THE LIGNITIC FORMATION AND ITS FOSSIL FLORA.

BY LEO LESQUEREUX.

COLUMBUS, OHIO, *July* 14, 1874.

DEAR SIR: I send you herewith my report on the botanical paleontology of the Tertiary formations of the Rocky Mountains.

The results of the explorations of 1873 in regard to my special researches are exposed in the description of the new species of fossil plants, and in the discussion of the data furnished by these plants on the age of the Lignitic formations.

As there has been of late some discussion on this last subject, and as the opinions of the explorers do not yet agree, I have reviewed in the first part of my report the facts and arguments bearing evidence on the age of the Lignitic; in the second part, I have marked, by tables, &c., the distribution of the Tertiary flora in relation to the periods which they seem to represent; in the third part, the description of the new species, or of those which were not yet known from American specimens, is given; and the fourth has a review on the climate during the North American Tertiary epoch, as indicated by the character of the groups of its fossil flora.

Besides what is due to the co-operation of the members of your corps in the collection of specimens of fossil plants, the survey is greatly indebted to Captain Berthoud, and to Mr. A. Lakes, of Golden, for the discovery of new species and the communication of splendid specimens.

Very respectfully, yours,

L. LESQUEREUX.

Dr. F. V. HAYDEN,
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INTRODUCTION.

I shall begin my report of this year by a more detailed review of the essential facts and data which, furnished essentially by vegetable paleontology, have forced my conclusions on the age and the geological distribution of the Lignitic formations of the West.

There is always some uncertainty in the reference of fossil species to peculiar geological stations, when the paleontologist is called to describe them and judge of their geological relations without having himself examined the localities wherefrom the materials have been derived; this on account of a casual mixing up of specimens, and also because the more characteristic species, which are sometimes of rare occurrence, escape the eye of those who, unacquainted with fossils, collect specimens at random, and wherever they find them, for the examination of a specialist. For this reason I have to base my classification on the localities which I have visited myself, and on those which, either from stratigraphical evidence or by a close analogy in the characters of their fossil remains, are ascertained as synchronous.

1st. I refer to Eocene (Lower American Eocene,) all the coal-strata of the Raton Mountains; those of the Cañon City coal-basin; those of Colorado Springs, where a coal-bed, the Gehrung's, is opened and worked; those of the whole basin of Central and North Colorado, extending from Platte River or from the Pinery divide to south of Cheyenne, including Golden, Marshall, Bowlder Valley, Sand Creek, &c., and, in Wyoming, the Black Butte, the Hallville, and the Rock Spring coal. By analogy of geological characters, compounds, and succession of strata, as indicated by Hayden, Leconte, and others, and also by the presence of species of fossil plants, which I consider as leading plants of the group, I refer to the same Eocene formation the Lignitic beds of New Mexico as far south, at least, as the Placière anthracite coal; in Wyoming, those of Bear River; and in Utah, those of Coalville, as described by Professor Meek in the former report of Dr. Hayden, (1872, p. 435.) From its fossil plants, the coal of Nanaimo, Vancouver Island, is referable to this section.

2d. I consider as American Upper Eocene (or Lower Miocene, the coal-strata of Evanston, and from identity of the characters of the flora, as seen from the specimens communicated to me, those of six miles above Spring Cañon, near Fort Ellis; of the locality marked near Yellowstone Lake, among basaltic rock; of Troublesome Creek, Mount Brosse, and Elk Creek, Colorado. The specimens from Bellingham Bay, Washington Territory, refer this locality to the same horizon.

3d. To the Middle Miocene I refer the coal-basin of Carbon, and from the identity of vegetable remains the Washakie group, Medicine Bow, Point of Rocks, and Rock Creek.

4th. To the Upper Miocene belongs the Green River group of Wyoming; the coal of Elko Station, Nevada; the leaf-bearing strata of South Park, near Florisant and Castello Ranch; of Middle Park, and of Barrell's Spring.

The localities where only a few specimens of undeterminate relation have been obtained, and which are not named in this connection, are of little importance. They may become positively identified with one of these stages of the Tertiary, and for this reason, in order that the means of comparison may be more easily recognized, I propose to modify the

plan of my former reports in the following manner: The specimens examined from the exploration of past year (1873) will be described in separate sections or groups, to which are referable the localities wherefrom they are derived; and instead of placing in a single synoptical table all the species known from our American Tertiary measures, it will be more appropriate to prepare a table for each of the Tertiary stages, as recognized above; reserving a general table for a later time, when our Tertiary divisions are more positively recognized. It is to this last end especially, and as stated above, that these different tables may be useful. The materials which we have now on hand are abundant enough to point out a marked difference in the vegetation of the different horizon of the Tertiary, though the general characters of the separate groups which they represent are not yet well determined enough to give positive evidence in regard to the exactness of these divisions. As our Tertiary measures are of wide extent, and are likely to become more and more carefully studied, these different tables will afford points of comparison for local floras, and therefore for identification of local formations, just as, in the former reports, the general tables furnished for the comparison of the geological epochs, the Cretaceous and Tertiary, an evidence which is needed no more; for, indeed, I believe that from the descriptions, details, and expositions of the characters of each of these separate groups of the Tertiary, its age and its disconnection from the Cretaceous will be established positively enough to prevent any further discussion on the matter.

§ 1.—AGE OF THE NORTH AMERICAN LIGNITIC.

Besides the evidence furnished on the age of this formation by the characters of the vegetable remains, I have, in my former annual report to Dr. Hayden, drawn some collateral conclusions, which I wish to briefly review now, in order to separately consider, in regard to them, any new evidence afforded by the researches of 1873.

These conclusions were taken, 1st, from the fact of the immediate superposition of the strata bearing plants to well-characterized strata of the upper series of the Cretaceous, the Fort Pierre and the Fox Hill beds of Hayden's section, in the Report for 1871, (p. 87.) This immediate superposition of the heavy fucoidal sandstones and of the Lignitic over Upper Cretaceous rocks, is seen in full evidence, as remarked in the report, in the Raton Mountains of New Mexico, around Trinidad; all along the ridge of sandstone from Trinidad to the Spanish Peak; at the Cañon City coal-basin under the Lignitic formation, as marked in the section of Mr. Nelson Clark, superintendent of the coal-mines; at Colorado Springs, in following the bed of Monument Creek, from the depot to Gehrung's coal; at Golden, Marshall, &c. On this subject my observations agree with those formerly recorded by Dr. Hayden, Dr. Leconte, and others; the succession of the strata has been recognized by all the geologists.

2d. I have not denied, and do not deny now, the presence of animal Cretaceous remains in the strata of the Lignitic, though persisting to consider the formation as Tertiary notwithstanding; for I regarded and still regard the presence of some scattered fragments of Cretaceous shells as of little moment in comparison with the well-marked characters of the flora, characters which have been fully established by a large number of specimens obtained from all the localities referred to the Lignitic. I remarked, however, on the scarcity, if not the total absence, of Cretaceous animal remains in the whole extent of the Colorado basin, from the Raton Mountains to Cheyenne.

Since then, new evidence has been supplied to this subject, first by a

letter of Prof. E. T. Cox, who, in company with Dr. R. Owen, found specimens of *Scaphites* and *Inoceramí* in strata supposed to belong to the Cretaceous Lignitic, as quoted by Dr. Leconte in his Notes on the Geology of the Union Pacific Railway, (p. 19.) Professor Cox says, concerning these specimens, which are still in his cabinet—

I copy from my memorandum-book the section and notes made at Spanish Peak, a range of the Rocky Mountains, from a stage-station on Purgatory Creek.

Cretaceous.

Hard band	20 feet.
Thin and thick bedded sandstone, Schistose sandstone and shale, Solid bedded sandstone.	200 feet.
Thin coal	——
Solid grit, with pebbles	70 feet.
Talus at base	400 feet.

The talus rested upon the table-land, which is 240 feet above the bed of the creek; total height, from bed of creek to top of section, 930 feet. The ridge extended back from face of hill, and appeared to be about 100 to 150 feet higher.—(Note on section from memorandum-book:) Found in the wash at foot of talus in the above section, *Scaphites nodosa*, and a species of *Inoceramus*.

The section is similar to those given in Hayden's Report for 1872, (p. 319), of the Lignitic and its underlying heavy sandstone, on the Purgatory Creek, near Trinidad, which is underlaid by a talus of Cretaceous black shale, No. 4. It compares especially well to my own, in the same report (p. 320), of the range opposite Trinidad, where the underlying black and Cretaceous shales and covered space to the bed of the creek measure 300 feet. From this place, and along the stage-road to Spanish Peak, the distribution of the strata is the same, the heavy Lignitic sandstone towering over the talus of the black shale, like a wall, as reported, (*loc. cit.*, p. 321,) and overlaid by the beds of lignites, or the productive Lignitic. That, therefore, the Cretaceous fossils found at the base of the talus of black shale No. 4 do not prove that the Lignitic above is of Cretaceous age is evident enough. The section of Professor Cox, on the contrary, confirms the deductions taken in relation to the superposition of the Tertiary Lignitic to the Cretaceous in that part of the country.

The authority of Captain Berthoud, of Golden, has been often quoted on the same subject, and is generally considered as of great weight in geological matters of Colorado, a region which this gentleman has for many years surveyed for the construction of railroads and carefully examined with the eye of a practical geologist. He has been reported as supporting the assertion that Cretaceous mollusks had been found above the beds of the Lignitic formations. In regard to my inquiries on this subject, he had, like Professor Cox, the kindness to give his detailed opinion in a letter, whose statements are worth preserving. He says,

1st. That if Professor Stevenson observed *Inocerami, Ammonites, Scaphites, Baculites, Nuculæ*, &c., in superposition to Lignitic strata of Colorado, it is clear to me that it is only a case of local inversion; *i. e.*, that, as shown in our basin of Golden, the Lignitic sandstone has been so tilted up that, with the coal-seams near by, it was thrown over the perpendicular, and thus Cretaceous strata would appear in superposition.

2d. That between this Lignitic and the Cretaceous beds holding *Inoceramus*, &c., on Bear Creek, there is fully one mile on an east or west line, so that the Cretaceous beds and the Lignitic coal-shale, fire-clay, and sandstone are not conformable in dip, and clearly show the superposition of the Lignitic beds. This is undoubted, as the Cretaceous limestone *debris*, under green and yellow clay-beds, disappear under the coal-beds at our old camp on Bear Creek that you visited with me.

At Golden I cannot see that the Cretaceous beds are conformable to the sandstone and coal; so far I wrote to A. R. Marvine. Now, I will add to this for you some other remarks. It has always seemed to me a stumbling-block when ten years ago, or more, and until 1868–'69, I supposed and believed that our coal was Cretaceous, to find everywhere, when examined by me, that there was no conformability between the Lignitic Measures and the outcrop west; and that at Ralston, Bear Creek, Table Mountain, the

stratification was also unconformable to all from the coal westward. But when I find that as we proceed east, the superimposed Tertiary beds are getting more and more horizontal, and that in the clays and sandstones above the coal, we see a well-developed resemblance in fossil plants up to the basalt overflow, I gave up the idea of the Cretaceous origin of this Lignitic, and the possibility that a salt-water deposit could belong to the same geological horizon, as indicated by the Tertiary fresh-water deposits, particularly as the conformability of this coal and this Cretaceous limestone can nowhere be shown. As to Dr. Leconte's report of what I found east of Pike's Peak, it is in the main true. I found coal when on a scout. I judged it was nine feet thick. It seemed almost horizontal, but I would not say it was horizontal, as it was badly cut up by the drainage of the small gully we found it in. In bluffs north or northwest I found several *Baculites* that seemed to come from a clay-bed in the bluffs; but whether this coal was superimposed to this baculite clay, or the clay was over the coal, I could not say positively either way. Southwest of this locality, twenty-five miles, on the Arkansas, the *Baculite* clay-beds are below the *Inoceramus* limestone, and no coal whatever above.

3d. The coal-bed opened near Platte Cañon I have not yet seen. I know that fine *Baculites* and *Scaphites* have been obtained there, said to be near the coal, but have no evidence of it; will visit and report to you, as soon as I can, just what I find there. But I think it is a case of local inversion, as the coal, to within three and one-half miles of South Platte River, is tilted up the same as at Bear Creek, Golden, Ralston, &c. Eleven miles north of Golden, on Coal Creek, these Lignitic beds are regularly inclined east, and no Cretaceous beds west of them can I find. At Murphy's coal-mine no Cretaceous fossils are found east of the coal. In Golden, cutting a deep well in the green Tertiary clay about 1,000 feet east of the coal has exposed a stratum of deep-green clay, with a large deposit (leaf-bed) with leaves changed into glossy coal. They seem to belong to *Salix, Platanus, Rhamnus*, &c.; a gramen, also a small fragment of an elytra, or wing-case of an insect. The fossil beds near Bowlder County are accompanied with clay full of casts of leaves, of sedges and grasses, mollusks, fossil turtles, and one or two bones that Professor Marsh thinks are *Dinosaurus*.

This is sufficient to show that, except the specimen of *Inoceramus* found by Dr. Leconte at the Raton over Lignitic beds, no Cretaceous fossil mollusks have been found till now in the whole Lignitic basin from the Raton Mountains to Cheyenne.

3d. To answer the objections that at Black Butte, Coalville, Bear Biver, and other localities in Wyoming, the Lignitic beds and sandstone bearing plants had been recognized underlying strata with fossil remains of Cretaceous animals, I had to examine if, from its nature and its fossil plants, the Lignitic formation should be of necessity recognized as a whole, or if it could be separated into different members, the one representing the Upper Cretaceous, the other the Lower Tertiary. For this, of course, the essential documents to be considered in the view of my special researches are the fossil plants. From the large number of Fucoids in the sandstone, and from the identity of some of the species of these marine plants found by Professor Meek, even in connection with the lower strata of the Lignitic as far down as the arenaceous beds of Bear Creek and Coalville, with Cretaceous animal remains; from the prodigious preponderance of palms, leaves and fruits, recognized also in the same circumstance, &c., I forcibly admitted the unity of the Lignitic formation in its whole, and therefore limited the discussion to this point: the Cretaceous or the Tertiary age of the formation. The detailed examination of the fossil plants of the Lignitic and of their distribution affords more evidence on this question.

4th. To strengthen my position in regard to the conclusions afforded by vegetable remains, I compared the Lignitic formations to those of the Carboniferous epoch, remarking that, having positively a preponderance of land-plants or a land-character, they should be considered as a land-formation; that in every formation, especially in every land formation like that of the Carboniferous, the fossil animal types are more or less in discordance with the vegetable forms in regard to the data furnished by them on the age of the formation. As in the Carboniferous we find Devonian mollusks far above the millstone-grit, and also Permian shells far below the Permian, and as the Carboniferous is now generally recog-

nized as a homogeneous single formation, I argued that, the same disaccord being remarked in our Lignitic measures, we had to explain it in the same way, and should not, on that account, force an abnormal division of a formation whose flora is positively analogous or synchronous in its characters in the whole thickness. A discrepancy of the same kind is recognized in the Cretaceous formations of Europe, even between the groups of animal fossils which characterize them. The president of the Society of Natural History of Geneva, my honored friend, Rev. Duby, says, in his discourse of 1861, in regard to the geological observations recorded during the year,

That the society had been favored by Professor Pictet with numerous communications relative to paleontology, of which the most important is a notice of the succession of the cephalopod mollusks during the Chalk period in the region of the Swiss Alps and Jura. Mr. Pictet derives, from a detailed study of the fossils contained in the Cretaceous strata and their comparison with contemporaneous repositories, an argument in favor of the idea propounded by Mr. Barande, that two successive faunas must necessarily have existed together for some time, and he concludes by showing that paleontological faunas, distinguished through by marked characters, are not ordinarily susceptible of any rigorous limitation.

Messrs. Claparède and Favre took occasion to remark on this, how much the conclusions of Mr. Pictet must in future complicate the task of geologists who undertake to determine the age of the formations. On the same subject Count Saporta, one of the highest European authorities in vegetable paleontology, remarks,* in speaking of the presence of *Ammonites, Baculites, Inoceramus*, &c., in the American strata, which, by their fossil plants are characterized as Eocene, that these mollusks have persisted for a longer time in the Cretaceous of America than in Europe; a fact which is easily admitted, as, in France, the chambered cephalopods had left the Cretaceous seas of the south long before they disappeared from the north. The same remark is repeated in Jukes and Geikie's Manual of Geology, (p. 664.)

In parts of the north of France there occur curious banks of white pisolitic limestone, resting apparently in hollows of the chalk, &c., but sometimes on the same level as the lower beds of the Tertiary rocks above it. Some of the fossils are true Cretaceous, while none, I believe, are Tertiary forms.

We have apparently something like this in our geological Upper Cretaceous formation, if, as it seems proved, we do not find any kind of Cretaceous mollusks in the Lignitic basin of Golden, when their presence is still ascertained in the Lignitic of Bear River and Coalville. The English geologists remark on facts of this kind, (*loc. cit.*, p. 665:)

That the existence of local groups of rocks that will not exactly fit into the general series, either from their containing fossils different from those found in any other group, or from their uniting parts of two sets of fossils which are elsewhere distinct, although sometimes perplexing, seems neither unnatural nor different from what might be expected. It merely shows us that our geological series is a series of fragments, not one of absolutely continuous succession.

In his travels with the Hassler, Professor Agassiz has observed a case which may serve to explain anomalies between the records furnished by animal and vegetable remains in regard to the age of the strata.†

The geology of the coast of Possession Bay is interesting to the highest degree. All along the coasts, north of the Straits of Magellan, the Tertiary formations, same as along the coasts of Eastern Patagonia, are perfectly distinct, even seen from a distance, by their horizontal strata, also remarked on the coast of Fuego. In Possession Bay we landed to more carefully recognize the character of the country, &c. One mile inland from the cliffs I found, at 150 feet above the sea-level, a pond of salt water, which, to my great surprise, had an abundance of marine shells, identical with those of the sea along the coast. They were in a perfect state of preservation; many were living,

* In letters.

† Letter of Professor Agassiz to Professor Peirce, in Boston Advertiser. I have to retranslate this from the French *Revue scientifique*, No. 46, May, 1873.

and I could collect a large number of specimens, with living animals, for preserving in alcohol. The most numerous were *Fuci, Buccini, Fissurellæ, Patellæ, Volutæ*, &c., all in the same numeric relation which was remarked in the sea under the cliffs. The presence of this salt pond, with its living inhabitants, proves a very recent upheaval of the coast. The exact time could not be precisely fixed without a more extensive geological examination. The fact is the most complete confirmation of Darwin's assertion, published more than thirty years ago, that there has been a recent upheaval of the coasts.

Admitting the fact as it is exposed by Professor Agassiz, and supposing that, after an epoch of time, there should be a contrary, slow movement or depression of the same land, and that from the start this depression should be accompanied by the introduction of fresh-water lakes, of swamps, &c., the growth of extensive bogs, and the formation of peat-beds by plants; that over it a succession of shales and sandstone should be formed by more rapid depression and the invasion of muddy or sandy water, &c., the result of this heaping-up of new materials would represent, of course, a more recent formation, characterized by its remains of fossil plants, this, under or below the level of a more ancient one, characterized by its fossil invertebrate animals, &c.

5th. In recording the opinions of geologists, who, by their researches, have furnished materials (animal fossils) as evidence of the Cretaceous age of the Lignitic, I quoted Professor Meek's passage of a letter, where his opinion is exposed rather in favor than in contradiction of mine. Of course, I was not then informed of his conclusions published later. We have now, in the report of Dr. Hayden for 1872, (pp. 431–462,) the result of the researches of this careful observer, tending to prove that the Lignite deposits of Coalville have been positively recognized underlying strata characterized as Cretaceous by their remains of mollusks. As no fossil plants have been discovered in connection with these coal-beds, except the omnipresent fucoid, *Halimenites major*, no argument can be put forward from the comparison of vegetable fossil remains. It is, however, remarkable that the constitution of the Lignite of Coalville, the thickness, the distribution of the beds, is about the same as that of Evanston; so similar, indeed, that the more experienced miners and superintendents of the mines at Evanston and other places consider these Lignitic beds as the same. The difference of fixed carbon in the lignite of the two localities is only 1 per cent.; that in the proportion of water, only 2; in volatile matter, only 3. And if we admit that the chemical compound of the coal and the lignite, like that of the peat, depends especially from the original constituents, the plants, we have in this fact of identity of chemical compounds more than a probability of a homogeneity of original or vegetable components. In this case the discussion is recalled to this point, as remarked above: the whole Lignitic being a homogeneous formation, we have to decide if it is Cretaceous or Tertiary.

The locality where the discussion on the relation of fossil remains may be made with the most advantage is that of the Bitter Creek series, where there is an abundance of vegetable remains represented, at Black Butte especially, and of animal fossils, saurians, shells, &c., also found in profusion in the strata of this series from Black Buttes to Rock Springs. In the whole series, neither Professor Meek nor his assistant have found any shells truly characteristic of Cretaceous age; and Professor Meek says himself, (p. 458,) "that although partly committed to the opinion that this formation belongs to the Cretaceous, and still viewing it as most probably such, he does not wish to disguise or conceal the fact that the evidence favoring this conclusion, to be derived from the mollusks alone, as now known, is by no means strong and convincing." As from the flora of Black Butte we do not have any identical or intimately related species to the Cretaceous plants, as all the types are Tertiary, even a large number Miocene, the conclusion

is forcibly in favor of the Tertiary age of the Lignitic. Nearly one-half of the species of fossil plants found at Black Butte are identical with or closely related to Eocene and Miocene species of Europe. On this subject even the invertebrate animals seem to point out to the same conclusions; for Professor Meek remarks, (*loc. cit.*, p. 460,) "that he found directly associated with the reptilian remains of Black Butte (that saurian imbedded in Tertiary leaves) a shell which he cannot distinguish from *Viviparus trochiformis*, originally described from the Lignitic formations at Fort Clark, on the Upper Mississippi, a formation that has always been regarded as Tertiary by all who have studied its fossils, both animal and vegetable." The whole discussion on the subject, continued by Professor Meek, and reviewed clearly on the following pages, (pp. 461–462,) establish the same fact, that paleontological evidence from remains of invertebrate animals is rather in favor of the Tertiary than of the Cretaceous age of the group.

The conclusion of Professor Cope amounts to this: that from the Dakota group to the top of roof of the Black Butte main coal he met with an uninterrupted series of animal Cretaceous remains, mollusks in the lower beds and vertebrates in the higher, proving that the beds are Cretaceous(!). Comparing this with the flora of the Lignitic, he concludes that a Tertiary flora was contemporaneous with a Cretaceous fauna, establishing an uninterrupted succession of life across what is generally regarded as one of the greatest breaks in geological time.

This conclusion does not appear to exactly conform to facts, at least on the point of view of vegetable paleontology, for on this account, and contrary to what is remarked by Professor Cope in following his researches on the bones of extinct species of animals, we have from the Dakota group to the lowest strata of the Lignitic, or to the same bed at Black Butte, where the bones of that dinosaurian were found, an evident and total break in the succession of vegetable type, quite as marked as it can be in passing from the Jurassic to the Cretaceous. This anomaly may be explained in considerinig this fact: that the flora is in direct collateral relation with atmospheric circumstances which do not influence, at least not in the same way and with the same activity, the marine world and the land vegetation. Morever the lower Eocene of Europe has a series of clay beds bearing remains of land plants. They are intermediate, it seems, between the upper Cretaceous and the Lignitic formations, and thus indicate long periods of time sufficient to account for great modifications in the flora.

6th. Leaving aside these considerations, which bear indirectly on the subject, I have to come back to the question of the precedence which in a case like this should be accorded to fossil plants, for the determination of the age of the formation; for I cannot leave without contradiction a critical remark made against the report of last year, which, among others, says:*

Mr. Lesquereux has met the statements of Professors Meek, Cope, and Marsh, that Cretaceous mollusks had been found in and overlying the Colorado lignite deposits, by pointing to his 250 species of fossil plants, claiming that they far outweigh the testimony of the animal remains. In fact, however, these fossil plants have little bearing on the question.

The absence of fossil mollusks in the Colorado basin has been proved; but even admitting the contrary, and taking as an analogous case the coal of Black Butte, over which the skeleton of a dinosaurian, *Agathauma sylvestris*,† has been found imbedded into leaves of Eocene plants, shall we for the reason of the presence of these Cretaceous remains, still more

* Dr. Newberry, in Journal of American Arts and Sciences, vol. vii, April, 1874, p. 403.
† Cope, Second Bulletin of the United States Geological Survey.

important as characteristic than mollusk, admit the formation as Cretaceous, and consider the plants as without bearing on the question? I have last year spent some days at Black Butte and in the surrounding country, and may here record the observations which, related to this question, may not find their place elsewhere.

The Saurian bed, as it is now called, is at the top of the ridge facing the depot, at a short distance, half a mile east from it. The *débris* taken out in digging the bones of the animal are still mixed with a quantity of fragments of these bones, and some of the specimens are remarkably interesting, bearing as they do, fragments of bones on one side and fossil leaves on the other. The bed is a kind of arenaceous clay, mixed with ashes, and hardened to the consistence of brick by the combustion of the underlying beds of coal. It overlies, east of the station, three alternate ridges of whitish weathered sandstone of the thickness, taken altogether, of 96 feet, being 10 feet 8 inches above the upper ledge, which is a compact, white, hard sandstone, 10 feet thick, and is exposed and can be followed easily to the south for about a quarter of a mile, where the main coal-bed of Black Butte is worked. At this place the section in descending order is:

12. Fire-clay and shaly sandstone, 9 feet.
11. Yellow sandstone, 6 feet.
10. Shale and coal-brash, 1 foot.
9. Shaly sandstone and plants, 12 feet.
8. Coal, 3 to 5 feet.
7. Fire-clay, 2 to 7 feet.
6. Main coal, 5 to 7 feet.
5. Fire-clay, 5 feet.
4. Clay, capped with slaty sandstone, 5 feet 4 inches.
3. Coal, 3 feet.
2. Shale and clay, with oysters, 7 to 10 feet.
1. White sandstone, 10 feet 8 inches.

This sandstone, being the same as the upper sandstone under the Saurian bed, the former section shows the exact horizon where the bones have been found as within or above the lower 3-foot bed of coal No. 3, separated by 10 feet of fire-clay from the main Black Butte coal. It is very probable that both coal-beds disjointed, at the locality of the Saurian, by a mere clay parting, were destroyed by fire under the stratum of clay. Anyhow, I did not find in connection with the bones any species of plants differing specifically from those found in the sandstone No. 9 above the upper coal. The specimens represent *Sabal*, *Viburnum dichotomum*, *Ficus planicostata*, *Myrica Torreyi*, *Aleurites eocenica*, *Paliurus zizyphoides*, some stems, *Caulinites*, and fragments of leaves of a *Platanus*, whose middle part only is preserved, and which may be referable to *P. Haydenii*, the only kind of plant which was not recognized in the shale of the main coal. The case is clear: from all the fossil plants described from Black Butte none is referable to a Cretaceous species; they are all Tertiary, and force the admission made by Professor Cope in his review (*loc. cit.*, p. 16) that here a Tertiary flora is contemporaneous with a Cretaceous fauna. Now, this flora is typical for the compounds of the coal-strata, and, of course, the coal-strata are Tertiary. What shall be the name of this formation; is it Cretaceous on account of the saurian bones, or is it Tertiary on account of the fossil plants in which the skeleton is entombed, and which are found of the same relation all over the Lignitic formations, and at some places, as at Golden, the Raton, &c., from its base to the upper strata, and which two have entered into the composition of its essential strata, the Lignite? No geologist, I think, will hesitate a moment in pronouncing it, from its

land-character, a Tertiary formation, therefore giving the precedence to the fossil flora over the fossil fauna for the determination of the age of this formation. It is, then, evident that the fossil plants have some weight and must decide.

7th. This brings me to the essential question which has to be examined in considering the relation of the age of the fossil plants of the Lower Lignite of the Rocky Mountains.

Though the flora is evidently related to that of the Tertiary of Europe by a large number of its species, it is, however, difficult to point out with uncontestable evidence to what stage of this Tertiary the relation is the more intimate. To come to an understanding on this subject, we have to compare the American fossil species with those known as yet from the publications of European authors, and at once are met with a scarcity of materials, especially from the Lower Tertiary strata or the Eocene, to which, considering the position of the Lignitic, its flora should be especially related. The Tertiary of Europe seems to have been, as expressed by Dr. Ettinghausen in his Contributions to the Radoboj Flora, "a kind of universal vegetable repository, representing types of all the regions of the world; a seminarium, which hereafter dispersed its offsprings over the whole surface of the earth." This conclusion is not my own. I should only say that the European Tertiary formations have been the recipient of species representing an heterogeneous vegetation, type of multiple and local changes. But this matter is out of the subject; we have only to record the fact that, so mixed in their *facies* are the floras of the Tertiary basins of the Old World that as yet no reliable delimitation has been established for the stages which they represent.*

In considering the characters of our Lower Lignitic flora, a critic has asserted that its genera are all, as well as the species, without relation to Eocene vegetable types of Europe, quoting as a proof of his assertion the flora of Mount Bolca, and that of Shepey in England. This last flora is merely known by fruits whose forms or species have been described and figured by Bowerbank, and which are heaped in prodigious quantity in the so-called London clay of England. This Eocene flora, however, cannot be taken for America any more than it has been for Europe as a point of comparison, for it has no leaves, and its fruits, of various and uncertain affinity, have as yet not been found elsewhere in the Tertiary of Europe, except a few *Nepadites*, merely mentioned (not described yet) from the Eocene of Mount Bolca. These Shepey fruits, as Heer remarks, are not characteristic of the formation, even say nothing in regard to the climate of the locality where they are found, as, from appearance, they have been floated down some river for a great distance, and are analogous to present deposits of this kind at the mouth of the Ganges. The Eocene flora of the Isle of Wight, at Alumbay, is represented by numerous leaves of *Aralia*, *Daphnogene*, *Ficus*, *Zizyhus*, *Cæsalpinia*, &c., which, according to Heer, have such a marked tropical and subtropical character that the fruits of Shepey may have been derived from the plants of this locality. These Alumbay leaves, to quote the same authority, are similar to species of Mount Bolca; three species are identified as the same, and three others are closely related. But also a number of them are Miocene; as, *Quercus lonchitis; Laurus primigenia; Myrica (Diandra) acutiloba; Cassia phascolites;* or four species,

* Since writing this, the third and last volume of W. P. Schimper, *Palontologie végétale*, has appeared. The author, considering the vegetable groups of the Tertiary, divides the formation in the five following stages: *Paleocene*, intermediate to the Cretaceous and Tertiary; *Eocene, Oligocene, Miocene,* and *Pliocene.* The relation of our Lignitic vegetation seems to be with the Oligocene.

and four other species, *Laurus Forbesii*, *Daphnogene anglica*, *Quercus Burmensis*, and *Juglans Laharpii*, are related to Miocene species in the same degree. From this, it seems, the conclusion should be in favor of a more intimate relation of the flora of Alumbay, which is positively recognized of Eocene age, with that of the European Miocene than with that of Mount Bolca; for it has only six species identical or in relation with the Mount Bolca flora, while it has eight, bearing the same degree of relation to the Miocene. Some of the species of the North American Lignitic are identical with or closely related to those named by Heer. *Quercus furcinervis* is probably identical with *Q. Burmensis;* for, in many of the numerous American specimens of this species, the absence of an upper branch of the lateral veins, which, according to Heer, is the essential character which separates these two species, is positively remarked. *Daphnogene anglica*, is as positively identified as it can be from the short description given by Heer, it being different from *D. melastomacea* by the symmetrical form of the leaves and the branching of the lateral nerves. Heer says that the middle nerve is also branching. In our specimens it is simple; in Unger's species neither the lateral nor the middle vein branches. Though these species re-appear in some forms of the Miocene of Europe, they should be considered, I think, rather as Eocene than as Miocene types.

The Mount Bolca flora is represented by a large number of specimens of leaves and fruits disseminated in the numerous museums of Italy. Until now few of the species which they represent have been satisfactorily described. The little which is known of this flora is from the table of families furnished to Professor Heer by Professor Massalongo, and published with remarks in Fl. Tert. Helv., (vol. iii, p. 275.) This table has 53 groups of plants, among which the more numerously represented are: *Algæ*, 48 species; *Podocapeæ*, 5; *Palms*, 7; *Proteaceæ*, 5; *Ericaceæ*, 10; *Sterculiæ*, 10; *Buttneriaceæ*, 14; *Myrtaceæ*, 8, &c.; and among the species the most abundant, *Eucalyptus Italica*, Mass.; *Eugenia laurifolia*, Mass.; *Guayacites Heerii*, Mass.; *Zanthoxylum ambiguum*, U.; *Ficus Bolcensis*, Mass., which Heer says is similar to *F. multinervis* of the Miocene; *Santalum memecyloides*, Mass.; *Aralia primigena*, de la H.; in all ten species not described but briefly remarked upon by Heer. From the characters of the Mount Bolca flora as indicated in this exposition of Heer, it does not appear, indeed, that our Lower Lignitic flora has any marked relation to it; but the scantiness of materials, together with the uncertainty of the characters of a number of species named by Massalongo, renders a comparison impossible. Heer himself, in his exposition, remarks on this insufficiency of reliable characters. He, for example, counts only four species of Mount Bolca as represented in the Miocene of Europe, and a few more as closely related to Miocene species. He mentions among those ascending to the Molass of Switzerland, *Banksia longifolia* and *Dryandra Veronensis*, two species which have close relation with species of our Upper Miocene, the Green River group, rather than with species of the Lower Lignitic. Since Heer's short review of the Mount Bolca flora was published, in 1859, paleontology has not received any more precise information in regard to its characters. Schimper, in his Vegetable Paleontology, 1873, mentions only from this locality, besides 21 species of marine plants or fucoids, *Cyperites Bolcensis*, Mass., considered or described formerly by the same author as a *Flabellaria; Halochloris cymodoceoides*, Ung., also found at Soltzka; *Potamogeton tritonis*, U., and *P. nayadum*, U.; *Typha spadæ*, Mass., a species which Schimper supposes to be made from the leaves of some *Cyperaceæ;* five forms of *Castallinæ*, fruits comparable to the *Nepadites* of the London clay, representing probably a single species; *Latanites parvulus*,

Mass., a palm; *Lomatia Bolcensis*, U.; *L. latior*, Heer, of which a small broken part is figured in the Baltic Flora, and to which one of the most abundant species of Black Butte *Myrica Torreyi*, Lesqx., so much resembles by its peculiar nervation and by the form of the leaves that better specimens only of the European plants can decide between positive identity or a very close relation; *Myrica Meneghini*, U., of a type represented with us in the Upper Tertiary of South Park; and *Daphnogene Veronensis*, Mass., which Schimper compares to *Cinnamomum Scheuchzeri*. This is all that is positively known of the flora of Mount Bolca. It is impossible to consider it as a kind of typical flora of the Eocene of Europe, and to assert that if we cannot point out any of our Lignitic species as identical with this flora, it is for that reason deprived of the character of the Eocene vegetation.

France has in the deposits of the old Travertins of Sezane a number of species whose types seem to be intermediate between the Cretaceous species and those of the Upper Eocene. This flora is known by the admirable work of Count Saporta,* who describes in it a *Sassafras* comparable to *S. Mudgii*, and leaves of *Magnolia*, related to *M. alternans* and *M. capellini*, three species described from the Dakota group. A number of forms of this Lower Eocene flora are also related to the Tertiary species of Europe, especially to those of the Mount Promina flora; and with our Lignitic flora it has closely allied two of the more characteristic and more abundant species of Black Butte, *Sterculia variabilis*, Sap., distinguishable only from *Ficus planicostata* by the unequal lateral base of the European leaves, and the beautiful *Viburnum giganteum*, related, by its size and nervation, to *V. marginatum*. Besides this, it has *Asplenium subcretaceum*, Sap., intimately related to the species which I have described as *Sphenopteris eocenica*, most abundant at Golden; *Cissus primæva* to *C. lobato-crenata*, also abundant at Black Butte and in the Colorado Lignitic basin, Mount Brosse, &c.; *Cornus platiphylla*, related to *C. impressa*. These all show affinity indeed to a flora so positively marked as Lower Eocene, that some of its types are still Cretaceous.

I have admitted, as indication of the Eocene age of our Lignitic flora, the great abundance of fucoidal remains, or of marine plants, in the underlying sandstone of the Lignitic, a character remarked in the sandstone of Mount Bolca, and also of the Flysh of Switzerland. One of the few species which I have as yet been able to describe, from the difficulty of obtaining specimens, *Halimenites minor*, is known from this last formation. Besides this, a comparatively large number of species of ferns, some of them identical with species of *Promina: Goniopteris polypodioides*, Ett., and *Sphenopteris eocenica*, or with that of Boernstadt: *Diplazium Muelleri;* then a great proportion of remains of palms, referable to as many species as have been described from Europe at least, some of them identical with species of Promina, Boernstadt, Häring, representing, like *Flabellaria latania*, *F. longirachis*, *F. Zinkeni*, some of the more ancient forms of palms recognized in the Ctenzoic times. The remarkable preponderance of palm remains has been mentioned from all the stations of the Lower Lignitic where fossil plants have been discovered: Vancouver, Fort Union, Black Butte, Golden, Sand Creek, Gehrung's, Cañon City, Raton Mountains, Placière, the Mississippi, &c. They have given to the vegetation of the epoch a subtropical character, marked still by a number of species of *Ficus* of the broad-leaved and palmately-three-nerved group, most of them new species, and none of the type of the lanceolate-pinnately-nerved leaves like *Ficus lanceolata*, *F. multinervis*, &c., which, with us

*Prodrome d'une flore fossile des Travertins anciens de Sezane, (1868.)

at least, represent types of the Upper Miocene only. Among species of the other genera of Eocene type, the Lignitic flora has still *Myrica Torreyi* of Black Butte, possibly identical, as seen above, with a *Lomatia* of Mount Bolca; three species of *Platanus*: *P. Haydenii*, *P. Raynoldsi*, *P. rhomboides*, without any affinity with any of the Cretaceous or of the Miocene species known as yet; *Artocarpidium olmediæfolium*, U., described by the author from Sotzka; a fine new species of *Pisonia*, *P. racemosa*, allied to *P. eocenica*, Ett., of Häring, as well by the seed (or unopened buds) as by the leaves; *Daphnogene anglica* (?), which has been remarked upon as found at Alumbay; two species of *Nelumbium*, related to *N. Buchi*, Ett., of *Promina; Eucalyptus Häringiana*, of Häring; *Dombeyopsis grandifolia*, U., of Sotzka; a number of species of *Rhamnus* of a peculiar type, comparable, by the form of the leaves and the nervation, to tropical species of *Bridelia*. These can be considered as already giving to the flora of the Lignitic, in comparing it to that of Europe, an Eocene facies.

But we have in America a more reliable point of comparison, still forcing the conclusion that if even the Lignitic flora of the Rocky Mountains had no relation whatever to that of Europe, it should, notwithstanding, be considered as Eocene. I allude to the flora of the Mississippi, described from very good specimens obtained from such a lower stratum in the Tertiary that its reference to this formation rather than to the Cretaceous was for a long time uncertain. In the Geological Report of the State of Mississippi, Prof. Eug. V. Hilgard has given (p. 108) a section of the general distribution of the strata in the geological formations of the State, marking the place of the Lignitic of the Mississippi State and of the formations where his fossil plants were found as underlying the Vicksburgh and Clayborne beds, which form the upper stage of the American Eocene, the Lignitic representing the lower one. The correlation of the Mississippi fossil flora with that of Golden and of Black Butte is evident enough. Of the Mississippi plants, the following have been recognized in the Western Lignitic: *Sabal Grayana*, Vancouver; *Populus monodon*, Raton Mountains; *P. mutabilis*, Black Butte, Raton Mountains, Vancouver; *Quercus chlorophylla*, Golden; *Quercus crassinervis*, Vancouver; *Ficus Schimperi*, intimately related to *F. platinervis*, as widely represented at Black Butte, Golden, &c., as the former is in the South; *Laurus pedata*, Raton Mountains; *Cinnamomum Mississippiense*, one of the most prevalent species of the Western Lignitic; *Magnolia Hilgardiana*, Raton Mountains; *M. Lesleyana*, Raton and Golden. This, without mentioning a number of closely-allied species and the identity of genera, gives to both the floras of the Mississippi and of the Western Lignitic formation a general character which can but be recognized as identical.

After all this, we remark in our Eocene flora some characters which may be called negative, namely, the absence of certain groups of plants represented either in the Cretaceous or in the upper groups of the Tertiary. No species has been discovered in the Lignitic which had been described from the Dakota group. This is the more remarkable that some peculiar types of this group, like *Liriodendron*, *Sassafras*, &c., re-appear above the Lignitic in the Evanston or second group, and in still greater numbers in more recent Tertiary divisions; and that even one of its rare species, *Cinnamomum Scheuchzeri*, is also absent until now, at least in the lower group, and present in the same second group and above. Heer remarks, in considering the fossil flora of Mount Bolca, the absence of representatives of a number of genera or families which take an important place in the Miocene, thus: *Salicineæ*, *Acerineæ*, *Cupuliferæ*, *Betulaceæ*, *Ulmaceæ*, *Abietineæ*, &c.

The absence of these types is as remarkable in the Lignitic flora as in the Eocene of Mount Bolca. While the upper group of our Tertiary abounds with conifers, *Abietineæ*, 11 species in 81, the Lower Lignitic has only two, one as yet of uncertain affinity, *Abietites dubius*, and two species of *Salisburia*, in nearly 200 species; of the *Salicineæ* it has only three species, two of which, *Salix tabellaris* and *S. densinervis*, both described from the Mississippi Eocene, are uncertain, the last, perhaps, an *Acacia*. It has also no species of *Acer*, none of *Betula*, *Alnus*, *Carpinus*, *Corylus*, &c.; no species of *Ulmus*, except one doubtful, with entire borders; for it is, indeed, the absence of leaves with dentate or serrate borders which is the more remarkable character of this group as well as of the Cretaceous; *Quercus furcinervis* and *Q. saffordi*, (perhaps a *Myrica*,) make with the *Viburnum maginatum* and its related species an exception, which is also remarked in the Cretaceous types *Q. primordialis* and some peculiar leaves with equal teeth turned outside and separated by obtuse sinuses, just of the same form as in this *Viburnum* of the Eocene. It is not to be denied, as seen in the comparative table, that a number of species of our Lower Lignitic are found in the two following groups of Evanston, Carbon, and even a few in the Green River group. But we have seen the same in the Eocene, even the Lower Eocene flora of Europe, and cannot from this reason admit that our Lower Lignitic flora is not Eocene, because some of its types have passed up to the other groups of the Tertiary.

§ 2.—DISTRIBUTION OF THE FOSSIL PLANTS IN THE DIFFERENT GROUPS OF THE TERTIARY.

The succession of the strata of the Lower Lignitic in relation to the distribution of the coal strata and to that of the fossil plants which characterize the formation is not positively known. The section at the Raton Mountains near Trinidad records an alternation of sandstone, shale, clay-beds, &c., 300 feet thick, with five beds of lignite, measuring altogether 11 feet 6 inches. Here the fossil plants are found in sandy shale at the base of No. 6 or in the upper part of No. 7 (Report for 1872, p. 319) in the middle of the section. At Cañon City, as indicated by Mr. Clark's section, (*loc. cit.*, p. 323,) the main coal 2 feet 2 inches is overlaid by shale, clay or thin coal, and a sandstone, over which, in No. 15, are found leaves of *Sabal* and of *Platanus Haydenii*, about 70 feet above the coal. At Gehrung's coal, near Colorado City, a shale bearing an abundance of *Sabal* leaves, *Ficus*, *Platanus Haydenii*, and *Rhamnus*, is also from 60 to 75 feet above the coal opened near by at the base of a compact sandstone. From Marshall a detailed section has been published by Dr. Hayden in his Report for 1869, (second edition, p. 129,) placing the strata bearing fossil plants at No. 22, about in the middle of the section, 200 feet higher than the lower main coal, and about 260 feet from the top. As far as I know, and from the explorations of others as well as from my own, no other strata bearing identifiable plants have been remarked in this section.

At Erie, the coal 8 to 9 feet is worked near the surface; its soft sandy shale is profusely mixed with remains of plants, which, to my regret, could not be examined sufficiently. They represent a few species of the Lower Lignitic of Golden, and also some remarkable vegetable fragments representing species not found elsewhere. As the underlying strata are not known, the position of this coal in the Lower Tertiary measures could not be ascertained. At Black Butte, the main coal, overlaid by soft shaly sandstone, with fossil plants in abundance, a stratum which, as remarked before, is the equivalent of the Saurian bed, is here apparently at the upper part

of a section of 1,000 feet of measures of the productive lignitic.* In going west toward Point of Rocks, in a contrary direction to the dip of the strata, the Hallwell coal, a workable bed, and other Lignitic beds of unimportant thickness, are passed until reaching the abrupt terminus of the ridge near Saltwell. No remains of fossil plants were found in connection with any of these coal strata. From Hallwell to Rock Springs, the dip of the measures is to the west until the upper strata of Lignitic are reached. Near this last place, a bed of coal 4 feet thick is passed, two miles before reaching the station, and here the main coal, 100 feet higher, is worked 6 to 9 feet thick. I was not able to discover any fossil plants in the whole thickness of the measures, and at Rock Springs the coal, which is evidently one of the highest of this group, has not any other plants but the fucoidal *Halimenites*. Its shale, however, is mixed with a profusion of shells. Considering this, it would appear that the upper beds of the Eocene Lignitic are, in Wyoming, the repositories of fossil plants. At Golden we have perhaps the best evidence concerning the distribution of the fossil plants in relation to Lignitic strata. The lowest strata of coal, in close proximity to the Cretaceous, and tilted up to the perpendicular, are interlaid by beds of white hard sandstone, which all, three of them at least in succession, have identifiable remains of fossil plants. The lowest sandstone has especially some species of Fucoids, among which the fine *Delesseria fulva*, together with a quantity of *Sabal*, *Rhamnus Goldianus*, *Platanus Haydenii*, *Quercus angustiloba*, &c. Under the basaltic deposits, which cover the Lignitic on the eastern side of the valley, half a mile distant from the Lignitic beds, the fossil strata bearing plants are horizontal; at some places composed of soft white clay, as east of Golden, on the slopes of North Table Mountains; at others, of shaly sandstone, as northeast of the School of Mines, on South Table Mountains. These deposits are all about at the same altitude of 300 feet above Clear Creek, 60 to 100 feet lower than the base of the lava-beds. They all contain not only the same types but mostly the same species of fossil plants as the sandstone, interlying the Lignitic beds in proximity to the Cretaceous. It therefore appears from this that the flora of the Lower Lignitic has the same characters in the whole thickness of the measures. There may be, of course, some difference in the species, or a predominance of some kinds at a higher or lower station, but the difference has not been yet remarked.

LIST OF THE SPECIES OF THE FIRST GROUP.

[Abbreviations for names of localities, &c.: R., Raton Mountains; P., Placière; G., Golden; M., Marshall's; S. Cr., Sand Creek; B. B., Black Butte; Y. St., Yellow Stone; Miss., Mississippi; V., Vancouver; Mo., Miocene; Gr., Group.]

Spheria lapidea, Lesqx.—R.
S. myricæ, Lesqx.—B. B.
Sclerotium rubellum, Lesqx.—G.
Opegrapha antiqua, Lesqx.—B. B.
Chondrites subsimplex, Lesqx.—R.
C. bulbosus, Lesqx.—R.
Delesseria fulva, Lesqx.—G.
D. incrassata, Lesqx.—R.
D. lingulata, Lesqx.—R.
Halymenites striatus, Lesqx.—G., R.
H. major, Lesqx.—G., R., B. B., (Gr. 2, 3.)

* Professor Meek estimates it to at least double this thickness, and considers the lower unproductive strata of this formation as Cretaceous. No evidence is afforded on this subject by vegetable remains.

H. minor, F. Os.—G.
Woodwardia latiloba, sp. nov.—G.
W. latiloba, var. minor.—B. B.
Pteris pennæformis, H.—G., Mo.
P. anceps, Lesqx.—G.
P. affinis, sp. nov.—G.
P. erosa, Lesqx.—R. G. (Gr. 4.)
P. subsimplex, sp. nov.—G.
P. Gardneri, sp. nov.—S. Cr.
Diplazium Muelleri, Heer.—G.
Aspidium goldianum, sp. nov.—G.
Goniopteris polypodioides, Ett.—S. Cr.
Sphenopteris eocenica, Ett.—G.
S. membranacea, sp. nov.—G.
S. nigricans, sp. nov.—B. B.
Hymenophyllum confusum, sp. nov.—G.
Gymnogramma Haydenii, Lesqx.—R., (Gr. 2.)
Lygodium compactum, Lesqx.—Miss.
Selaginella Berthoudi, sp. nov.—G.
Equisetum lævigatum, sp. nov.—S. Cr.
Sequoia Langsdorfi, A. B.,—B. B. V.—Mo., (Gr. 4.)
Abietites dubius, Lesqx.—R., G., (Gr. 2.)
Salisburia binervata, Lesqx.—Miss.
S. polymorpha, Lesqx.—V. (Gr. 2.)
Arundo Goepperti, A. Br.—R.—Mo.
Phragmites œningensis, A. Br.—R., G., M., B. B.—Mo., (Gr. 2, 3, 4.)
Carex Berthoudi, Lesqx.—G.
Smilax grandifolia, U.—G.—Mo., (Gr. 3.)
S. obtusangula, Heer.—B. B.
Sabal Grayana, Lesqx.—V., Miss.
S. Campbellii, Ny.—R., G., B. B., &c.
S. Goldiana, sp. nov.—G.
S. major, U.—G.
Flabellaria zinkeni, Heer.—G.
F. latania, St.—G.
F. eocenica, Lesqx.—B. B.
F. longirachis, U.—R., Y. St.
F. fructifera, sp. nov.—G.
Calamopsis Danai, Lesqx.—Miss.
Palmacites, species.—G.
Caulinites sparganioides, Lesqx.—B. B., (Gr. 2 and 3.)
C. fecunda, Lesqx.—M.
Eriocaulon porosum, sp. nov.—S. Cr.
Zingiberites undulatus, sp. nov.—G.
Rhizocaulon gracile, sp. nov.—B. B.
Populus attenuata, Goepp.—G., B. B.—Mo., (Gr. 3.)
P. monodon, Lesqx.—Miss., R.
P. mutabilis, A. Br.—B. B., Miss., R., V.—Mo., (Gr. 2 and 3 in var.)
P. balsamoides, Goepp.—P.—Mo., (Gr. 2.)
P. leucophylla, U.—B. B.—Mo., (Gr. 2.)
P. heliadum, U.—G.—Mo.
Salix integra, A. Br.—G., B. B.—Mo.
S. tabellaris, Lesqx.—Miss.
S. (?) densinervis, Lesqx.—Miss.
Myrica Torreyi, Lesqx.—B. B.
M. Torreyi, var. minor.—S. Cr.
Betula gracilis, sp. nov.—G.

Ulmus irregularis, Lesqx.—R., G.
Celtis brevifolia, Lesqx.—Miss.
Quercus angustiloba, A. Br.—G.
Q. Moorii, Lesqx.—Miss.
Q. platinervis, Lesqx.—V.
Q. Lyelii, Heer.—Miss.—Mo.
Q. retracta, Lesqx.—Miss.
Q. chlorophylla, U.—G., Miss.—Mo., (Gr. 2.)
Q. triangularis, Goepp.—G.—Mo.
Q. stramineus, Lesqx.—G.
Q. Wyomingiana, Lesqx.—B. B.
Q. furcinervis, Rossm.—Oregon, G.—Mo.
Q. Goldianus, sp. nov.—G.
Q. Saffordi, Lesqx.—Miss.
Q. crassinervis, U.—Tenn., V.
Q. multinervis, Lesqx.—V.
Q. Benzoin, Lesqx.—V.
Q. myrtifolia (?), W.—Miss.
Q. attenuata, Goepp.—S. Cr.
Q. Cleburni, sp. nov.—B. B.
Fagus feroniæ, U.—G.—Mo., (Gr. 4.)
Ficus Schimperi, Lesqx.—Miss.
F. cinnamomoides, Lesqx.—Miss.
F. tiliæfolia, Al. Br.—P., B. B., S. Cr., G., &c.—Mo., (Gr. 2 and 3.)
F. planicostata, Lesqx.—B. B.
F. planicostata, var. latifolia.—B. B., M.
F. planicostata, var. Goldiana—G., S. Cr.
F. Clintoni, Lesqx.—B. B.
F. asarifolia, Ett.—G.—Mo.
F. zizyphoides, sp. nov.—G.
F. spectabilis, Lesqx.—G.
F. auriculata, Lesqx.—G., (Gr. 2.)
F. truncata, sp. nov.—G.
F. corylifolia, Lesqx.—B. B.
F. ulmifolia, Lesqx.—R.
F. Haydenii, Lesqx.—B. B.
Platanus Raynoldsii, Ny.—B. B.
P. Haydenii, Ny.—G., R.
P. rhomboidea, sp. nov.—G.
P. Guillelmæ (?), Goepp.—B. B. (?), R.—Mo., (Gr. 3.)
Artocarpidium olmediæfolium, U.—G.—Mo.
Pisonia racemosa, sp. nov.—B. B.
Laurus pedata, Lesqx.—R., Miss.
L. colombi, Heer.—V.
Persea lancifolia, Lesqx.—Miss.
Benzoin antiquum, Heer.—B. B., G.—Mo.
Cinnamomum Mississippiense, Lesqx.—Miss., R., P., G., M., (Gr. 2 and 3.)
C. Rossmæssleri, Heer.—G.—Mo., (Gr. 2.)
C. Heerii, Lesqx.—V.
Elæagnus inæqualis, Lesqx.—Miss.
Banksia helvetica, Heer.—Miss.—Mo.
Andromeda Grayana, Heer.—R., V.—Mo., (Gr. 2.)
A. dubia, Lesqx.—Miss.
A. vacciniæfoliæ affinis.—Miss.
Diospyros stenosepala, Heer.—Y. St.—Mo.
D. brachysepala, Heer.—S. Cr., B. B.—Mo.
D. lancifolia, Lesqx.—V., (Gr. 2.)

D. anceps, Heer.—B. B.
Sapotocites americanus, Lesqx.—Miss.
Viburnum marginatum, Lesqx.—B. B.
V. Wymperi, Heer.—B. B.—Mo.
V. contortum, Lesqx.—B. B.
V. Lakesii, sp. nov.—G.
V. dichotomum, Lesqx.—B. B., R.
Cornus incompleta, Lesqx.—M.
C. Studeri, Heer.—G.—Mo., (Gr. 2.)
C. Holmesii, sp. nov., S. Cr.
C. orbifera, Heer.—G.—Mo.
Cissus lævigata, Lesqx.—G.
C. lobato-crenata, Lesqx.—B. B., (Gr. 2.)
Vitis tricuspidata, Heer.—B. B.—Mo.
Nelumbium tenuifolium, sp. nov.—S. Cr.
N. Lakesianum, sp. nov.—G.
Magnolia Hilgardiana, Lesqx.—R., Miss., (Gr. 2.)
M. laurifolia, Lesqx.—Miss.
M. Lesleyana, Lesqx.—G., Miss., R.
M. ovalis, Lesqx.—Miss.
M. cordifolia Lesqx.—Miss.
M. Inglefieldi, Heer.—B. B.—Mo., (Gr. 3.)
Terminalia radobojensis, U.—R.—Mo.
Asimina (?) leiocarpa, Lesqx.—Miss.
Eucalyptus Hæringiana (?) Ett.—B. B.—Mo.
McClintockia Lyallii (?) Heer.—B. B.—Mo.
Dombeiopsis trivialis, Lesqx.—G.
D. occidentalis, Lesqx.—G.
D. grandifolia (?), U.—G.—Mo.
D. obtusa, Lesqx.—R.
Acer (?) secreta, Lesqx.—R.
Sapindus undulatus, Lesqx.—Miss.
S. caudatus, Lesqx.—G., B. B.
Aleurites eocenica, Lesqx.—B. B.
Zizyphus distortus, sp. nov.—G.
Paliurus zizyphoides, Lesqx.—B. B., M.
Ceanothus fibrillosus, Lesqx.—G., B. B.
Berchemia parvifolia, Lesqx.—G., R.
Rhamnus marginatus, Lesqx.—Miss.
R. obovatus, Lesqx.—G., R., M., (Gr. 2.)
R. deletus, Heer.—R.—Mo.
R. Fischeri, Lesqx.—R.
R. salicifolius, Lesqx.—M., G., B. B.
R. rectinervis, Heer.—B. B., G., M.—Mo., (Gr. 2.)
R. Dechenii, Web.—B. B.—Mo.
R. acuminatifolius, W.—G.—Mo.
R. Goldianus, Lesqx.—G.
R. Goldianus, var. latior.—G.
R. Cleburni, Lesqx.—G., B. B.
R. discolor, Lesqx.—B. B.
R. inæqualis, sp. nov.—G.
R. alaternoides Heer.—G.—Mo.
R. Meriani, Heer.—B. B.—Mo.
Xanthoxylon dubium, Lesqx.—R.
Juglans appressa, Lesqx.—Miss., (Gr. 2.)
J. Saffordiana, Lesqx.—Miss.
J. rugosa, Lesqx.—M., G., B. B., (Gr. 2 and 3.)

J. Smithsoniana, Lesqx.—R., G.
J. Schimperi, Lesqx.—G., M., (Gr. 4.)
J. rhamnoides, Lesqx.—G., B. B., (Gr. 2.)
J. Baltica (?) Heer.—B. B.—Mo.
Cercis eocenica, Lesqx.—M.
Phyllites truncatus, Lesqx.—Miss.
P. Mahoniæformis, Heer.—V.
Carpolithes palmarum, Lesqx.—B. B., G., R., (Gr. 2.)
C. falcatus, Lesqx.—B. B.
C. spiralis, Lesqx.—P.
C. compositus, Lesqx.—P.
C. Mexicanus, Lesqx.—P.

REMARKS ON THE SPECIES OF THE FIRST GROUP.

In looking for the species which characterize essentially this group, and may be considered as leading species of the Lower Lignitic, we have first to eliminate those which, as omnipresent Tertiary species, are about equally distributed in at least three stages of the Tertiary measures. They are considered as typical for the whole epoch, but cannot be taken as characteristic of any of its subdivisions, no more in this country than in Europe, where they have the same general distribution. Among them we count: *Sequoia Langsdorfi*, *Phragmites Œningensis*, *Arundo Gœpperti*, *Platanus Guillelmæ*, *Ficus tiliæfolia*, *Cinnamomum Scheuchzeri*, *Rhamnus rectinervis*, *Juglans rugosa* and the closely allied *Juglans acuminata*. *Cinnamomun Scheuchzeri* has not been yet discovered in the Lower Lignitic, but has been recently found in the Cretaceous strata of the Dakota group. Of the species as yet known only from American specimens, the ones more generally recognized at different localities of the Eocene Lignitic, are: All the fucoidal or marine remains of plants, especially *Halimenites major;* and in the other classes: *Abietites dubius*, most of the species of *Sabal* and *Flabellaria*, especially *S. Campbellii*, *S. Grayana;* *Caulinites sparganioides*, *Populus monodon*, *Myrica Torreyi*, *Quercus crassinervis*, *Ficus planicostata* and its varieties, *Ficus auriculata*, *Platanus Haydenii*, *P. Raynoldsi*, *Laurus pedata*, *Cinnamomum Mississippiense*, *Viburnum marginatum*, *V. dichotomum*, *Cissus lobato-crenata*, *Magnolia Hilgardiana*, *M. Lesleyana*, *Sapindus caudatus*, *Paliurus zizyphoides*, *Ceanothus fibrillosus*, *Rhamnus oboratus*, *R. salicifolius*, *R. Goldianus*, *R. Cleburni*, *Juglans Smithsoniana*, and *J. Rhamnoides*. To this list, already numerous, we have to add the European species of the Lower Tertiary, recognized in the same circumstances as the former, *Flabellaria latania*, *F. longirachis*, *Quercus chlorophylla*, *Q. angustiloba*, and those which have been already compared to Eocene species of Europe, and found identical and closely allied to them. These, however, have a less extensive distribution than those mentioned above, not only considering the horizontal but also the vertical distribution. None of them has been seen at a higher stage of the American Tertiary, while of the others, *Halimenites major*, *Caulinites Sparganioides*, *Cinnamomum Mississippiense*, *Cissus lobato-crenata*, *Magnolia Hilgardiana*, *Rhamnus obovatus*, ascend up to the second group. Even the four first species named above have representatives in the third division of the Tertiary.

In considering the species of the whole list in regard to their vertical distribution, we find 25 species, or 13 per cent., represented in both groups 1 and 2; 11 species, or 6 per cent., ascend to group 3, and only 5, or 2½ per cent., to the upper division. Of these, *Pteris pennæformis*, *Fagus feroniæ*, and *Juglans Schimperi* have not as yet been

found in the intermediate groups. I have placed in the table of the first group the species of fossil plants described from the Lower Mississippi Tertiary, in order to show their relation to species of the Western Lignitic, a relation which has been remarked already. For the same reason, the species of Vancouver, described from the specimens of Dr. Evans, are placed in the table, indicating, with the flora of the lower group, a relation as evident as that of the Mississippi flora by *Sequoia Langsdorfi*, one of the universal Tertiary species; *Salisburia polymorpha*, recognized at Spring Cañon or of the second group; *Sabal Grayana*, of Mississippi; *Populus mutabilis*, *Quercus crassinervis*, described from Mississippi specimens in the Geological Report of Tennessee;* *Quercus platinervis*,† whose nervation is similar to that of *Ficus planicostata*. *Laurus Colombi* is described by Heer in his flora of Vancouver, together with *Sequoia Langsdorfi*, *Andromeda Grayana*, and *Diospyros lancifolia*. These two last species, however, are from Buzzard Inlet, and are probably referable to an upper stage of the Eocene, as they ascend to the second group in our Western Lignitic measures. The little known, therefore, of the Vancouver flora refers it to this lower stage of the Tertiary.

LIST OF THE SPECIES OF THE SECOND GROUP.

[Names of localities and abreviations: E., Evanston; Sp. C., Spring Cañon, near Fort Ellis; Tr. Cr., Troublesome Creek; Mt. Br., Mount Brosse; E. Cr., Elk Creek; Y. S. L., southern borders of Yellowstone Lake; B. B., Bellingham Bay; Mo., Miocene; Gr. Group.]

Halymenites major, Lesqx.—E., (Gr. 1 and 3.)
Gymnogramma Haydenii, Lesqx.—Sp. C., (Gr. 1.)
Equisetum (!) limosum (?) Lesqx.—Y. S. L.
Abietites dubius, Lesqx.—Sp. C., (Gr. 1.)
Abies setigera, Lesqx.—Sp. C.
Salisburia polymorpha, Lesqx.—Sp. C., (Gr 1.)
Phragmites Œningensis, A. Br.—E.—Mo., (Gr. 1, 3, 4.)
P. Alaskana, Heer.—Sp. C.—Mo.
Cyperites angustior, A. Br.—E. Cr.—Mo.
Cyperus chavannesis, Heer—E.—Mo.
Caulinites Sparganioides, Lesqx.—Sp. C., (Gr. 1.)
Populus arctica, Heer.—E., Tr. Cr.—Mo., (Gr. 3.)
P. mutabilis, var. lancifolia, H.—Sp. C.—Mo., (Gr. 1 and 3.)
P. mutabilis, var. repando-crenata, H.—E., Sp. C.—Mo., (Gr. 1 and 3.)
P. balsamoides, Gp.—Y. S. L.—Mo., (Gr. 1.)
P. leucophylla, U.—Sp. C.—Mo., (Gr. 1.)
P. ovalis (?), Gp.—E.—Mo.
P. Zaddachi, Heer.—Sp. C.—Mo.
Salix Grœnlandica, Heer.—Sp. C.—Mo.
S. Evanstoniana, Lesqx.—E.
S. angusta, A. Br.—Sp. C.—Mo., (Gr. 4.)
S. Islandica, Lesqx.—B. B.
Myrica ambigua, Lesqx.—Sp. C.
Alnus Kefersteinii, Gp.—E., Sp. C.—Mo., (Gr. 3.)
Planera dubia, Lesqx.—B. B.
Betula caudata, Gp.—E.—Mo.
B. Stevensoni, Lesqx.—E., (Gr. 3.)
Quercus platania, Heer.—Sp. C.—Mo., (Gr. 3.)
Q. negundoides, Lesqx.—E.
Q. drymeja, U.—E.—Mo.

* Geology of Tennessee, by James M. Safford, (1869,) p. 427, Pl. K, Fig. 1.
† No specimens of this species are entire enough to show any part of the borders.

Q. Gaudini, Lesqx.—B. B.
Q. Ellisiana, Lesqx.—Sp. C.
Q. Pealei, Lesqx.—Sp. C.
Q. Godeti, Heer.—Sp. C.—Mo.
Q. Laharpi, Gd.—Sp. C.—Mo.
Q. chlorophylla, U.—Sp. C.—Mo., (Gr. 1.)
Q. Evansii, Lesqx.—B. B.
Corylus McQuarryi, Heer.—E., Sp. C.—Mo., (Gr. 3.)
Fagus Deucalionis, U.—E.—Mo., (Gr. 3.)
F. Antipofi, Heer.—E. Cr.—Mo., (Gr. 3.)
Ficus tiliæfolia, A. Br.—Sp. C., E.—Mo., (Gr. 1 and 3.)
Ficus Gaudini, Lesqx.—E.
F. auriculata, Lesqx.—Sp. C., (Gr. 1.)
Morus affinis, Lesqx.—E.
Platanus nobilis, Ny.—E. Cr., E.
P. dubia, sp. nov.—Tr. Cr., Mt. Br.
P. aceroides, U.—E., Sp. C.—Mo., (Gr. 3.)
Laurus primigenia, U.—Sp. C.
L. sessiliflora, sp. nov.—E.
Persea Brossiana, sp. nov.—Mt. Br.
Sassafras, species.—Sp. C.
Cinnamomum Mississippiense, Lesqx.—E., (Gr. 1 and 3.)
C. Scheuchzeri, Heer.—E., Sp. C.—Mo., (G. 4.)
C. crassipes, Lesqx.—B. B.
Cinnamomum Rossmæssleri, Heer.—Sp. C.—Mo., (Gr. 1.)
Andromeda Grayana, Heer.—E., Sp. C.—Mo., (Gr. 1.)
A. reticulata, Ett.—Sp. C.
Persoonia oviformis, Lesqx.—B. B.
Diospiros lancifolia, Lesqx.—E., B. B., (Gr. 1.)
Fraxinus denticulata, Heer.—Sp. C.—Mo.
Cornus impressa, sp. nov.—Mt. Br.
C. Studeri, Heer.—E.—Mo., (Gr. 1.)
Nyssa lanceolata, Lesqx.—Sp. C.
Cissus lobato-crenata, Lesqx.—Mt. Br., (Gr. 1.)
Vitis Olriki, Heer.—E.—Mo.
Liriodendron species.—Sp. C.
Magnolia Hilgardiana, Lesqx.—E., (Gr. 1.)
Acer trilobatum, A. Br.—E., Tr. Cr., B. B.—Mo., (Gr. 3.)
Rhamnus obovatus, Lesqx.—E., (Gr. 1.)
R. acuminatifolius, Web.—Sp. C.—Mo.
R. rectinervis, Heer.—E., Sp. C., (Gr. 1.)
Rhus deleta, Heer.—E.—Mo.
R. Evansii, Lesqx.—E.
R. bella (?), Heer.—Sp. C.—Mo.
Juglans denticulata, Heer.—Sp. C.—Mo., (Gr. 3 and 4.)
J. appressa, Lesqx.—E., (Gr. 1.)
J. rugosa, Lesqx.—Sp. C., E., E. Cr., &c., (Gr. 1 and 3.)
J. obtusifolia, Heer.—E.—Mo.
J. rhamnoides, Lesqx.—E., (Gr. 1.)
J. Woodiana, Heer.—Buzzard Inlet.
Carya antiquorum, Ny.—E.
Cassia concinna, Heer.—E.—Mo.
C. phaseolites U.—Sp. C.—Mo.
Calycites hexaphylla, Lesqx.—E.
Carpolithes arachioides, Lesqx.—E.
C. palmarum, Lesqx.—E., (Gr. 1.)
C. osseus, Lesqx.—E. Cr.

REMARKS ON THE SPECIES OF THE SECOND GROUP.

The flora of group No. 2 seems to be composed of species in part identical with or closely allied to those of group No. 1, or with those of group No. 3. The species of Spring Cañon have, besides those which are represented in the whole Tertiary, *Gymnogramma Haydenii*, *Abictites dubius*, *Salisburia polymorpha*, *Caulinites Sparganioides*, *Ficus auriculata*, or five species considered as Eocene, type of the first group. The same locality has, however, of species represented in the third group, and which are truly Miocene, *Salix angusta*, *Alnus Kefersteinii*, *Quercus platania*, *Corylus McQuarryi*, *Platanus aceroides*, and *Juglans denticulata*, or seven species. The flora of Evanston is mixed in the same way, for it has, in common with the first section, fruits of palms, (no leaves, however, have been found there as yet,) *Magnolia Hilgardiana*, *Rhamnus obovatus*, *Juglans appressa*, *J. rhamnoides*, or five species; and, with the third group, *Populus arctica*, *Betula Stevensoni*, *Fagus Deucalionis*, *Platanus aceroides*, *Acer trilobatum*. This intermixture of types might be explained in supposing that the specimens of Spring Cañon were obtained from different localities; but, as we have the same *facies* at Evanston, this supposition is groundless. Evanston has an enormous thickness of lignite deposits, separated in a number of beds of pure coal by clay partings, or thin intermediate layers of shale and sandstone. Four beds of lignite, measuring altogether 43 feet, are reported in a section of 99 feet*, the middle one, 32 feet thick, being cut by four clay partings. It seems, therefore, that there was at this locality, and perhaps also at Spring Cañon, a protracted formation of lignite beds, continuing, nearly without interruption, from the Lower to the Upper Eocene. I am inclined to consider this group No. 2 as Upper Eocene on account of the conglomerate beds by which it is overlaid. Its flora has, however, a marked character of its own by a number of species which as yet have not been seen out of it: *Salix Evanstoniana*, *Myrica ambigua*, *Quercus negundoides*, *Q. Ellisiana*, *Q. Pealei*, *Ficus Gaudini*, *Morus affinis*, *Platanus dubius*, *Laurus sessiliflorus*, *Calycites hexaphylla*, *Carpolithes arachioides*, &c. All the European species recognized in this group are Miocene. A number of its types, too, mostly found also in the third group, are northern types, arctic or Alaskanian: *Phragmites Alaskana*, *Populus arctica*, *P. Zaddachi*, *Salix Grœnlandica*, *Quercus platania*, *Corylus McQuarryi*, *Fagus antipfi*, *Fraxinus denticulata*, *Vitis olriki*. Taking all together, one-half of this flora is a compound of arctic or of European Miocene species.

LIST OF THE SPECIES OF THE THIRD GROUP.

[Abbreviations for names of localities: C., Carbon; W. G., Wahsatch or Washakie group; M. B., Medicine Bow; R. C., Rock Creek; P. of R; Point of Rocks; Mo., Miocene; Gr., Group.]

Sclerotium pustuliferum, Heer.—C. (?)
Halymenites major, Lesqx.—C., (Gr. 1 and 2.)
Taxodium, dubium, Heer.—C.—Mo., (Gr. 4.)
Sequoia Heerii, Lesqx.—C.
Equisetum Haydenii, Lesqx.—C., (Gr. 4.)
Phragmites Œningensis, A. Br.—M. B.—Mo., (Gr. 1, 2, 4.)
Cyperites, species.—P. of R.
Smilax grandifolia, U.—C.—Mo., (Gr. 1.)
Acorus brachystachys, Heer.—W. G., C.—Mo.
Caulinites Sparganioides, Lesqx.—C., (Gr. 1, 2.)

* Dr. A. C. Peale in Hayden's Report, 1871, pp. 194, 195.

Liquidambar gracilis, Lesqx.—W. G.
Populus arctica, Heer.—W. G., P. of R., M. B., C.—Mo., (Gr. 2.)
P. decipiens, Lesqx.—C.
P. attenuata, A. Br.—R. C., C.—Mo., (Gr. 1.)
P. æqualis, Lesqx.—R. C.
P. mutabilis, var. repando-crenata, A. Br.—C.—Mo., (Gr. 1 and 2.)
P. latior, var. transversa, A. Br.—W. G.—Mo.
P. latior, var. cordifolia, A. Br.—M. B.—Mo.
Alnus Kefersteinii, Gp.—C.—Mo., (Gr. 2.)
Betula Stevensoni, Lesqx.—C., (Gr. 2.)
Quercus platania, Heer.—C.—Mo., (Gr. 2.)
Q. Olafseni, Heer.—P. of R.—Mo.
Q. æmulans, Lesqx.—W. G.
Q. acrodon, Lesqx.—R. C., C.
Q. Haydenii, Lesqx.—R. C.
Corylus McQuarryi, Heer.—C.—Mo., (Gr. 2.)
C. grandifolia (?), Ny.—P. of R.
Fagus antipofi, Heer.—P. of R.—Mo., (Gr. 2.)
Fagus Deucalionis, U.—C.—Mo., (Gr. 2.)
Ficus tiliæfolia, A. Br.—W. G.—Mo., (Gr. 1 and 2.)
F. oblanceolata, Lesqx.—C. (?)
F. lanceolata, Heer.—C.—Mo., (Gr. 4.)
F. multinervis, Heer.—C.—Mo.
F. arenacea, Lesqx.—C.
F. Gaudini, Lesqx.—C.
Platanus aceroides, U.—C., R. C.—Mo., (Gr. 2.)
P. Guillelmæ, Gp.—C., P. of R.—Mo.
Coccoloba lævigata, Lesqx.—C.
Cinnamomum Mississippiense, Lesqx.—C., (Gr. 1 and 2.)
Cinnamomum species.—C.
Cornus rhamnifolia, Heer.—P. of R.—Mo.
C. acuminata, Ny.—W. G.—Mo.
Vitis Islandica (?), Heer.—P. of R.—Mo.
Magnolia Inglefieldi, Heer.—W. G.—Mo., (Gr. 1.)
Asimina miocenica, Lesqx.—C.
Dombeyopsis æquifolia, Gp.—P. of R.—Mo.
Acer trilobatum, var. productum, Heer.—C.—Mo., (Gr. 2.)
Paliurus Columbi, Heer.—W. G., C.—Mo.
Zizyphus Meekii, Lesqx.—C.
Z. hyperboreus, Heer.—C.—Mo.
Rhamnus intermedius, Lesqx.—W. G.
R. Goldianus, var. latior, Lesqx.—C., (Gr. 1.)
Juglans acuminata, A. Br.—W. G.—Mo., (Gr. 4.)
J. rugosa, Lesqx.—C., W. G., P. of R., (Gr. 1 and 2.)
J. denticulata, Heer.—C.—Mo., (Gr. 2 and 4.)
Carpolithes cocculoides, Heer.—C.—Mo., (Gr. 2.)

REMARKS ON THE SPECIES OF THE THIRD GROUP.

The general character of the flora of the third group is positively Miocene. Its types are not mixed with older ones, and indicate for the localities where the specimens were found a higher stage of the Lignitic, which, however, appears to succeed the second group without any marked disturbances. According to the observations of Messrs. Meek and Hayden, the Washakie group is conformably superposed to the Black Butte or Bitter Creek series, without changes of lithological

characters, and there are still at Carbon and other localities a few remnants of the lower Lignitic flora: *Halymenites major*, *Smilax grandifolia*, *Caulinites Sparganioides*, *Ficus tiliæfolia*, especially *Cinnamomum Mississippiense*, and a variety of *Rhamnus Goldianus*. But of the 56 species of the group, 31 are identified with species of the European Miocene, or of the Arctic flora. Of these last it has 13 species, or 23 per cent., four of them already counted in the Evanston division: *Acorus brachystachys*, *Populus arctica*, *P. decipiens*, *Quercus platania*, *Q. Olafseni*, *Corylus McQuarryi*, *Fagus antipofi*, *Vitis Islandica*, *Magnolia Inglefieldi*, *Paliurus Colombi*, *Zizyphus hyperboreus*, *Juglans denticulata*, and *Carpolithes coccaloides*. The Miocene *facies* of the flora of this division is equally well marked in species of its own or American species, like *Equisetum Haydenii*, *Betula Stevensoni*, *Ficus Gaudini*, *Coccoloba lævigata*, *Asimina miocenica*, *Zizyphus Meekii*, &c., all species evidently of more recent types than those of the two lower groups. The relation of this division with No. 2 is, however, indicated by 17 identical species, more than one-fourth of the whole number, while it is allied to the upper group only by a few of the omnipresent species, *Taxodium dubium*, *Phragmites Œningensis*, *Juglans acuminata*, *J. denticulata*, and by only two species, *Equisetum Haydenii* and *Ficus lanceolata*, not recognized in the lower groups.

The plants of all the localities referred to this division are of the same type. But the specimens labeled Point of Rocks and Rock Creek have apparently been mixed, or indicate different localities than those which now bear these names. The Point of Rocks station is lower in the measures than Black Butte, and its flora should have the Eocene character, of course. But I could not find any remains of plants there or around in that barren country, though I spent two days in searching for them. The Rock Creek station is Cretaceous, and for miles around I found there nothing but representatives, in rocks and fossil animal remains, of the two upper groups of this formation, to fifteen miles farther west than Medicine Bow, where heavy sandstones of the Tertiary are covered by the lignite deposits of carbon.

LIST OF THE SPECIES OF THE FOURTH GROUP.

[Abbreviations for names of localities: B. Sp., Barrel's Spring; Hy. F., Henry Fork; Gr. R., Green River; S. P., South Park; M. P., Middle Park; El., Elko; M. Cr., Muddy Creek; Mo., Miocene; Gr., Group.]

Hemitelites Torelli(?), Heer.—Gr. R.
Pteris pennæformis, Heer.—Hy. F.—Mo., (Gr. 1.)
Blechnum Gœpperti, Ett.—Hy. F.
Aspidium Fischeri, Heer.—M. Cr.—Mo.
Lygodium neuropteroides, Lesqx.—B. Sp.
Ophioglossum Alleni, Lesqx.—S. P.
Salvinia cyclophylla, sp. nov.—M. P.
Lycopodium prominens, sp. nov.—El.
Equisetum Haydenii, Lesqx.—B. Sp., (Gr. 3.)
E. Wyomingense, sp. nov.—Gr. R.
Taxodium dubium, St.—El.—Mo., (Gr. 3.)
T. tijanorum, Heer.—B. Sp.—Mo.
Glyptostrobus Europeus, Heer.—S. P.—Mo.
Sequoia angustifolia, Lesqx.—El.
S. Langsdorfi, A. Br.—S. P.—Mo., (Gr. 1.)
S. Coutsiæ(?), Heer.—M. P.—Mo.
Thuya Garmani, Lesqx.—El.
Thuites callitrina, U.—S. P.—Mo.

Pinus polaris, Heer.—S. P., E.—Mo.
Pinus(!), species.—S. P.
Abies Nevadensis, Lesqx.—El.
Arundo Gœpperti, Mu.—Gr. R.—Mo., (Gr. 1.)
Phragmites Œningensis, A. Br.—Hy. F., B. Sp., El.—Mo., (Gr. 1, 2, 3.)
Juncus, species.—Gr. R.
Poacites lævis, H.—B. Sp., El.—Mo.
Cyperus(!) Braunianus(?), Heer.—B. Sp.—Mo.
Cyperites Deucalionis, Heer.—B. Sp.—Mo.
Carex tertiaria, Heer.—Hy. F.—Mo.
Sparganium, species.—B. Sp.
Acorus(!), species.—S. P.
Populus Richardsoni, Heer.—El.—Mo.
Salix elongata, Web.—El.—Mo.
S. angusta, A. Br.—Gr. R.—Mo., (Gr. 2.)
S. media(?), A. Br.—El.—Mo.
Myrica nigricans, Lesqx.—Gr. R.
M. copiana, sp. nov.—S. P.
M. acuminata, U.—M. P.—Mo.
M. undulata, Heer.—El.
M. latiloba, Heer.—M. P.—Mo.
M. partita, sp. nov.—El.
Comptonia Brongnarti(?), Ett.—El.
Ulmus tenuinervis, sp. nov.—M. P.
Planera longifolia, Lesqx.—S. P.
Quercus semi-elliptica, Gp.—El.—Mo.
Q. lonchitis, U.—Gr. R.—Mo.
Q. Elkoana, sp. nov.—El.
Q. neriifolia, Heer.—S. P.—Mo.
Fagus feroniæ, U.—El.—Mo., (Gr. 1.)
Ficus lanceolata, Heer.—S. P., M. P., Gr. R.—Mo., (Gr. 3.)
Ficus Jynx, U.—El.—Mo.
F. Ungeri, Lesqx.—G. R.
F. populina, Heer.—G. R.—Mo.
Cinnamomum Scheuchzeri, Heer.—Gr. R.—Mo., (Gr. 2.)
Diospyros Copeana, sp. nov.—El.
Fraxinus prædicta, H.—M. P.—Mo.
Ampelopsis tertiaria, Lesqx.—Gr. R.
Weinmannia (?) rosæfolia, sp. nov.—M. P.
Eucalyptus americana, Lesqx.—Gr. R.
Acer, species.—B. Sp.
Sapindus angustifolius, sp. nov.—M. P.
S. coriaceus, sp. nov.—El.
Staphylea acuminata, sp. nov.—M. P.
Ilex affinis, Lesqx.—Gr. R.
I. stenophylla, U.—Gr. R., M. P.—Mo.
I. subdenticulata, sp. nov.—M. P.
I. undulata, sp. nov.—M. P.(?)
Ceanothus cinnamomoides, Lesqx.—Gr. R.
Paliurus Florisanti, sp. nov.—S. P.
Rhus drymeja, sp. nov.—M. P.
R. Haydenii, sp. nov.—M. P.
Juglans acuminata, Heer.—Gr. R.—Mo. (Gr. 3.)
J. Schimperi, Lesqx.—Gr. R., (Gr. 1.)
J. denticulata, Heer.—Gr. R.—Mo. (Gr. 2 and 3.)
J. thermalis, Lesqx.—M. P.

Pterocarya americana, sp. nov.—M. P.
Carya Heerii(?), Ett.—Gr. R.
Podogonium, fruit.—M. P.
Podogonium, leaf.—S. P.
Cæsalpinia(?) linearifolia, sp. nov.—S. P.
Acacia septentrionalis, sp. nov.—S. P.
Leguminosites, fruit and leaf.—El.
Carpolithes et semina.—M. P.

REMARKS ON THE SPECIES OF THE FOURTH GROUP.

The fourth group is remarkably distinct from the lower ones by its peculiar *facies*. It has for characters of its flora a proportionally large number of ferns, 6 species, a *Salvinia*, a *Lycopodium*, 2 species of *Equisetum*, 11 species of conifers, and 9 species of *Glumaceæ*, viz: 30 species of acrogenous monocotyledonous and gymnospermous plants, or 37 per cent. of the whole number of species as yet known as its representatives. Moreover, the balance of the species is limited to few genera: to *Salix*, 3 species; *Myrica* and *Comptonia*, 7; *Quercus*, 5; *Ilex*, 4; *Rhus*, 2; *Juglandeæ*, 6. At first sight, this group appears scarcely referable to a Miocene flora, so different is its *facies* from that of any of the former divisions. It has, however, 32 of its species identical with species of the European Miocene, or a proportion of 40 per cent.; while it is allied only to the lowest American group by 5 species, mostly of general distribution: *Pteris pennæformis*, *Phragmites Œningensis*, *Fagus feroniæ*, *Juglans Schimperi*. With the second group it has in common the same *Phragmites*, *Salix angusta*, *Cinnamomum Scheuchzeri* and *Juglans denticulata;* and with the third *Phragmites* still, *Equisetum Haydenii*, *Taxodium dubium*, *Ficus lanceolata*, *Juglans acuminata*, and *J. denticulata*. It has thus preserved a remnant of the flora of the other groups, which, considered altogether, is very little; for the three first divisions have 267 species, and in eliminating *Phragmites Œningensis*, represented in all the divisions of the Tertiary, we find only 11 species, or 5 per cent., of the flora of the Green River group represented in the others. If it had not so many typical representatives of the Miocene of Europe, and if at the same time it had some one of our living species, it might be considered as Pliocene. But of more recent types than those of the former groups, it has scarcely any; I can name only *Ulmus tenuinervis*, the fine *Staphylea acuminata*, and *Ampelopsis tertiaria*. The remains of plants at Green River are found in laminated shales with an abundance of skeletons of fishes. At Elko station, South and Middle Parks, the plant-bearing beds, composed of the same kind of thin, laminated, fragile, soft shale, have also preserved remains of fishes, insects, and feathers.

The peculiar compound of the thin laminated slates of the formation, and the similarity of animal fossil remains, prove, as well as the general character of the flora, that the localities named in the above table are referable to the same group. Very few species, however, have been observed at more than one locality; while, on the contrary, the species, most of them at least, are represented by a very large number of specimens. This fact, like the distribution of the species, indicates a vegetation of high land, covered with lakes, swamps, and deep forests of conifers, with a thick undergrowth of ferns and shrubs. With a vegetation of this kind, the number of species is limited, and these are generally circumscribed in local groups. A vegetation analogous to this, covered the northern half of Europe after the Drift period. In the Tertiary epoch it has its analogue with the Œningen or upper stage of the Miocene.

§ 3.—DESCRIPTION OF SPECIES.

I have described here only the forms which are considered as new species, with those, which though already known from Europe, had not yet been recognized from American specimens. A few also are remarked upon, which, represented by better specimens, have their characters and their relation more clearly defined.

The researches of the past year have added to the American Tertiary flora about one hundred species, of which sixty are new ones. The whole number represented in the tables of distribution amounts now to nearly three hundred and sixty.

I have followed for the description the same plan as in the two former annual reports of Dr. Hayden, briefly exposed the essential characters of the species, and quoted references for analogies whenever I could find any in the publications of European authors, in order to obviate the absence of figures, which, though, now already made, have to be reserved for a final report.

Except for the specimens found by myself, the names of the discoverers are carefully recorded, with the localities where the fossil remains have been found.

SPECIES OF THE FIRST GROUP.

WOODWARDIA LATILOBA, *sp. nov.*

Frond large, bipinnatifid; pinnæ opposite, decurrent upon the thick rachis, long, linear, slightly tapering to the point, equally lobed; lobes disjointed to three-fourths of their length, united by narrow obtuse sinuses, broadly lanceolate, obtuse, scythe-shaped upward, becoming more connivent toward the point of the pinnæ; upper pinnæ more and more obtusely and less deeply lobed, passing to mere equal undulations; nervation undistinct, except the middle nerve of the lobes, which is narrow but well marked, ascending to the point of the lobes; secondary veins parallel to the rachis and to the middle nerve, branching in ascending, forming by anastomoses of their divisions one or two rows of large areolæ, and joining the borders in parallel veinlets.

Large and splendid specimens have been obtained of this form by Mr. Arthur Lakes, of the School of Mines of Golden, to whom the survey owes many valuable discoveries. The numerous fragments represent the characters of the whole frond. Its consistence is thick, coriaceous; the surface is smooth, nearly polished; and the details of nervation are recognizable only upon fragments which show the lower surface of the pinnæ, or whose upper surface is destroyed by maceration. The fructifications have not been discovered yet.

Habitat.—Golden; South Table Mountain, *A. Lakes.*

WOODWARDIA LATILOBA, *var.* MINOR.

Only small fragments of this form have been obtained at Black Butte. They represent the upper part of a pinna of exactly the same form and with the same mode of division as the specimens of Golden. The lobes, however, are much smaller, less scythe-shaped; the basilar veins follow the rachis, as in the former species, going from the base of one middle nerve to that of the other above, forming thus a band on both sides of the rachis, passing also in long areas up and along the middle nerve of the lobes and from their anastomoses ascending to the borders and forking twice. In the normal form, the veins, though thicker, are less

distinct, and form two rows of polygonal areolæ in passing up to the borders; in this variety (?), the veinlets are merely forked in going up.

This small form is closely allied to *Woodwardites arcticus*, Heer, differing, however, by the nervation. The fragments representing Heer's species are, like those of Black Butte, too small for an exact comparison. His described specimens are from Greenland and from Alaska.

Habitat.—Black Butte; Wyoming.

PTERIS PENNÆFORMIS, Heer.

Pinnæ long, linear-lanceolate, taper-pointed, entire to above the middle, undulate upward, serrate at or near the point, thickish; medial nerve thick, especially toward the base of the leaflets, where it is bi-grooved and three-striated; veins in an acute angle of divergence, close, thin, mostly simple, or forking once. The fragments of leaves or pinnæ, as described here, closely resemble the species of Heer, (Fl. Tert. Helvet., I, p. 38, Pl. xii, Fig. 1,) differing slightly by the borders, which, serrulate at or near the point, are undulate or distantly and obtusely dentate above the middle, and entire downward. Heer describes his species as serrulate near the point and entire downward. In comparing our specimen to the figure marked above, the denticulation appears merely more marked in the American form.

This species has been described already in Hayden's Report for 1871, (p. 283,) from specimens from Henry's Fork, too fragmentary for positive determination.

Habitat.—Golden, Col.

PTERIS AFFINIS, *sp. nov.*

Frond simply pinnate; pinnæ subcoriaceous or thickish, short, about 5 centimeters long, oblong-lanceolate, broader at the middle, rapidly tapering to a slightly obtuse point, gradually narrowed downward, and rounded to the point of attachment; borders undulate; nervation thin, but very distinct; veins open, curving from the middle nerve to the borders, slightly more deflexed downward in reaching the midrib, dichotomous, none simple, or scarcely any, forking once or twice, rarely three times.

Different from the former by its nervation, shorter obtuse pinnæ, undulately-crenate borders, and thinner substance of the leaves. From *P. anceps*, Lesqx., (Hayden's Report, 1872, p. 376,) it differs especially by more distant and more oblique veins.

Habitat.—Golden; rare like the former, but obtained in better specimens.

PTERIS EROSA, Lesqx.

Pinnæ broadly-lanceolate or ovate-lanceolate, taper-pointed or acuminate, serrate upward, with crenulate or lacerate borders below; medial nerve thick; veins oblique, straight, mostly simple, forking near or at the base, rarely above the middle, distant, parallel. It has been formerly described in Supplement to Hayden's Report, 1871, (p. 12.)

By its nervation and the form of its pinnæ this species is related to *P. longifolia*, *L.*, or to some of its varieties with serrate borders.

Habitat.—Raton Mountains, where the first incomplete fragments were discovered; Golden, where it was found in more perfect specimens.

PTERIS SUBSIMPLEX, *sp. nov.*

Pinnæ thick, coriaceous, simple, entire, linear-lanceolate, narrowed in curving to the base, (point broken,) large, varying in size, from 2 to 4 centimeters broad, and at least 10 to 12 centimeters long; middle nerve

narrow, deeply marked; veins distinct, simple, or merely forking once near the base or above the middle, open, slightly curved downward in passing to the borders, which are slightly crenate by contraction to the point of the veins. This fine fern is comparable to some species of *Danæa*. It differs, however, from those which I have for comparison, by the direction of the veins, which do not turn upward in reaching the borders, but join them in the same curve and degree of divergence which they follow from their point of attachment to the middle nerve.

Habitat.—Golden. It is in the collection in many fragments, none showing the point of the leaflets.

PTERIS GARDNERI, *sp. nov.*

Frond large, simply pinnate; pinnæ large, linear, in right angle to the rachis, sessile, rounded to the base, with entire, deeply undulate borders; middle nerve broad, thin, grooved in the middle, flattened on the borders; veins nearly at right angle to the midrib, abruptly curved down at the base or decurring to it, forking once near the base, and once, also, generally above the middle; divisions or veinlets joined by cross-branches, forming here and there some irregular elongated polygonal areolæ. The pinnæ are larger than those of *P. pennæformis*, but apparently of about the same form. The species essentially differs by its strong, thick veins, more distant, joined by cross-branches, &c.

Habitat.—Roof of coal-mines, Sand Creek, Colorado, *A. Gardner.*

DIPLAZIUM MUELLERI (?), Heer.

Pinnæ narrowly-lanceolate, tapering to a long acumen; borders margined, inflated, distantly equally serrate; medial nerve broad, bi-grooved; veins at an acute angle of divergence, very close, dichotomous, some of the branches uniting by anastomosis; substance very thick, coriaceous. The substance of the leaflets seems composed of two layers; the upper one, either scaly or villous, is sometimes destroyed or erased as a pellicle of coaly matter. Through this crust the veins are somewhat obsolete; but when it is destroyed, the details of nervation are very clear. The anastomosis or cross-branches of the veinlets is somewhat like that of *Pteris Gardneri;* it is, however, not as frequent.

I consider this form as identical with *Diplazium Muelleri* as described in Heer, (Boernst. Fl., p. 8, Pl. i, Fig. 2.) There is, however, a difference in the borders of the pinnæ, which, in the European species, are doubly serrate, while they are equally and simply serrate in the American form; and in the cross-branches of the veinlets, which are not remarked in the description and figures of Heer. It is probable that the specimens from Boernstadt had the upper surface covered by the coating of scaly matter, and that, therefore, the minute details of nervation were not observable. Professor Heer finds the relation of his species to the living *Diplazium celtidifolium*. Ours is rather comparable to some species of *Acrostichum*, like *A. aureum*, which has also its veins here and there joined by cross-veinlets.

Habitat.—Golden; South Table Mountain.

ASPIDIUM GOLDIANUM, *sp. nov.*

Frond bi-tripinnatifid; primary pinnæ enlarged, broadly deltoid; secondary pinnæ linear, alternate, rapidly decreasing in length in ascending, joined to the rachis in an obtuse angle of divergence, alternately equally pinnately-lobed; lobes free for two-thirds or three-fourths of their length, oblong, obtusely or slightly acute, inclined outside; mid-

dle nerve distinct; veins 5 to 7, simple, slightly curved inward, parallel, obsolete, marking the borders as slightly serrulate by their impressions. The substance of the leaflets is subcoriaceous; the surface smooth; the borders really entire, but, as it is the case in species of this kind when they have a thick consistence, they are marked as apparently denticulate by the impression of the veins. Both primary and secondary rachis are narrow; the secondary pinnæ are sessile, not decurrent by the lowest lobe.

This species is closely allied to *A Serrulatum*, Heer, of the Boernstadt flora, differing by the more entire borders, more numerous tertiary veins, &c.

Habitat.—Golden; found only in fragments.

GONIOPTERIS POLYPODIOIDES, Ett.

Pinnæ linear, lanceolate-pointed, remotely denticulate; primary veins parallel and at equal distance; secondary veins at an obtuse angle of divergence, apparently alternate, simple, curved inward. By the form of the pinnæ and the distantly denticulate borders, the specimens represent the European species as figured and described by the author in Mount Promina flora. The veins are, however, scarcely discernible, as also the very small crenulations exposing the points of the secondary veins; the points of the middle veins, however, are marked by small, distinct teeth. The identity of this form with the European species is not quite certain. Its nervation is very undistinct.

Habitat.—Sand Creek, *W. H. Holmes.*

SPHENOPTERIS MEMBRANACEA, *sp. nov.*

Frond bi-tripinnate; primary pinnæ long, linear-lanceolate, rigid, erect, or at a narrow angle of divergence; tertiary pinna short, oblong-lanceolate, decurrent, deeply and equally 5-6-lobed; lobes oblong, acute, or slightly obtuse, distinct, to near the base, single-nerved.

This is perhaps a variety of *S. eocenica*, Ett., described in Hayden's Report for 1872, (p. 376,) a species very common at Golden. It has, however, a different *facies*, especially by its membranaceous shining substances, the rigid divisions, the much shorter ultimate pinnæ, the more distinct narrower pinnules, and the decurring base of the secondary pinnæ joined by a margin along the rachis, &c.

Habitat.—Golden, rare, *A. Lakes.*

SPHENOPTERIS NIGRICANS, *sp. nov.*

Frond polypinnate; secondary (?) pinnæ narrow, linear in outline, (as much as can be seen from the fragments;) tertiary pinnæ at a right angle of divergence from the narrow slightly-winged rachis, short, sessile, (the lowest pinnules covering the rachis by their borders, but not decurrent,) linear, abruptly narrowed to a small obtuse terminal lobe, pinnately deeply-lobed; pinnules in right angles to the rachis, free to near the base, oblong, obtuse, undulately pinnately-lobed on the borders; middle vein scarcely distinct, alternately pinnately-divided in 4 to 6 pairs of veinlets, curving downward, and forking once, except the upper pair, which is simple. The surface seems to be villous or squamose, covered as it is by a black pulverulent thin coating of coaly matter. The nervation of this species is pteroid, somewhat like that of *Pteris blechnoides*, Heer, (Fl. Tert. Helv., I, p. 40, Pl. xii, Fig. 8^b;) the form of the leaflets refers it, however, to the genus *Sphenopteris.*

Habitat.—Black Butte.

HYMENOPHYLLUM CONFUSUM, *sp. nov.*

Frond polypinnate; tertiary (?) rachis grooved, thick, divisions in an open, nearly right angle of divergence to the main rachis, dichotomous; pinnules cuneiform, enlarged upward, dichotomously three many times divided in linear, short obtuse lobes, entered each by a simple veinlet diverging from dichotomous branches of the primary veins. The divisions are decomposed many times, the last pinnule being only 3 millimeters long and 1½ millimeters broad; all are crowded and mixed upon another. The surface is minutely punctulate, as if it had been tomentose or ciliate. The specimens are fragmentary.

Habitat.—Golden.

SELAGINELLA BERTHOUDI, *sp. nov.*

Stem slender, spreading, prostrate(?), or creeping(?), dichotomous, divisions simple, or the longer ones the lowest, also dichotomous; leaves four-ranked, by two rows of alternate distichous linear-oblong, lingulate, pointed, longer leaflets, spreading on both sides of the stem and branches, and two rows of small oval or nearly round ones, closely appressed to the base of the longer leaves and covering it. The distichous leaflets are 3 to 4 millimeters long and 1 millimeter wide, the small ones less than 1 millimeter square. This fine species greatly resembles some species of our time, like *S. stolonifera*, *S. Martensii*, &c. Its characters are distinctly recognizable.

Habitat.—Golden. Discovered by *Capt. E. Berthoud*, to whom the survey owes the communication of this remarkable species.

EQUISETUM(?) LÆVIGATUM, *sp. nov.*

Stem thick; its surface irregularly wrinkled lengthwise, not costate, contracted at the articulations, of which only one is seen upon the specimen in the middle of the stem. The articulation bears the scars of four branches, marked by whorls of somewhat undistinct, close rays, enlarging from the center to the circumference. The characters are not sufficiently discernible; the scars of branches are scarcely distinct, and the stem, apparently crushed above or below the articulation, is nearly half as large on one side of it as on the other. It may represent a root of *Equisetum* marked around with the scars of rootlets.

Habitat.—Sand Creek, *W. C. Holmes.*

SEQUOIA LANGSDORFII, A. Br.

Is represented by small, somewhat obscure specimens. The leaves are slightly shorter. It is the only difference which may be remarked in comparing it to the numerous figures published of this species by European authors. It may represent the same species as Abietites dubius, Lsqx., from the Raton mountains. (Hayden's Report, 1872, p. 347.)

Habitat.—Black Butte, above main coal.

SMILAX(!) GRANDIFOLIA(?), Ung.

The lower half of the leaf only is preserved upon the specimen. Its base is rounded to the petiole, three-nerved from the base or irregularly five-nerved by the division, near its base, of one of the lateral veins, and on the other by a marginal veinlet coming out from the top of the petiole; middle nerve and lateral veins crossed by few thin branches or oblique nervilles. The nervation is similar to that of Unger's species in Sillog., (Pl. ii, Figs. 5–8;) the form of the leaf, however, differs, it being rounded to the petiole, not cordate.

Habitat.—East of Colorado Springs, *A. C. Peale.*

FLABELLARIA LONGIRACHIS, Ung.

Leaves very large, as seen from numerous fragments; rays attached in an acute angle of divergence to the very narrow rachis, obtusely carinate, marked in the length by obtuse equal striæ less than one millimeter apart; epidermis comparatively thick. As Unger remarks it, the rays are not duplicate or folded in their contact to the rachis. The species is represented by many specimens; it appears identical with that described by Unger.

Habitat.—Divide between Yellowstone Lake and Snake River, *Hayden*; Raton Mountains, Golden.

FLABELLARIA(?) FRUCTIFERA, *sp. nov.*

Two fragments representing the base of an apparently large palm-leaf, with very numerous rays, 60 to 80, acutely carinate, nerved; primary nerves a little more than 1 millimeter distant; secondary veins very thin, slightly discernible; top of the rachis or petiole flat or enlarged on the sides, reniform. Joined to it is a small raceme of cylindrical oblong obtuse fruits, tapering to a slender peduncle, narrowly striated in the length, slightly flattened by compression, 1 centemiter long, ½ centimeter wide in the middle. Four of these fruits are attached to a common pedicel, partly imbedded into the stone, alternately diverging from it by short peduncles.

Habitat.—Golden.

ERIOCAULON(?) POROSUM, *sp. nov.*

Leaves basilar, rosulate, spreading, entire, linear-lanceolate, broader at the middle, gradually tapering upward to a slightly obtuse point, and downward to a very short petioled base; medial nerve broad, concave; lateral veins two, nearly parallel, with apparent ramifications toward the borders, forming round polygonal small areolæ. The leaves are thick, of a spongious texture apparently; the meshes along the borders are not distinct, and may be formed by contraction of the epidermis. I do not find any species to which this form may be comparable, except the leaves of some large rossulate *Eriocaulon*. The specimen is cut through by rootlets nearly as thick as the leaves are broad.

Habitat.—Sand Creek, *W. H. Holmes.*

ZINGIBERITES(?) UNDULATUS, *sp. nov.*

Fragments of large leaves, whose outlines are not preserved, equally undulate on the surface, marked with oblique, distinct, parallel primary veins, 2 millimeters distant, with 6 to 7 very thin intermediate veinlets. The surface is covered with a thick epidermis or the leaf is subcoriaceous. The surface-undulations are formed by deep furrows, which, however, are more or less distinct, and which do not cut the connection of the veins. There is no trace of rachis to which the fragments of an evidently large leaf may have been attached.

Habitat.—Golden.

RHIZOCAULON GRACILE, *sp. nov.*

Branches slender, straight, irregularly forking, bearing oblanceolate, scythe-shaped, very obtuse, small leaves, with the base descending or decurring along the stem, joined to it by a very short, thickish petiole, appearing like a swelling of the narrowed base of the leaves. The leaves are about 7 millimeters long, 2½ millimeters broad toward the point where they are broadly rounded; they curve downward from the point, of attachment, appearing placed upon the slender stem, or rachis, in a spiral order. They are of a thick consistence; their surface covered with a coating of coaly matter, obliterating nearly every trace of nervation An undefined medial nerve seems apparent on some leaves; but it may be a mere linear artificial depression. On other leaves, deprived of epidermis, some thin striæ running parallel and lengthwise are recognizable. By the disposition of the branches and of the leaves these vegetable fragments resemble those figured by Schimper as illustration of the genus *Rhizocaulon*, Sap., (in Paleont. Veget., Pl. lxxv. Fig. 8.)

Habitat.—Black Butte, burned shale above the main coal.

POPULUS MUTABILIS, Heer.

One leaf only, representing a small form, (like that of Heer, Flor. Tert. Helv., II, Pl. lxi, Figs. 9, 10.) The basilar veins are also attached to the middle nerve, a little above the borders and opposite, with three pairs of alternate secondary veins above them, all in an acute angle of divergence. The leaf, however, does not appear coriaceous.

Habitat.—Black Butte.

POPULUS HELIADUM, Ung.

Leaves broadly-ovate, round-truncate to the base, long-petioled; borders entire, merely undulate toward the point; lower secondary veins open, marginal, thin, the upper ones parallel, close, simple, or forking once, ascending in an acute angle of divergence close to the borders, where they curve. By its form, the direction of the lateral veins ascending straight to near the borders, &c., this leaf is similar to that described by Unger, (Fl. v. Sotzka, p. 37, Tab. xv, Fig. 7,) differing, however, by the secondary veins more numerous and at equal distance; a difference which may be merely casual.

Habitat.—Golden.

SALIX INTEGRA, A. Br.

Leaves entire, linear-lanceolate, taper-pointed or acuminate, narrowed or tapering to the petiole; lateral veins mostly opposite, in an acute angle of divergence, the lowest pair less open than the upper ones, at least in the leaves with a tapering base.

We have specimens of Golden and of Black Butte; in these last, the leaves are more rounded to the short petiole, and the secondary veins are all under the same angle of divergence. There is, however, no marked difference, and both forms agree in their characters with the leaves of this species as described by Herr, (Fl. Tert. Helv., II, p. 32, Pl. lxviii, figs. 20–22.) The nervation of the leaves of Golden is the same as Fig. 21, while the form of the leaves of Black Butte more closely resembles Fig. 22.

Habitat.—Golden and Black Butte.

MYRICA TORREYI, Lsqx., *var.* MINOR.

One leaf only has been found of this variety (?) Leaf shorter, shorter-pointed, less gradually decreasing downward to the petiole; borders denticulate, with close, smaller teeth. No other difference separates this leaf from the typical form described from Black Butte in Report for 1872, (p. 392.) It is probably a mere local variety.

Habitat.—Sand Creek, Colorado, *A. Gardner.*

BETULA GRACILIS (?), Ludw.

Species represented by only one ovate, obtusely-pointed leaf, unequal at the round subcordate base; borders crenulate; nervation campto-

drome; veins curving close to the borders and following them, anastomosing downward with thick nervilles, in right angles to the secondary veins. The impression of the leaf upon the stone is deep, and, therefore, it represents apparently a coriaceous leaf, a character which is not mentioned in the description of the author. (Paleont., vol. viii, p. 99, Pl. xxvii, Fig. 4.) All the veins, like the nervilles, are coarsely marked.

Habitat.—Golden.

QUERCUS FURCINERVIS, Rossm.

Leaves subcoriaceous, lanceolate, more generally oblanceolate, rapidly narrowed to an acute point, tapering downward and rounding from near the base to a short petiole, distantly and regularly dentate from near or above the base; lateral veins parallel, at equal distance, (11 pairs in a leaf of 10½ centimeters long,) slightly curving in passing up to the borders, mostly simple, all craspedodrome, rarely forking near the point by an upper thin tertiary vein passing upward under the base of the teeth; nervilles distinct, in right angle to the veins, forming by cross branches large rectangular areas. The lower part of the leaves is generally entire, and the lowest veins camptodrome or undulating in ascending along the borders. When dentate near the base, the lower veins enter the teeth. Heer, in describing *Q. Burmensis*, de la H., (in Fl. Tert. Helv., III, p. 315, foot-note,) says that the form of leaves, dentation, and nervation of this species identify it to *Q. furcinervis*, from which, however, it differs by the absence of an upper branch on the point of the secondary veins. In the leaves of Oregon most of the secondary veins are simple, rarely one or two are seen with the upper small branch passing up under the teeth. These leaves, therefore, are referable as well to *Q. furcinervis* as to *Q. Burmensis*.

Habitat.—Oregon, under the lava-beds of the Cascade Mountains, *Prof. Jos. Le Conte;* clay-beds of Spanish Mountains, California, *Prof. Whitney.* Golden, in fragments.

QUERCUS GOLDIANUS, *sp. nov.*

Leaves oblong, rounded to an obtuse point, narrowed to the base (?) (destroyed,) with borders undulate or slightly rarely dentate with short obtuse teeth; nervation camptodrome and craspedodrome.

This species may be a mere deviation of the former, though the leaves, for their point, at least, are far different. The nervation is the same; the borders of the leaves undulate, entire, except near the middle, where they are distantly dentate, the teeth being then entered by the point of the secondary veins, which forks under the base of the teeth by a small border-branch. The nervation is, therefore, the same as in the former species, modified only according to the divisions of the borders of the leaves, which are either entire, with secondary veins camptodrome, or dentate, with the same veins craspedodrome. The nervilles are also of the same character, like the details of areolation. The form of the leaves, however, especially at the entire obtuse point, is far different, and in one of the leaves the borders seem to be perfectly entire or merely undulate. There is only in the collection two specimens, one representing the upper part of a leaf, the other a longer and larger leaf, with the point and the base destroyed.

Habitat.—Golden.

QUERCUS ATTENUATA (?), Göpp.

Leaf oval-oblong, narrowed downward to a slender petiole and upward to a short point; penninerve; lateral veins nearly opposite, at an acute angle of divergence, slightly curving in passing to the borders

and with few branches, craspedodrome, their points and those of their divisions entering short distant teeth. Except that on this leaf the denticulation of the borders is simple and the teeth equal or of a same order, while, as represented by Göppert, in Fl. v. Schossnitz, (p. 17, Pl. viii, Figs. 4–5,) there are generally two or three small teeth between the larger ones, which only are entered by the veins, there is not any appreciable difference between the American and the European leaves. That this difference is not a specific one is seen by Fig. 5, (*loc. cit.*,) whose teeth are mostly equal and of the same order.

Habitat.—Sand Creek, Colorado, *A. R. Marvine.*

QUERCUS CLEBURNI *sp. nov.*

Leaf oblong, oval, obtusely-pointed, distinctly obtusely-dentate, tapering to the base and decurring to the short petiole, penninerve; medial nerve thick; secondary veins at a very open angle of divergence or nearly at right angle to the middle nerve, obsolete. This form is closely related to *Q. urophylla*, Ung. (Fl. v. Sotzka, p. 33, Pl. ix, Fig. 9,) differing by smaller, more regular teeth. The leaf is unequilateral, as in Fig. 9, (*loc. cit.*,) and on one side the divisions or denticulation of the borders are smaller and more regular than on the other.

Habitat.—Black Butte.

FICUS TILIÆFOLIA, Al. Br.

The species is common enough in the Colorado basin. Specimens from Sand Creek are covered with fragments of its large leaves of the same type and as well characterized as those figured by Heer, (Fl. Tert. Helv., III, Pl. cxlii, Fig. 25.) One of the fragments indicates a leaf of 18 centimeters long and 14 centimeters wide. Specimens from Golden represent also this species, but in smaller leaves.

Habitat.—The whole Lignitic basin, common.

FICUS PLANICOSTATA, Lsqx., *var.* GOLDIANA.

This form differs from the normal one, so abundant at Black Butte, by narrower, more gradually acuminate leaves, and by the primary veins thin and not flattened. This variety is closely related to the leaves described by Saporta in his Fl. Foss. de Sezanne, (p. 406, Pl. xii, Figs. 6–7) as *Sterculia variabilis.* Fig. 6 represents a leaf slightly unequilateral, a character not remarked in the leaves of Golden. The author says that *F. Micheloti* of Watelet is apparently the same species. The normal form of *F. planicostata* is different by its broad, flat primary nerves and its coarser areolation. Except this, the essential characters are the same.

Habitat.—Golden. The variety only is found at this place; the normal form most abundant at Black Butte has been discovered above a bituminous shale of Coal Creek, Colorado, by *W. H. Holmes.*

FICUS ZIZYPHOIDES, *sp. nov.*

A small oval, obtuse(?) (point destroyed,) entire, thick-nerved leaf, palmately 5-nerved; lower pair of veins marginal; second pair turned upward and branching; middle nerve thick, simple, with close, thick fibrillæ in right angle to the veins; petiole thick, apparently long. The lateral veins branch twice, the marginal ones many times, in short divisions, curving along the borders in festoons. The leaf is wrinkled across by the pressure of the nervilles; if representing a *Ficus* it belongs to the section of the *Populineæ.* The petiole is thick from the base of the leaf downward.

Habitat.—Golden.

FICUS TRUNCATA(?), *sp. nov.*

Leaves oblong-ovate, truncate-cordate at base, obtusely-pointed, entire, undulate, penninerve; secondary veins nearly parallel, distant, on an acute angle of divergence, the lower pairs only slightly more open and opposite, camptodrome. The substance of the leaves is subcoriaceous; they are short-petioled and some of them unequilateral; the lowest pair of secondary veins is from above the base of the leaves, and under them there are still one or two pairs of shorter, thin, marginal veinlets curving downward and following the borders. The species is, for the form of the leaves, comparable to *Quercus fagifolia*, Göpp., of which we have specimens from Golden. But the nervation and areolation are far different, and similar to that of *Ficus auriculata*, Lesqx., to which, also, the species is related by the general outline of the leaves. It may be a variety of it.

Habitat.—Golden.

PLATANUS RHOMBOIDEA, *sp. nov.*

Leaves coriaceous, rhomboidal in outline, largest in the middle, cuneate, and entire from the middle to the base, slightly lobed with short, acute lobes, broadly-lanceolate to the point and strongly dentate, the acute teeth being nearly as long as the lobes and all equal; nervation platanoid; areolation undistinct. This leaf might be considered as a young leaf or a form of *Platanus Haydenii*, Newby. It differs, however, greatly by its cuneate base, the sharp, broadly-lanceolate, long, equal teeth, and the thick, coriaceous leaves. The base is destroyed.

Habitat.—Golden; communicated by *A. Lakes.*

ARTOCARPIDIUM OLMEDIÆFOLIUM(?), Ung.

A single leaf, elliptical, acuminate, narrowed to the base, slightly unequilateral, penninerve; borders obtusely unequally dentate, entire near the base, which appears slightly decurring upon the petiole; secondary veins thin, parallel, more oblique on one side than on the other. Though this leaf is smaller than those figured by Unger, (in Fl. v. Sotzka, p. 36, Pl. xiv, Figs. 1–2,) and by Heer, (in Fl. Tert. Helv., II, p. 70, Pl. lxxxiv, Fig. 8,) I have scarcely any doubt about its identity with the European species. The surface of the leaf is crumpled; its substance appears rather thin. Except the difference in size, there is no character indicating any kind of difference.

Habitat.—Golden, *A. Lakes.*

PISONIA RACEMOSA, *sp. nov.*

Leaves small, entire, thickish, rather membranaceous, obovate, round-obtuse, gradually narrowed to a flexuous petiole, penninerve; lateral veins, four pairs, on an acute angle of divergence, parallel, curving quite near the borders; areolation obsolete; fruits or unopened buds(?) in branching corymbs or clusters of 6–8 pedicelled, either erect or horizontal or pending achenia(?), which are short, narrowly ovate, acute, with a truncate base; pedicels filiform. This species is closely allied to *P. eocenica*, Ett., (Fl. v. Häir., p. 43, Pl. xi, Figs. 1–22,) differing especially by its much shorter achenia(?) in more divided racemes. D'Ettinghausen compares the fruits(?) of his species to the unfolded buds or the ovaries of some *Pisonia*. In the American specimens, these ovaries appear like ripe small seeds, their tegument being a thin shell, and the inner substance, transformed into coal, appearing as a small nutlet split in two.

Though these remains are referable to the same kind of vegetables as those published by D'Ettinghausen, their relation to the genus *Pisonia* is uncertain.

Habitat.—Black Butte, very rare.

CINNAMOMUM AFFINE, Lesqx.

From the comparison of a large number of specimens representing various forms of this species, (mentioned first in Am. Jour. Sc., vol. xlv, p. 206,) it proves to be, as I supposed, a mere variety of *C. Mississippiense*, Lesqx., described in Trans. Phil. Soc., vol. xiii, p. 418. Pl. xix, Fig. 2.

Habitat.—The species is common at Golden, and found in the whole thickness of the North American lignitic measures.

DAPHNOGENE ANGLICA(?), Heer.

This form has been described from fragmentary specimens as *Cinnamomum Rossmæssleri*, Heer, in Report for 1872, (p. 379.) From a more complete leaf, it appears referable to Heer's species as described in Flor. Helv., (vol. iii, p. 315.) He says that the leaves are ovate-lanceolate, long-acuminate, triplenerved, with the middle and lateral nerves branching, remarking still that it differs from *D. melastomacea*, Ung., by the equilateral base of the leaves and the lateral veins at a more acute angle of divergence. In comparing the American leaf with Unger's species, the same difference is marked as that indicated by Heer, and it appears, therefore, that these leaves of ours are, if not identical, at least very closely allied to the Eocene species of England.

Habitat.—Golden, *Capt. Berthoud.*

DIOSPYROS BRACHYSEPALA, Heer.

Leaves broadly oval or slightly obovate, obtuse, narrowed in a curve to the base, entire, rather membranaceous, but not thick; secondary veins alternate, curving to and along the borders, mostly simple or with few branches, deflected downward in reaching the middle nerve. Though this leaf is not in a perfect state of preservation, the details of areolation being obsolete, it agrees in its recognizable characters with Heer's description of the species in Fl. Tert. Helv., III, (p. 11, Pl., c.i, Figs. 1–14,) resembling especially Fig. 6 for its form and Fig. 2 for the nervation or the distribution of the lateral veins. Leaves of the same kind have been described in Report for 1872, (p. 394,) from Black Butte.

Habitat.—Sand Creek, Colorado, *A. R. Marvine.*

VIBURNUM MARGINATUM, Lesqx.

This species is described from Black Butte, the only locality where it has been discovered till now, in Report for 1872, (p. 395.) By its size and the nervation of its leaves, it is related to *Viburnum giganteum*, Sap., (Fl. Foss. de Sezanne, p. 370, Pl. ix, Fig. 1,) distinct, however, by the more tapering point of this last species, and the form of its triangular sometimes double dentate teeth. The author remarks also the relation of his species to the American living *V. lantanoides*, and to *V. erosum*, Thb. of Japan, to which the species of Black Butte has still more affinity than the Eocene species of France.

VIBURNUM LAKESII, *sp. nov.*

Leaf coriaceous, round in outline, obtusely(?) trilobate (the upper part is broken,) with obtuse sinuses; serrate along the borders to near its

base, borders and teeth thicker and membranaceous or cartilaginaceous; three-nerved from the base, lateral nerves thick, much divided, divisions branching also like the secondary veins, which are nearly at equal distance from the primary ones and parallel, few, opposite, all the branches going up to the points of the teeth. The species has a close relation to *V. marginatum*, so abundant at Black Butte. It has the same type of nervation, but is, however, very different by the thicker substance of the leaves, the thicker primary and secondary veins, the three-lobate form of the leaves, and the truly serrate (not dentate) borders. The base of the leaf also is abruptly turned downward or nearly truncate. The species is a very fine one, and it is regrettable that it is represented as yet by a single fragmentary specimen.

Habitat.—Golden; communicated by *A. Lakes.*

CORNUS STUDERI, Heer.

Leaves variable in size, entire, oval-lanceolate, taper-pointed or acuminate, rounded in narrowing to the petiole; lateral veins simple, parallel, curving in passing up to near the borders, along which they join each other in festoons; fibrillae distinct, in right angle to the veins, or sometimes diverging upward. This species is represented by numerous leaves of different size, the largest at least 14 centimeters long, with 12 to 14 pairs of veins, (the base is broken,) the small leaves only 6½ centimeters long with 9 to 10 pairs of lateral veins. The lowest veins are always closer than the upper ones; these near the top become nearly parallel to the midrib. The substance of the leaves is thickish and somewhat coriaceous.

Habitat.—Golden. It is also common at Evanston.

CORNUS HOLMESII, *sp. nov.*

The upper part of an ovate-lanceolate entire leaf, with secondary veins thin, very distant, alternate, much curved in passing up in an acute angle from the middle nerve toward the borders. The point of the leaf is broken. Though the specimen is fragmentary, it represents evidently a *Cornus* specifically distinct from the other fossil species by the great distance of the secondary veins. By this character only it is distantly related to *C. Buchi*, Heer.

Habitat.—Bituminous shale, Coal Creek, Colorado, *W. H. Holmes.*

CORNUS ORBIFERA, Heer.

Leaves round or broadly oval, entire; rounded upward to the point, and also downward to a short, curved petiole; medial nerve thick; secondary veins deep, though narrow, inflated at their point of union to the midrib, which they join in a broad angle of divergence, arched in ascending to the borders. The substance of the leaves is thickish, the surface rough, secondary veins all simple, effaced close to the borders, the lowest in right angle and marginal. The nervilles are close, oblique to the veins, simple or branching.

Habitat.—Golden.

NELUMBIUM TENUIFOLIUM, *sp. nov.*

Leaves exactly round, peltate from the middle, small, 8 to 9 centimeters in diameter, of a thin texture, with flat, undulate borders; primary nerves 13, equal and at equal distance, thin or narrow, nearly simple or sparingly branching, crossed at right angle by nervilles, which by ramification form large square areas. The leaf shows the upper side somewhat convex at the center. The species is represented by two leaves, one of which is in a good state of preservation.

The essential difference between this and the next consists in the thin substance of its leaves; the veins scarcely ramified, and their divisions not half as thick; the surface smooth, not roughened by the secondary and tertiary nervation, and one primary nerve the less. Differences of the same kind are, however, remarked sometimes between leaves of the same species of our time. In *N. luteum*, for example, the upper surface is generally smooth, and the nervation less distinct, while the lower one is coarse, with the veins apparently thicker; in the same species the tissue of the leaves is thicker and harder in the floating leaves than in those raised above water by longer pedicels. The difference of one nerve the less might also be considered as of no value for a specific distinction. However, in the numerous leaves of *N. luteum*, large and small, the primary nerves are always of the same number—21. Both these fossil forms have no trace of a middle nerve; at least this one has none; but the leaves representing the next described species has, between two of the veins, a split, which may represent the medial nerve or take its place.

Habitat.—Sand Creek, *A. Gardner.*

NELUMBIUM LAKESIANUM, *sp. nov.*

Leaves coarse, thickish, peltate, exactly round, with the petiole central; borders turned down; center concave, regular; all the veins, (14,) equal in thickness, equally diverging from the center to the circumference, deeply marked, branching near the borders, crossed by thick, flexuous nervilles at right angles and disjointed; surface rough. This species is represented by three specimens of the same form, two small leaves and a much larger one. They differ from *N. Buchi*, Ett., (Fl. Mt. Promina, p. 36, Pl. ii, Fig. 1,) by the central point of attachment of the petiole, the absence of a thick branching principal or middle nerve, &c.

A number of nuts or fruits, which I think referable to the same species, have been found at the same localities as the leaves. They are cylindrical-oblong, truncate at base, with a small central mamilla, or round scar, representing the point of attachment at the base of the alveolæ of the receptacle; covered by a thin, shelly integument, and obtusely pointed. The point is crushed in all the specimens. They are comparatively of large size; nearly 2 centimeters long, 8 millimeters in diameter. The forms of these fruits is somewhat like that of those of our *N. luteum;* they are proportionally longer, however, the shelly surface is thinly lined or striate in the length; the basilar scar marking the point of attachment is 1½ centimeters broad, slightly conical or convex pointed, with a rough surface.

Habitat.—Golden; discovered and communicated by *A. Lakes.*

MAGNOLIA LESLEYANA, Lesqx.

Represented by the upper part of a very large leaf, its widest part 9 centimeters broad, rounded in tapering to a point; lateral veins parallel, distant, at unequal distance, at the same angle of divergence, and curving to and along the borders, as in the leaf described from Mississippi in Proc. Phil. Soc., (vol. xiii, p. 421, Pl. xxi, Fig. 1.) The more distant of the secondary veins are separated by shorter, more open, tertiary veins, as marked upon the same figure. The tertiary nervation and areolation are distinct, and evidently refer this fragment to a *Magnolia.*

Habitat.—Golden.

DOMBEYOPSIS TRIVIALIS, Lesqx.

This species is described in Hayden's Report for 1872 (p. 380) from an imperfect specimen. We have now a nearly entire leaf, 3-palmately-nerved, round-square in outline, obtusely 3–5-lobed, the two lateral principal lobes short obtuse, the middle one broad, nearly round, base of the leaf deeply cordate or auricled, marked by two simple marginal veinlets coming out from the round point of attachment of the petiole, and descending toward the borders of the auricles. The three primary nerves are ramified, the lateral bearing two or three outside branches, the middle one a few alternate pairs. The nerves, at least the primary divisions, are craspedodrome; their largest branches also ascend to the point of the lateral shorter lobes. Besides the analogy of form of this species with *Ficus Dombeyopsis*, Heer, remarked in the first description, (*loc. cit.*,) its relation to *D. tridens*, Ludw., (Paleont., vol. viii, p. 127, Pl. xlix, Figs. 2, 3,) is noticeable.

Habitat.—Golden, in the white sandstone overlying the lowest coal-beds.

DOMBEYOPSIS GRANDIFOLIA(?) Ung.

A mere fragment, referable to this species described by Unger in Fl. v. Sotzka, (p. 45, Pl. xxvii, Fig. 1.) This fragment shows six principal veins from the flattened top of a thick striate petiole, with strong nervilles, dividing in the middle of the space between the veins, and forming large, square, or polygonal areolæ. The specimen is, however, too fragmentary to allow a satisfactory comparison.

Habitat.—Golden, South Table Mountain.

ZIZYPHUS DISTORTUS, *sp. nov.*

Leaves large, membranaceous, entire, at least near the base, where only the borders are distinctly preserved, round obtuse, enlarged on the sides, abruptly rounded and slightly cordate to the petiole, palmately 5-nerved from the base; middle nerve simple, not branching; lowest veins thin, merely marginal veinlets; middle pair of lateral nerves divided in 3 to 4 branches curving upward; nervilles close, numerous, at right angle to the middle nerve; petiole comparatively long, 2 centimeters. The nervation of this species is similar to that of *Z. plurinervis*, Heer, (Flor. Tert. Helvet., III, p. 76, Pl. cliv, Fig. 31,) as marked upon the right side of the leaf; the secondary veins are, however, less numerous, more distant, longer, and in a more acute angle of divergence; the middle nerve has no branches; and the nervilles are closer, numerous, parallel, and continuous from the middle nerve to the borders. The leaves are mostly unequilateral, or more enlarged on one side, and irregular in shape, either rounded or more narrowed to the base.

Habitat.—Golden.

CEANOTHUS FIBRILLOSUS, Lesqx.

Species described in Report for 1872, (p. 381,) from imperfect specimens. Others of the same kind have been obtained; one shows a deeply cordate base, broader than any of the same species, 7-nerved from the base; external veins merely marginal and simple, the lateral ones branching, especially in the upper part of the leaf; surface crossed by close, distinct nervilles, in right angle to the veins, continuous. This leaf is coriaceous, and does not show any trace of areolation; the nervilles are scarcely half a millimeter apart.

Habitat.—Golden, Black Butte, &c., rare.

RHAMNUS RECTINERVIS, Heer.

A fragmentary specimen found at Coal Creek, Colorado, by *A. R. Marwine*, is referable to this species. The leaf is, however, shorter and broader than those representing this species from Black Butte, the Raton Mountains, and Golden.

RHAMNUS GOLDIANUS, Lesqx.

This species, described in Report for 1872, (p. 382,) is very common at Golden, and its numerous leaves, as seen from the specimens, are extremely variable. The small form is oval, obtusely or abruptly pointed, rounded at base to a short petiole; lateral veins close, 3 millimeters distant, more or less ramified, especially in the middle or near the base of the leaves; nervilles nearly as thick as the veins, very close, and oblique to the veins. This form closely resembles *Berchemia multinervis*, Heer, differing merely by the narrower, more lanceolate form of the leaves, more rounded or cordate at the base, by the nervilles more oblique to the secondary veins, and by their divisions, the veins being all simple in *Berchemia*. To this species is, perhaps, referable the small leaf from Marshall, described as *B. parvifolia*, Lesqx., in Am. Jour. Sci. and Arts, (vol. xlv, p. 207.) I am unable to compare the specimens communicated to me by Dr. J. Leconte, and now out of my hands. Two figures of these leaves, which were carefully made, do not show any trace of ramification of the secondary veins.

Habitat.—Most abundant at Golden; the variety with large leaves has been found also at Black Butte.

RHAMNUS INEQUALIS, *sp. nov.*

Leaf ovate, lanceolate, apparently rounded to the petiole, (point and base of leaf destroyed;) medial vein turning to one side near the point; lower secondary veins at an angle of divergence of 25°, and at a greater distance from the second pair, which is more open and parallel to those following it in ascending, all simple; nervilles numerous, distinct at right angle to the veins. Intermediate to the lower pair of secondary veins, and the more distant second pair above, there is a thick tertiary vein passing out to the middle of the leaf, and there anastomosing on both sides with nervilles. By its unequal sides and its nervation this fragment is related to *R. Œningensis*, Heer, (Fl. Tert. Helv., III, p. 78, Pl. cxxiii, Fig. 31.)

Habitat.—Golden.

RHAMNUS ALATERNOIDES, Heer.

A very small leaf, 14 millimeters long, 7 millimeters broad, oval, pointed, narrowed to the base, distinctly nerved by 5 pairs of lateral veins, the lowest opposite, the others alternate, curving near and along the borders, which are irregularly and distantly serrate. This leaf has the same form and characters of nervation as those of the species described by Heer in Fl. Tert. Helv., (III, p. 78, Pl. cxxiv, Figs. 21–23,) being intermediate for the size between Figs. 21 and 22. The middle nerve is thick; the lateral veins distinct and at irregular distances.

Habitat.—Golden.

RHAMNUS MERIANI(?), Heer.

Leaf oblong, enlarging gradually from the rounded narrow base to above the middle, where it is abruptly acuminate and sharply and dis-

tantly dentate; borders entire downward to the base; nervation camptodrome; secondary veins parallel, in an acute angle of divergence, ascending nearly straight to the borders, where they curve and which they follow, entering the teeth by their divisions. From *R. Meriani*, Heer, as represented in Fl. Tert. Helv., (III, p. 82, Pl. cxxvi, Figs. 5–11,) this leaf differs by its oblanceolate or lingulate form, the veins more straight and on a more acute angle of divergence, and the borders entire from under the dentate acumen. There is, however, a marked difference in form and nervation in the numerous leaves of this species, as figured by Heer, (*loc. cit.*;) therefore the separation into a new species of this only leaf, whose characters are so closely related to those of the European form, is questionable.

Habitat.—Black Butte; in shale, above the main coal.

SPECIES OF THE SECOND GROUP.

POPULUS ARCTICA, Heer.

This species has been already mentioned from the Washakie group, Medicine Bow, Carbon, &c., (Reports for 1871 and 1872.) but not described. The present form appears to be the most common in the Lignitic measures. Leaves coriaceous, entire or undulately crenate, round or more enlarged on the sides and reniform, obtuse, or obtusely short-pointed, truncate at base; nervation 7-palmate from the top of the petiole; middle nerve crossed by strong nervilles at right angle, with two pairs of secondary veins in its upper part; inner pairs of basilar veins curving inward in passing up toward the point where they join the branches of the middle nerve; lateral basilar veins ramified outside, except the lowest pair, which is simple and marginal, all distinctly camptodrome. The two specimens from the locality indicated below have the same form of leaves as those in Heer's Fl. Arct. (Pl. v, Fig. 3,) one with the borders nearly entire, the others with crenulate borders. It appears generally distributed in the whole thickness of the Lignitic measures, except in the first group, where it has not yet been discovered.

Habitat.—Troublesome Creek, Colorado, *Mitchell.*

PLATANUS DUBIA, *sp. nov.*

This form, represented by a large number of specimens, corresponds evidently with the description of *P. nobilis*, Newby., in Extinct Floras of North America, (p. 67.) In this last species, however, the lateral and basilar nerves are described as straight and parallel, terminating, and their branches also, in the teeth of the margins. In the new species or variety, *per contra*, the leaves are perfectly entire, and the secondary veins and their divisions are all camptodrome, or curving near the borders, and following them in festoons. It is probable that this difference is merely casual. One of the specimens from Troublesome Creek shows the close secondary veins camptodrome along the borders of the inner side of the lobes, while on the outside a few of them teminate in small teeth, and are therefore craspedodrome. This remarkable species, which seems rather related to some southern forms of *Araliaceæ* than to *Platanus*, and which too is related by form and nervation to the *Sassafras* leaves of the Cretaceous, has apparently, like these, two distinct kinds of nervation and of border-leaves, resulting from the disposition of the secondary veins.

Habitat.—The specimens, all presenting the same characters, are from Mount Brosse, *Dr. Hayden*; Willow Creek, *Holmes*; Troublesome Creek, *Mitchel.* The distribution of this species appears to be limited to few

localities, where its remains are generally in great abundance and exclusive of those of any other.

LAURUS SESSILIFLORA, *sp. nov.*

A fructified narrow branch, bearing, attached to it, at equal distance and sessile, four involucre or persistent calyces, nearly equally divided to near the point of attachment in four oblong lanceolate-obtuse sepals 4 to 5 millimeters long, diverging crosswise. The appearance of the remarkable fragment representing this vegetable is not easily conceivable from a mere description. It is somewhat like a small branch of a *Galium*, with whorls of four thick, short, half-open leaflets, the two opposite ones on each side of the pedicel being joined to below the middle, and rounded on the other side to the point of attachment like split involucral teguments. They are alternately placed upon each side of the pedicel and sessile. The same piece of shale bears some small oval-obtuse seeds or nutlets, obscurely striated in the length, which seem to have been detached from these involucres. The relation of these fragments is apparently with some kind of *Laurineæ*, like those described by Heer, (Fl. Tert. Helv., II, Pl. xc, Fig. 17,) and also with the fruit of *Benzoin antiquum*, (same plate, Fig. 8.) The relation is confirmed by the presence upon the same specimen of a fine well-preserved leaf of *Laurus*, which I refer to the same species as *L. sessiliflorus.* It is small, narrowly-elliptical, blunt-pointed, narrowed to the base; secondary veins alternate in an acute angle of divergence; the upper pairs at equal distance and parallel; the lower ones more distant and on a more acute angle of divergence, all camptodrome, following the borders in festoons, anastomosing by nervilles, which are numerous, in right angle to the middle nerve, forming large rectangular areas. This leaf also resembles that of *Benzoin antiquum*, Heer, (*loc. cit.*, Fig. 2,) differing especially by the secondary veins more regular and still more distant.

Habitat.—Evanston; shale, above the upper coal, *Wm. Cleburn.*

PERSEA BROSSIANA, *sp. nov.*

Leaves large, subcoriaceous, rigid, with entire, recurved borders, oblong-lanceolate, narrowed in a curve to a short acumen, and attenuated to a short petiole; nervation deeply marked; surface undulate or bossed between the secondary veins, which are parallel, on an acute angle of divergence; nervation and areolation of a *Laurus.* The form of the leaves is the same as that of *L. Canariensis.* The axils of a few of the secondary veins are marked by a small tubercle or inflation as in this last species, and also in the leaves of *Daphnogene Heerii*, Gaud., but less distinct.

Habitat.—Mount Brosse or Troublesome Creek, *Dr. Hayden.*

CINNAMOMUM ROSSMÄSSLERI, Heer.

Two leaves, subcoriaceous, entire, or long oval, pointed(?), (broken,) narrowed to a thick petiole; palmately 3-nerved; lateral veins thin, obsolete from above the base of the leaves, curving at a distance from the borders in following them upward.

The details of nervation are very undistinct, and the species not positively identified. The leaves resemble especially those represented under this name by Unger, in Fl. Radoboj, (Pl. 1, Figs. 10, 11;) the lateral veins, however, seem to approach nearer to the border in the American form.

Habitat.—Troublesome Creek, *W. H. Holmes.*

CISSUS LOBATO-CRENATA, Lesqx.

The specimens exactly represent the species as described from Black Butte, (Report for 1872, p. 396;) the large leaves, with obtuse teeth or undulate borders; the smaller leaves, more acutely lobed and dentate, representing apparently *Vitis tricuspidata* of Heer. In all the leaves the base is truncate, and one of the specimens shows them to be long-petioled.

Habitat.—Willow Creek and Mount Brosse.

CORNUS IMPRESSA, *sp. nov.*

Leaves thick, coriaceous, entire, deeply impressed into the stone, regularly elliptical, rounded to a very short, scarcely marked acumen, rounded also to the base, which is broken; secondary veins on an acute angle of divergence, slightly curving in ascending to the borders, regularly camptodrome, simple or rarely branching once near the point, and anastomosing in festoons along the borders with strong nervilles; these are in right angle to the middle nerve, mostly simple and continuous; the upper veins abruptly join by a curve the point of the middle nerve. This distinct species is related to *Cornus orbifera* by the form of the leaf, which is, however, more elongated, and by its strong nervilles, which are, however, more distant and less ramified; it also differs from it by the lateral veins curving at a distance from the borders, and less numerous.

Habitat.—Mount Brosse, Colorado, *Dr. Hayden.*

ACER TRILOBATUM, Al. Br.

Leaf broadly oval in outline, round-cordate at base, 3-obtusely short-lobed, and obtusely dentate on the borders, which are erased and undistinct; nervation 5 palmate, the lower pairs of basilar nerves being mere thin marginal veinlets; middle nerve branching from the middle; secondary veins in an acute angle of divergence; areolation similar to that of *A. trilobatum* as figured by Heer, (Flor. Tert. Helv., III, Pl. cxiii, Fig. 8.) From all the forms of this species, however, the leaf differs by the base rounded and more deeply cordate, and by shorter obtuse teeth and lobes. The middle lobe is broadly taper-pointed. The leaf is also comparable to *A. Sismondi* of Gaudin.

Habitat.—Troublesome Creek(?) The specimen is without label, but mixed with those of this locality.

THIRD GROUP.

None of the localities referable to the third group had been visited by any member of the explorations of Dr. Hayden in 1873, and no new materials have been added to the flora of this group since the publication of the Report for 1872.

SPECIES OF THE FOURTH GROUP.

SALVINIA CYCLOPHYLLA, *sp. nov.*

Leaf nearly round, slightly cordate or truncate, 21 millimeters long, 25 millimeters broad, therefore slightly reniform, very entire; lateral nerve on a broad angle of divergence, or nearly in right angle to the straight half-round middle nerve, scarcely thicker than their divisions or the nervilles, which, crossing the areas in various directions, form an irregularly quadrate or polygonal areolation. This species does not compare with any fossil one known as yet; it is related by its size to *S. Reussi*, Ett., (Bil. Fl., p. 18, Pl. 1, Fig. 21,) and by the areolation to *S. reticulata*, Heer., (Fl. Tert. Helv., III, p. 156, Pl. cxlv, Fig. 16.)

Habitat.—Middle Park, *Dr. Hayden.*

LYCOPODIUM PROMINENS, *sp. nov.*

Stem or branch slender, dichotomous; divisions short, erect, slightly open, distant, 2 centimeters long; leaves alternate or in spiral, cylindrical, inflated to the more or less acute point, apparently connate at the narrowed base, 4 to 5 millimeters long, half a millimeter broad, half open, some of them curved outside. With the sterile branch, the specimen has a somewhat obscure fragment, apparently a crushed fruiting ear, whose surface is rough or granulate. It is, however, too obscure for positive identification.

Habitat.—Elko, Nev., *Prof. Cope.*

EQUISETUM WYOMINGENSE, *sp. nov.*

Fragments of stems, equally distinctly striate, 2 centimeters broad, articulate, bearing at the articulations whorls of thickish long rootlets. These stems or rhizomas, evidently referable to *Equisetum*, are in profusion in the shale at the cut four miles west of Green River Station; but none of the specimens have any remains of a sheath or of leaves and branches. This form is comparable to *E. Braunii*, Heer., (Fl. Tert. Helv., III, p. 157, Pl. cxlv, Fig. 29.) On the American specimens, however, the rootlets are in fascicles, diverging star-like, much longer and thicker than in Heer's species; at least 1 millimeter broad and 5 to 6 centimeters long.

Habitat.—Green River.

TAXODIUM DUBIUM, Sternb.

The species is represented by a large number of fragments or branches with distichous, linear, short, obtuse leaves, narrowed and rounded to the point of attachment, sessile. This form is rather comparable to *T. dubium* as described and figured by Heer in Fl. Arctica, (Pl. ii, Figs. 24, 26,) than to the variety *T. distichum-miocenicum*, represented in Spitz. Fl., (Pl. iii,) whose leaves are slightly narrower proportionally to their length.

Habitat.—Elko Station, very abundant, *Prof. Cope.*

GLYPTOSTROBUS EUROPEUS, Al. Br.

Only two small branches are referable by their size and the form and disposition of the leaves to this species. Some of the leaves are lingulate, short, appressed, mixed with linear-lanceolate-pointed, open, and longer ones. The fragments are small, and do not bear any cones. The shales of the same locality are, however, marked by irregular, generally round-oval cavities, which appear to have been made by the impressions of cones of this species.

Habitat.—South Park, Castello Ranch, *Dr. Hayden*; near Florisant, *Prof. Cope.*

SEQUOIA ANGUSTIFOLIA, Lesqx.

A short diagnosis of this species is given in Report for 1872, (p. 372,) from specimens from Elko Station. It was sent this year in a large number of specimens, from the same locality especially, and all the specimens bear the same character. Leaves comparatively narrow and pointed, decurrent at base, half open or even nearly erect; seeds large, round-oval, truncate, at the slightly enlarged base, rounded at the top. It is comparable to *S. Nordenskiöldi*, Heer, of the Spitzbergen Flora. (Tab.

iv, Figs. 4–38,) differing by longer, narrower, more acute leaves, and by the larger seeds, quite round or obtuse, not pointed upward. The same character, the large size of the seeds, separates this species from *S. Langsdorfii*, which it resembles somewhat more by the form of the leaves; these, however, are still narrower than in any of the numerous forms of this species.

Habitat.—Elko, *Prof Cope.* Two specimens, with more open, shorter leaves, but equally narrow, come from Middle Park, *Dr. Hayden.*

SEQUOIA LANGSDORFII(?), Brgt.

Only a small fragment, identifiable with this species, as figured by Heer, (Arct. Fl., II, p. 464, Pl. xliv, Fig. 2.) It is not possible to ascertain identity from such a fragment. It, however, shows the two forms of leaves as in the quoted figure. There is also from the same locality a small branch with lateral simple branchlets, bearing short, linear, pointed leaves, similar to those of *S. Coutsiæ*, Heer, (*loc. cit.*, Pl. xli, Fig. 10^{b},) except that all the leaves are erect, not curved inward. This may be still referable to *S. Langsdorfii*, though the leaves are shorter and more acutely pointed.

Habitat.—Elko Station, *Cope*; the var., Middle Park, *Cope* and *Hayden.*

PINUS POLARIS, Heer.

Leaves very long proportionally to their narrow size, 1 millimeter broad, 6 to 7 centimeters long, obtusely-pointed; medial nerve thick and broad; lateral veins thin but distinct, three or four on each side. As far as the leaves indicate it, these fragments represent, indeed, Heer's species, as described in Fl. Spitz., (p. 39, Pl. v, Figs. 18, and 15^{b}–15^{d}.) There are, however, no seeds indicating relation to the same species. The shales are covered with crushed fragments of conifers, scarcely discernible, and, therefore, mostly undeterminable. Among these are wings of coniferous seeds similar to those which the same author figures as P. *stenoptera*, (same plate, Figs. 21, 23.)

Habitat.—South Park, near Castello Ranch, *Dr. Hayden*, Florisant, *Prof. Cope.*

The shale of South Park, Middle Park, and Elko station have a quantity of crushed remains of conifers, leaves, cones, separate scales, and seeds, which may be described hereafter with figures, but whose description without illustration would be incomprehensible for the reader and useless to science.

ACORUS AFFINIS, sp. nov.(?)

Stem thick, evidently striate or nerved by parallel, distant, thick veins; bearing a broad, short, crushed ear, with seeds placed in parallel or spiral rows, and whose form is undistinct. The species is related to *A. brachystachys*, Heer, (Spitz., Fl., p. 51, Tab. viii, Fig. 7,) which has been described already from Creston and from Carbon, (Report for 1872, p. 385;) differing by its larger stem, with more distant and thicker striæ, and its broader ear, which is crushed and somewhat indistinct, though of the same form. The seeds, apparently trigonal in form, are flattened, and in rows, which rather seem parallel than in spiral. The form is still specifically uncertain.

Habitat.—Florissant, South Park, *Prof. Cope.*

POPULUS RICHARDSONI, Heer.

Leaves petioled, broadly ovate or nearly round, truncate at the base, deeply obtusely crenate, 5-nerved from the base; primary nerves flexuous, branching in right angle or at a broad angle of divergence; substance thin or not coriaceous. Of the six specimens representing leaves of this species, none is preserved in its whole. Though fragmentary, however, enough is left to recognize the essential characters and identify the species. The leaves are variable in size, from 4 to 8 centimeters in diameter, some narrower, more elongated, ovate truncate or slightly emarginate to the petiole. From *P. arctica*, it differs essentially by the thinner substance of the leaves, and by the deeply-crenate borders. Some of the obtuse teeth are longer and narrower than represented in the figures of this species, (Fl. Arct., p. 98, Tab. iv, vi.)

Habitat.—Elko, *Prof. Cope.*

SALIX MEDIA, Al. Br.

The species already described from Green River specimens, (in Supplement to Report for 1871) is represented still by two others, which, also, have not preserved any trace of nervation, and are identifiable only by the form of their leaves.

Habitat.—Elko, *Prof. Cope.*

MYRICA COPIANA, *sp. nov.*

Leaf lanceolate, taper-pointed, 10 to 11 centimeters long, 3 centimeters broad, doubly and deeply serrate, with alternate longer and shorter acute teeth, penninerve; nervation craspedodrome; secondary veins open or nearly in right angle to the middle nerve, passing up to the point of the larger teeth, with thinner, shorter tertiary veins between them, ascending to the point of the shorter teeth; all curving slightly upward in entering the teeth. This fine species, represented as yet by a single specimen, is distantly related to *Myrica Gaeffii*, Heer, (Fl. Tert. Helv., III, p. 176, Pl. cl, Figs. 19, 20;) the leaf of the American species being, however, twice as large, the teeth turned outside, sharp, pointed, &c. The same specimen bears some alate seeds of a conifer, like those described by Heer in Spitz. Fl. as *Pinus abies.*

Habitat.—Near Florisant, South Park, *Prof. Cope.*

MYRICA ACUMINATA, Ung.

Leaves coriaceous, with smooth surface, linear-lanceolate-acuminate, dentate; nervation camptodrome, obsolete. These leaves, compared to Unger's species as figured in Fl. of Sotzka, (Pl. vi, Figs. 5–10,) appears, indeed, identical with it. But the author says of his species, (p. 30,) *serraturis equalibus, minimis, approximatis*, a character which is in disaccord with the figures (*loc. cit.*) and with that of our specimens. This character, however, is of little importance in regard to identification; for one of our specimens, representing a long, acuminate leaf, has equally serrate border on one side, while on the other the teeth are close and unequal. As far as it can be seen, the secondary veins appear close, straight to the point of the teeth, and on an acute angle of divergence from the middle nerve. From another locality a set of specimens represent the same species under the same form and nervation, but with much smaller, narrower, and shorter leaves than those figured by Unger, and also than the first ones described above.

Habitat.—Middle Park, *Dr. Hayden*, one mile west of Florissant, South Park, *Dr. Peale.*

MIRICA UNDULATA, Heer.

Leaf membranaceous or subcoriaceous, small, 3½ centimeters long, (the point and base are destroyed,) 1 centimeter broad, linear-oblong, with deeply-undulate borders; nervation camptodrome; lateral veins open, joined by curved fibrillæ nearly in right angle to the veins, forming by ramification a small polygonal areolation; the direction of the secondary veins intermixed with shorter tertiary ones, their mode of curving to and along the borders, and the areolation, are of the same kind as in the leaves of *Myraca* (*Diandra*) *undulata*, Heer, (Fl. Tert. Helv., III, p. 188, Pl. cliii, Figs. 22, 23.) The American leaf is in its size and its tapering base exactly similar to Fig. 23; its undulations are only more definite. I consider it as identical.

Habitat.—Elko, *Prof. Cope.*

MYRICA LATILOBA, Heer, *var.* ACUTILOBA.

Leaves membranaceous, linear-lanceolate or oblong-lanceolate, pinnately deeply divided in large, pointed, triangular lobes, narrowed to a short petiole; secondary veins distinct, craspedodrome, open, ascending to the point of the lobes; tertiary veins under the same degree of divergence, curving along the borders, and anastomosing with pinnate branches of the secondary ones. This species is represented by one fragment only, showing the lower part of a leaf, bearing three lobes on one side and only one on the other. In Heer's species, (Fl. Tert. Helv., III, p. 176, Pl. cl, Figs. 12–15,) the leaflets are more obtuse or less pointed than in the American leaf, which also differs by a somewhat longer petiole. This form is apparently a mere variety.

Habitat.—Middle Park, Colorado, *Dr. Hayden.*

MYRICA PARTITA, *sp. nov.*

Leaf subcoriaceous, linear, narrow, one centimeter broad, alternately equally lobate; lobes distinct to the base, turned upward, broadly lanceolate, narrowed to a short point, denticulate along the lower side and near the point of the upper border; secondary vein ascending to the point of the acumen; tertiary veins parallel, shorter, passing up to the lower teeth in anastomosing by nervilles in right angle to the secondary vein; areolation round-polygonal, small. Like the former, the species is represented by a fragment only. It is distantly related to the following.

Habitat.—Elko, Nevada, *Prof. Cope.*

MYRICA (COMPTONIA) BRONGNARTI(?), Ett.

Leaf coriaceous, linear, narrow, half a centimeter broad, alternately pinnately obtusely dentate; nervation obsolete, pinnate, camptodrome; secondary veins simple. It is not possible to positively recognize the nervation of this leaf, which, by undulation of its surface corresponding with the teeth, has the *facies* of a small branch of conifer. It resembles some of the leaves published in Ett. (Häring Flor.) as *Diandra Brongnarti*, especially that of Pl. xix, Fig. 20; the lobes, however, being less deeply parted, or like mere obtuse teeth, though the appearance is that of a lobate leaf.

Habitat.—Elko, *Prof. Cope.*

ULMUS TENUINERVIS, *sp. nov.*

Leaves thin, very unequal at the base, deeply cordate on one side, tapering on the other to the middle nerve, half a centimeter higher up;

oblong or ovate, lanceolate, taper-pointed, unequally serrate; lateral veins thin, flexuous, or curved to the borders, craspedodrome, simple or branching. The species is closely allied to *U. Bronnii*, Heer, which Massalongo considers identical to his *U. affinis.* Ours differs by thinner, more distant, lateral veins, by its shorter petiole, and the more acute teeth of the borders. None of our living American species is comparable to it.

Habitat.—Middle Park, *Dr. Hayden.*

PLANERA LONGIFOLIA, Lesqx.

This species has been briefly described in Report for 1872, (p. 371.) The collection has received a large number of specimens from Middle Park, representing it in its various forms. The leaves are generally ovate-lanceolate or merely lanceolate, more or less acutely, and all equally simply dentate; lateral veins simple, strong, going straight up to the point of the teeth, under various degrees of divergence; petiole 5 millimeters long, thickened to the base. The leaves vary in length and width, being generally smaller and narrower than those of *P. Ungeri.* Captain Berthoud, however, has sent me sketches of leaves of a *Planera*, one of which is 2½ centimeters long and 2 centimeters broad, therefore broadly oval, with sharp teeth, exactly like the leaf published by Heer, (Arct. Flor. II, Pl. xlv, Fig. 5ª) as *P. Ungeri.* This leaf is so different in *facies* from all those which I have seen and used for the description of the American species that I cannot consider it as representing the same. I have, therefore, to admit that two species are represented in the Upper Tertiary measures of the Rocky Mountains, at least till I have seen the specimens or recognized intermediate forms.

Habitat.—Elko and South Park. The last specimens were sent by *Dr. Hayden.*

QUERCUS ELKOANA, *sp. nov.*

Leaves subcoriaceous, flat, ovate, taper-pointed or acuminate, 8 to 10 centimeters long, rounded and narrowed to the base, (broken,) doubly serrate, with teeth alternately long, irregular, sharp-pointed, and one or two small ones at their base; nervation pinnate; lateral veins simple, parallel, craspedodrome, (straight or scarcely curving in passing up to the borders; fibrillæ thin; areolation same as that of *Fagus feroniæ*, which this leaf resembles, and to which it could be referable but for the large size of the regular and regularly-pointed teeth. The substance of the leaves is thicker than in this last species.

Habitat.—Elko, *Prof. Cope.*

QUERCUS NERIIFOLIA, Heer.

Only a fragment of an oblong-lanceolate, entire leaf, with distinct nervation; secondary veins at right angle to the middle nerve, branching and effaced near the borders, with intermediate shorter tertiary veins, more or less oblique to the secondary ones. The form of the leaf is like that of Fl. Tert. Helv., (II, Pl. lxxiv, Fig. 4,) and the nervation similar to that of Fig. 5.

Habitat.—Near Florissant, west of Pike's Peak, *Dr. A. C. Peale.* This locality may be referable to another group.

FAGUS FERONIÆ, Ung.

This species is represented by a dozen specimens, representing the leaves in their various forms, as figured and described by Ett. Bil. Flor.,

(p. 50, Pl. xv, Figs. 12–20.) These leaves are variable in size, from 5 to 8 centimeters long and proportionally broad, oval in outline, taper-pointed, narrowed downward and wedge-form to a long petiole, doubly, irregularly, unequally serrate; nervation craspedodrome; secondary veins on an acute angle of divergence, simple, straight; fibrillæ thin, in right angle to the veins; areolation composed of very small, irregularly square and polygonous meshes. The American form agrees by all its characters with the leaves of the Bilin Flora. It differs, however, from Unger's figures (Chloris Prot., Pl. xxviii,) by the teeth of the borders more numerous and generally more accute, and by the longer petiole.

Habitat.—Elko, *Prof. Cope.*

FICUS LANCEOLATA, Heer.

Leaves thickish, lanceolate, gradually tapering to a thick petiole, penninerve; secondary veins open, parallel from the base, camptodrome; nervilles close, in right angle to the secondary veins; areolation in small polygonal meshes. This species is represented by specimens of two localities. All agree with the characters represented by the author (Flor. Tert. Helv., II, p. 62, Pl. lxxxi, Figs. 2–5,) the leaves being only somewhat smaller.

Habitat.—Florisant, South Park, *Cope*; Willow Creek, Middle Park, *Holmes*; Cut-off, west of Green River Station, with fish remains.

FICUS JYNX, Ung.

Leaves coriaceous, linear-lanceolate, tapering to the petiole, penninerve; secondary veins open, close, numerous, thickish, straight to the borders, along which they abruptly curve. This leaf is comparable to some forms of *F. multinervis*, Heer, but still more to the leaf of Bil. Fl. (Pl. xx, Fig. 7,) referred by Ettinghausen to *F. Jynx*, Ung. The petiole is narrower than in *F. multinervis.*

Habitat.—Elko, *Prof. Cope.*

DIOSPYROS COPEANA, *sp. nov.*

Leaf of medium size, 7 centimeters long and half as wide, broadly obovate, entire, gradually narrowed downward to a short petiole, rounded upward to an obtuse point; nervation penninerve, camptodrome; lateral veins thin, distinct, the lowest in a slightly more acute angle of divergence, curving in passing to the borders, which they follow in anastomosing in double festoons, and separated by shorter tertiary veins. The nervation and the form and *facies* of the leaf are of a *Diospyros;* some of the leaves of our living *D. Virginiana* have about the same form, though generally broader, and rounded at the base.

Habitat.—Elko, *Prof. Cope.*

FRAXINUS PRÆDICTA, Heer.

A small leaf, broad in the middle, gradually narrowed to its base, (petiole broken,) and upward in the same degree in a long obtuse acumen; borders slightly and distantly dentate; nervation camptodrome; secondary veins curving upon each other in following the borders, with border-branches or veinlets passing up to the points of the very short and small teeth marked only from the middle downward; borders nearly entire upward. There is only one leaf representing this species; but it so much resembles those of Fl. Tert. Helvet., (III, p. 22, Pl. civ, Figs. 13, &c.,) that it is scarcely possible to doubt the identity of these forms. In the specimen described here, the nervation is perfectly distinct.

Habitat.—Middle Park, *Dr. Hayden.*

WEINMANNIA, ROSÆFOLIA, *sp. nov.*

A compound, imparipinnate leaf, with 3 to 5 pairs of narrowly elliptical leaflets, obtusely pointed, rounded to the sessile base, the terminal leaflet only short-petioled, obtusely serrate toward the point, entire from the middle downward; medial nerve thick, half-round; lateral veins and areolation obsolete; rachis half-round, narrowly margined. The dentation of the leaves is not distinct; some leaflets, separated from the rachis upon the same piece of shale, are smaller and have entire borders. I refer this leaf to the genus *Weinmannia* on account of the likeness of these remains with living species of this genus figured in Fl. v. Häring by Ettinghausen, (Pl. xxiii, Figs. B, C.) In these American forms, the rachis is not alate; it is so, however, in *W. Glabra*, DC., whose leaflets, though much smaller, have the same form. In the leaves of this genus, the secondary nervation is also mostly obsolete or scarcely distinct; the surface being generally covered with villous hairs. In the fossil species, the base of the leaflets seems to bear a thick tuft of hairs. The specimens are very fine.

Habitat.—West of Florisant, *Dr. A. C. Peale.*

SAPINDUS ANGUSTIFOLIUS, *sp. nov.*

Leaves compound, imparipinnate; rachis thick, flat, but not winged; leaflets linear-lanceolate, entire, unequilateral, larger above the base at the upper side, tapering gradually upward to a slightly reflexed or straight acumen, rounded and narrowed to a very short margined petiole or sessile; nervation and areolation of the genus. The leaf bears about 6 pairs of alternate leaflets; the upper lateral ones erect along the terminal, the others half open. This species is represented by a large number of specimens.

Habitat.—Middle Park, *Dr. Hayden*; near Florissant, South Park, *Prof. Cope.*

SAPINDUS CORIACEUS, *sp. nov.*

Leaflets thick, large, oblong-lanceolate, entire, with borders reflexed; slightly unequilateral and scythe-shaped, short-petioled; middle nerve thick; secondary veins open, scarcely discernible; surface polished. This species is distinct by the thickness and leathery texture of the leaves, which are long comparatively to their width. All the leaflets are isolated or separated from the main rachis.

Habitat.—Elko Station, *Prof. Cope.*

STAPHYLEA ACUMINATA, *sp. nov.*

Leaves trifoliate, at the top of an elongated common pedicel; lateral leaflets opposite, rounded to the short-petioled base, ovate-lanceolate acuminate, crenulate to near the base; medial or terminal leaflet longer-pointed, attenuated to the base, with a longer pedicel; secondary veins alternate, camptodrome, curving to and along the borders, with slender ramifications entering the teeth. The areolation of this leaf, the form of its leaflets and their relative position, &c., are similar to those of the living American *S. trifoliata*, L. The species merely differs by the longer tapering point of the leaflets and the short petiole of the middle one; the divisions of the borders are of the same kind.

Habitat.—Middle Park, *Dr. Hayden.*

ILEX SPHENOPHYLLA(?), Heer.

A very small leaf, 12 millimeters long, 7 millimeters broad, oval, rounded in narrowing to the point and to the base; distantly acutely-

dentate by three or four pointed or spinulose teeth on each side; secondary veins opposite, craspedodrome, simple, passing up in a slight curve to the point of the teeth. The identification of this leaf with Heer's species, represented (Flor. Tert. Helv., III, p. 73, Pl. cxxii, Fig. 24,) by still smaller leaves without any trace of nervation, is uncertain.

Habitat.—Middle Park, *Dr. Hayden.*

ILEX SUBDENTICULATA, *sp. nov.*

Leaves coriaceous, linear-lanceolate, acuminate? (point broken,) irregularly denticulate from the middle upward with small, sharp-pointed teeth; penninerve; lateral veins distant, opposite, curving up under an acute angle of divergence from the middle nerve, and at a distance from the borders, forming, by anastomose with the veins above, a double festoon along the borders, and entering the teeth by outside, small branchlets. This species is closely related to *I. denticulata*, Heer, (Flor. Tert. Helv., III, p. 72, Pl. cxxii, Fig. 20,) differing, however, by the taper-pointed or acuminate form of the leaf; the more numerous teeth descending lower on the borders; the more distant and all opposite secondary veins, which curve farther inside and at a more acute angle of divergence, &c. The nervation is, however, of the same type. The same shale bears a small, round, crushed fruit, representing, apparently, a pulpy berry, bearing one or two ovate-pointed seeds similar to those of this genus. The berry is 5 millimeters wide; the seeds 1½ millimeters broad near the rounded base, and 3 millimeters long.

Habitat.—One mile west of Florisant, Colorado, *Dr. A. C. Peale.*

ILEX UNDULATA, *sp. nov.*

Leaf narrowly oblanceolate, pointed, tapering downward to a short petiole; borders undulate, obtusely dentate in the upper part of the leaf, entire from the middle; nervation of the same type as that of the former. It may represent a variety of the same species.

Habitat.—This specimen is without label; mixed with those of Middle Park.

PALIURUS FLORISANTI, *sp. nov.*

Leaf small, 2½ centimeters long only and 1 centimeter broad, ovate-pointed(?), (point broken,) rounded at the base to a short, thick petiole, slightly crenulate all around, triple-nerved; lateral primary veins from above the base of the leaf curving up and following quite near the borders to above the middle, where they anastomose with the lowest pair of secondary veins, also opposite; all curving along the borders, camptodrome. The leaf has the same areolation as those of *P. aculeatus*, Lam., of Europe, from which it merely differs by its round base, the lower veins closer to the borders, and the secondary veins from the middle only of the leaf and nearly opposite.

Habitat.—Near Florisant, South Park, *Prof. Cope.*

RHUS(?) DRYMEJA, *sp. nov.*

Leaves narrowly lanceolate, acuminate, equally acutely serrate, penninerve; lateral veins close, numerous, simple, craspedodrome, parallel from the base, on an acute angle of divergence; areolation in primary quadrate rectangular areas, divided into small irregular quadrate or polygonal areolæ. I doubt that this form, represented by numerous well-preserved thickish leaves, may be referable to a species of *Rhus*. It is comparable to *Quercus lonchitis*, Ung., in Fl. of Sotzka, (p. 33, Pl. ix, Fig. 1);

the leaves, however, are smaller and generally unequilateral, either narrowed to the short thick petiole or rounded to it, at least on one side, like the leaflets of a compound leaf.

Habitat.—Middle Park, *Dr. Hayden.*

RHUS HAYDENII, *sp. nov.*

Leaf pinnately divided in alternate linear or lanceolate, acute, entire leaflets, from a broadly alate rachis, to which they are joined in decurring; terminal leaflet of the same size and form; nervation pinnate, camptodrome. This fragment of a compound leaf represents a fine and remarkable species. It is about 5 centimeters long, with a broadly-winged rachis 3 millimeters wide on each side of the thin, middle nerve, with three pairs of alternate leaflets 4 to 6 millimeters broad, 2½ centimeters long, lanceolate, obtusely-pointed, nearly at right angle to the main rachis, which they join by an acute sinus in the upper side and a decurring base on the lower one. The camptodrome nervation is similar to that of *R. copallina*, L.; the alar tissue of the rachis is also marked by forking parallel veinlets, as in the same species.

Habitat.—Middle Park, *Dr. Hayden.*

PTEROCARYA AMERICANA, *sp. nov.*

Fragment of an oblong-lanceolate leaflet, slightly scythe-shaped, with crenulate border, and camptodrome nervation. The outline of the leaflet, though the lower and upper parts are destroyed, is, like the nervation, well defined. It is comparable to the leaves published by Gaudin, in Cont. (I, p. 40, Pl. ix, Fig. 2,) under the name of *P. Massalongi*. The substance of the leaflet is thin, the secondary veins more or less distant, curving in ascending to the borders, and following them in successive bows, anastomosing with branches of intermediate shorter veins; nervilles distinct, nearly at a right angle to the secondary veins. Except that the borders of this leaflet are not as deeply serrulate, and that the secondary veins curve nearer to the borders, there is not any noticeable difference between the American and the Italian form.

Habitat.—Middle Park, *Dr. Hayden.*

PODOGONIUM, species.

The collection has, representing this genus, a capsule, with its pedicel. It is, however, broken in the middle, and its specific relation undiscernible. There is also, from another locality, a fragment of a lingulate leaflet, with a close, thin camptodrome nervation, comparable to the leaves of *P. Knorrii*, Heer.

Habitat.—Middle Park: the leaflet, *Dr. Hayden*; the fruit, Florisant, South Park, *Dr. Peale.*

CÆSALPINIA(?) LINEARIS, *sp. nov.*

A branch of a compound leaf, with a narrow filiform rachis, bearing seven pairs of small, opposite, linear leaflets, sessile, rounded to the point of attachment, sharp-pointed, concave or scythe-shaped at the upper side, thickish, without trace of nervation of any kind. I know nothing to which this fragment could be compared. It resembles a branch of distichous conifer; but the mode of attachment of the leaflets, rounded to the base, all opposite; their scythe-shaped form, &c., are at variance with the characters of conifers. It is distantly related to species of *Cæsalpinia*, like *Cadia varia*, Heer, or some *Acacia*, like *A.*

parschlugiana, Heer, of the European Miocene, but remarkably distinct by the absence of a midrib, whose place is scarcely indicated by a depression in the middle of some of the leaflets.

Habitat.—Florisant, South Park, *Prof. Cope.*

ACACIA SEPTENTRIONALIS, *sp. nov.*

Leaflet small, entire, coriaceous, rigid, with a rough surface; oblanceolate, rounded to a short acumen or mucronate, gradually tapering downward to the base; nervation pinnate; lateral veins very thin, acrodrome, sparingly branching, anastomosing by cross-veinlets in passing up to near the point where they curve toward the middle nerve. This leaflet is, for its thick, rigid substance and its nervation, comparable to *A. rigida*, Heer., (Fl. Tert. Helv., III, p. 133, Pl. cxl, Fig. 22,) differing, however, by its form.

Habitat.—South Park, near Castello Ranch, *Dr. Hayden.*

LEGUMINOSITES, species.

A small legumen, which is open, and shows its two valves, linear, oblong, truncate, mucronate on one side, narrowed on the other to a short pedicel; substance cartilaginous; inner face smooth, shining. The exact form of this and the two following remains is not well comprehensible from mere description.

Habitat.—Elko, *Prof. Cope.*

CARPOLITHES, species.

An oblong-obtuse, flattened fruit, or nutlet, truncate at its base, somewhat more enlarged on one side, marked from the base to above the middle by small striæ, slightly diverging in ascending.

Habitat.—West of Florisant, *Dr. A. C. Peale.*

SEMEN, species.

An agglomeration of four oval, small seeds, 3 to 4 millimeters long, half as wide, obtusely-pointed, striate.

Habitat.—Middle Park, *Dr. Hayden.*

SPECIES WHOSE REFERENCE TO THE FORMER GROUPS IS UNCERTAIN.

LASTRÆA STYRIACA, Heer.

Fragments of ultimate linear pinnæ, pinnately alternately lobed; lobes oval-obtuse, disjointed to near the middle, pinnately-veined; veins 8 pairs, simple, curving inward in going up to the borders, thin, distinct. The species is represented by a number of fragments in silex, all very distinct. By the form of the leaflets and their nervation, they are referable to this species, very common in the Miocene of Europe. The pinnules, however, are somewhat more disconnected than seen in the figures, (Flor. Tert. Helv., I, Pl. vii–viii.)

Habitat.—Blake's Fork, Uintah Mountains.

MUSOPHYLLUM COMPLICATUM, *sp. nov.*

Stem thick, wrinkled-striate in the length, bearing imbricated and amplectant leaves, folded upon another, especially near the point of union to the stem, opening in right angle, variable in size, obtuse; veins simple, three-fourths of a millimeter distant, parallel; crossed in right angle by obscure veinlets. The stem divides at its base into thick diverging

rootlets, curving to an horizontal direction. Though the specimens representing this species are very numerous and very large, I could not obtain one showing exactly the size and the form of these leaves. They appear either folded around a thick stem, from which they diverge, or on both sides of a thick rachis extending along it like wings, two to three centimeters wide on each side. From the fact that large specimens are covered by fragments of these leaves crushed and folded upon another, without any trace of middle nerves or peduncles, the leaves must have been of great size. Their substance is not very thin. The surface is perplace covered with an epidermis which shows the veins as crossed by veinlets at right angle. When the epidermis is destroyed, this character is not observable; it may, therefore, result of a wrinkling of the epidermis. The species is related to *Musa Bilinica*, Ett., (Bil. Fl. p. 28, Pl. vi, Fig. 11, and Pl. vii, Figs. 4–5;) differing, however, by essential characters.

Habitat.—Roof-shale of a thin coal, with the following species:

SAPINDUS OBTUSIFOLIUS, *sp. nov.*

Leaves compound, pinnate, apparently long; leaflets alternate, very variable in size, from 1½ to 7 centimeters long, and from 6 millimeters to 3½ centimeters broad, coriaceous, perfectly entire, sessile, unequilateral, ovate-lanceolate, obtusely-pointed; nervation camptodrome; lateral veins at a broad angle of divergence, curving in passing up to the borders and following close along them by a series of undulations; areas large, equilateral; ultimate divisions obsolete. This fine species differs from any fossil published as yet. The leaves have been apparently very large; some of the detached leaflets greatly differing in size from the few ones which were obtained still attached to the main rachis or pedicel.

Habitat.—The same locality as the former; top of hills, apparently overlying the coal-bearing strata of Rock Springs, seen to the east, five to six miles distant. The clay beds of this locality, with an abundance of silicified and petrified wood, the thinness and poor quality of the lignite beds, mark this place as referable to the Upper Lignitic measures. Though I worked at the locality for an entire day with a miner, I could not find in the shale any other distinct vegetable remains but the two species described here. As yet, we have nothing related to them from the lower lignitic flora.

§4.—CLIMATE OF THE AMERICAN TERTIARY AS REPRESENTED IN ITS FLORA.

That the flora of a country is in correlation to local atmospheric circumstances; that ancient floras, too, bear characters which relate to the same cause, is an axiomatic assertion which does not need any discussion. In considering the development of vegetable types from the first apparition of land-plants, as far as this origin is known, it has been admitted also that the point of departure of the vegetation has been from the simplest organisms, passing up to more and more complex ones in ascending the series of the formations. According to this principle, the first representatives of dicotyledonous plants, which seem to have made their appearance near the base of the Cretaceous, but which have not been remarked as yet,* have been theoretically considered as being of a

* Professor Heer has, from the Lower Cretaceous of Greenland, a leaf resembling a *Populus*, mixed still with Jurassic or Wealden types.

very simple organization, or, so to say, in an adventive state of development, prepared in that way to rapidly undergo a series of modifications under every kind of physical influences. There is as yet scarcely any document in confirmation of this hypothesis and still less in contradiction of it. It is, in any way, adaptable to the explanation of some peculiar analogies remarked in the characters of the geological floras.

The vegetation of the Dakota group has a distant relation to that of the Upper Cretaceous flora of Europe by identity of a few of its species, especially ferns. But, as yet, little is known of the succession of the vegetable groups during the European Cretaceous, and of the relations of plants to the geological divisions of that epoch; and though the analogies may become more marked by future discoveries or publications, it is only from the data furnished by the American Cretaceous flora that we can get some kind of criterion of the climatic circumstances which have marked its general characters.* The descriptions of the species of this flora and the details in regard to their relation, as published in our flora of the Dakota group,† evidently show its relation to a moderate climate, about of the same average degree as that of the middle region of North America. A number of Cretaceous genera are still represented in our arborescent vegetation.

From the Dakota group upward, there is no trace of land-vegetation in the whole North American continent until we reach the Lower Lignitic formation. All the intermediate strata are marine, and the series of animal remains, which they have preserved in great abundance, are uninterrupted and uninterruptedly Cretaceous in their characters as high as the Lignitic. Animal Cretaceous remains have been found, as remarked formerly, even in shale overlaying Lignitic deposits. Now, in comparing fossil plants of the first or lowest group of the Lignitic, we should expect to find, merely considering its immediate succession to strata of Cretaceous age, a flora with some distinct analogy to that of the Dakota group: most of its genera, some of its species, too. But it is not the case. Some genera, of course, are represented in both floras, but by different types; and they do not have any identical species, nor even any closely-related forms. There is in the general character a kind of related *facies;* but specific types of the former floras seem to have been destroyed during the prevalence of the marine Cretaceous period, and above its fucoidal sandstone, even within its upper strata, and in connection with Lignitic deposits, there appears a new flora without positive relation with former vegetable types, and with but few of those of subsequent groups of plants or younger geological floras. This anomaly may be explained in two ways; either by supposing that during the prevalence of the marine formations, or by the submersion of the land, all the genera and species of the Cretaceous have been annihilated, and that a new generation of vegetable types has covered the new land as fast as it appeared above the surface of the water; or that during the period of the marine Cretaceous, the climate has been gradually modified, and that, therefore, the land at its first apparition has been invaded by a vegetation in harmony with the climatic circumstances governing this new epoch. This last supposition seems the only one admittable, the more so as it does not consider the hypothesis of a general destruction of vegetable types and of subit renovation of others or of the creation of a new vegetable world.

* Two memoirs of the Lower and Upper Cretaceous floras of Greenland have been prepared and are now in the way of publication by Professor Heer.

† Memoir on the fossil plants of the Cretaceous Dakota group of the United States, (1874.)

But where have the new types come from, and where have they originated?

The climatic difference indicated by the characters of the North American Cretaceous flora, in regard to that of the Lower Lignitic, may be exposed in degrees of latitude rather than by thermometrical figures of an average temperature. It is about the same as that between Ohio and South Florida. In the Lower Lignitic, the palms compose a large proportion of the flora. This family of plants is still represented in our present flora by species of *Chamærops* and *Sabal*. But they mostly inhabit the shores of the Gulf of Mexico, in South Carolina, and especially South Florida. They are scarcely found inland. The highest north station of *Sabal* is in the swamps, at the mouth of the Arkansas River, and here it is a mere dwarf, not above one to two feet high, vegetating under the deep shade of canes and swamp-trees. With palms the Lignitic has 15 species of *Ficus* of a type related to subtropical forms of this genus. Then *Artocarpidium*, *Pisona*, a number of *Diospyros*, large-leaved species of *Viburnum*, *Magnolia*, and *Dombeyopsis*, with *Rhamnus*, species of southern types. There is not, however, in the flora, any true tropical form; nor do I find any of the so-called Indo-Australian types. *Cinnamomum* and *Laurus* species are more numerous than in the Dakota group, but scarcely of a different type. The distribution of these two genera, however, does not appear to have had a marked relation to climate in the geological times. *Diospyros* and *Magnolia* are also represented in the Dakota group, but the forms or species are very distinct and not as numerous. Many species of *Rhamnus* of the Lower Lignitic are characterized, most of them at least, by thick, close secondary veins, referring these, for analogy, to the present *R. Carolinianus* and *Berchemia volubilis*, whose range of distribution is from Florida to North Carolina and South Arkansas. The difference of temperature is, therefore, in the average, equal to that marked in about 10° to 15° of latitude. It is, indeed, a small difference in considering the distribution of the floras of the Dakota group, and of the subsequent groups of the Tertiary, and it would be easy to explain the gradual invasion of another kind of vegetation from a distance equaling the 15° of latitude upon the new land of the Tertiary, and after the disappearance of the anterior vegetable types, if only the pre-existence of such a flora was admittable. There is no difficulty to account for a higher degree of temperature for the Lower Lignitic in considering the flora of the Dakota group as a land-flora, or at least as a flora covering the coast of an upland of wide extent, therefore under the influence of a dry atmosphere. On the contrary, the Lower Tertiary land emerging from an extended sea-surface, as low swamps, under a foggy or very wet atmosphere, should have its climate tempered in a proportional degree, and its vegetation an insular rather than a continental one. But this does not explain the disappearance of the more marked vegetable types of the Dakota group, and still less their re-appearance in the upper stage of the Tertiary.

The flora of the second group*, especially characterized by the plants of Evanston and Spring Cañon, preserves some relation to that of the first by the palms. Remains of plants of this family are, however, in this second group, very rare, and represent mostly fruits, which, though identical with organs of the same kind found at Golden, Black Butte, and the Raton, with Sabal leaves, may, however, belong to some other kind of vegetable. There is, besides, a diminished proportion of the leaves referable to subtropical types. With this the second group has

*See above: *Remarks on species of the second group.*

some species and representatives of genera which have been described from the Dakota Cretaceous, *Cinnamomum Scheuchzeri*, *Liriodendron*, and *Sassafras*, and it has also some of its species identical with those of the Arctic Miocene. Its *facies*, therefore, positively indicates a somewhat colder temperature than that of Lower Lignitic.

With the third group, the palms have disappeared entirely, as well as the subtropical types of the Lower Eocene. Its flora has also a *Liquidambar*, *L. gracile*, closely allied to a Cretaceous species, *L. integrifolium*, and with this it has a more marked predominance of arctic forms or species identical with those of the Miocene of Greenland and Alaska, as seen in the remarks on the tables. The lowering of the temperature is there still more marked than with the second group. In the whole extent of the Lignitic formations we can see, therefore, from the character of the successive floras, a slow decrease in the degrees of temperature, accountable, it seems, to the diminution of atmospheric humidity in proportion to a gradual consolidation and drainage of the land. The same phenomenon is indicated by the deposits of Lignitic beds, which, though of as great thickness in the second and third groups, cover less extensive areas.

The *facies* of the flora of the fourth group evidently represents the colder climate of a mountainous region, by the superabundance of conifers as the essential constituents of the forests of that epoch. It has, besides, many species of shrubs, *Salix*, *Myrica*, *Comptonia*, *Ilex*, *Rhus*, which generally form the undergrowth of pine-woods, or border the swamps and streams intersecting them, and in accordance, a less proportion of trees with deciduous leaves. This vegetation of the Upper Tertiary recalls by its character that of the Adirondacks of New York or of the Black Mountains of North and South Carolina, where each knob is overgrown by one species of conifers, here and there intermixed with poplars, birches, sometimes oaks and beeches, and where the undergrowth scarcely allows to penetrate in the dark recesses of the forests. As remarked in describing and comparing the species of this group, the flora of each place where fossil plants have been obtained is composed of some species of conifers which are not represented at the other localities. In the forests of the plains, conifers of a same kind are generally extensively and uniformly distributed, covering wide areas, as in some parts of Europe and of North America, especially in the maritime pine-woods of the South and the northern forests of the cold plains of Canada, Norway, &c. But in the mountains even at our time the forests are composed of numerous groups of a predominant species of conifers, represented in separate and limited areas, and varying in accordance to altitude, exposition, degree of declivity, &c. The limitation of conifer-species to different localities of our Upper Tertiary is thus characteristic of a mountain-flora.

In admitting, as positively proved, the exact and constant relation of the flora of a country or of a land surface with the climatic circumstances of the same localities, it is easily understood how doubtful are the conclusions taken concerning the relation of geological epochs in comparing the fossil floras of two continents. The four groups of our Tertiary are characterized by a succession of types bearing constant increasing analogy to those our present flora without the admixture of foreign vegetable forms, which imprint some local floras of Europe with peculiar and distinct *facies*. This indicates for this continent a long continuance of the same climatic circumstances without notable modification. These circumstances have not been of necessity the same in Europe during the same period of time. There may have been, for example, at the epoch of the Lower Tertiary or Eocene, a higher temperature, influenced by proximity to the sea, by its currents, by slanting areas exposed to the sun, &c., and of course a corresponding flora, Indo-Australian or tropical, &c., while, under different influence, we had at the same epoch a more moderate temperature and a flora with homologous types, related to those appearing later in Europe, when the temperature was at a lower degree, in the upper Miocene epoch, for example. This explains, of course, the non-correlation of vegetable types at epochs which are recognized as synchronous by their animal fossils, and, therefore, contract our deductions of synchronism of strata, as indicated by identification of fossil remains, into more narrow limits. It is probably for this reason that, in comparing the data furnished by our ancient floras with those of Europe, we have constantly recognized a kind of precedence of types which may be merely the expression or exposition of a difference of climatic circumstances at the same epochs. Of this, however, we have to learn a great deal more on those floras of old before we are able to take any reliable conclusions, and for this reason, also, it is of importance to limit our deductions on what we may learn in considering our North American fossil floras.

Paleontological data, animal and vegetable, have demonstrated, for the geological times, as far up as the Lower Tertiary, or at least the Upper Cretaceous, a uniformity of climate over the whole north hemisphere, from the pole to the equator, if not over the whole world. The causes of this phenomenon are multiple and not yet satisfactorily explained. In the flora of the Dakota group, and also in that of the second and third groups of the Tertiary, this isothermal *facies* is remarkably proved by identity of genera with those of the flora of the north, or as far up as remains of fossil plants have been found, especially with that of Greenland. The Cretaceous flora of Come, described by Heer in his Arctic Flora, is represented only by species of ferns and conifers, which do not have any relation to the plants of the Dakota group, except perhaps by one single species, *Sphenopteris Johnstrupi*, which is comparable to *Hymenophyllum cretaceum*. This flora of Come may be referable to a lower stage of the Cretaceous, as it has no remains of dicotyledonous leaves. In an upper flora of the same country, Professor Heer finds mostly dicotyledonous leaves, and recognizes them as referable to many of the genera represented in our Dakota group. As the memoir of those plants is not yet published, it is not known how intimate the relation may be; but the generic identity is enough already to indicate analogous climatic circumstances in Greenland and North America at this Upper Cretaceous epoch. The flora of our Lower Lignitic, the oldest of the American Tertiary, is as yet without relation with any northern flora known until now. But that of the second group and of the third are related, as remarked above, with the Miocene Greenland flora by a number of species and typical forms, which are characteristic enough to show that a same climate influenced at this epoch the vegetation of both countries. Therefore, from this, it seems that as far up as the Miocene period the isothermal zone extended from the tropic to the pole, or that at that epoch the same climatic circumstances have governed the vegetation of the North American continent.

The relation of the floras to the climate being forcibly recognized in local differences, or analogies of vegetable forms, it suggests another question, that of the origin of the groups of vegetables characterizing either different stages of the Tertiary or different localities of the same epoch.

Our flora of the Dakota group has for its essential representatives

(I consider dicotyledonous species only) leaves of a coarse coriaceous texture, mostly with entire borders. A character of the same kind is recognized in the flora of the Lower Lignitic group, which, like the former, has very few dicotyledonous leaves with serrate borders, a large proportion of coriaceous leaves, and also species of *Viburnum* with borders of leaves equally cut by short-pointed teeth turned outside, a same kind of dentation exactly which is remarked in a few dentate species of the Dakota group. In the European Cretaceous flora, as represented by *Credneria*, *Ettinghausenia*, &c., of the Quadersandstein of Germany, the leaves have a *facies*, which, though different in some points, could be, however, compared with that of a few species of our Cretaceous; for example, *Ettinghausenia Sternbergii*, Stiehler, or *Phyllites repandus*, Sternb., (figured in vol. ii, Tab. xxv, of Fl. der Vorwelt,) could be admitted as an original type of the multiple forms of *Sassafras* of the Dakota group. But when we look further and come to the floras of the lowest Tertiary of Europe, that of the lower Sezane for example, which, by the presence of Cretaceous and Tertiary types, seem to indicate a flora of transition between these two formations, and is recognized as Lower Eocene, we find characters pointing out, I think, to a multiple kind of derivation. This Sezane flora has its dicotyledonous types represented by 21 genera, with 47 species, with more or less serrate or doubly-serrate and dentate leaves, and 11 genera, represented by 20 species, with entire-bordered leaves; therefore, a large predominance of leaves marked by a character mostly absent from the Dakota group and Lower Lignitic American floras. Considering this Eocene flora of France only, with its species of *Betula*, 2; *Alnus*, 3; *Ulmus*, 2; *Populus*, 1; *Salix*, 3; *Aralia*, 6; *Greviopsis*, 5; *Juglandites*, 4; *Celastrites*, 4; *Rhamnus*, 1; &c., all, even *Salix*, *Juglandites*, *Rhamnus*, with serrate leaves, it would be rational to suppose that the original types of the dicotyledonous flora did represent essentially serrate leaves; while we had reason to admit a contrary conclusion from the characters of our Cretaceous and Lignitic floras, whose types, even from the same genera, *Juglans*, *Salix*, *Populus*, are represented by entire-leaved species. Also, in the dentate leaves of the North American Cretaceous and Eocene, the type is distinct. With very few exceptions, these have the peculiar dentation remarked in the description of *Greviopsis Haydenii* of Nebraska, and of *Viburnum marginatum* of Black Butte. I have compared this last species to *V. giganteum* of Sezane, but only for the size of the leaves and the character of the nervation, not for the division of the borders, as seen above; for the Sezane species has long, turned-upward teeth, some of them doubly dentate, a character in accordance with most of the other kind of leaves of this European group. How to account for discrepancies of this kind? Is the Sezane flora representative of a formation absent from the American geology, or not yet recognized in it; of a land-formation which, under different climatic influences, could have harbored the same types as the Sezane ones, introduced by some kind of agency? This is evidently not the case, as the series of the Cretaceous strata from the Dakota group to the Lignitic is uninterrupted, and especially as both successive floras are related by a general character far different from that of the contemperaneous floras of Europe and of those of intermediate epochs. Now, admitting that the succession of generic types indicates continuous development or multiplication of forms and characters in ascending from the lowest strata of the geological formations, shall we say that a single form or type or species has been at different times the first and only representative of each group, though wide and multiple in its representatives it may be now? Or, considering merely the dicotyledonous plants, which make their first appear-

ance at the beginning of the Cretaceous, are they all derived from the modification of a same lower form, developed at the same or at different localities under influences of the same kind? I do not think it possible to suppose that the first leaf representative of a dicotyledonous has appeared only at one place of the surface of the earth, nor that it has been derived from a same organism over the whole world, nor that the external first causes of modification have been the same. Therefore, even admitting the theory of successive transformation of vegetable types in a kind of ascending scale, it would be necessary to consider as multiple, local, varied in forms, the first dicotyledonous representatives. If this is true for the dicotyledonous plants, it has to be equally admitted for plants of a lower type. Simple as they were, then, in their characters, they did hold, as seeds do, all the future typical conformations of their offsprings, resulting of influences of divers natures; but as it is the case with seeds of different kinds, the result of their multiplication of growth should, of course, have been represented by groups of vegetables of different characters. This would account for the diversity of floras of the same epoch at distant localities, or for the isolation and dissimilarity of types in the flora of two continents in synchronous formations. I believe, therefore, that the disaccord remarked in the floras of geological epochs, and which have been explained by displacement of floras, or what is called a wandering of species, may be, in many cases at least, attributed to diversity of original forms. The more we descend toward the so-called primitive vegetable types, or the more simple have been the organism of plants, the more easily they should have been modified under local influences. A change of climate of a few degrees, which might have caused the disappearance or extinction of some species of plants, should have forced the deformation of others or the birth of new ones in a proportional degree. Though the intermediate links which connect ancestors and descendants in vegetable types are not always recognizable, even in the oldest fossil floras, it is certain that all the groups have a general family-*facies* modified by some new and discordant forms of unaccountable origin. In our Lignitic, the group of Evanston, for example, introduces to the Tertiary flora the serrate leaves, its *Carya*, *Alnus*, *Betula*, &c. That of Carbon comes after with *Acer*, *Ulmus*, and other new types. Have they been brought up from Greenland, from Europe, or from another country, or have they appeared for the first time where we find them now? They must have had their birth at some place, anyhow; and I do not see why this birthplace should not be accepted for the localities where the types are recognized, rather than to suppose them born elsewhere and transported hereafter, adding to the problem a new proposition, which renders its solution still more difficult. As said above, the question is merely touched upon, as I do not wish to take ground either for or against the present system, now generally admitted, of the succession of species, or of their development by modification of form under any kind of influence. My purpose is merely to point out the importance of the study of our ancient North American floras, represented by more homogeneous groups in a more regular succession, less diversified by geological disturbances, and which, therefore, may afford some more reliable data for consideration. The history of the vegetation of the earth is in intimate relation to that of the human races. The proverb, "All flesh is grass," is explainable in this way: that the vegetation of every epoch is in immediate relation to the synchronous beings; that vegetable life comes first and that animal life is dependent from it; that therefore the history of the vegetation from its origin, or the vegetable paleontology, should not be left aside in considering the successive phases of animal life in relation to the history of man.