important one in the Potomac flora, and has contributed a considerable number of individuals to the vegetation of that epoch. It is largely developed in association with Jurassic types of plants, as at Fredericksburg, where it is most abundant, and is almost wanting in the strata where more modern elements abound, as at Brooke, White House, and Baltimore. As illustrating the archaic and peculiar features of these leaves and those of *Proteœphyllum,* I may state that for some time no other leaves but these were found at Fredericksburg, and finding them associated only with plants of Jurassic facies I found it difficult to give any good characters distinguishing them from ferns. There is a general and strong resemblance between these plants and some species of Ficus, and for this reason it seems best to place them in a new genus, indicating by its name the apparent affinity with that genus. It is quite possible that these are ancestral forms of Ficus."

The foregoing diagnosis remains correct except that it should be pointed out that the slenderness of the secondaries is purely relative to the midrib, and not actual, as they are for the most part especially stout as may be seen from Fontaine's figures of these forms.

There is one other venation character which should be mentioned since it is of extreme importance in the writer's judgment as it gives the only clue to the relationship of these forms, a matter of great interest, since we are dealing with what have long supposed to be the most ancient known angiosperms. This is the internal free ending of the veins within the meshes. This type of venation, while present in various angiosperms as for example in certain species of *Ficus, Banksia, Cocculus,* etc., according to DeBary, is especially characteristic of netted-veined ferns of the *Drynaria* type and occurs also in the genus *Gnetum* among the Gnetales. Whether these features are anatomically accurate and the vascular bundles in contradistinction to the veins actually end in this way cannot be determined, but the relatively coarse ultimate venation does show these features.

The writer is inclined to think that both *Ficophyllum* and the allied genera *Proteæphyllum* and *Rogersia* are not angiosperms but are related either to ferns of the *Drynaria* type or to the Gnetales. In outline they are closer to Gnetum-like forms although *Ficophyllum serratum* agrees fairly well with the basal leaves of *Drynaria.* The fossils have been carefully compared with a large amount of recent material and with all of the described remains of fern genera like *Clathropteris* and *Dictyophyllum* without arriving at any definite conclusions other than the conviction that if the remains of *Ficophyllum* had happened to come from Rhætic instead of Cretaceous strata they would have been unhesitatingly referred to the ferns.

In the absence of more representative material, that already known being very poor, no definite result is possible, although the writer is inclined to consider *Ficophyllum* as being referable to the Gnetales, which were certainly more abundant in the Mesozoic than has ever been suspected. The fact that true dicotyledonous leaves from the Patapsco formation have been confused with these earlier forms by Fontaine has served to effectually complicate the whole question. As a matter of fact all of the specimens, except some doubtfully determined fragments from the Arundel formation in Maryland, come from the basal Potomac of Virginia, *i. e.*, from near the base of the Patuxent formation. The fact that some authors use the ending *phyllum* for all fossil representatives of existing genera should not be understood in the present case as indicating that any relationship with *Ficus* is implied by the retention of Fontaine's generic name. In the absence of positive data regarding the affinity of these forms *Ficophyllum* has been allowed to stand since no good could possibly result from an arbitrary change of name.

FICOPHYLLUM SERRATUM Fontaine

Ficophyllum serratum Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 294, pl. cxlv, fig. 2; pl. cxlix, fig. 9 (non Fontaine, 1899).
Quercophyllum tenuinerve Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 308, pl. cxlix, figs. 6, 7.
? *Quercophyllum tenuinerve* Fontaine, 1906, in Ward, Mon. U. S. Geol. Survey, vol. xlviii, 1905, p. 521.

Description.—"Leaves of moderate size, strongly serrate-toothed, teeth often irregular in size, sometimes double, acute, and directed forwards; shape of the leaf not fully disclosed, but apparently elliptical; midnerve proportionately very strong, lateral or primary nerves very slender, not fully disclosed, but apparently forming by the union of the branches of the primary nerves irregular large meshes; ultimate nervation not seen."—Fontaine, 1890.

This species was based upon very rare and indecisive fragments of the apical part of leaves whose botanical affinity is entirely unknown. Those equally rare fragments of the basal part of similarly toothed leaves from the same locality described as a species of *Quercophyllum tenuinerve* are clearly identical with the former and both are entirely distinct from the fragments described by Professor Fontaine from the Fuson formation of the Black Hills as *Ficophyllum serratum.* The species is clearly distinct from any other known Lower Cretaceous forms and while it shows no obvious relationship with the other Potomac species of *Ficophyllum* nothing is to be gained by any new proposal of botanical affinity since the latter is entirely speculative. The forms are obviously not related to any known forms of *Ficus;* in fact their dicotyledonous nature is entirely doubtful and they might equally well be referable to some member of the Monocotyledonæ, the Filicales, or even some member of the Gnetales among the Gymnosperms. No additional material of this species has ever been discovered and were the name not already in the literature it would be preferable to describe it under the non-committal name Phyllites or even leave it altogether undescribed.

Occurrence.—Patuxent Formation. Fredericksburg, Virginia. Arundel Formation. Langdon (?), District of Columbia.

Collection.—U. S. National Museum.

Ficophyllum oblongifolium (Fontaine) Berry

Proteæphyllum oblongifolium Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 284, pl. cxxxix, fig. 5; pl. cxl, figs. 1, 2.

Proteæphyllum sp., Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 284, pl. cxxxix, fig. 2.

Ficophyllum crassinerve Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 291, pl. cxliv, fig. 3; pl. cxlv, fig. 3; pl. cxlvi, fig. 1; pl. cxlvii, fig. 4; pl. cxlviii, figs. 1, 2, 4; pl. clvii, fig. 4; pl. clxxiii, fig. 10 (non Fontaine in Ward, 1906).

Ficophyllum tenuinerve Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 292, pl. cxl, fig. 3; pl. cxli, fig. 2; pl. cxlv, figs. 1, 4; pl. cxlvii, fig. 2; pl. cxlix, figs. 1, 3, 5; pl. clvi, fig. 1 (non Fontaine in Ward, 1906).

Ficus virginiensis Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 295, pl. cxliii, figs. 1, 3; pl. cxliv, fig. 1.

Ficus Fredericksburgensis Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 295, pl. cxlviii, figs. 3, 5.

Sapindopsis cordata Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 296, pl. cxlvii, fig. 1.

Saliciphyllum ellipticum Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, p. 303 (pars), pl. cxlvi, figs. 2, 4; pl. cl, fig. 3; pl. clxiii, fig. 5; pl. clxvi, fig. 2.

Proteæphyllum oblongifolium Fontaine, 1906, in Ward, Mon. U. S. Geol. Survey, vol. xlviii, 1905, p. 538.

Ficophyllum tenuinerve Fontaine, 1906, in Ward, Mon. U. S. Geol. Survey, vol. xlviii, 1905, p. 520 (non pp. 504, 510).

Description.—" Leaf rather large, spatulate, oblong or oblong-elliptical, narrowed very gradually below into the petiole; summit not seen; midnerve stout, and continuing to near the tip of the leaf; secondary nerves very slender, leaving the midrib at a more or less acute angle, and arching around in an irregularly flexuous manner to unite with those of the same order next above, sending off branches obliquely, mainly on the outer side, which pursue a flexuous course parallel to the margin of the leaf, finally dissolving into smaller branches; the lateral nerves anastomose into large, irregular meshes, made up of subordinate meshes, the minor branches of the lateral nerves, which meet under large angles, forming a net-work that is very irregular; leaf-substance moderately thick; the ultimate reticulation strong and fern-like."—Fontaine, 1890.

No new material representing this species has been collected and the types of the various supposed species which represent variously preserved fragments of it are obviously from the same plant and are too poorly preserved to repay refiguring. No evidence regarding its botanical affinity is available.

Occurrence.—PATUXENT FORMATION. Fredericksburg, Dutch Gap, near Dutch Gap, near Potomac Run, Virginia. ARUNDEL FORMATION. Arlington, Prince George's County, Maryland (1 doubtfully determined specimen). Langdon, District of Columbia (1 doubtfully determined specimen).

Collection.—U. S. National Museum.

Genus ARISTOLOCHIAEPHYLLUM Fontaine

[Mon. U. S. Geol. Survey, vol. xv, 1890, p. 322]

Leaves thick and of very large size with extremely stout and prominent primary and secondary veins. Tertiaries thin but prominent.

This genus of entirely unknown affinity except that it is undoubtedly angiospermous was founded in 1890 by Fontaine for fragments of a large leaf rather common in the Patapsco formation. Subsequently a second species entirely unlike the first and equally obscure was tentatively referred to the same genus.

ARISTOLOCHIÆPHYLLUM CRASSINERVE Fontaine

Plate XCVII

Aristolochiæphyllum crassinerve Fontaine, 1890, Mon. U. S. Geol. Survey, vol. xv, 1889, p. 322, pl. clx, figs. 3-6.

Aristolochiæphyllum crassinerve Fontaine, 1906, in Ward, Mon. U. S. Geol. Surv., vol. xlviii, 1905, pp. 481, 504, 528, pl. cix, fig. 1.

Description.—" Shape of leaf not seen; the leaves were apparently large and rather coarse; leaf-substance thick; petiole and primary nerves very strong and woody; subordinate nerves strong and cord-like; primary nerves go off from the midnerve at an angle of about 45°, sweeping around to form bow-shaped curves; they send off branches nearly at right angles, which anastomose to form irregularly shaped, strongly defined meshes filled by an ultimate reticulation which is very distinct and prominent, formed by nerves meeting nearly at right angles."—Fontaine, 1890.

Fragmentary remains of this exceedingly large leaf are not at all uncommon in the Patapsco formation, but they are so very incomplete that the general form of the leaf is not apparent nor are any speculations regarding its botanical affinity likely to prove profitable.

Occurrence.—PATAPSCO FORMATION. Fort Foote, Prince George's County, near Brooke, 72-mile post, and Hell Hole, Virginia.

Collection.—U. S. National Museum.

ARISTOLOCHIÆPHYLLUM (?) CELLULARE Ward

Aristolochiæphyllum ? celluare Ward, 1906, in Fontaine, Mon. U. S. Geol. Survey, vol. xlviii, 1905, p. 492, pl. cviii, fig. 5.

Description.—" Apparently a large leaf of thick, fleshy texture. It was probably rounded in form. The impressions show on their surface a series of cell-like meshes, separated by narrow, raised, flat borders, which appear to be the nerves of the leaf. The specific name of the plant is founded on the cell-like character of the spaces between these nerves. The meshes cover the entire surface of the leaves. They are polygons made by the meeting, under large angles, of several sides. The number of the sides varies. They are mostly 5 to 8, but may occasionally be fewer. Their size also varies, some being twice as large as others. Within the meshes and grouped, radiating from a central point, are ridges or depressions, according to the relation of the fossil to the original leaf. Depressions seem to have existed originally in the leaf and these leave elevations in the clay embedding the leaf. The number of these radiating inequalities varies. They are mostly 5 or under. The concavities existing on the leaf seem to be puckers in its thick texture. There is apparently nothing like a differentiation of the nerves into grades, such as primary, secondary, etc. The flat, strong, cord-like margins or sides of the cells form the whole of the nervation. But some of the margins of the cells, corresponding in position and placed in the central line of the leaf, are so located as to seem to be continuous of one another and to form an irregular flexuous midrib. This, however, is accidental, and the margins of the meshes are the only nerves possessed by the leaf. The true position of this peculiar leaf is very problematical. It is placed with doubt in the genus Aristolochiæphyllum."—Fontaine, 1906.

As suggested by Ward there is a superficial resemblance to *Kaidacarpum cretaceum* Heer. The nature of the present form is conjectural, and it may not represent a leaf at all.

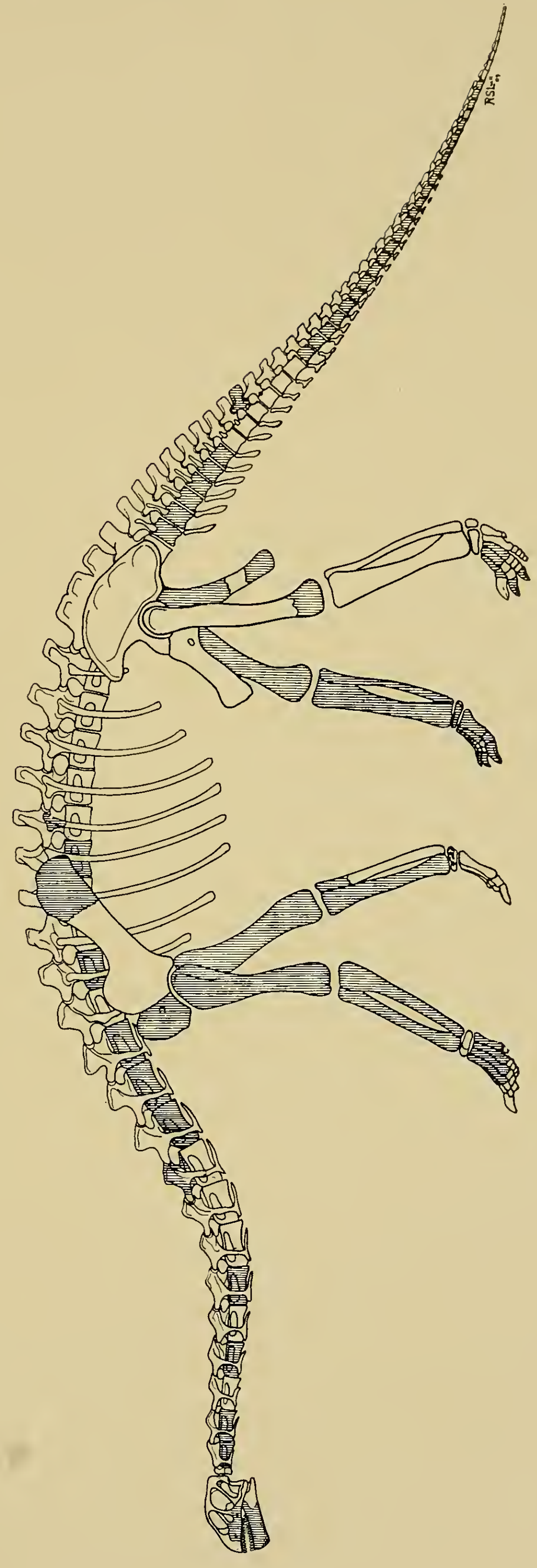
It is extremely doubtful if it bears any relation to *Aristolochiæphyllum crassinerve*. It may represent the underside of a thick floating leaf of unknown affinity.

Occurrence.—Patapsco Formation. Mt. Vernon, Virginia.

Collection.—U. S. National Museum.

PLATES

PLATE XI.



DINOSAURIA.

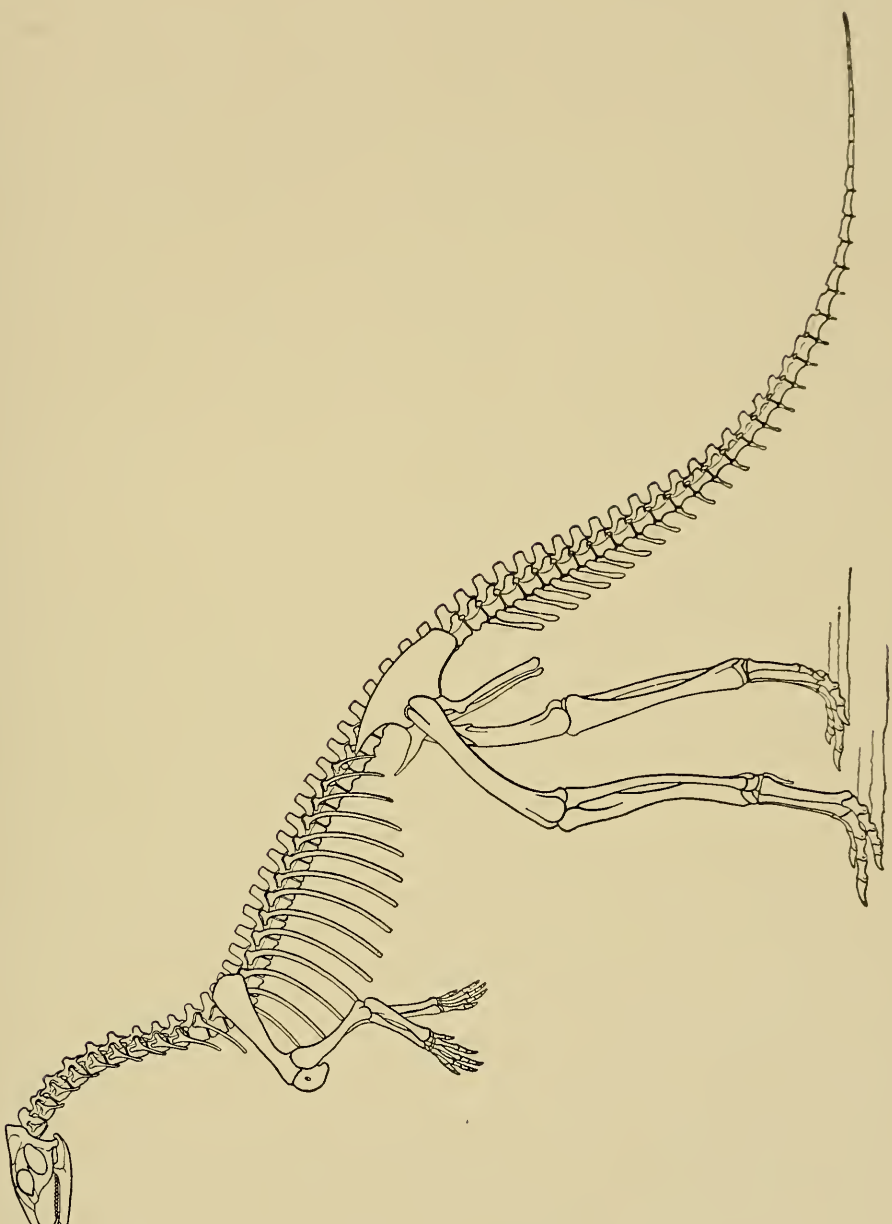
PLATE XII.

Restoration of a Theropod (carnivorous) dinosaur *Ceratosaurus* from the Morrison formation of Colorado, an ally of the Arundel form *Allosaurus*. 1/30 natural size. (After Marsh.)

DINOSAURIA.

PLATE XIII.

Restoration of a Predentate (herbivorous) dinosaur *Laosaurus* from the Morrison formation of Wyoming, a near ally of the Arundel form *Dryosaurus*. 1/10 natural size. (After Marsh.)



DINOSAURIA.

PLATE XIV.

PAGE

Figs. 1-3. ALLOSAURUS MEDIUS Marsh.................................. 183

1. Side view of Tooth. Natural size. Near Muirkirk. (3121 G. C.)
2. Front view same.
3. Proximal phalanx of hind foot. × ⅜. Near Muirkirk. (2521 G. C.)

Fig. 4. VERTEBRA OF CREOSAURUS POTENS Lull. × ⅓. Washington, D. C. (3049 M. G. S.).. 186

Figs. 5-8. PLEUROCŒLUS NANUS Marsh.................................. 188

5. Left dentary. × ½. Near Muirkirk. (5669 U. S. N. M.) s, symphysis; a, edentulous margin.
6. Left maxillary. Outer view. × ½. Near Muirkirk. (5667 U. S. N. M.)
7. Outer, front, inner, and back views of a tooth. Natural size. Near Muirkirk. (5691 U. S. N. M.) (After Marsh.)
8. Outer, front, inner, and back views of another tooth. Natural size. Near Muirkirk. (Unnumbered U. S. N. M.) (After Marsh.)

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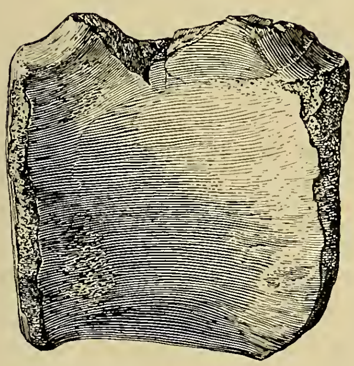

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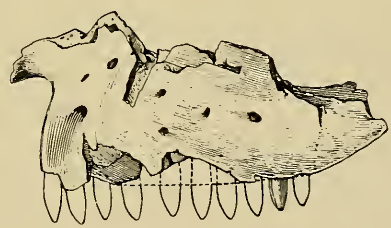

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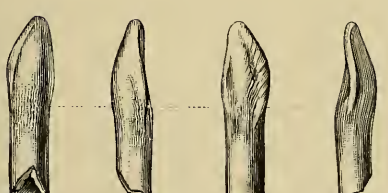

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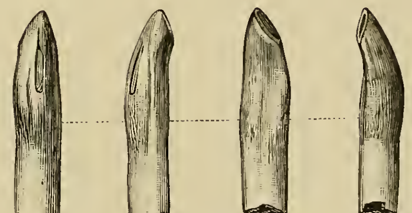

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DINOSAURIA.

PLATE XV.

2. Posterior cervical vertebra. × ½. Near Muirkirk. (5678 U. S. N. M.)

2a. Section of same at line *a-b*.

3a. Supra-occipital, superior view. × ½. Near Muirkirk. (5692 U. S. N. M.)

3b. Same, posterior view.

3c. Same, inferior view.

4. Dorsal vertebra. × ½. Near Muirkirk. (4968 U. S. N. M.)
   - f. Lateral cavity (pleurocœle).
   - a. Anterior end.
   - p. Posterior end.
   - n. Neural canal.
   - s. Suture for neural arch.

5. Sacral vertebra. Left lateral and posterior views. × ½. Near Muirkirk. (4946 U. S. N. M.) *r*, Facet for rib, other lettering as in Fig. 4.

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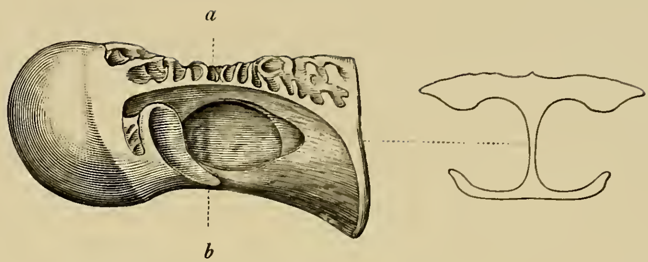

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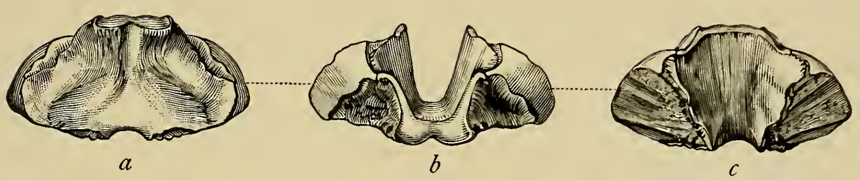

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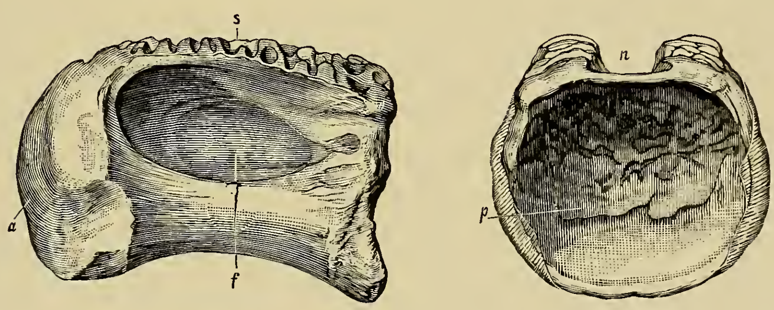

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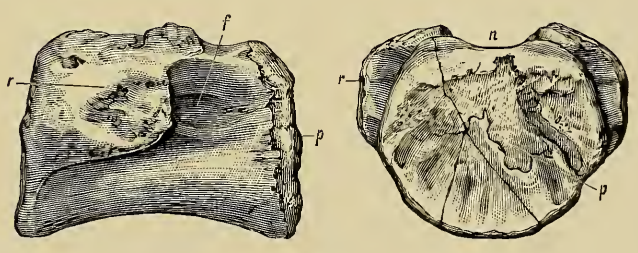

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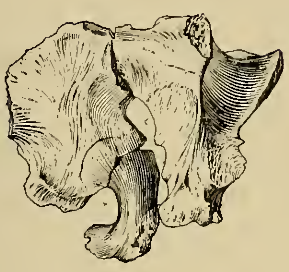
DINOSAURIA.

PLATE XVI.

PAGE

Figs. 1-5. Pleurocœlus nanus Marsh.................................. 188

1. Left alisphenoid, outer view. × ¾. Near Muirkirk. (5668 U. S. N. M.)
2. Middle caudal vertebra. × ½. Near Muirkirk. Outer and superior views. (4970 U. S. N. M.) (After Marsh.)
3. Front, side, and rear views of proximal caudal vertebra. × ¼. Near Muirkirk. (5639 U. S. N. M.) (After Marsh.)
4. Front, side, and rear views of distal caudal vertebra. × ½. Near Muirkirk. (5372 U. S. N. M.) (After Marsh.)
5. Rear, proximal, distal, and side views of humerus. × ⅙. Near Muirkirk. (2263 U. S. N. M.) (After Marsh.)



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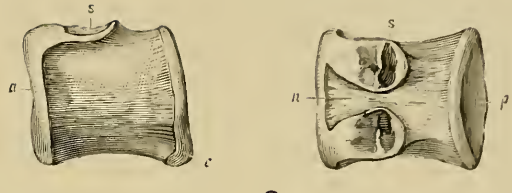

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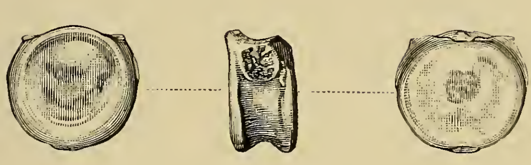

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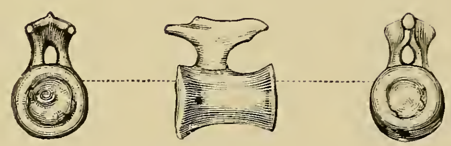

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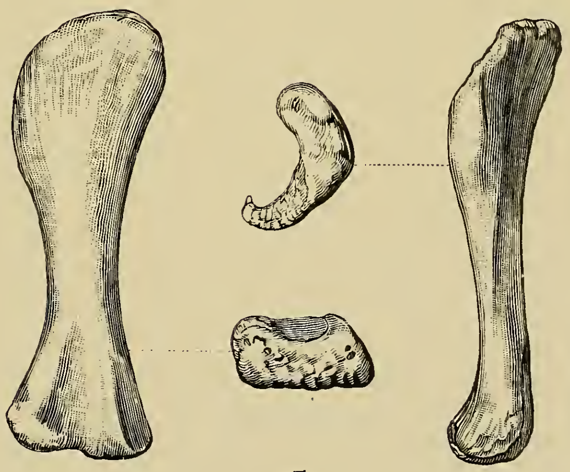

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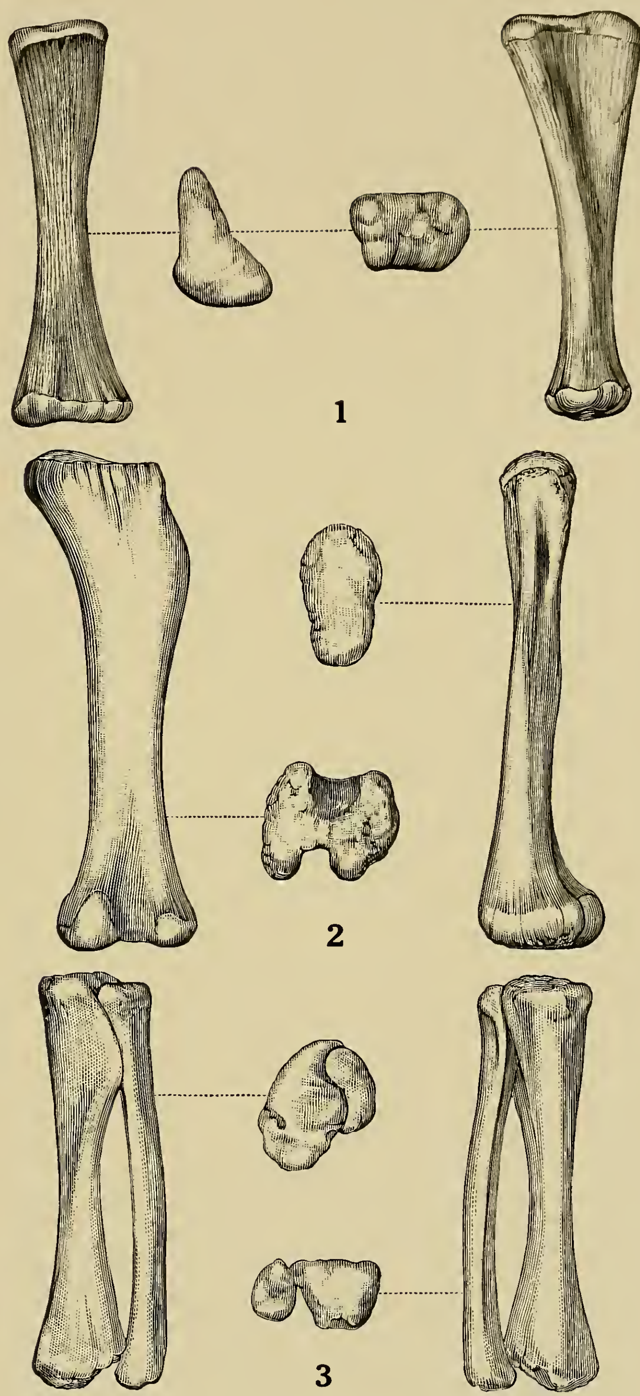
DINOSAURIA.

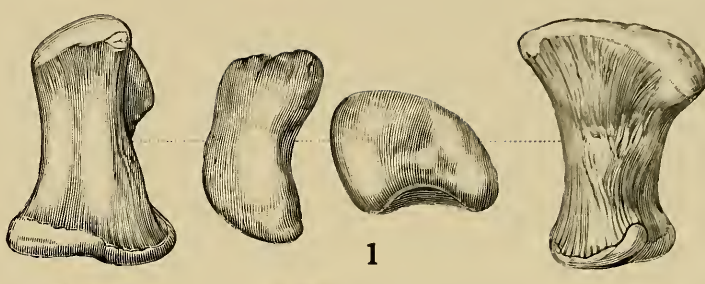
PLATE XVII.

1. Front, proximal, distal, and side views of metacarpal. × ½. Near Muirkirk. (2265 U. S. N. M.)
2. Front, proximal, distal, and outer views of femur. × ⅙. Near Muirkirk. (2263 U. S. N. M.)
3. Front, proximal, distal, and rear views of tibia and fibula. × ⅙. Near Muirkirk. (5656, 5657 U. S. N. M.)



DINOSAURIA.

PLATE XVIII.



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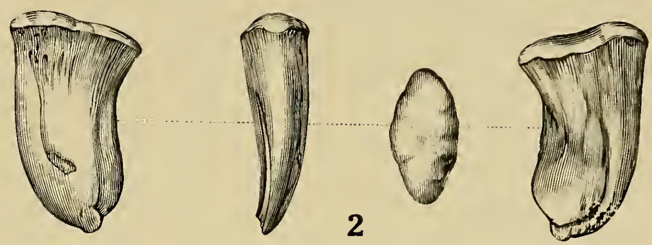

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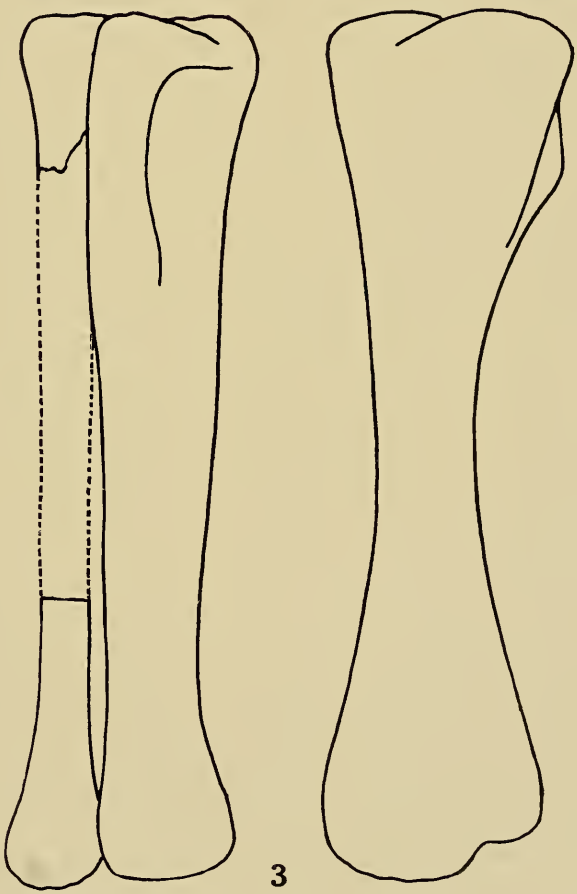

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DINOSAURIA.

PLATE XIX.

PAGE

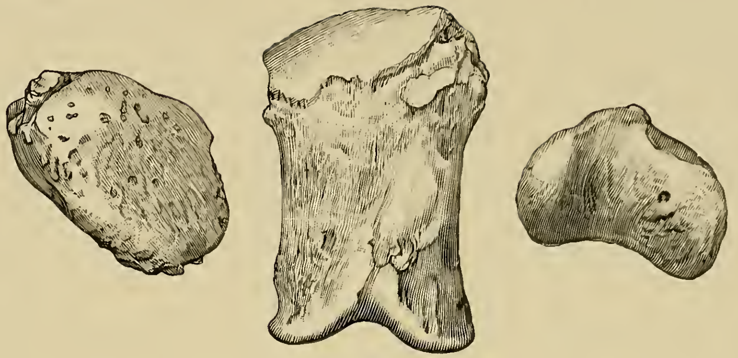
Figs. 1-4. Pleurocœlus altus Marsh 200

1. Metatarsal. × ¼. Near Muirkirk. (5687 U. S. N. M.)
2. Middle caudal vertebra, front view. × ⅓. Near Muirkirk. (5626 U. S. N. M.)
3. Same, side view.
4. Outer and side view of tooth. Natural size. Near Muirkirk. (3333 G. C.) (After Marsh.)

Fig. 5. Astrodon johnstoni Leidy. Outer, side, and inner views of tooth. Natural size. Bladensburg. (798 Yale Mus.) (After Marsh.) . 202

Figs. 6, 7. Dryosaurus grandis Lull 204

6. Astragalus, front view. × ½. Near Muirkirk. (5652 U. S. N. M.)
7. Metatarsals, front view. × ½. Near Muirkirk. (5684, 5704 U. S. N. M.) .



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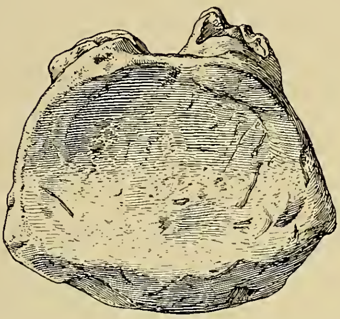

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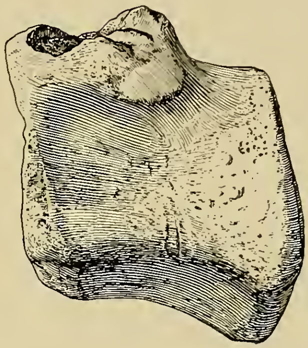

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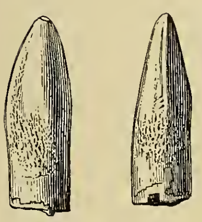

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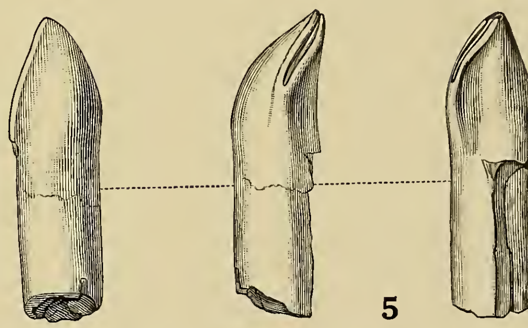

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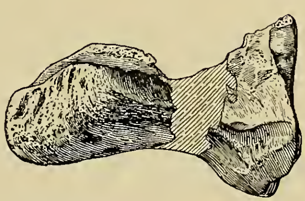

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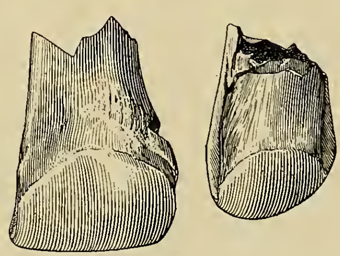

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DINOSAURIA.

PLATE XX.

PAGE

Figs. 1-4. DRYOSAURUS GRANDIS Lull 204

1. Side view of proximal phalanx. × ½. Near Muirkirk. (5453 U. S. N. M.)
2. Front view of same.
3. Phalanx. × ½. Near Muirkirk. (2609 G. C.)
4. Front and side views of ungual phalanx. × ½. Near Muirkirk. (U. S. N. M.)

Figs. 5, 6. PRICONODON CRASSUS Marsh. (After Marsh.) 207

5. Outer, edge, and inner views of tooth. Natural size. Muirkirk. (2135 U. S. N. M.)
6. Dorsal and left lateral view of dorsal vertebra. × ½. Near Muirkirk. (3101 G. C.)

Fig. 7. GONIOPHOLIS AFFINIS Lull 210

Edge view of tooth. Natural size. Branchville. (8175 W. C. B.)

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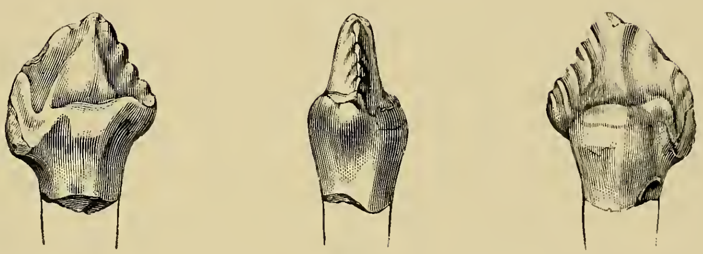

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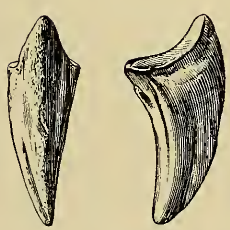

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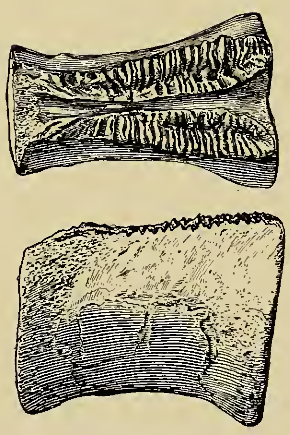

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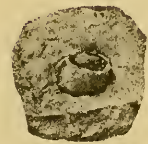
DINOSAURIA.—CROCODILIA.

PLATE XXI.



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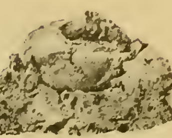

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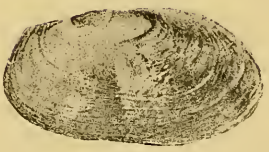

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MOLLUSCA.

COCKAYNE, BOSTON.

PLATE XXII.

1. Type specimen from Fredericksburg, Virginia, showing frond with attached groups of sporangia (nat. size).
2. Cast of cavity occupied by group of sporangia showing faint transverse lines which indicate the compound nature of these objects shown in Fig. 1 (enlarged × 4).
3. A fructification from Fig. 1, showing the continuation of the peduncular vein to the apex, indicating that these objects are not large simple sporangia, but compound (enlarged × 4).
4. Micro-photograph of a spore showing ornamentation and tetrad scar (enlarged × 365).

5-9. Camera lucida drawings of spores in various positions showing ornamentation, tetrad scars and thick walls (enlarged × 380).

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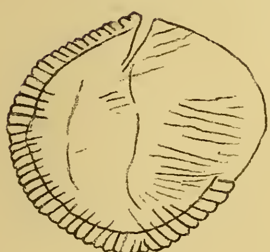

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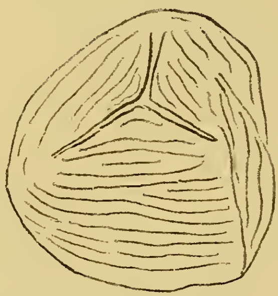

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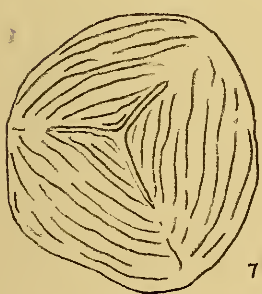

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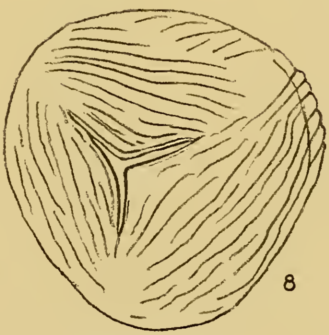

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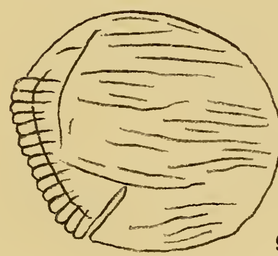

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PTERIDOPHYTA.

Cockayne, Boston.

PLATE XXIII.

PAGE

Figs. 1, 2. Acrostichopteris longipennis Fontaine.................... 223

1. Federal Hill, Maryland (after Fontaine).
2. Hell Hole, Virginia (after Fontaine).

Figs. 3, 4. Ruffordia Gœpperti (Dunker) Seward.................... 231

3. Fredericksburg, Virginia (after Fontaine).
4. Pinna of same. × 3.

Figs. 5, 6. Ruffordia acrodentata (Fontaine) Berry.................. 230

5. Dutch Gap, Virginia (after Fontaine).
6. Pinna of same. × 2.


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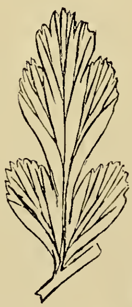
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PTERIDOPHYTA.

PLATE XXIV.

PAGE

Fig. 1. ACROSTICHOPTERIS CYCLOPTEROIDES Fontaine.................... 226
Dutch Gap, Virginia (after Fontaine).

Figs. 2, 3. ACROSTICHOPTERIS ADIANTIFOLIA (Fontaine) Berry........... 224
Fredericksburg, Virginia (after Fontaine).

Figs. 4, 5. ACROSTICHOPTERIS PARVIFOLIA Fontaine..................... 226
Fredericksburg, Virginia (after Fontaine).

Fig. 6. ACROSTICHOPTERIS PLURIPARTITA (Fontaine) Berry.............. 227
Dutch Gap, Virginia.

Fig. 7. ACROSTICHOPTERIS LONGIPENNIS Fontaine....................... 223
Aquia Creek Cut, Virginia.

PTERIDOPHYTA.

PLATE XXV.

PAGE

Figs. 1-9. KNOWLTONELLA MAXONI Berry 235
Fragments of fronds from near Glymont, Maryland.

PTERIDOPHYTA.

PLATE XXVI.

1. Tip of pinna from near Widewater, Virginia.

2-5. Specimens from same locality showing character of pinnules and habit of branching of pinnæ.

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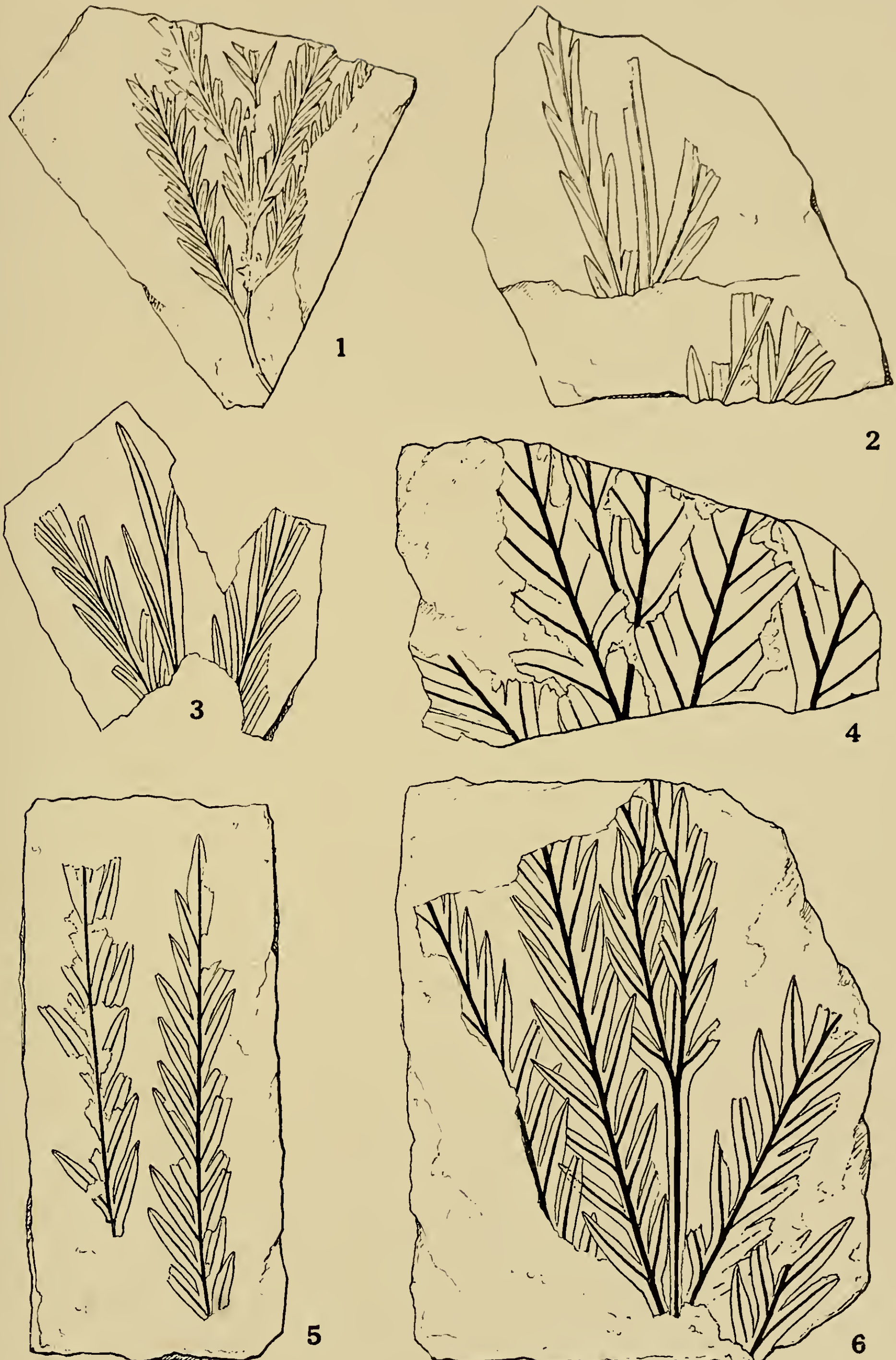
PTERIDOPHYTA.

COCKAYNE, BOSTON.

PLATE XXVII.



PTERIDOPHYTA.

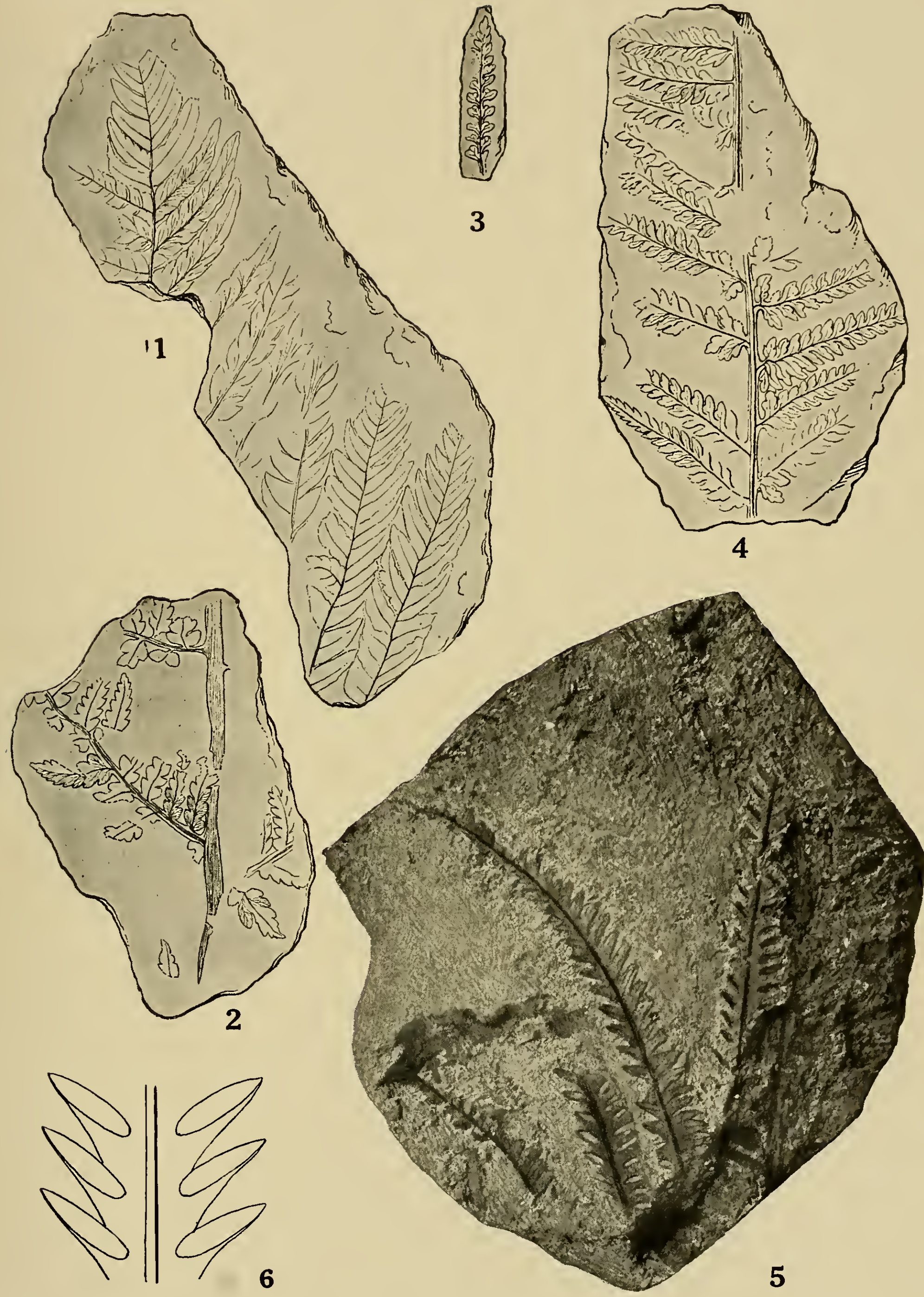
PLATE XXVIII.

PAGE

Figs. 1, 2. Cladophlebis parva Fontaine............................ 250
Specimens from Vinegar Hill, Maryland (after Fontaine).

Figs. 3, 4. Dicksoniopsis vernonensis (Fontaine) Berry............... 237
3. Fruiting specimen. White House Bluff, Virginia (after Fontaine).
4. Arlington, Maryland (after Fontaine).

Figs. 5, 6. Aspleniopteris pinnatifida Fontaine...................... 265
5. Fruiting specimen from Fredericksburg, Virginia.
6. Pinnules of same. $\times$ 4.



PTERIDOPHYTA.

PLATE XXIX.

PAGE

Figs. 1, 2. Cladophlebis Browniana (Dunker) Seward................. 243

1. Sterile frond, Vinegar Hill, Maryland (after Fontaine).
2. Fertile frond, same locality (after Fontaine).

Fig. 3. Cladophlebis constricta Fontaine............................ 246

Specimen from Chinkapin Hollow, Virginia (after Fontaine).

Figs. 4-6. Cladophlebis virginiensis Fontaine........................ 248

Specimens from Arlington, Maryland (after Fontaine).

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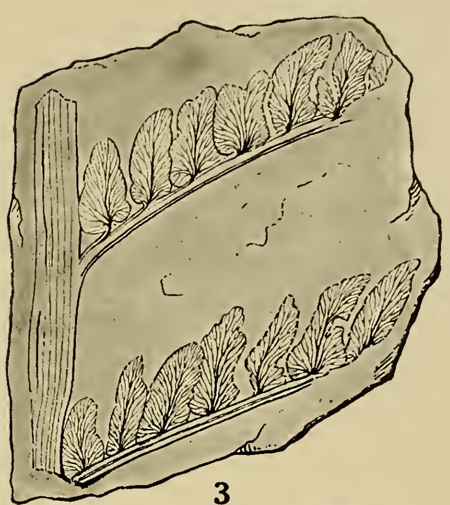

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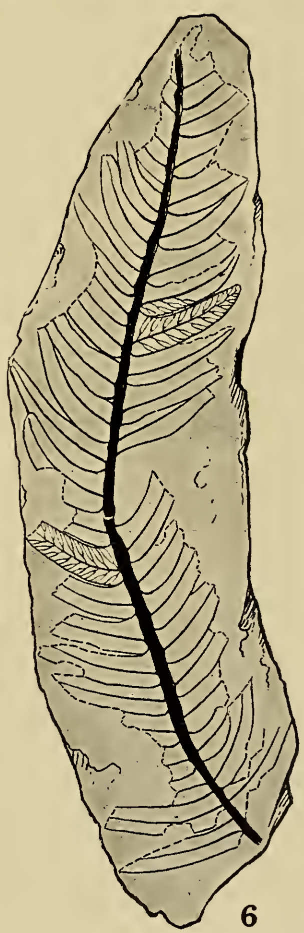

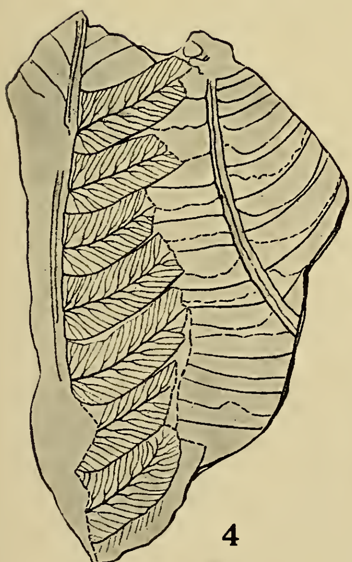

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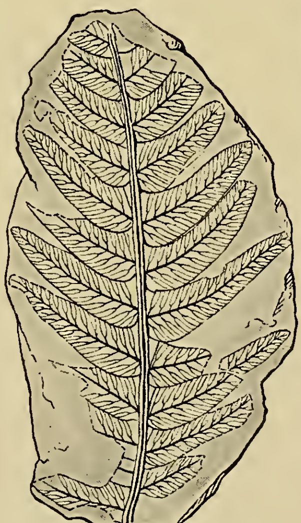

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PTERIDOPHYTA.

PLATE XXX.

PTERIDOPHYTA.

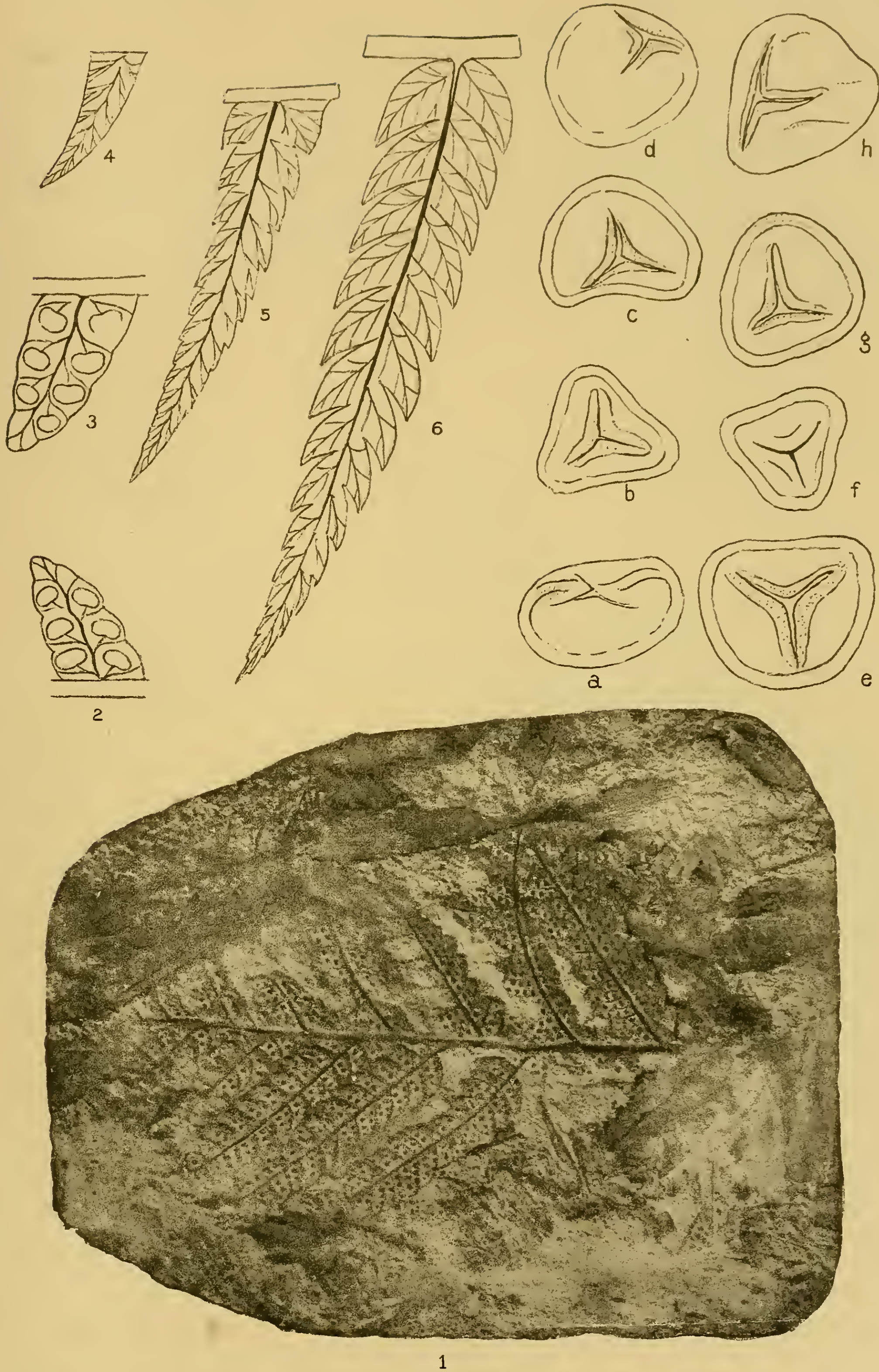
Cockayne, Boston.

PLATE XXXI.

PAGE

Figs. 1-7. CLADOPHLEBIS PARVA Fontaine.............................. 250

1. Fertile frond, Fredericksburg, Virginia.
2, 3. Fertile pinnules from foregoing specimen showing outlines and position of sori. × 4.
4. Ultimate pinnule from specimen shown on Plate XXX. × 4.
5. Pinnule ¼ distance from apex of a lateral pinna of same. × 4.
6. Pinnule from near the base of the same pinna. × 4.
7a-h. Group of spores from specimen shown in Fig. 1. × 350.



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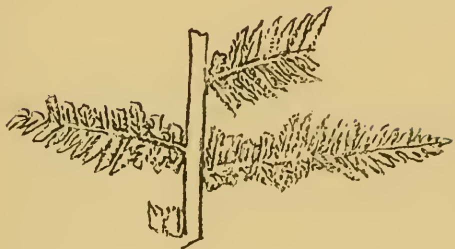
PTERIDOPHYTA.

Cockayne, Boston.

PLATE XXXII.

		PAGE
Figs. 1, 2.	Cladophlebis Ungeri (Dunker) Ward	255
	1. Poorly preserved fertile pinnæ from Dutch Gap, Virginia.	
	2. Portion of a somewhat larger sterile frond from same locality.	
Figs. 3, 4.	Cladophlebis Albertsii (Dunker) Brongniart	252
	3. Portion of frond from Telegraph Station, Virginia.	
	4. Enlarged pinnule of a variant with a dentate margin.	
Figs. 5, 6.	Cladophlebis distans Fontaine	258
	5. Vinegar Hill, Maryland.	
	6. Pinnule of same. × 4.	



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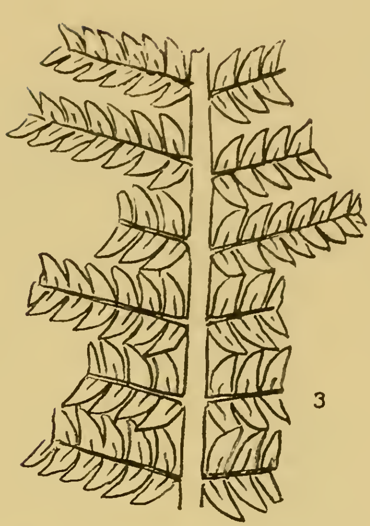

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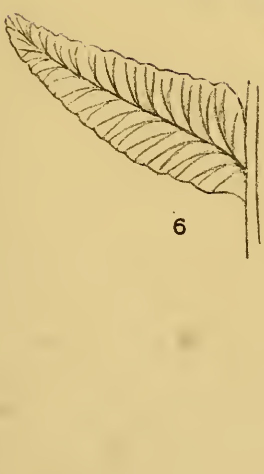

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PTERIDOPHYTA.

COCKAYNE, BOSTON.

PLATE XXXIII.

PAGE

Figs. 1, 2. Onychiopsis latiloba (Fontaine) Berry 273

1. Specimen showing the habit from Bay View, Maryland.
2. Pinnule of same. × 2.

1

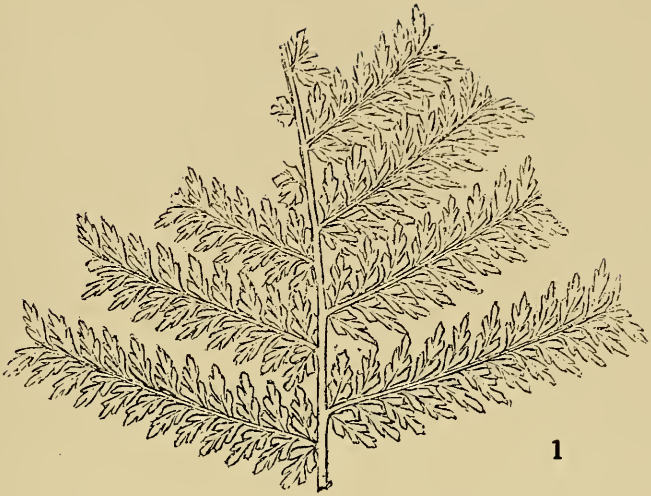
2

PTERIDOPHYTA.

Cockayne, Boston.

PLATE XXXIV.

	PAGE
Figs. 1, 2. Onychiopsis brevifolia (Fontaine) Berry	278
1. Specimen from Dutch Gap, Virginia (after Fontaine).	
2. Terminal pinnules of same. × 3.	
Figs. 3, 4. Onychiopsis Gœpperti (Schenk) Berry	281
3. Specimen from Fredericksburg, Virginia (after Fontaine).	
4. Specimen from Langdon, D. C., showing range in size (after Fontaine).	



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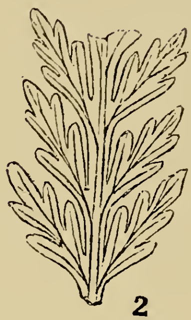

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PTERIDOPHYTA.

PLATE XXXV.

PAGE

Figs. 1-3. Onychiopsis psilotoides (Stokes and Webb) Ward........... 274

1. Hell Hole, Virginia (after Fontaine).

2, 3. New Reservoir, D. C. (after Fontaine).

PTERIDOPHYTA.

PLATE XXXVI.

PTERIDOPHYTA.

PLATE XXXVII.

1. Longitudinal section, natural size.
2. Transverse section from the same specimen showing numerous steles, petioles and rootlets, natural size.

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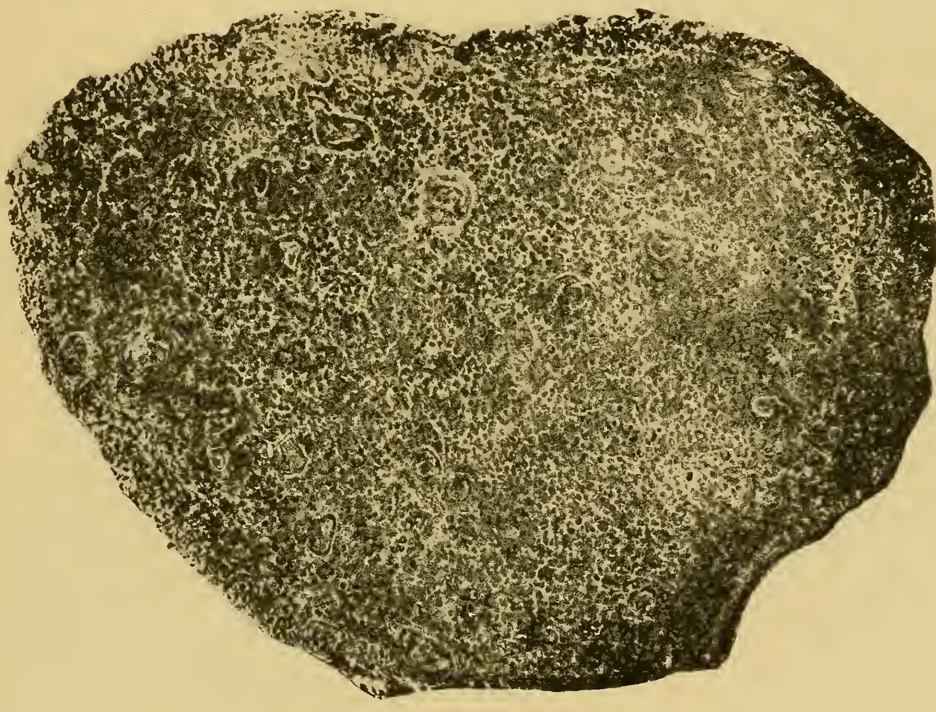

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PTERIDOPHYTA.

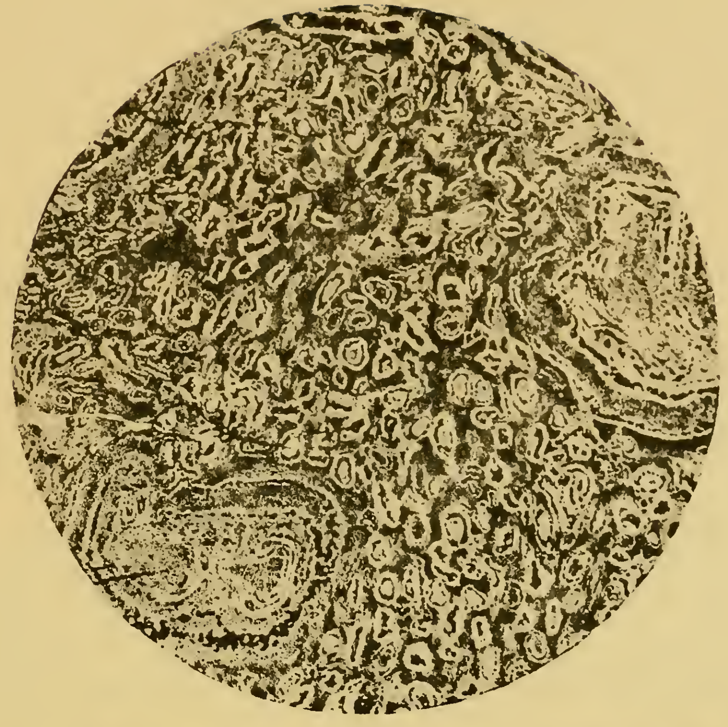
COCKAYNE, BOSTON.

PLATE XXXVIII.

PAGE

Figs. 1, 2. TEMPSKYA WHITEI Berry 298

1. Micro-photograph of a transverse section showing portions of two steles and numerous rootlets, × 5.
2. External appearance of a weathered fragment, natural size.



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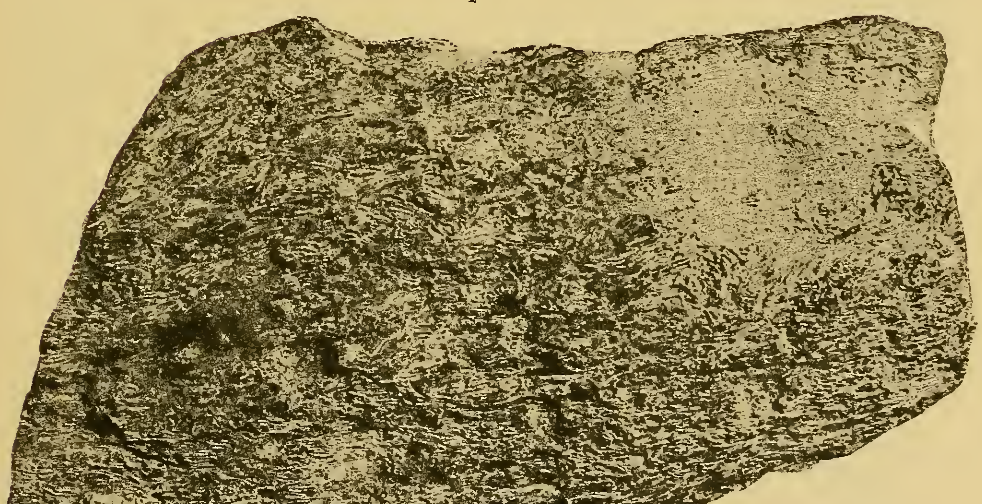

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PTERIDOPHYTA.

Cockayne, Boston.

PLATE XXXIX.

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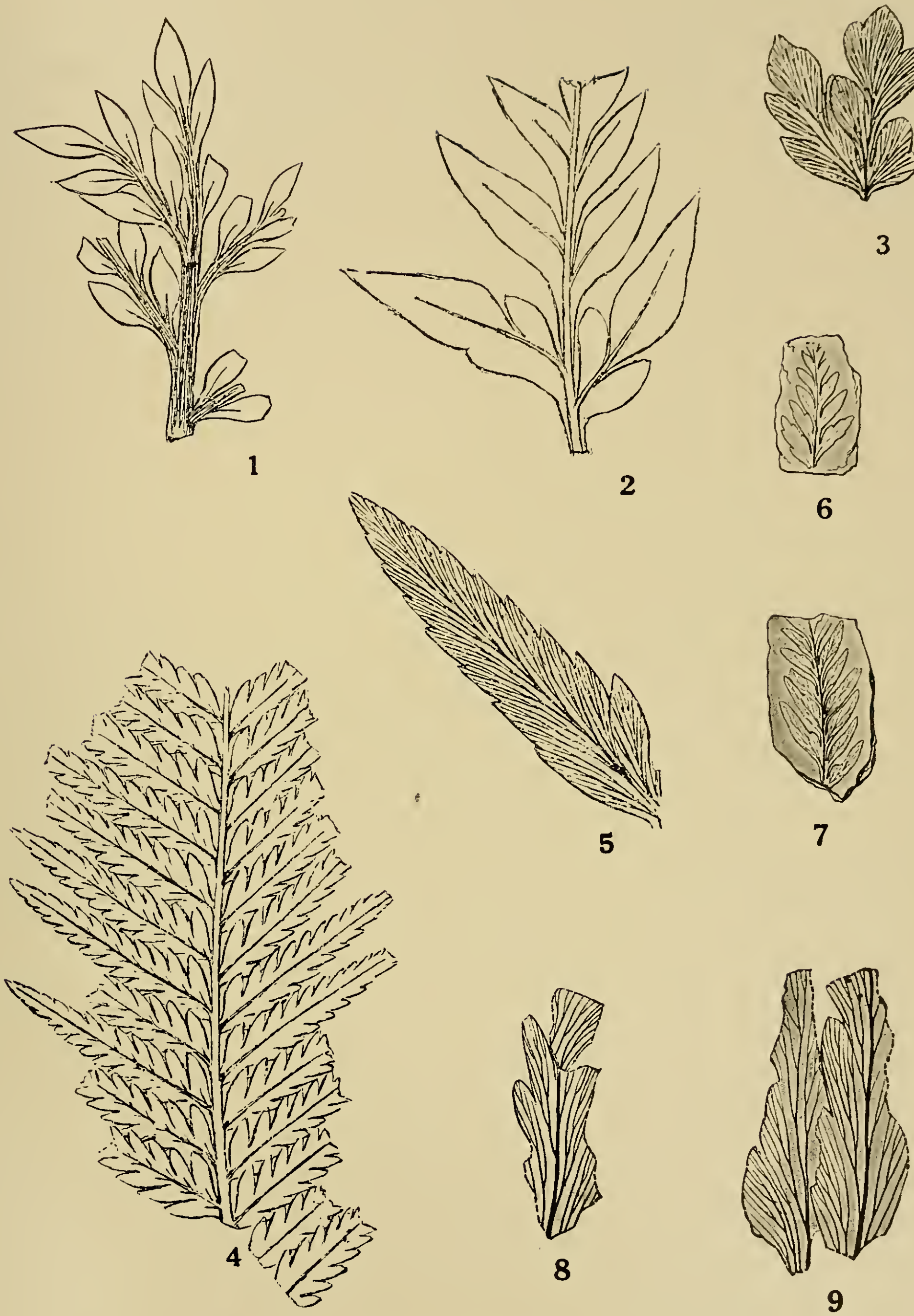
PTERIDOPHYTA.

Cockayne, Boston.

PLATE XL.



PTERIDOPHYTA.

PLATE XLI.

PAGE

Figs. 1, 2. Selaginella marylandica Fontaine........................ 307

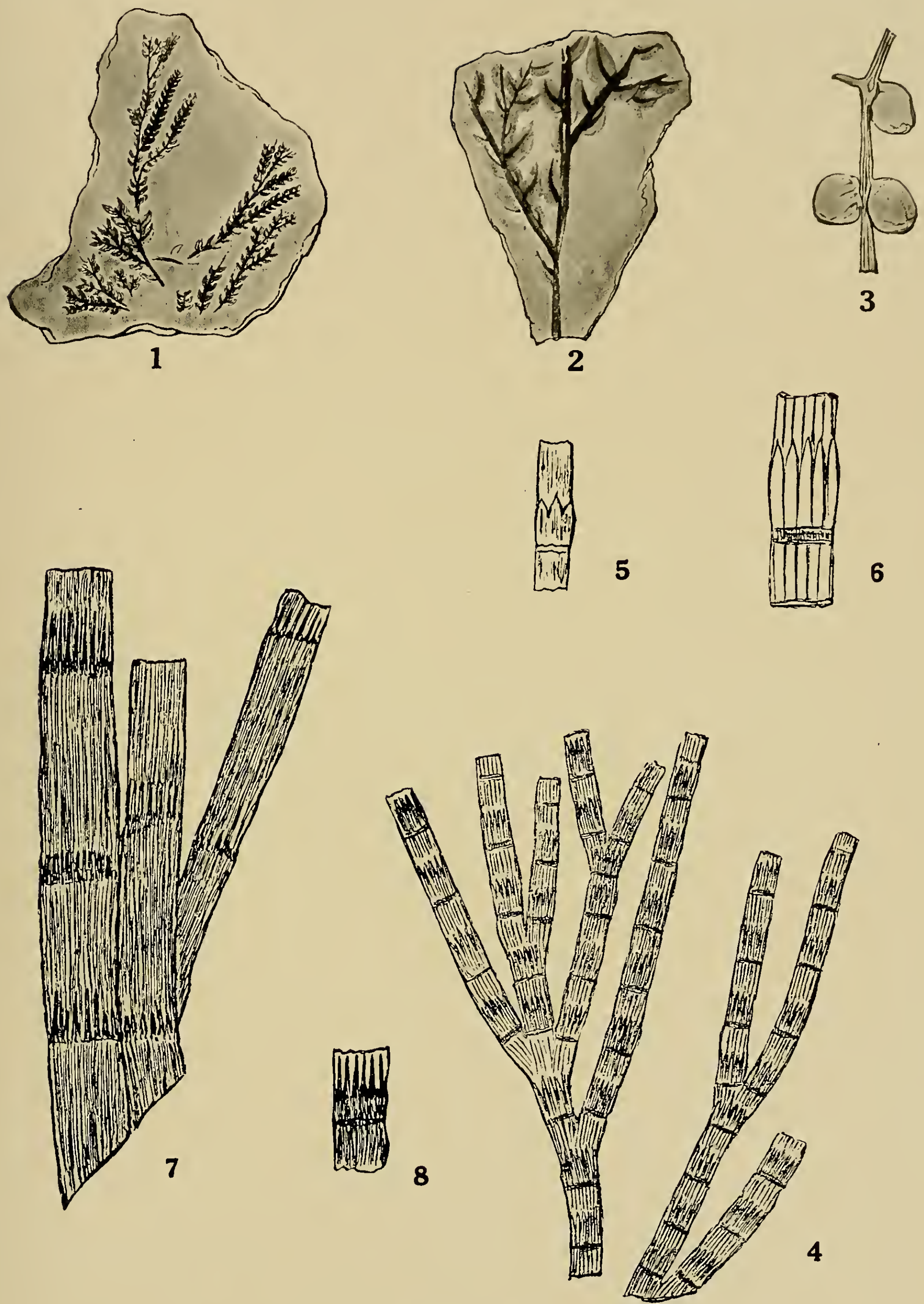
1. Specimen from Vinegar Hill, Maryland (after Fontaine).
2. Part of same. × 3.

Figs. 3-6. Equisetum Burchardti (Dunker) Brongniart................ 310

3. Rhizome with tubers, New Reservoir, D. C. (after Fontaine).
4. Branching specimen, Dutch Gap, Virgina (after Fontaine).
5, 6. Diagrammatical sketch of sheaths of same (after Fontaine).

Figs. 7, 8. Equisetum Lyelli Mantell................................ 311

7. Specimen from Fredericksburg, Virginia (after Fontaine).
8. Same showing sheath (after Fontaine).



PTERIDOPHYTA.

PLATE XLII.

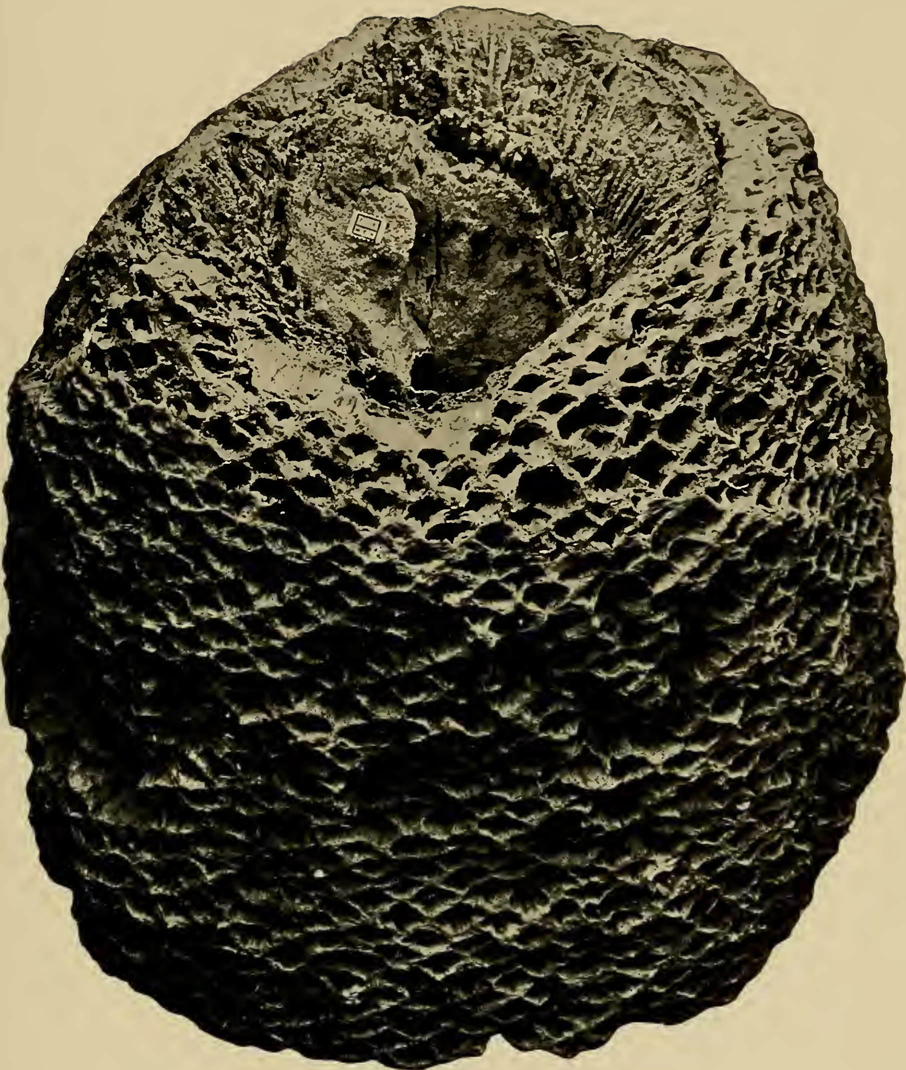
PAGE

Cycadeoidea marylandica (Fontaine) Cap. & Solms 320

View of the historic trunk discovered by Philip Tyson about 1860. The probable locality at Spring Gardens, Baltimore County, is shown on Plate IV, Fig. 2.

CYCADOPHYTÆ.

PLATE XLIII.



CENTIMETERS

CYCADOPHYTÆ.

PLATE XLIV.

	PAGE
Cycadeoidea McGeeana Ward..	323

View from the base, Nos. 1659, 1659a Goucher College (after Ward).

CYCADOPHYTÆ.

PLATE XLV.

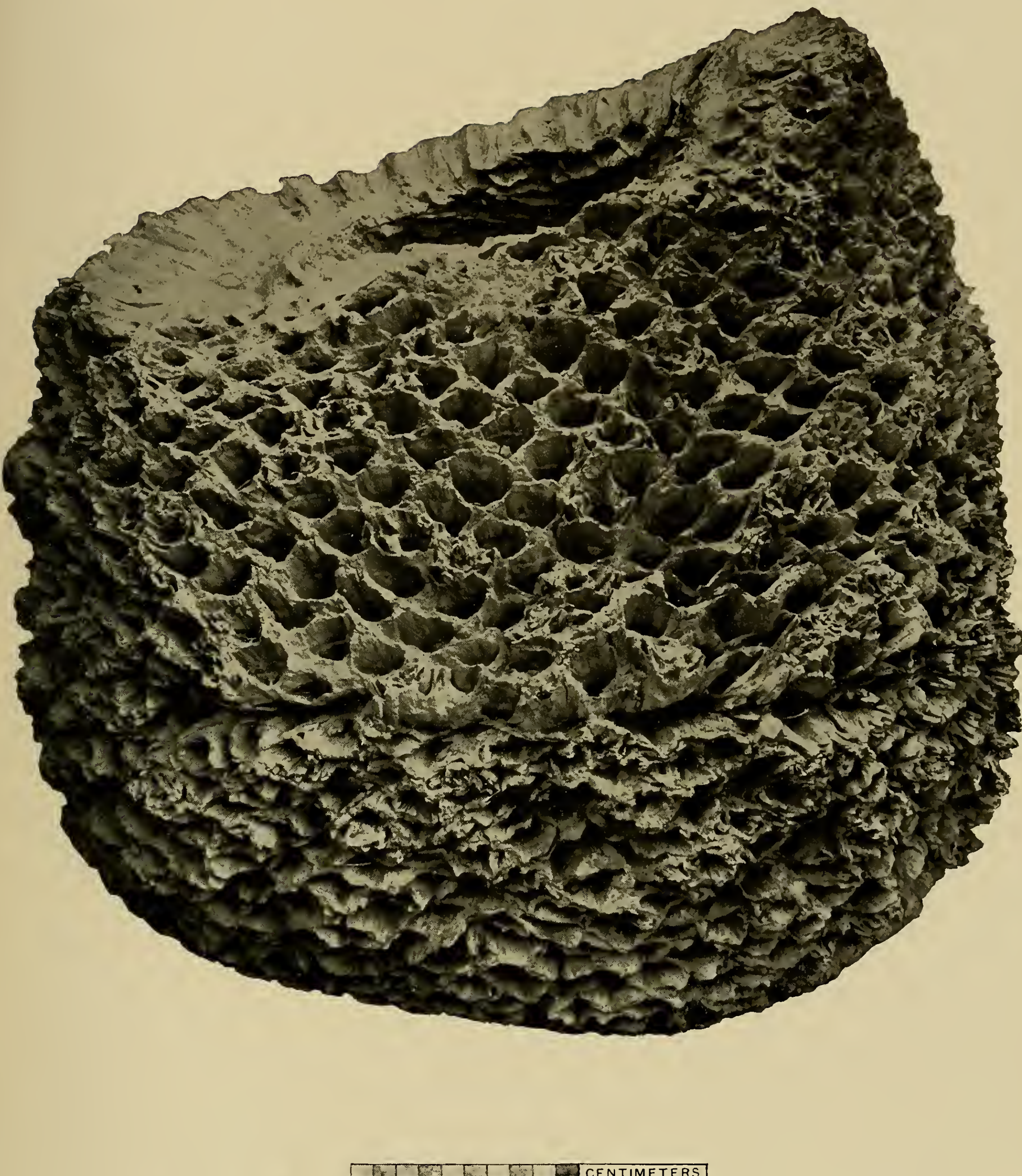
View of a longitudinal section showing the internal structure and terminal bud, No. 1467 Goucher College (after Ward).

CYCADOPHYTÆ.

PLATE XLVI.

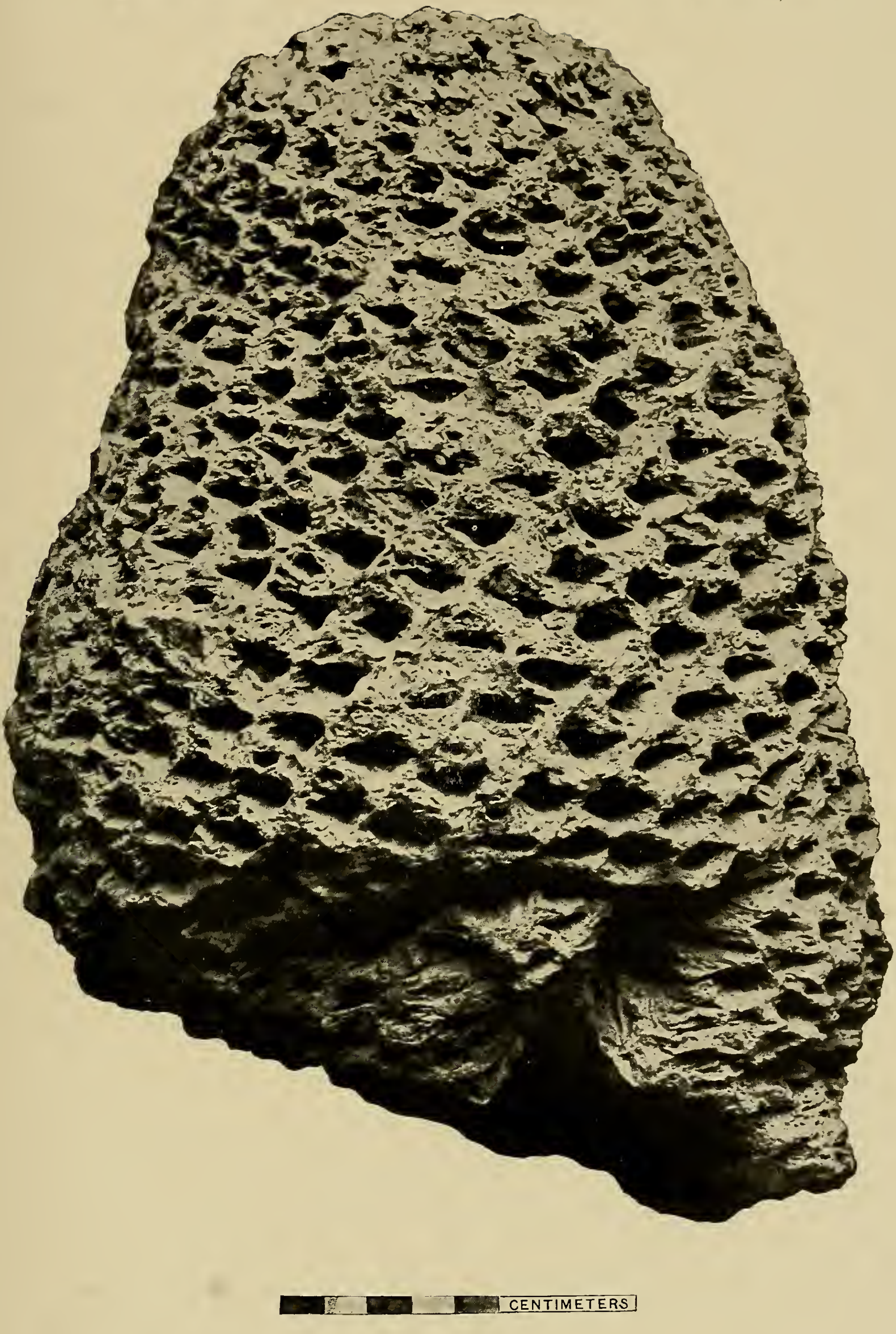
	PAGE
Cycadeoidea Goucheriana Ward	325

View of the type specimen, No. 1479 Goucher College (after Ward).



CYCADOPHYTÆ.

PLATE XLVII.

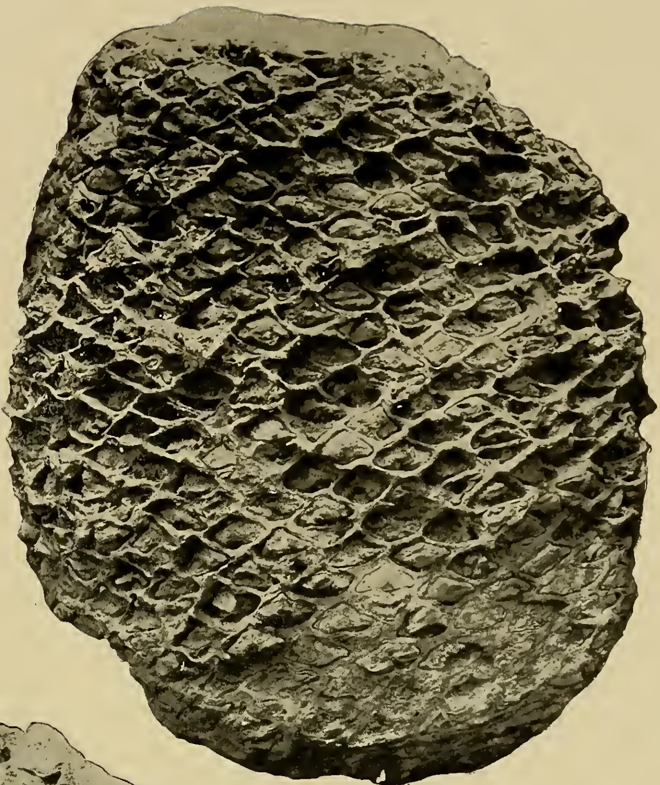


CYCADOPHYTÆ.

PLATE XLVIII.

	PAGE
Figs. 1, 2. CYCADEOIDEA BIBBINSI Ward	327

1. No. 1462 Goucher College (after Ward).
2. No. 1465 Goucher College (after Ward).



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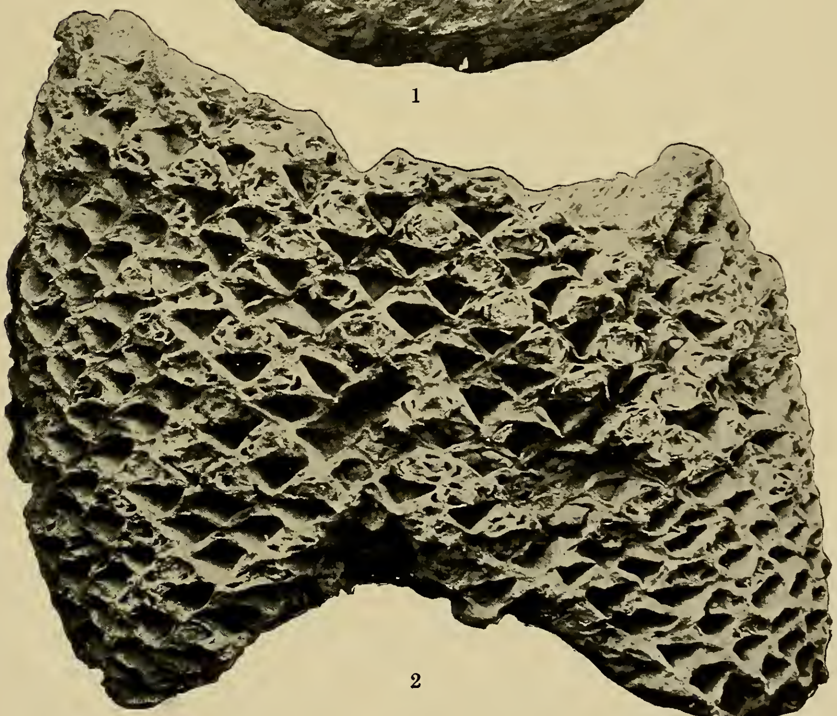

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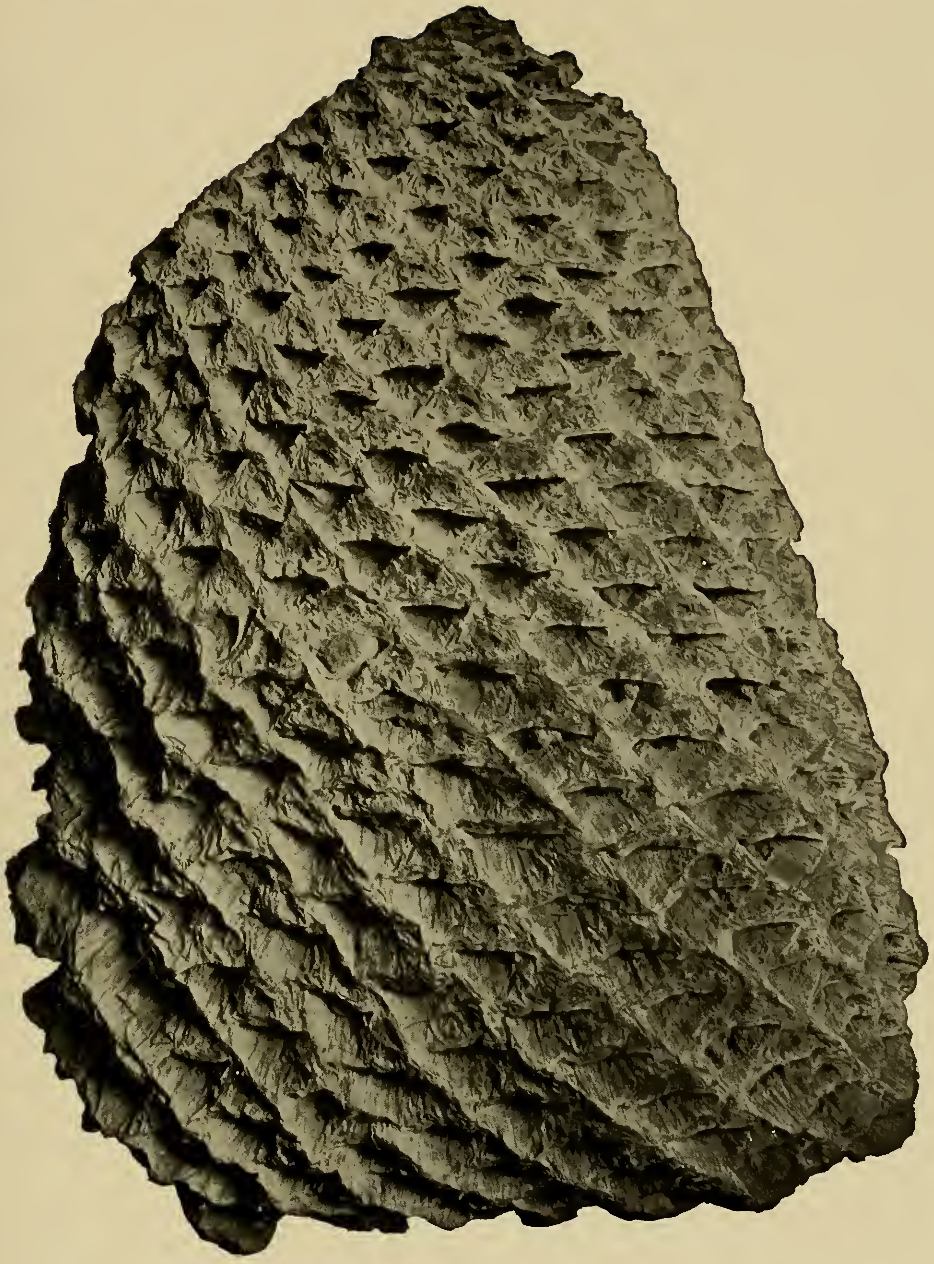
CYCADOPHYTÆ.

PLATE XLIX.

CENTIMETERS

CYCADOPHYTÆ.

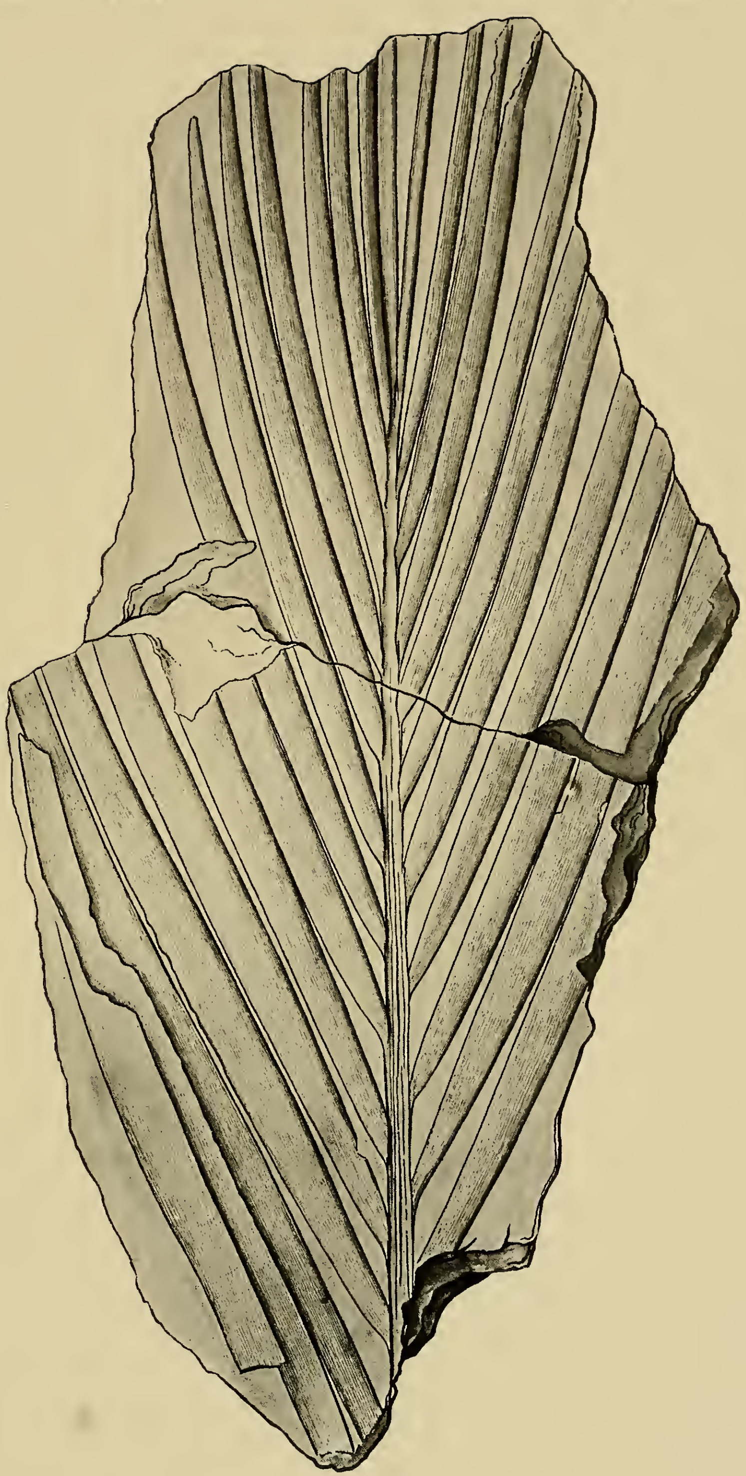
PLATE L.



CENTIMETERS

CYCADOPHYTÆ.

PLATE LI.

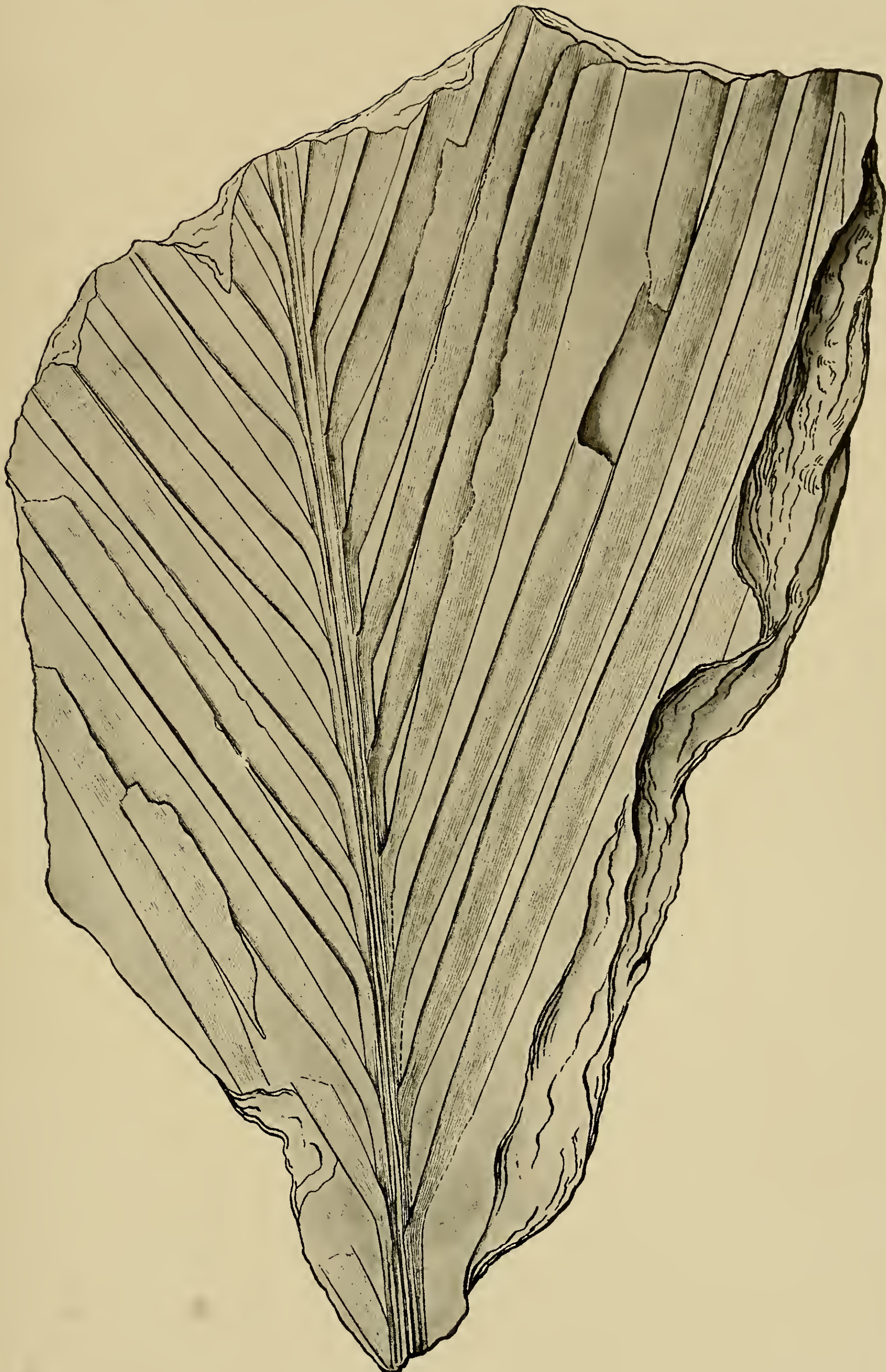


CYCADOPHYTÆ.

PLATE LII.

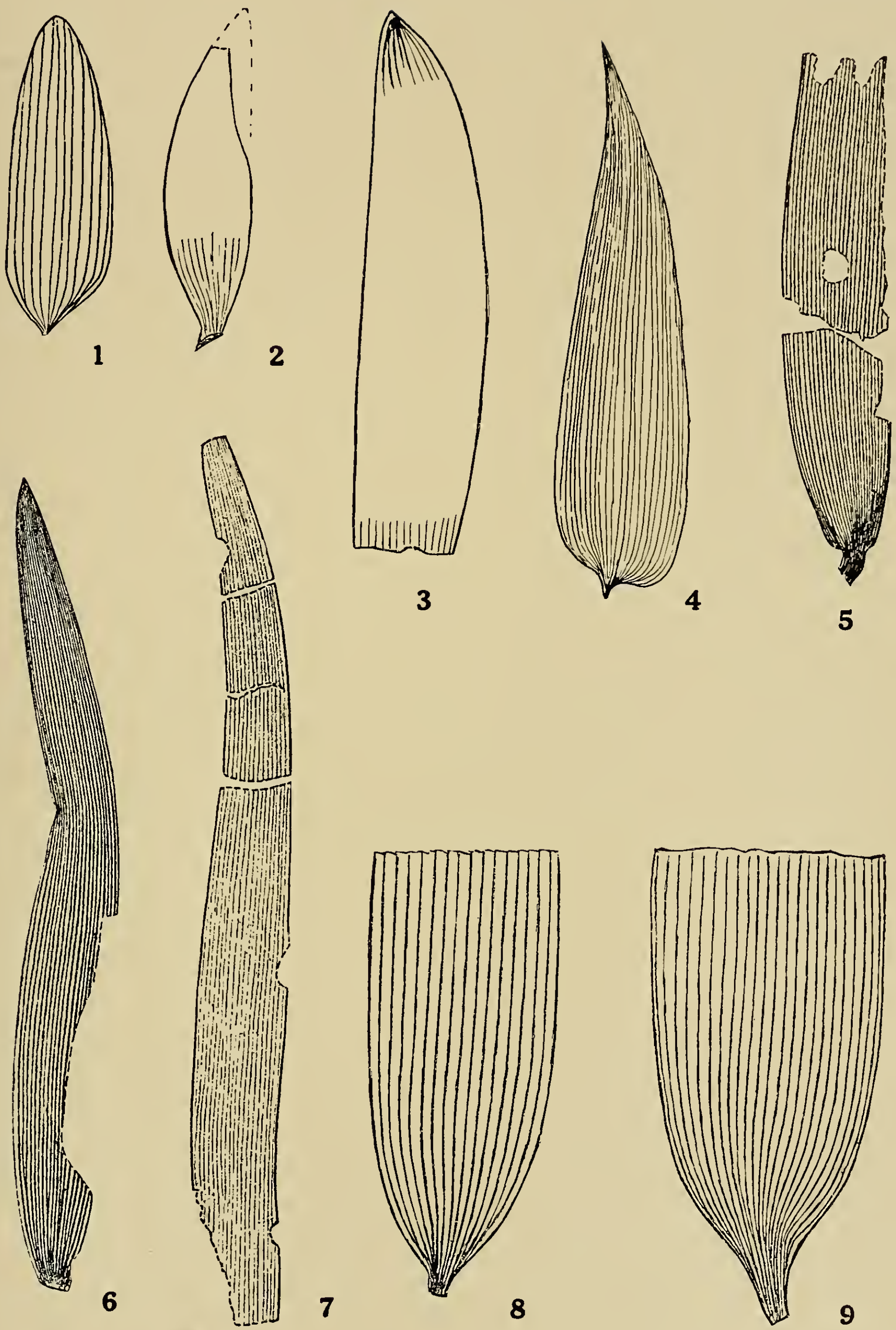
PAGE

Medial portion of a large frond of *Dioonites Buchianus* (Ettings.) Born., from Dutch Gap, Virginia (after Fontaine) 332



CYCADOPHYTÆ.

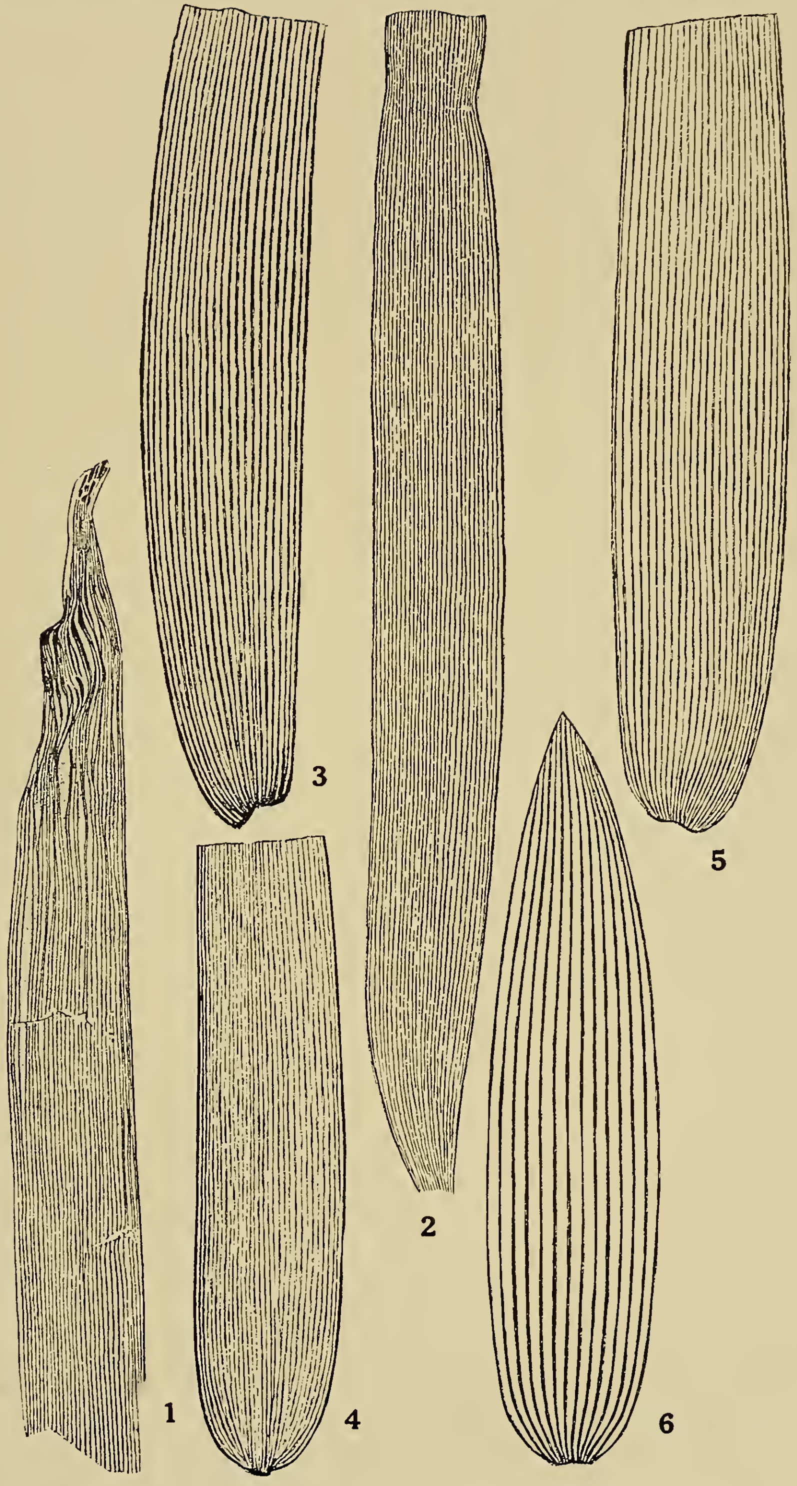
PLATE LIII.



CYCADOPHYTÆ.

PLATE LIV.

	PAGE
Figs. 1-5. ZAMITES TENUINERVIS Fontaine	345
1, 2. Mt. Vernon, Virginia (after Ward).	
3-5. Fredericksburg, Virginia (after Fontaine).	
Fig. 6. ZAMITES CRASSINERVIS Fontaine	347
Fredericksburg, Virginia (after Fontaine).	



CYCADOPHYTÆ.

PLATE LV.

PAGE

Figs. 1, 2. Ctenopsis latifolia (Fontaine) Berry...................... 349
Views from photographs of the type specimens from Fredericksburg, Virginia.

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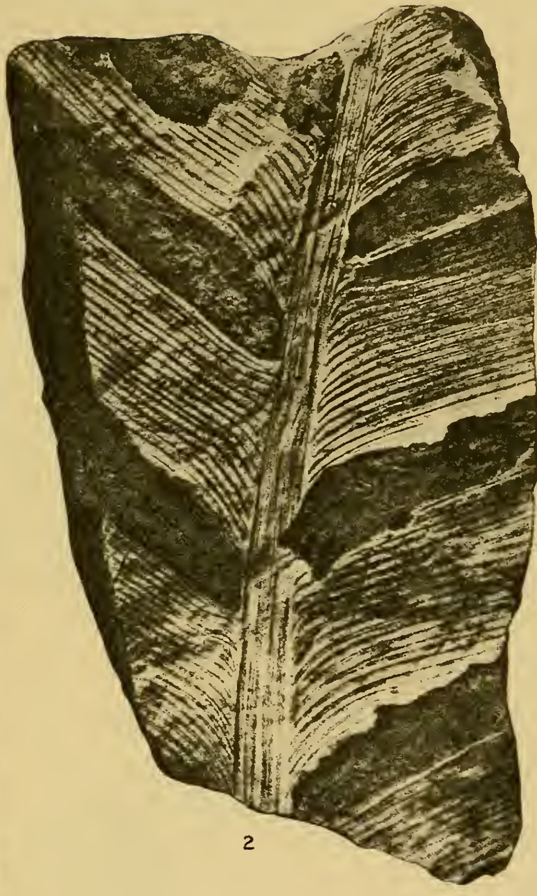

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CYCADOPHYTÆ.

Cockayne, Boston.

PLATE LVI.

	PAGE
Figs. 1, 2. ZAMIOPSIS DENTATA (Fontaine) Berry	355

1. Fredericksburg, Virginia.
2. Pinnule of same. Natural size.

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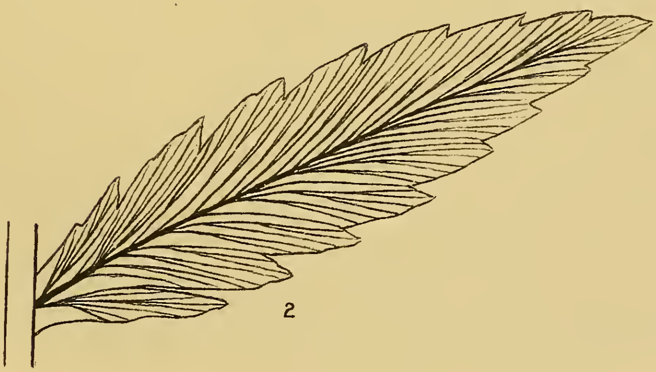

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CYCADOPHYTÆ.

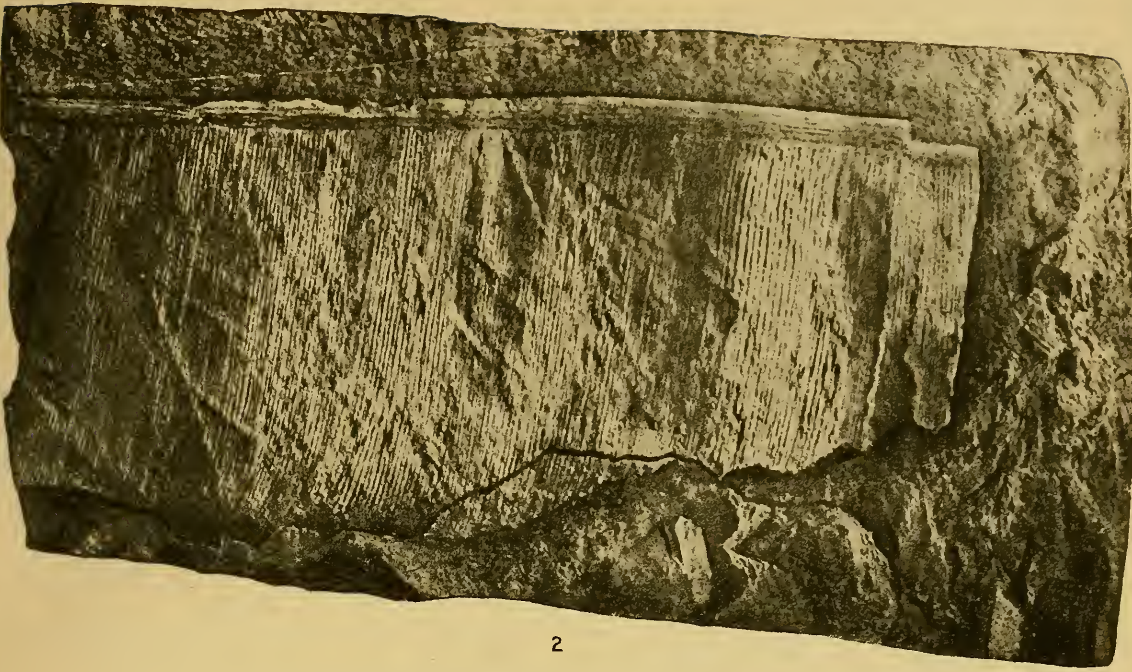
Cockayne, Boston.

PLATE LVII.

PAGE

Figs. 1, 2. NILSONIA DENSINERVE (Fontaine) Berry 362

1. Upper surface of large divided frond from Fredericksburg, Virginia.
2. Upper surface of entire frond from Fredericksburg, Virginia.



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CYCADOPHYTÆ.

Cockayne, Boston.

PLATE LVIII.

CYCADOPHYTÆ.

Cockayne, Boston.

PLATE LIX.

PAGE

Figs. 1-4. Baiera foliosa Fontaine 372

1. Specimen showing leafy shoot from Dutch Gap, Virginia.

2-4. Specimens of broken leaves from foregoing. × 5.

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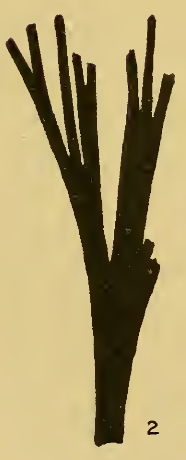

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GYMNOSPERMÆ.

Cockayne, Boston.

PLATE LX.

1 2

GYMNOSPERMÆ.

COCKAYNE, BOSTON.

PLATE LXI.

GYMNOSPERMÆ.

Cockayne, Boston.

PLATE LXII.

1

2

GYMNOSPERMÆ.

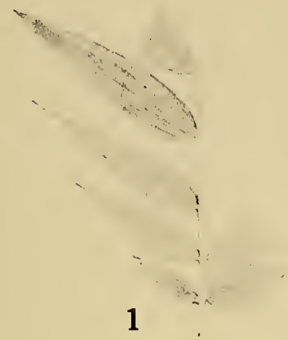
Cockayne, Boston.

PLATE LXIII.

PAGE

Figs. 1, 2. NAGEIOPSIS ZAMIOIDES Fontaine.............................. 386
Fredericksburg, Virginia.

Figs. 3, 4. NAGEIOPSIS ANGUSTIFOLIA Fontaine.......................... 389
Baltimore, Maryland (after Fontaine).



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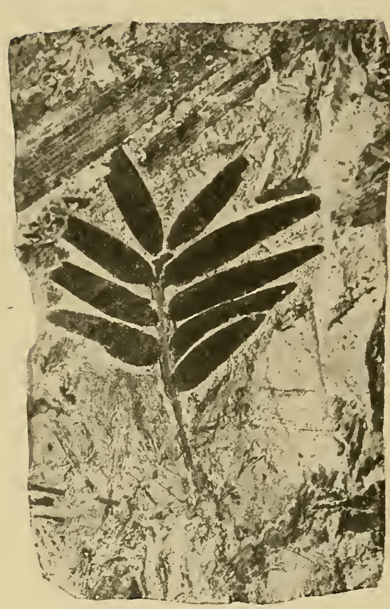

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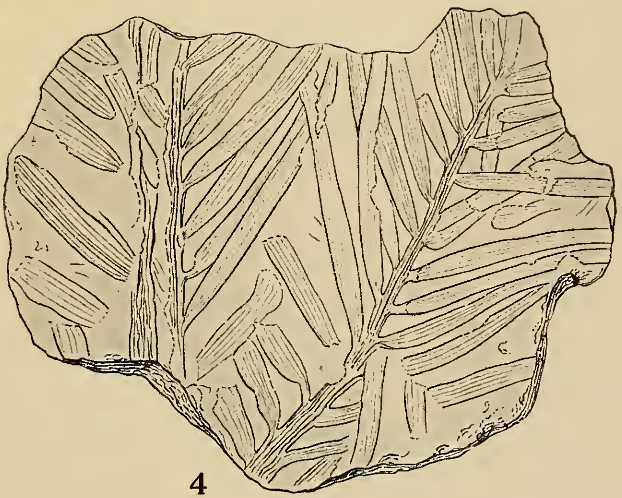

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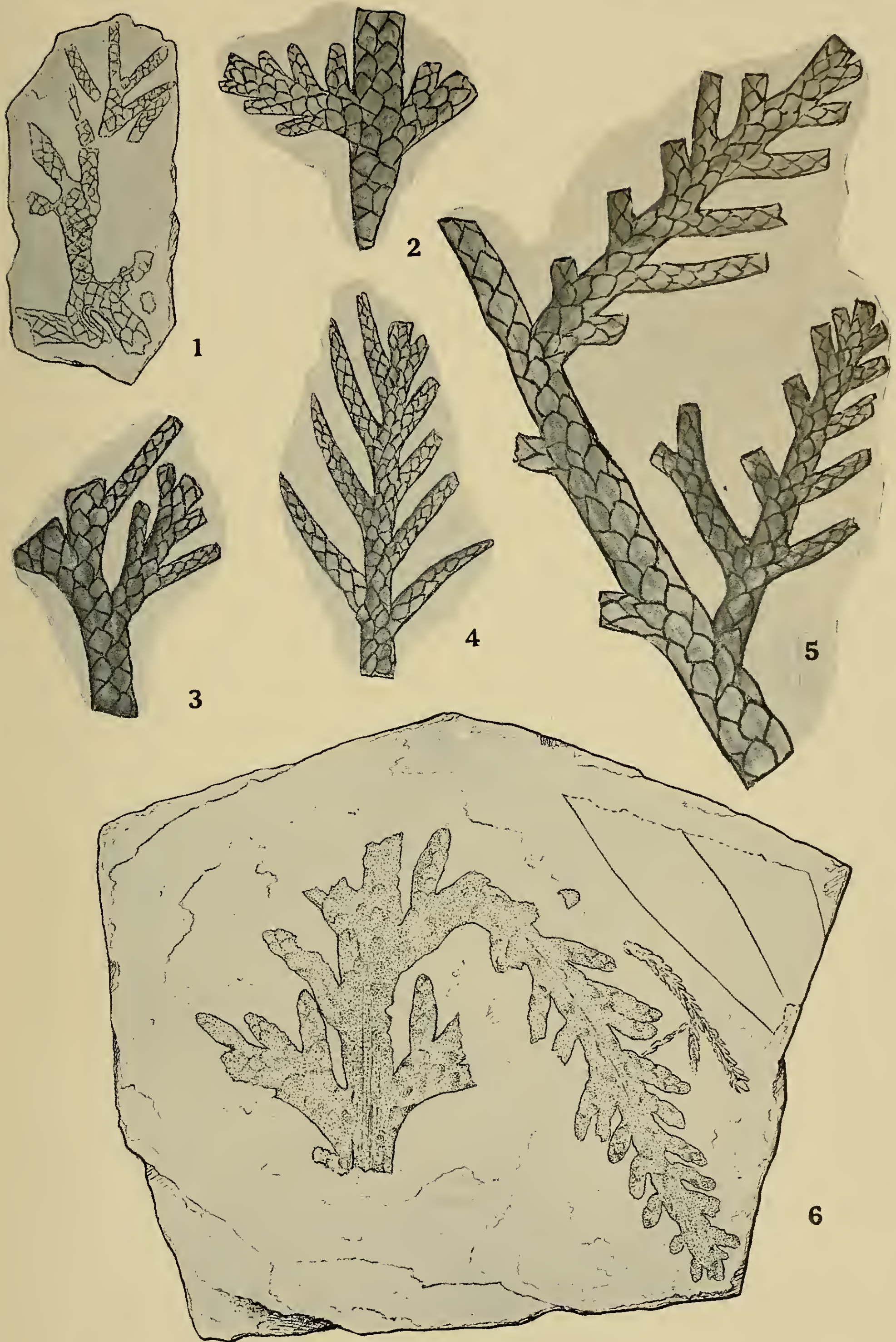
GYMNOSPERMÆ.

PLATE LXIV.

	PAGE
Figs. 1-6. BRACHYPHYLLUM CRASSICAULE Fontaine	393

1. Ft. Foote, Maryland (after Fontaine).
2-5. 72-Mile post, Virginia (after Fontaine).
6. Near Glymont, Maryland.



GYMNOSPERMÆ.

PLATE LXV.

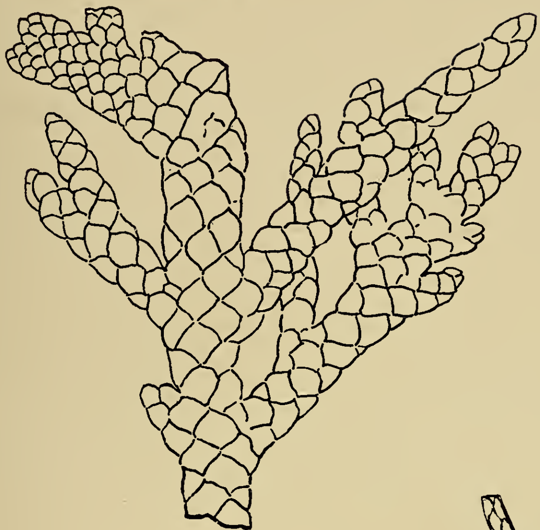
PAGE

Fig. 1. Brachyphyllum macrocarpum Newberry 394
From Raritan formation at South Amboy, New Jersey (after Hollick and Jeffrey).

Fig. 2. Brachyphyllum mamillare, Brongniart 394
A specimen of this species which is the type of the genus, from the Jurassic of France (after Saporta).

Fig. 3. Brachyphyllum obesum Heer 394
From the Aptian of Portugal (after Saporta).

Figs. 4, 5. Brachyphyllum parceramosum Fontaine 395
4. Telegraph Station, Virginia (after Fontaine).
5. From the Trinity of Texas (after Fontaine).



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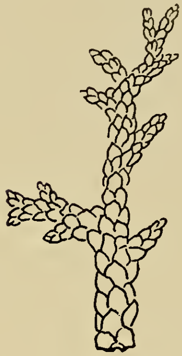

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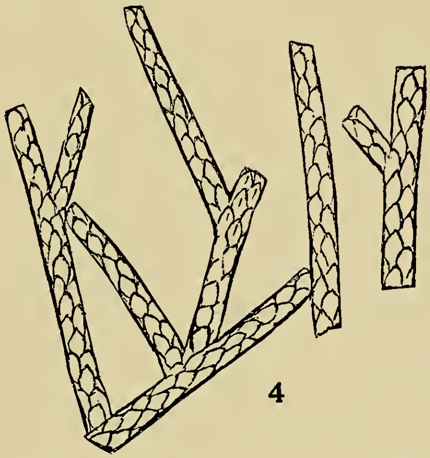

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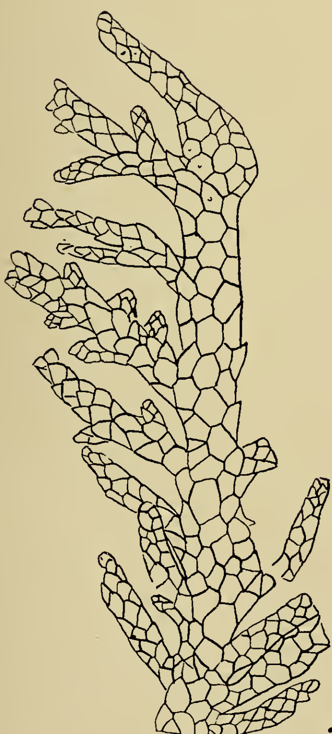

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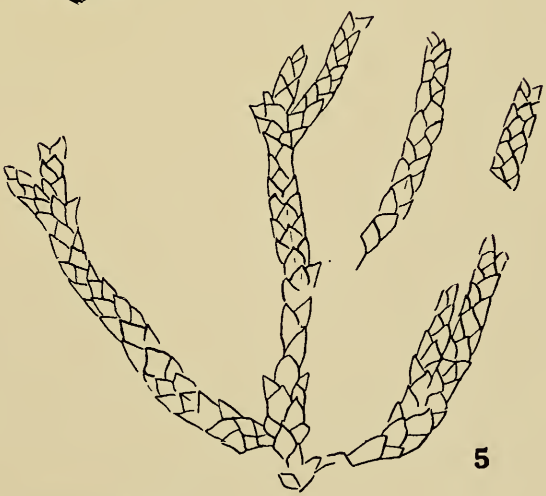

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PLATE LXVI.

1, 1a, 1b. Seeds from Mt. Vernon, Virginia (after Fontaine).

2, 2a, 2b. Seeds from Ft. Foote, Maryland (after Fontaine).

3. Cone-scale from near Widewater, Virginia, viewed from dorsal side.

3a. Same viewed laterally.

4-7. Cones from near Widewater, Virginia.

GYMNOSPERMÆ.

Cockayne, Boston.

PLATE LXVII.

PAGE

Figs. 1-4. ABIETITES MACROCARPUS Fontaine........................... 405

1-3. Vinegar Hill, Maryland (after Fontaine).

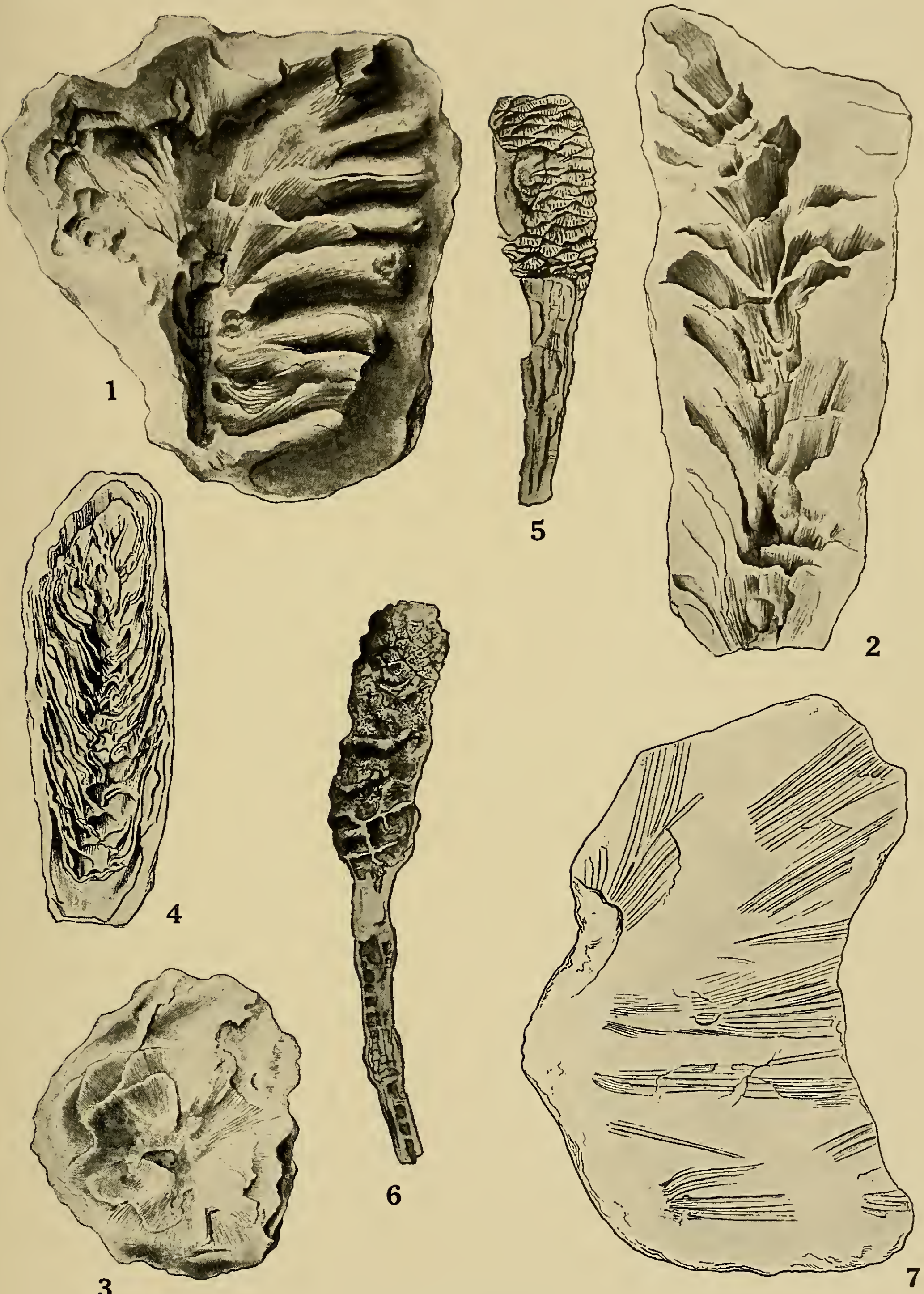
4. Lansdowne, Maryland (after Fontaine).

Figs. 5, 6. ABIETITES MARYLANDICUS Fontaine.......................... 406

Vinegar Hill, Maryland (after Fontaine).

Fig. 7. ABIETITES LONGIFOLIUS (Fontaine) Berry...................... 407

Federal Hill, Maryland (after Fontaine).



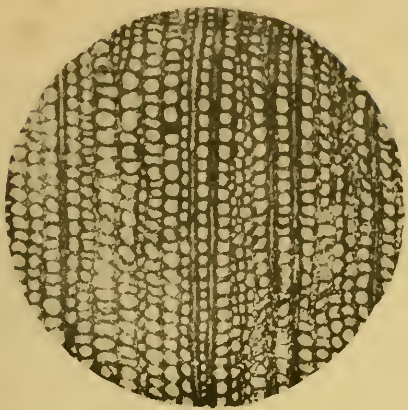
GYMNOSPERMÆ.

PLATE LXVIII.

PAGE

Figs. 1-6. Cupressinoxylon Wardi Knowlton, Clifton (Baltimore)...... 415

1. Transverse section. × 50.
2. The same. × 200.
3. Tangential section. × 50.
4. The same. × 200.
5. Radial section. × 50.
6. The same. × 200.



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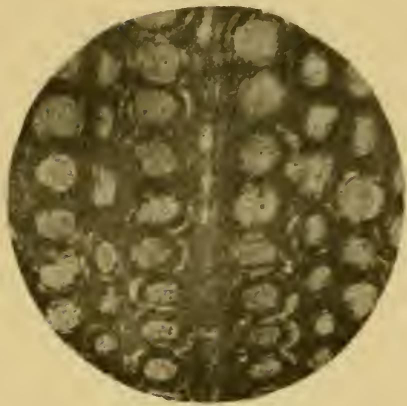

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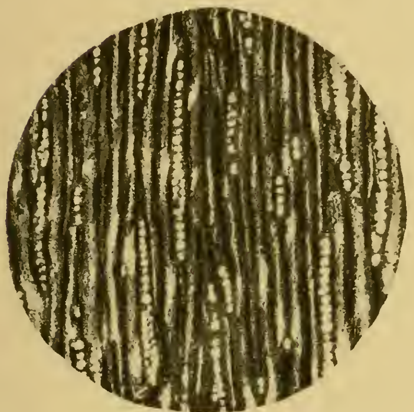

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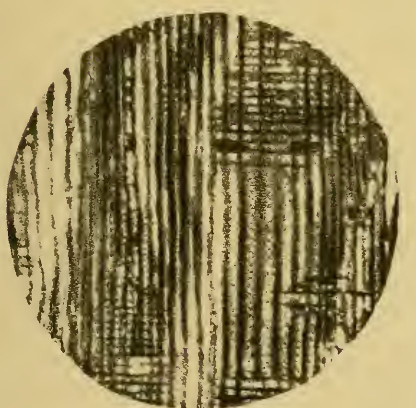

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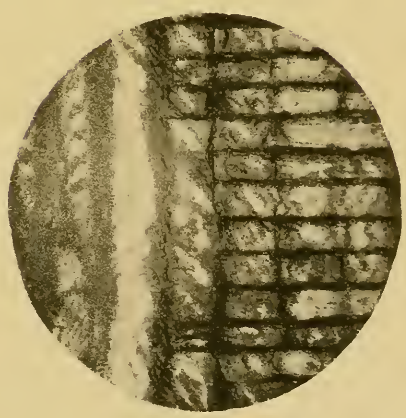

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GYMNOSPERMÆ.

COCKAYNE, BOSTON.

PLATE LXIX.

1. Transverse section showing annual ring. *a*, cells of fall wood; *b*, typical cell of spring wood; *c*, large intercellular space; *d*, smaller intercellular spaces. × 67.
2. Tangential section. *a*, resin-duct; *b*, bordered pits on tangential walls; *c*, sections of pits of radial walls. × 67.
3. Radial section. *a*, point at which the structure has disappeared; *b*, medullary rays, mostly showing oblong pores. × 67.
4. Radial section. Same section as Fig. 3. × 242. *a*, pits on walls of medullary rays; *b*, pits on walls of tracheids.
5. Transverse section further enlarged. *a*, medullary ray; *b*, cells of spring wood; *c*, section of pits on radial walls; *d*, section of pits on tangential wall. × 242.
6. Tangential section. *a*, resin-duct; *b*, bordered pits on tracheids; *c*, bordered pits on resin-duct connected by spiral lines.

7. Radial section. *a*, medullary rays; *b*, single row of pits on tracheids. × 67.
8. Tangential section. *a*, resin-duct; *b*, medullary two cells broad. × 67.

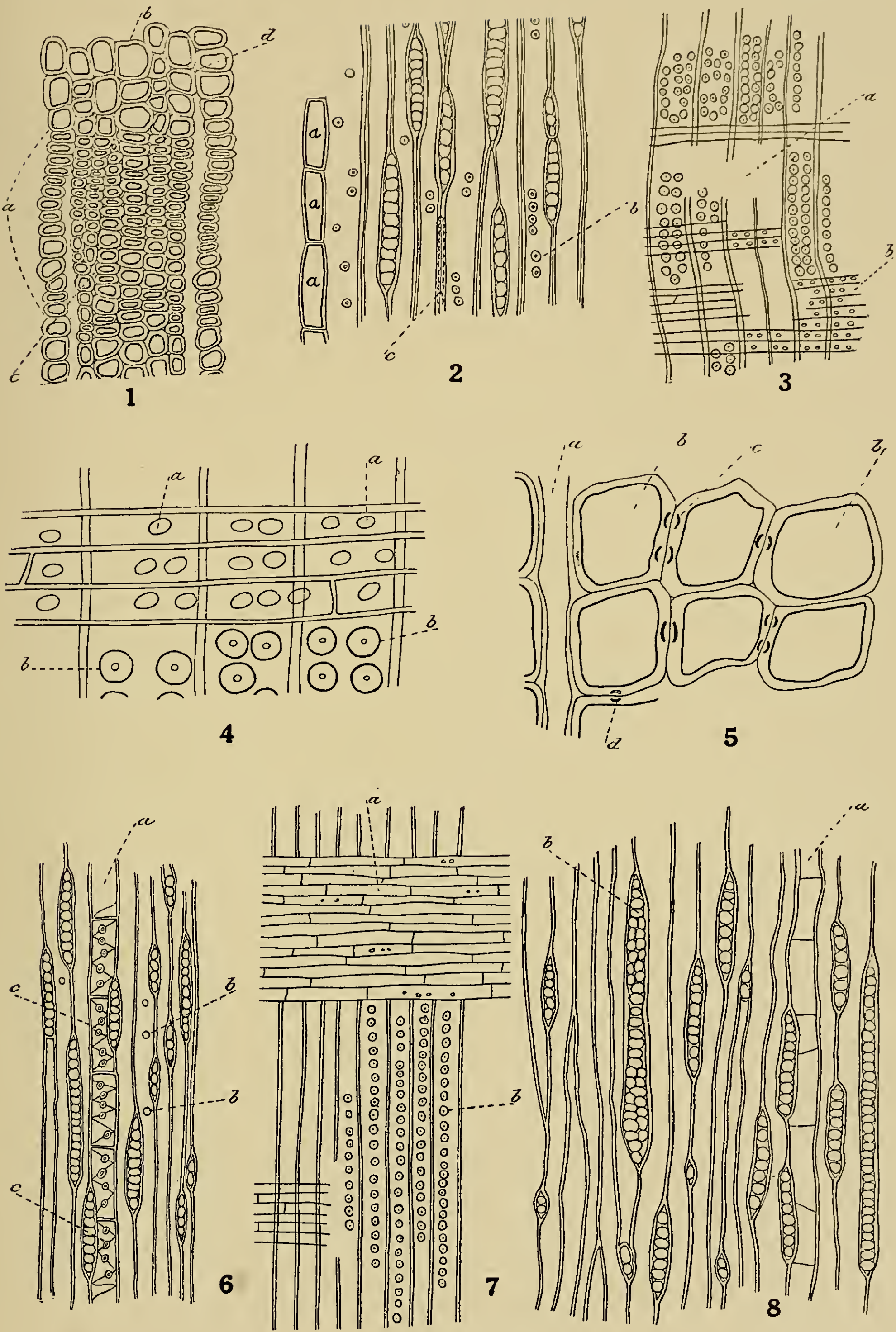

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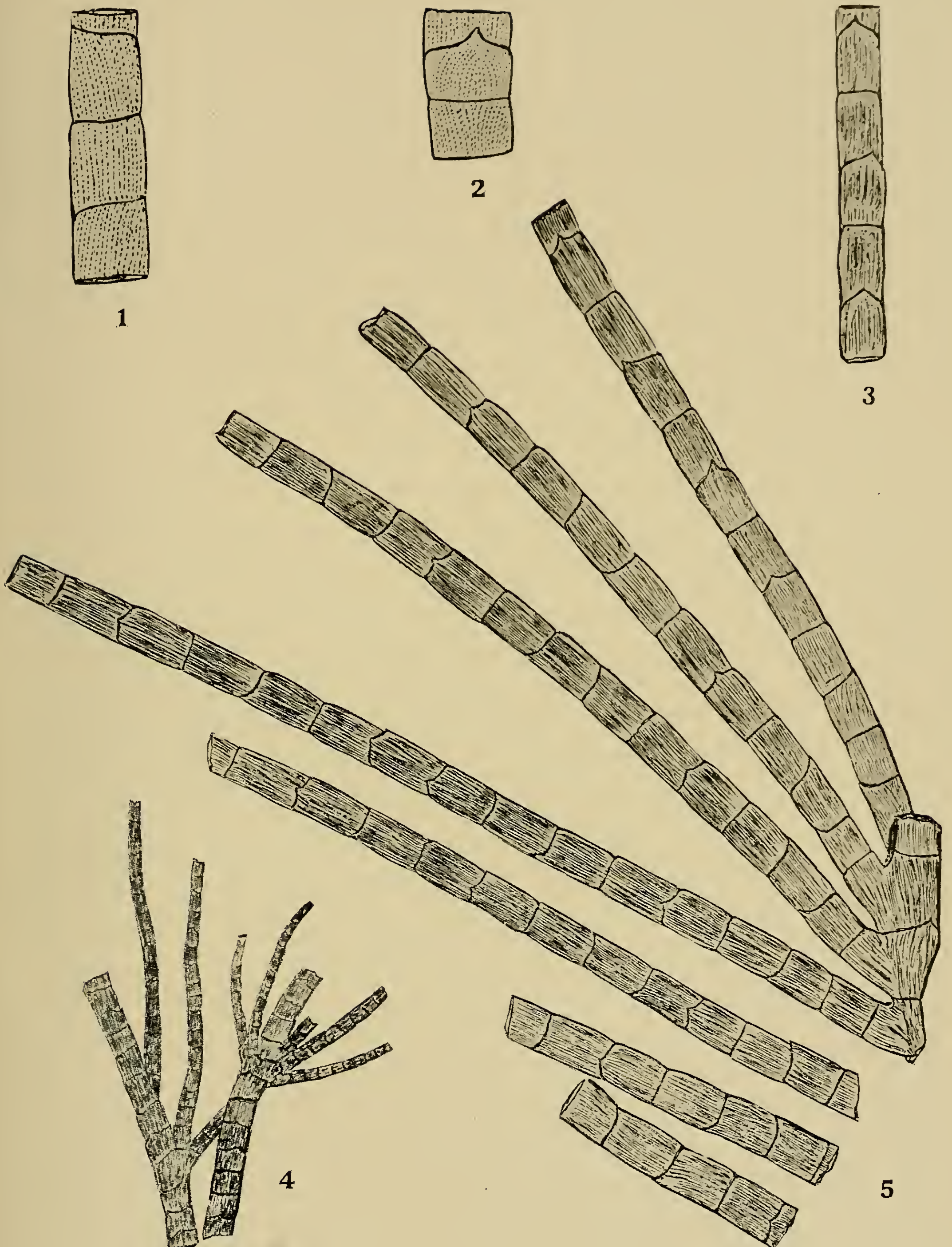
PLATE LXX.



GYMNOSPERMÆ.

PLATE LXXI.

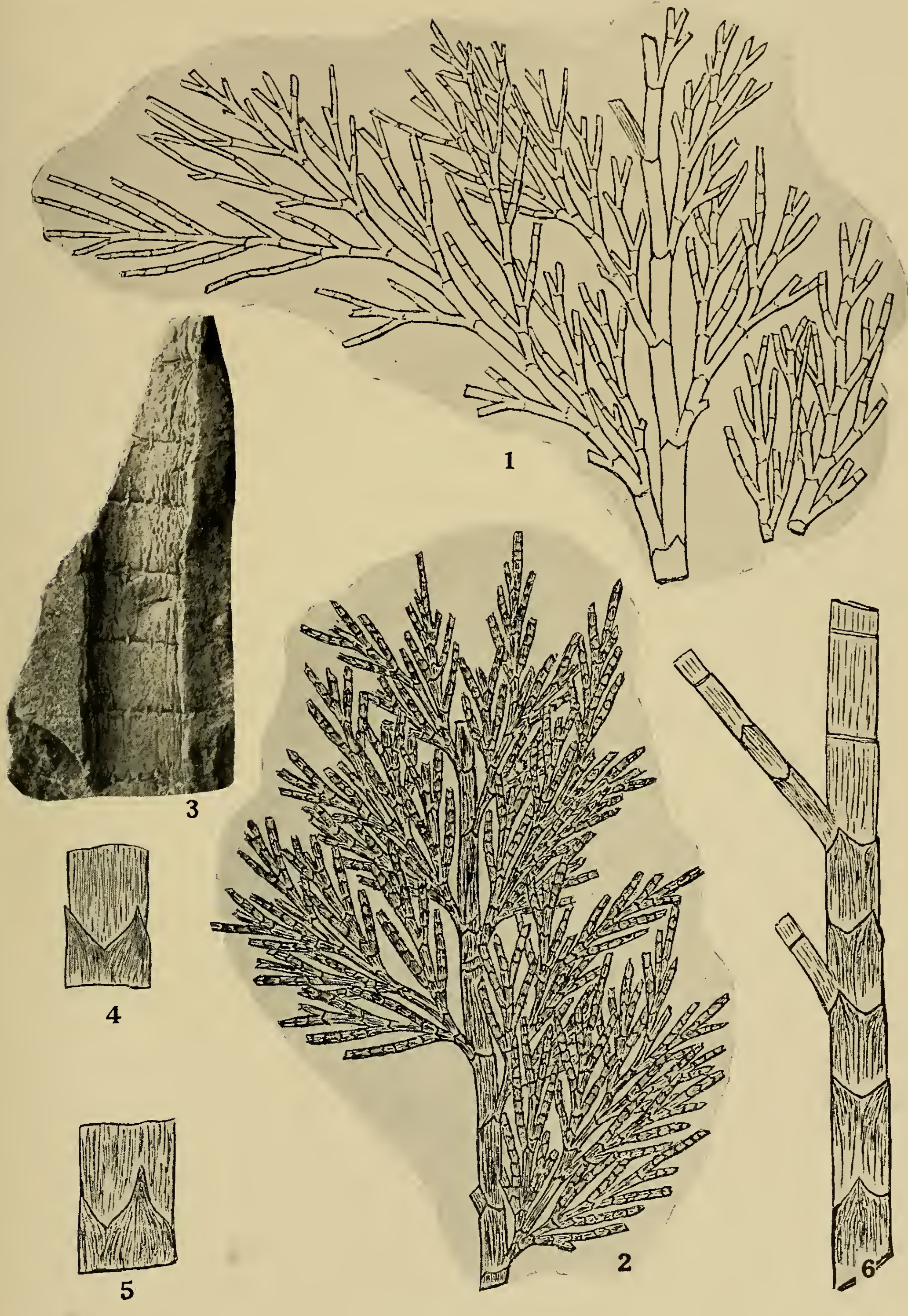
PAGE

Figs. 1-6. Frenelopsis ramosissima Fontaine.......................... 422

1, 2. Jointed twigs from Fredericksburg, Virginia (after Fontaine).

3. Large stem showing short internodes, same locality.

4, 5, 6. Views of portions of stems to show the reduced leaves of the nodes, somewhat diagrammatical (after Fontaine).



GYMNOSPERMÆ.

PLATE LXXII.

GYMNOSPERMÆ.

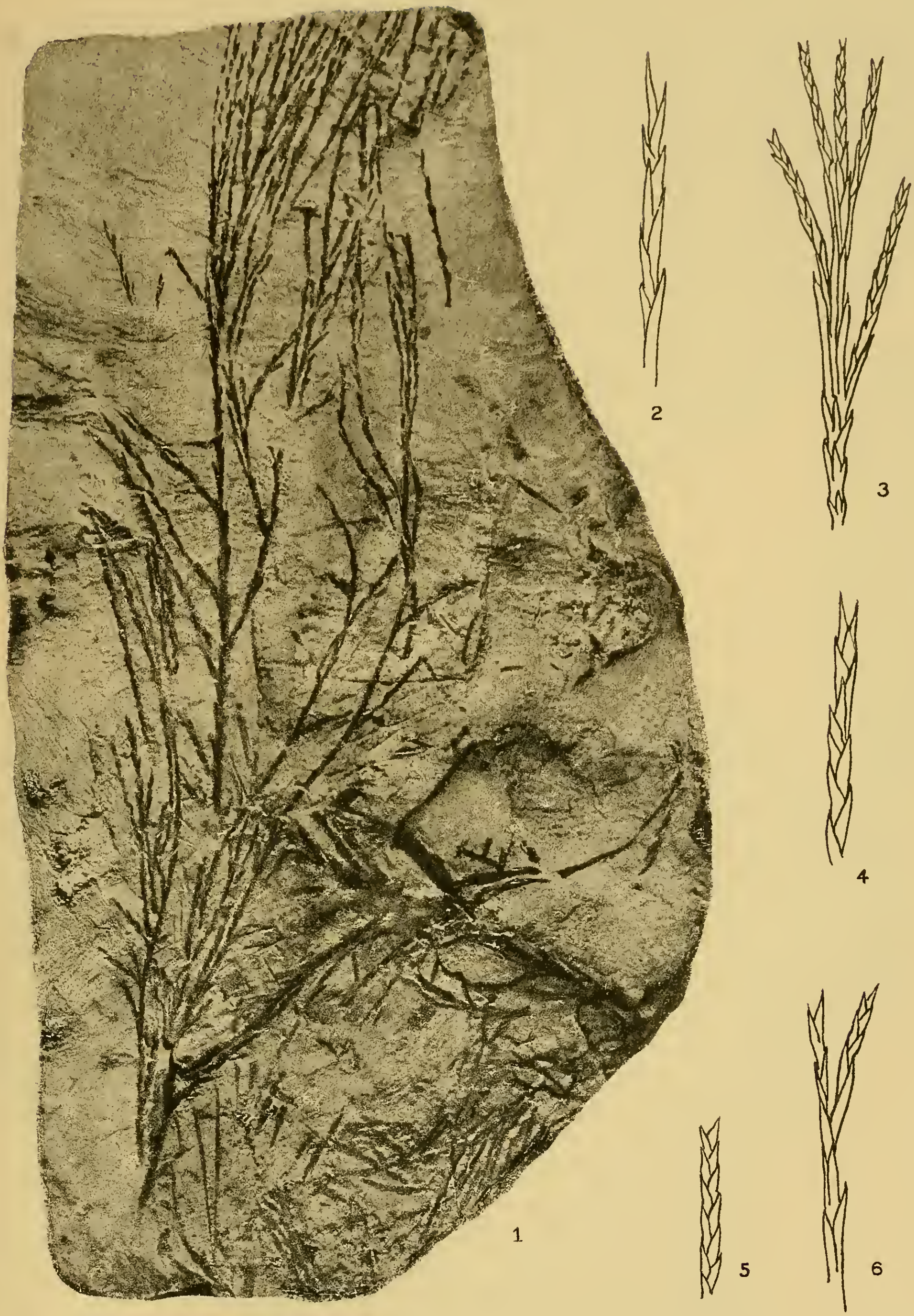
Cockayne, Boston.

PLATE LXXIII.

	PAGE
Figs. 1-6. Widdringtonites ramosus (Fontaine) Berry	428

1. Characteristic leafy twig from 72-Mile post, Virginia.

2-6. Drawings showing the variations upon a single small twig of the foregoing. × 3.



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GYMNOSPERMÆ.

Cockayne, Boston.

PLATE LXXIV.

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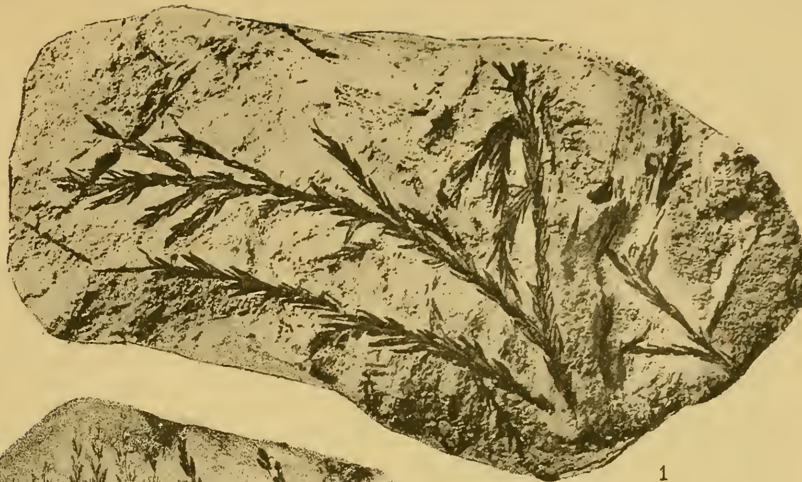
GYMNOSPERMÆ.

Cockayne, Boston.

PLATE LXXV.



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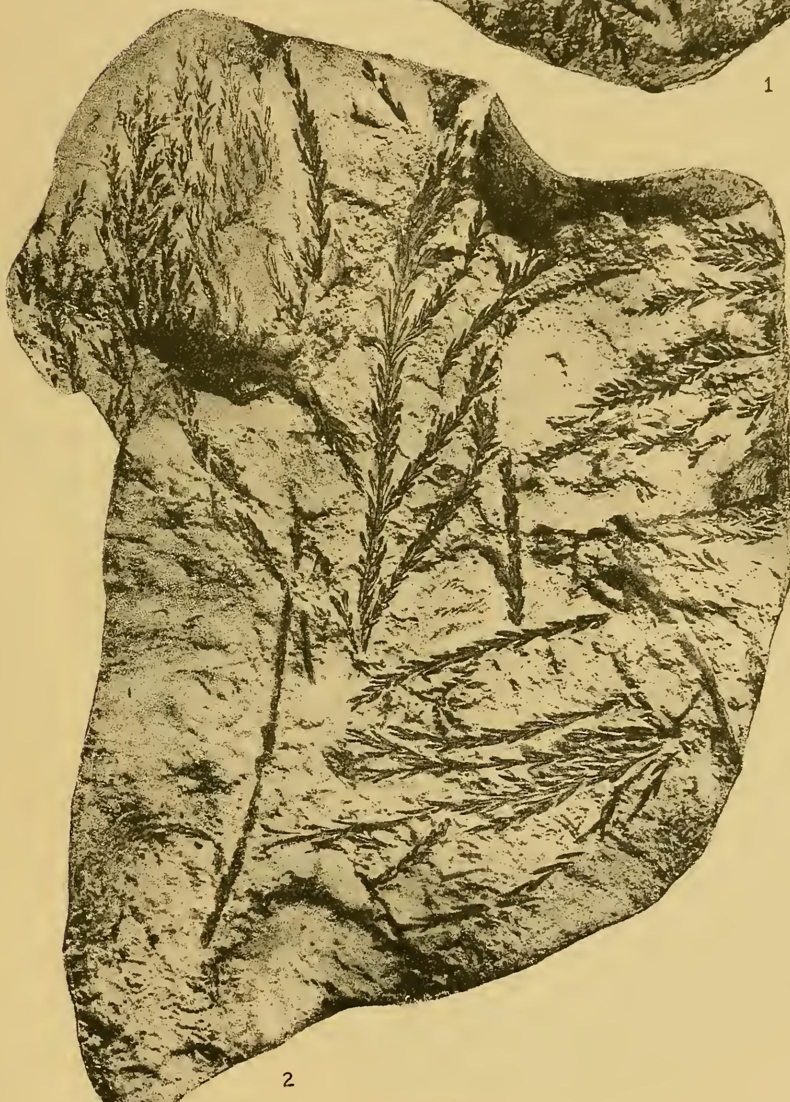

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GYMNOSPERMÆ.

Cockayne, Boston.

PLATE LXXVI.

GYMNOSPERMÆ.

Cockayne, Boston.

PLATE LXXVII.


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4a


5


5a


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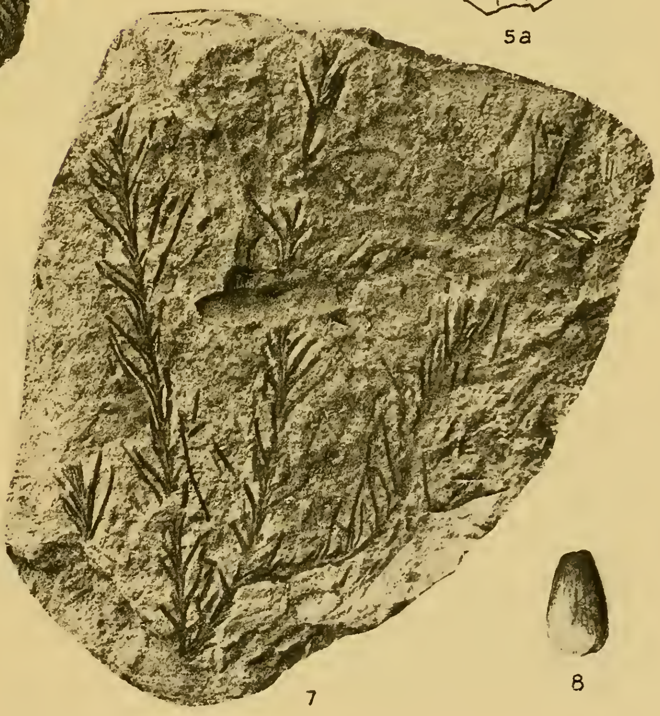
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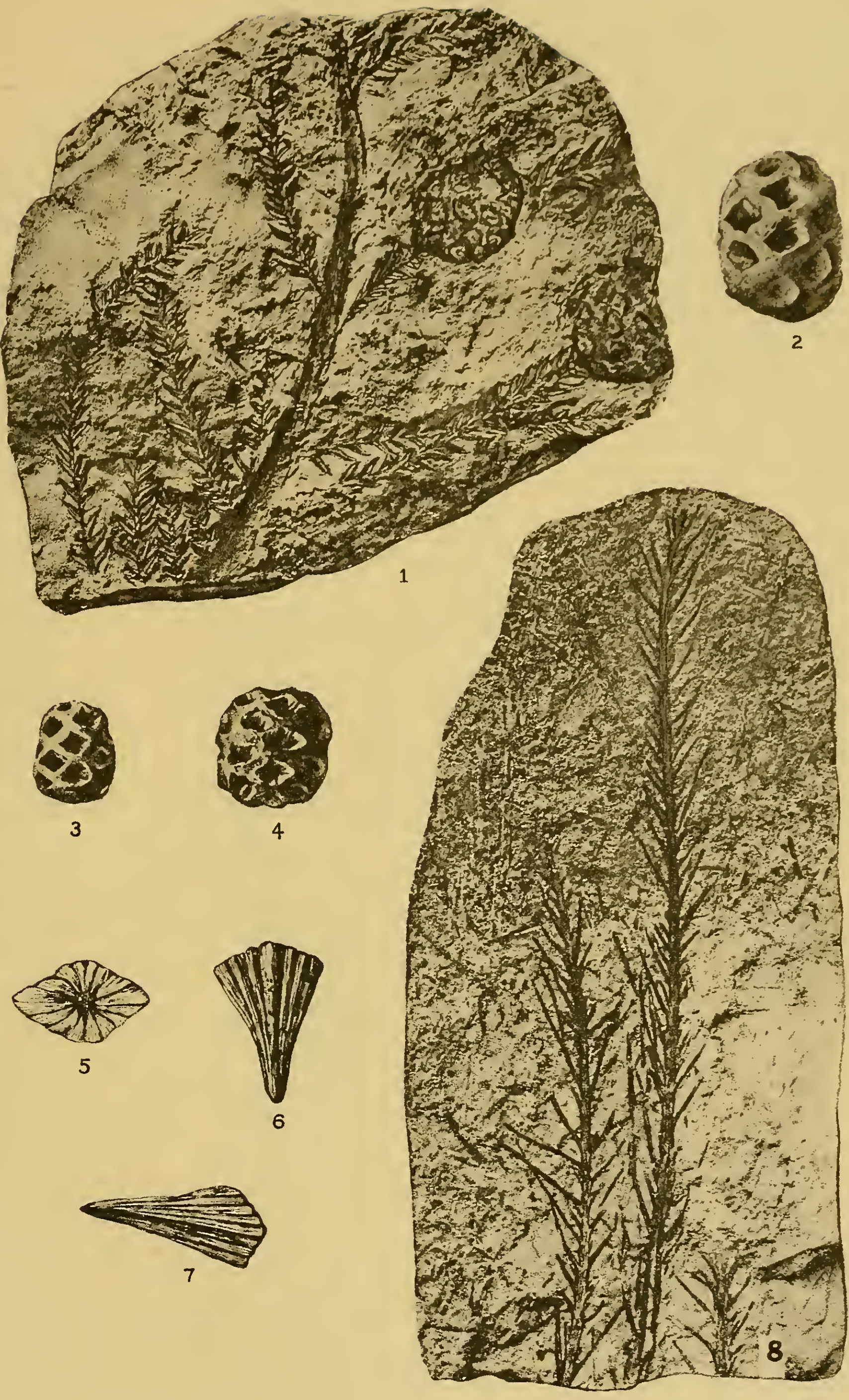
Cockayne, Boston.

PLATE LXXVIII.



GYMNOSPERMÆ.

Cockayne, Boston.

PLATE LXXIX.

	PAGE
Figs. 1-4. PLATAGINOPSIS MARYLANDICA Fontaine	456
Figs. 1, 4. Federal Hill, Maryland (after Fontaine).	
Fig. 5. ALISMAPHYLLUM VICTOR-MAMONI (Ward) Berry	453
White House Bluff, Virginia (after Ward).	
Fig. 6. CYPERACITES POTOMACENSIS Berry	455
Fruiting specimen from near Wellhams, Maryland. × 5.	

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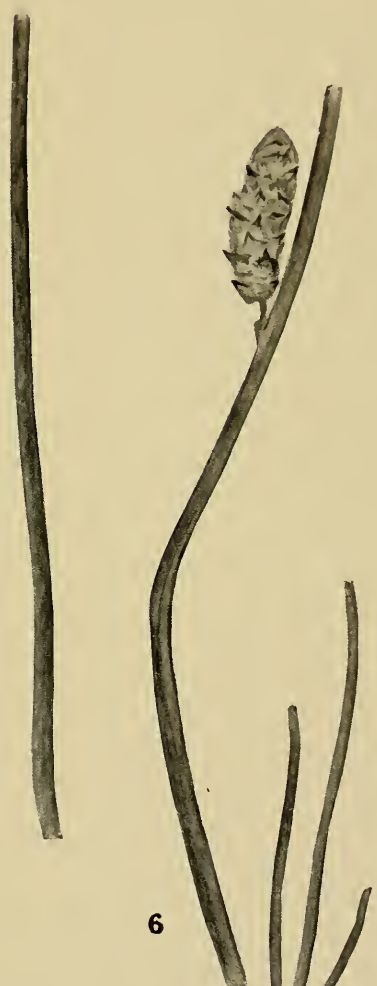

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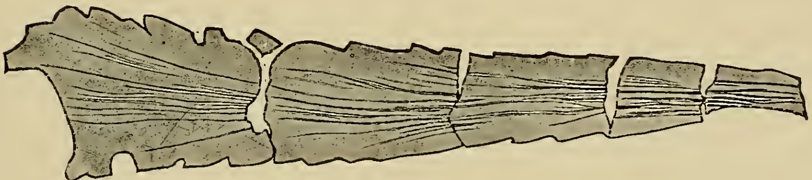
MONOCOTYLEDONÆ.

PLATE LXXX.

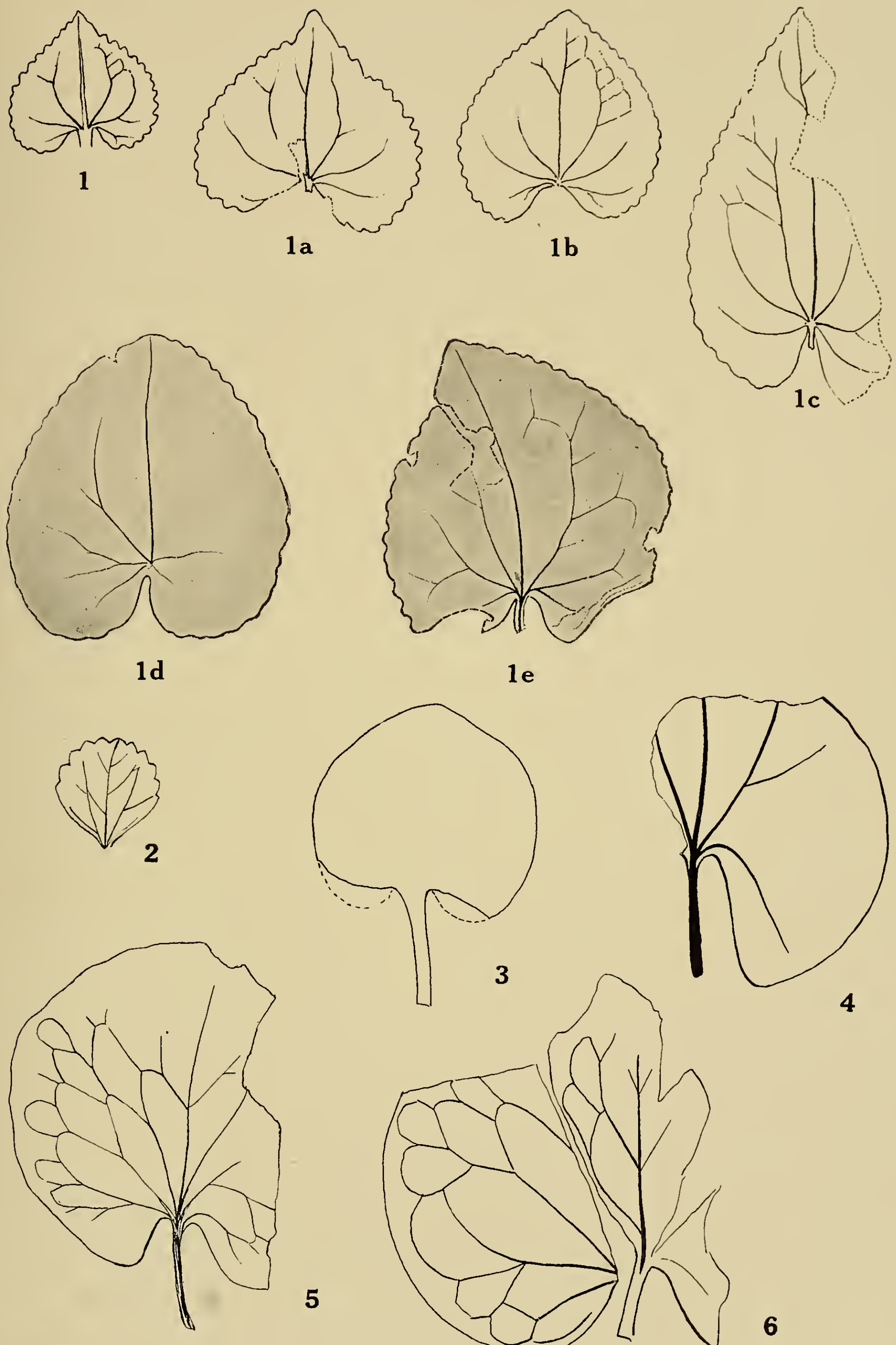
	PAGE
Figs. 1, 2. PLANTAGINOPSIS MARYLANDICA Fontaine	456

Federal Hill, Maryland (after Fontaine).



MONOCOTYLEDONÆ.

PLATE LXXXI.



DICOTYLEDONÆ.

PLATE LXXXII.

PAGE

Figs. 1, 2. Nelumbites tenuinervis (Fontaine) Berry.................. 464
Mt. Vernon, Virginia (after Fontaine).

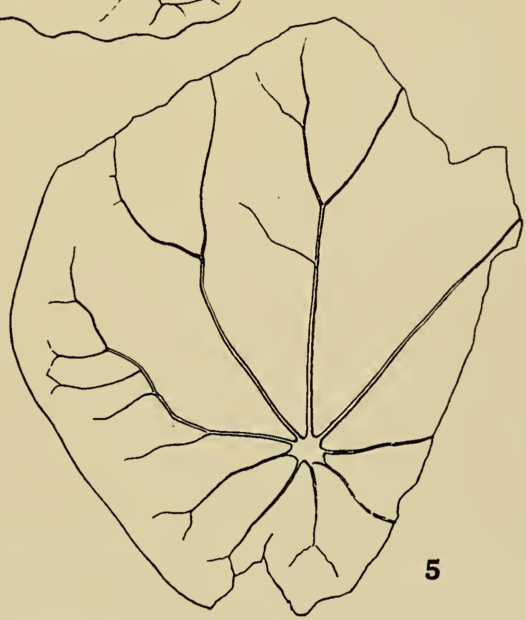
Figs. 3-5. Nelumbites virginiensis (Fontaine) Berry.................. 463
3. Mt. Vernon, Virginia (after Ward).
4, 5. Overlook Inn, Maryland (after Hollick).

1

2

3

4



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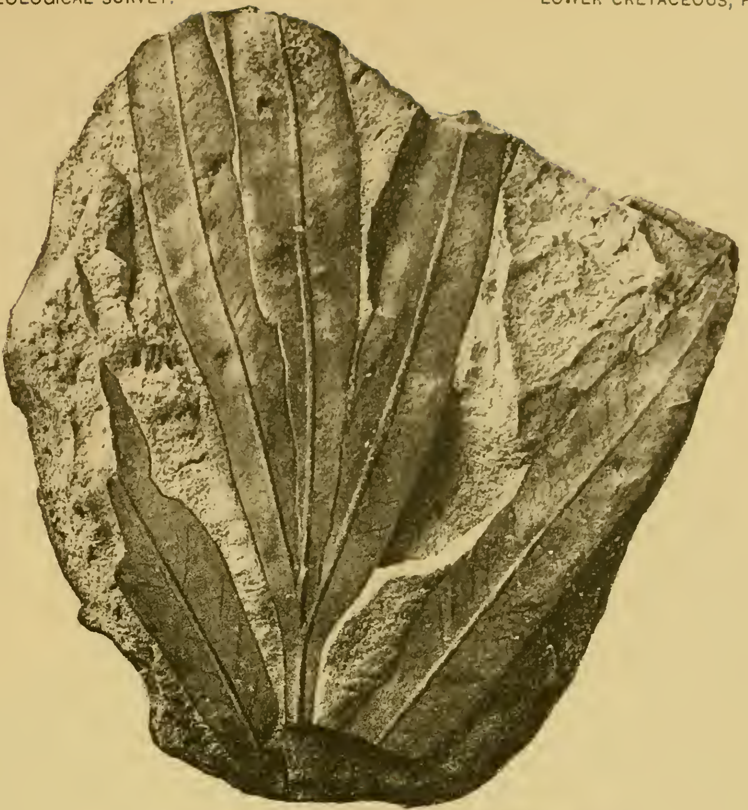
DICOTYLEDONÆ.

PLATE LXXXIII.

DICOTYLEDONÆ.

PLATE LXXXIV.



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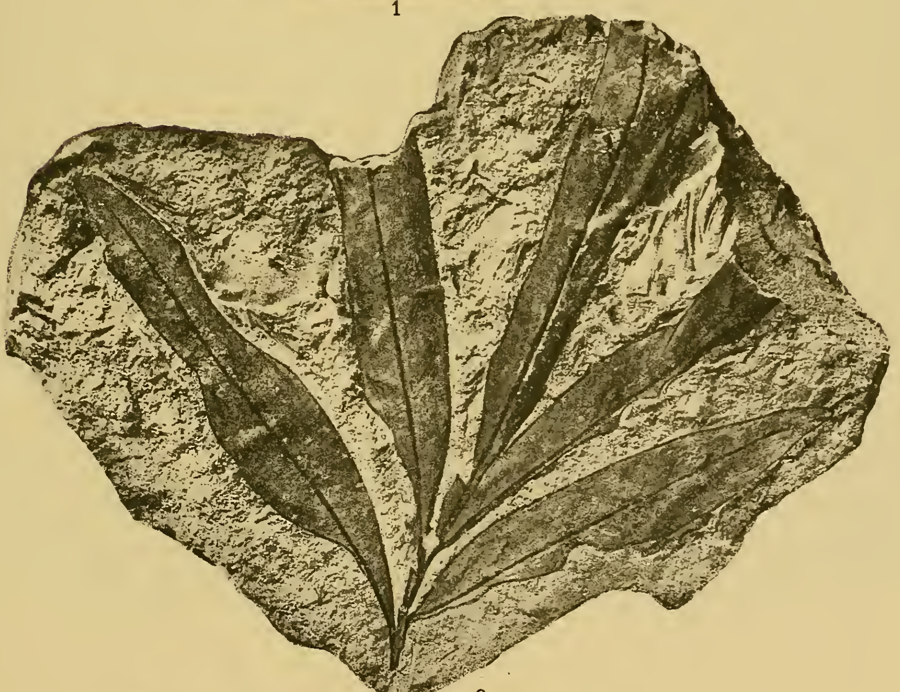

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DICOTYLEDONÆ.

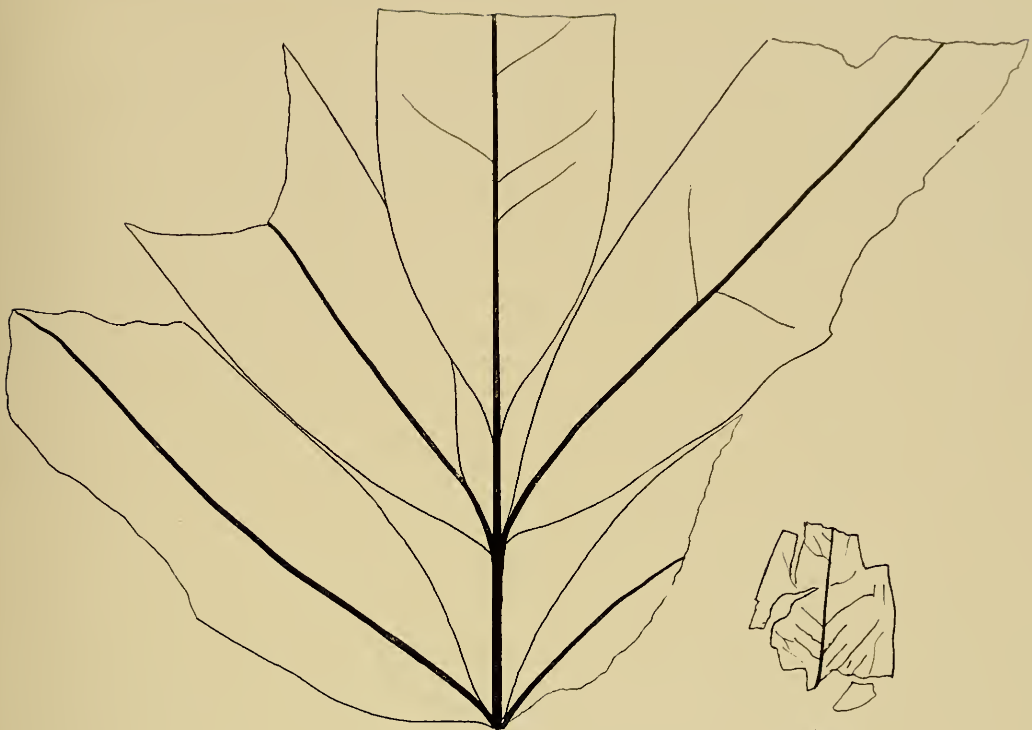
Cockayne, Boston.

PLATE LXXXV.

DICOTYLEDONÆ.

Cockayne, Boston.

PLATE LXXXVI.



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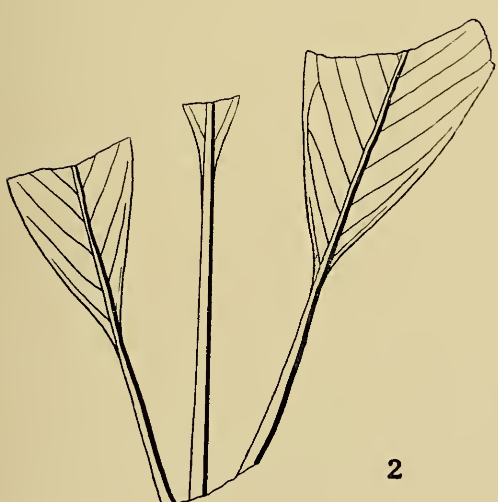


2

3

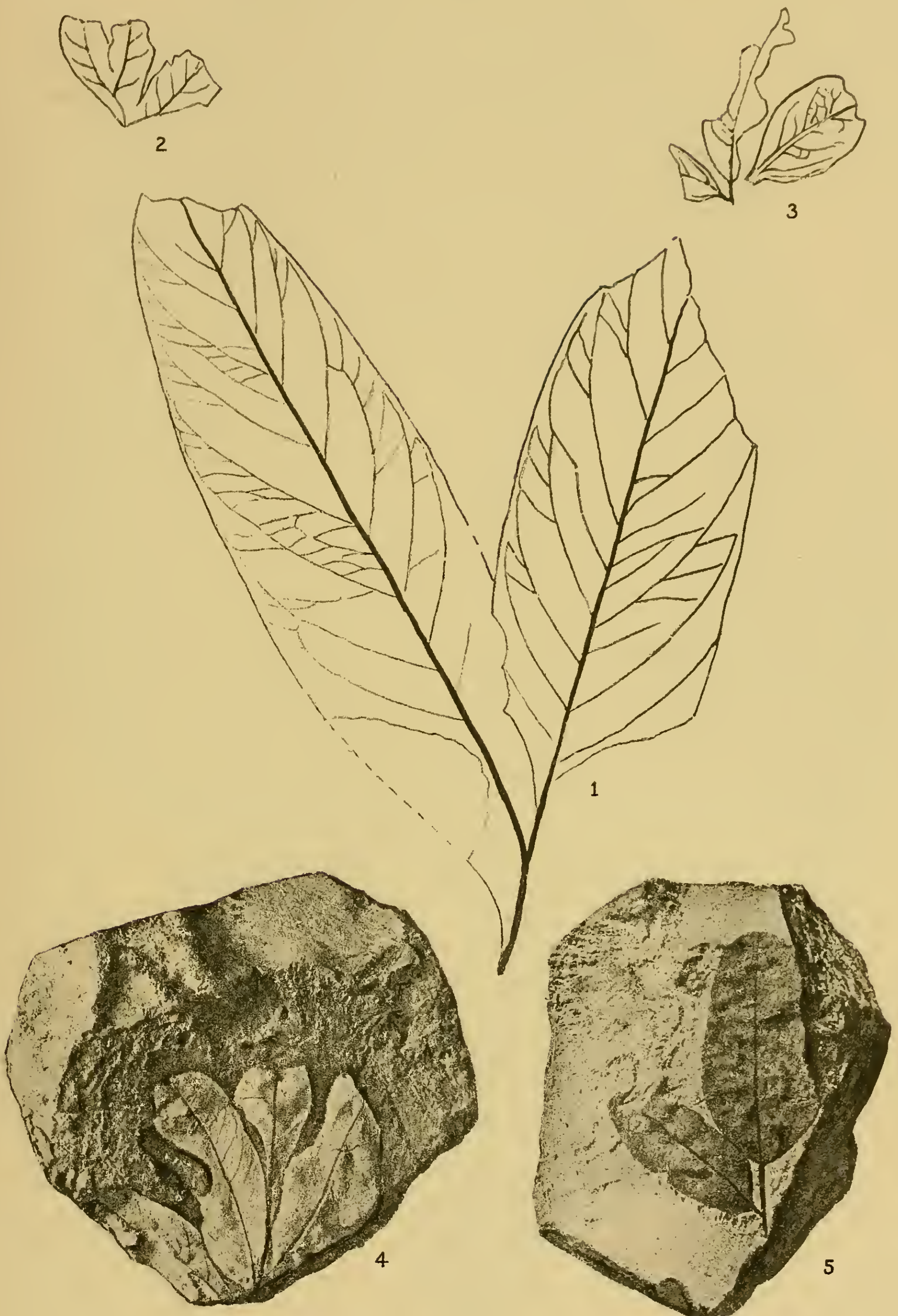
DICOTYLEDONÆ.

PLATE LXXXVII.

PAGE

Fig. 1. SAPINDOPSIS MAGNIFOLIA Fontaine.............................. 471
Stump Neck, Maryland.

Figs. 2-5. SAPINDOPSIS BREVIFOLIA Fontaine........................... 473
2, 3. Ft. Foote, Maryland.
4, 5. Near Brooke, Virginia.



DICOTYLEDONÆ.

COCKAYNE, BOSTON.

PLATE LXXXVIII.

DICOTYLEDONÆ.

Cockayne, Boston.

PLATE LXXXIX.

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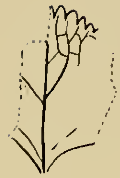

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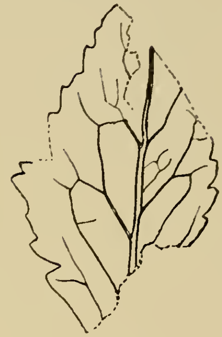

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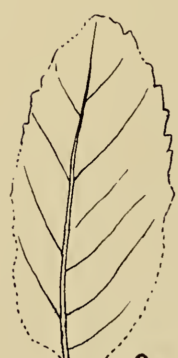

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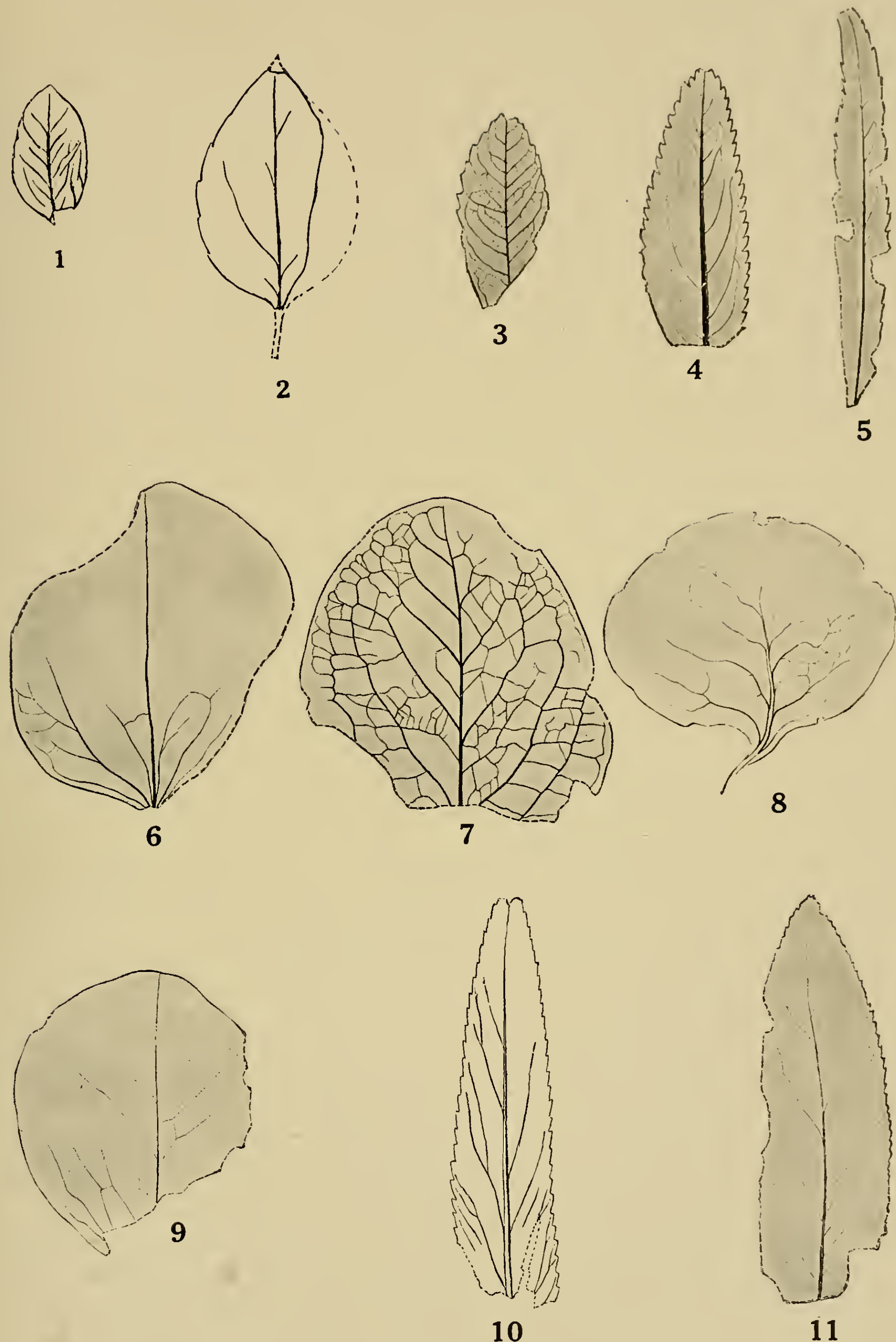
DICOTYLEDONÆ.

PLATE XC.



DICOTYLEDONÆ.

PLATE XCI.

PAGE

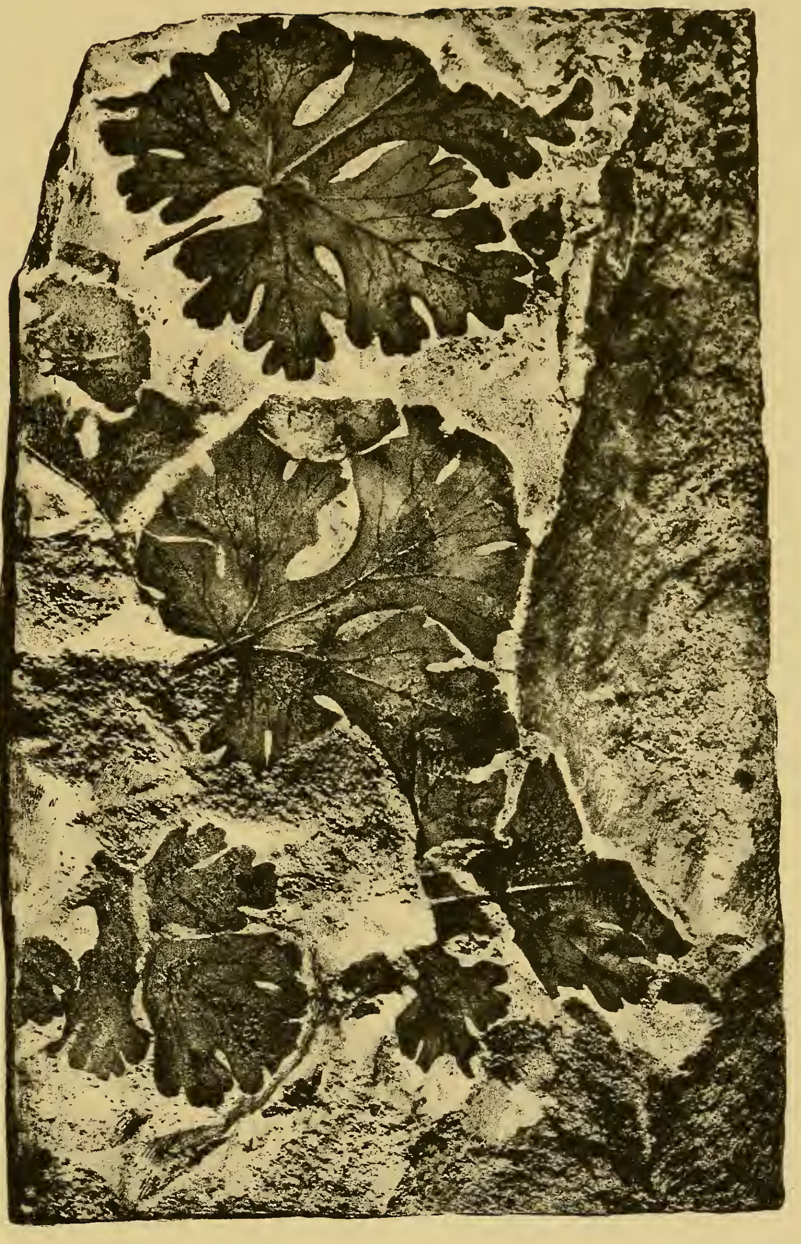
Figs. 1-8. Cissites parvifolius (Fontaine) Berry 482

1. From Albian of Portugal (after Saporta).

2-8. From Federal Hill, Maryland (after Ward and Fontaine).

DICOTYLEDONÆ.

PLATE XCII.



DICOTYLEDONÆ.

COCKAYNE, BOSTON.

PLATE XCIII.

PAGE

Fig. 1. Sassafras bilobatum Fontaine 484
Near Brooke, Virginia (after Fontaine).

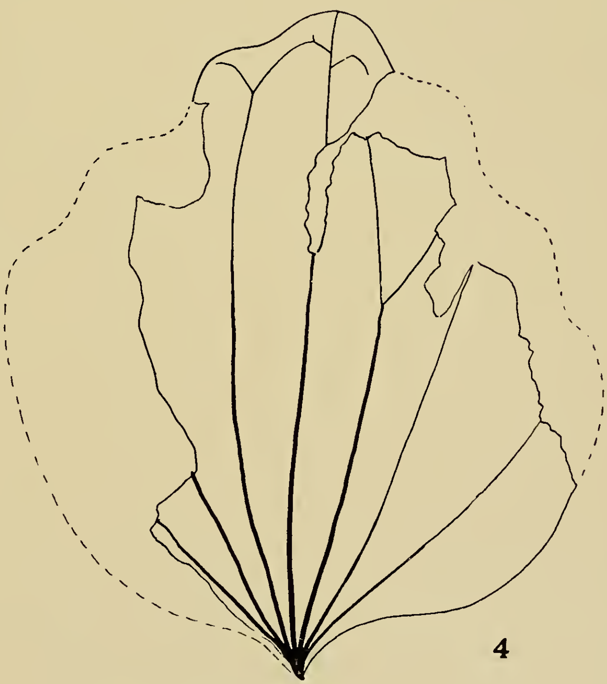
Fig. 2. Sassafras parvifolium Fontaine 486
Near Brooke, Virginia (after Fontaine).

Figs. 3, 4. Menispermites potomacensis Berry 466
3. Near Widewater, Virginia.
4. Stump Neck, Maryland.

1

2

3



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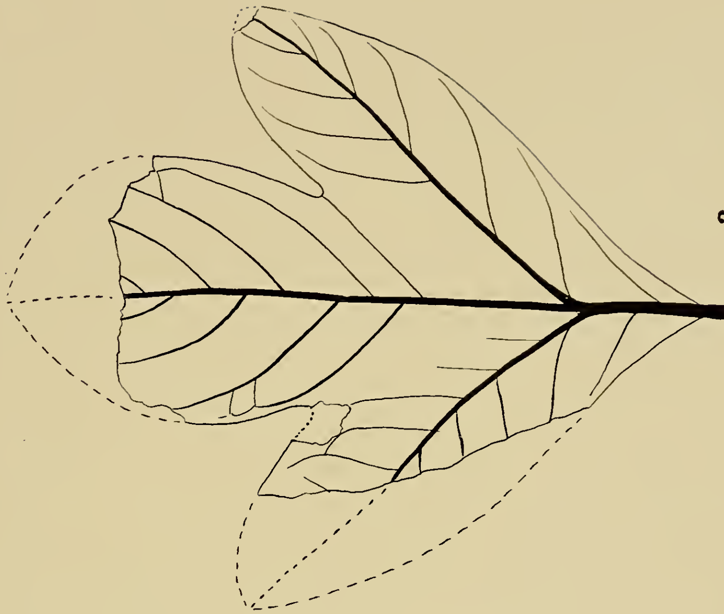
DICOTYLEDONÆ.

PLATE XCIV.



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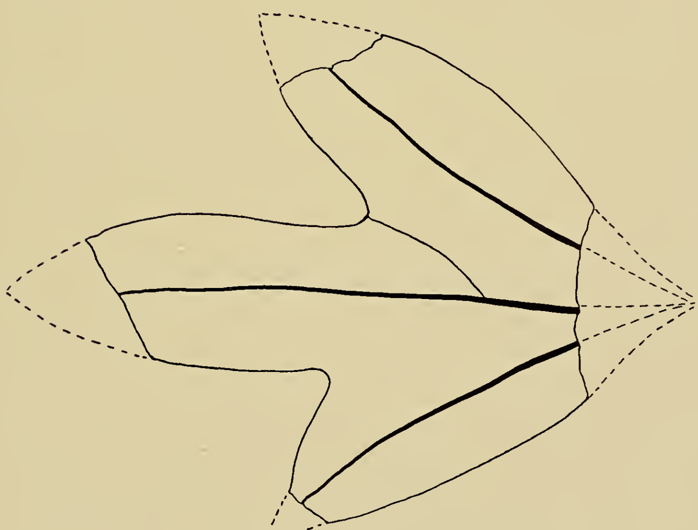

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DICOTYLEDONÆ.

PLATE XCV.

		PAGE
Figs. 1-3.	ARALLÆPHYLLUM CRASSINERVE (Fontaine) Berry	490

1. Near Glymont, Maryland.
2, 3. Stump Neck, Maryland.

1

2

3

DICOTYLEDONÆ.

PLATE XCVI.

PAGE

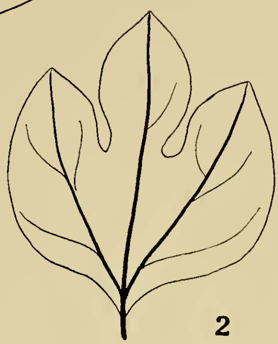
Figs. 1-5. ARALLÆPHYLLUM MAGNIFOLIUM Fontaine 491

1-3. Restoration of various leaves of this species, ⅓ natural size.

4, 5. Specimens from Stump Neck, Maryland.

1

3



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4

5

DICOTYLEDONÆ.

PLATE XCVII.

DICOTYLEDONÆ.

GENERAL INDEX

S

T

PALEONTOLOGICAL INDEX

Figures in **bold face** indicate principal discussion.

T

U

V

W

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