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THE FLORA OF THE DENVER AND ASSOCIATED FORMATIONS OF COLORADO

BY

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EDITOR'S PREFACE

The present work was one upon which Doctor Knowlton had labored at intervals over a long period of years and which was practically completed at the time of his death. The editor's task has been that of comparing the figures with the types and supplying a few gaps in the text. At no point has he deemed it desirable to give expression to opinions differing from those of the author, and the work as it stands is entirely Doctor Knowlton's. The few comments that have seemed advisable have been placed in footnotes signed by the editor's initials.

E. W. B.

THE FLORA OF THE DENVER AND ASSOCIATED FORMATIONS OF COLORADO

By FRANK HALL KNOWLTON

INTRODUCTION

In the introduction to my report on the Laramie flora of the Denver Basin[1] I stated that that was the first of what was proposed to be a series of papers dealing with the stratigraphy and paleobotany of certain Upper Cretaceous and lower Tertiary plant-bearing formations of the Rocky Mountain region. The present paper is the second of this series and deals with the flora of the Denver formation and certain identical or closely related formations that occur mainly in or adjacent to the Denver Basin of Colorado. The additional formational units treated are the Arapahoe formation, the Dawson arkose, and the Middle Park formation.

HISTORICAL REVIEW

As the history of the recognition and subsequent naming of the Arapahoe and Denver formations is more or less closely interwoven with that of the Laramie formation, it is necessary to give a brief review of certain portions of the Laramie history. This review is in the main an adaptation from a historical review of opinion concerning the Laramie formation, which forms the first part of the paper cited above.

AREA AROUND DENVER

The area about the city of Denver, Colo., now well known as the Denver Basin, is in a way classic ground for geology. It has been visited and studied in greater or less detail by all the geologists and paleontologists who have been interested in Rocky Mountain geology. Included among the pioneers in this study are John L. Le Conte, F. V. Hayden, A. C. Peale, A. R. Marvine, Leo Lesquereux, C. A. White, L. F. Ward, S. F. Emmons, G. H. Eldridge, and Whitman Cross. The coal-bearing rocks lying conformably above the marine Fox Hills sandstone were at first believed to be a southern extension of the "Lignitic group" of the upper Missouri River region and were held by Hayden, Lesquereux, White, and others to be of Tertiary age. When the Laramie was established by King as the uppermost member of the conformable Cretaceous series above the Fox Hills this portion of the section in the Denver Basin and adjacent areas along the Front Range fell within its limits and was regarded by him and by those who accepted his views as Cretaceous. This so-called Laramie was for many years considered to be a unit, notwithstanding the fact that at certain points along the base of the mountains, notably at Golden, there is evidence of discontinuity in deposition and difference in lithologic composition. Thus in the lower or coal-bearing portion of the section some of the beds are nearly vertical, whereas certain other beds, as those in Table Mountain, are nearly horizontal. Ward invoked the presence of a hypothetical fault to account for this apparent discordance. Both lower and upper beds had furnished extensive collections of plants, which had been studied mainly by Lesquereux, but, as it later appeared, no distinction was made in the records concerning them, all being called simply Laramie, with the result that when the several formations were subsequently proved to be distinct the greatest confusion and difficulty resulted in attempting to separate these floras.

As early as the summer of 1881, when Cross[2] began his studies in the Denver Basin, he "first observed," to use his own language, "that the Table Mountain strata possessed characteristics proving them to belong to a series distinct from the normal Laramie." No published announcement of this discovery was made at the time, and for a number of succeeding years field work was continued in the region, during which it was ascertained by George H. Eldridge, who was associated with Cross, that there was apparently another distinct Tertiary formation between that discovered by Cross and the normal Laramie. A preliminary statement of the most significant results of this investigation was made by Eldridge and Cross in two papers read before the Colorado Scientific Society July 2, 1888, and published in its proceedings. In the first of these papers Eldridge[3] named and described the Arapahoe formation,[4] which, he stated, was "the

[1] U. S. Geol. Survey Prof. Paper 130, p. 3, 1922.

[2] Cross, Whitman, The Denver Tertiary formation: Am. Jour. Sci., 3d ser., vol. 37, p. 262, 1889.

[3] Eldridge, G. H., On some stratigraphical and structural features of the country about Denver, Colo.: Colorado Sci. Soc. Proc., vol. 3, pp. 86–118, 1888.

[4] This was first named the "Willow Creek beds," but on the ground of preoccupation the name was changed in a footnote (p. 97) to Arapahoe.

formation next succeeding the Laramie in geological order, and unconformably resting on it." It was characterized as follows:

> It is composed of a basal member of conglomerate or gritty sandstone, according to its distance from the foothills, with an overlying zone of gray argillaceous or arenaceous shales, with an occasional ironstone; when confined between underlying and overlying groups it has a thickness of between 600 and 1,200 feet.

In the succeeding article Cross[5] named and described the "Denver Tertiary formation," which he believed to be unconformably overlying the Arapahoe. Lithologically it was found to be composed almost entirely of andesitic volcanic material; its thickness was given as 800 to 1,200 feet.

As already indicated, both the Arapahoe and Denver formations were regarded originally as of Tertiary age, and both were found to contain fairly abundant vertebrate remains belonging to turtles, crocodiles, and dinosaurs. These remains were studied by O. C. Marsh, who pronounced the dinosaurs from the Denver to be "typical Jurassic dinosaurs of both herbivorous and carnivorous types."[6] Later, when the Ceratopsidae, a group of peculiar horned dinosaurs especially abundant in the Lance formation of Converse County, Wyo., was described, these dinosaurs were found to belong to it. The presence of these dinosaurs was considered by the vertebrate paleontologists as fixing the age of the beds containing them as Cretaceous. The invertebrates consisted of only a few fresh-water types and proved of very little value in indicating the age.

Fossil plants were abundant, especially in the Denver beds; but, as already stated, the large collections previously made were without specific locality labels, and all were then considered to be of Laramie age. Before they could be used in the light of this newer information regarding their stratigraphic relations it was necessary to separate them if possible, and it was found that this could be done almost invariably on the basis of the matrix in which they were preserved. These earlier collections were fortunately deposited in the United States National Museum, and the study of the matrix undertaken by Cross resulted in showing that they were distinct from those of the underlying Laramie—in fact, out of about 98 species in the Laramie and 140 in the Arapahoe and Denver only about 15 nominal species were found in common. It may be added that subsequent studies of the Arapahoe and Denver plants have shown them to be essentially Tertiary in type.

In 1892 Cross[7] briefly reviewed the relations of the Arapahoe and Denver formations of the Denver Basin and also enumerated additional Colorado localities in the Huerfano Basin, Gunnison County, the Yampa River region, the Animas River region, Middle Park, and elsewhere, in which identical or similar stratigraphic relations had been established. He discussed at length the conflicting paleontologic evidence of the age of these deposits, and concluded as follows:

> The writer wishes to advocate the restriction of the term "Laramie," in accordance with its original definition, to the series of conformable beds succeeding the marine Montana Cretaceous, and the grouping of the post-Laramie lake beds described, with their demonstrated equivalents, in another series to which a comprehensive name shall eventually be given. * * * The question as to whether the series shall be referred to the Cretaceous or to the Eocene can not be finally settled until the various conflicting elements of the evidence have been adjusted on a basis of further and more exact information.

In 1892 Cross[8] published an amplification of the previous brief notice, in which it was shown that the large area referred to the "Lignite" or Laramie was made up of a thick series of mainly andesitic rocks resting unconformably on marine Cretaceous, there being no beds corresponding to the Laramie of the Denver Basin. These beds, called the Middle Park beds, were correlated with the Denver beds on account of their position, their lithologic similarity, and the identity of the contained floras.

The publication of the monograph on the Denver Basin, by Emmons, Cross, and Eldridge,[9] was delayed until 1896, a delay which in many ways was perhaps of advantage, for it permitted the incorporation and discussion of many pertinent facts that had been made available in the meantime regarding the stratigraphic and other relations of the formations under discussion. The Laramie, Arapahoe, and Denver formations of the Denver Basin were, of course, described in detail, and the relations between the Laramie and overlying rocks especially were made plain. The magnitude of this time interval was insisted upon as of major importance in Rocky Mountain stratigraphy. The Arapahoe and Denver formations were referred to the Cretaceous out of deference to the views of Marsh, at that time vertebrate paleontologist of the Geological Survey. The lithologic and stratigraphic relations of these formations and a very full discussion of the several lines of paleontologic evidence were given by Cross, who prepared this portion of the volume.

[5] Cross, Whitman, The Denver Tertiary formation: Colorado Sci. Soc. Proc., vol. 3, pp. 110–133, 1888; recast and republished under the same title in Am. Jour. Sci., 3d ser., vol. 37, pp. 261–282, 1889.

[6] See Cannon, G. L., On the Tertiary Dinosauria found in Denver beds: Colorado Sci. Soc. Proc., vol. 3, p. 143, 1888.

[7] Cross, Whitman, Post-Laramie deposits of Colorado: Am. Jour. Sci., 3d ser., vol. 44, pp. 19–42, 1892.

[8] Cross, Whitman, The post-Laramie beds of Middle Park, Colo.: Colorado Sci. Soc. Proc., vol. 4, pp. 1–27, 1892.

[9] Emmons, S. F., Cross, Whitman, and Eldridge, G. H., Geology of the Denver Basin in Colorado: U. S. Geol. Survey Mon. 27, 1896.

For 10 years after the publication of the Denver Basin monograph little active work was prosecuted in this region, though investigations in adjacent or more remote areas were found to have a more or less direct bearing on the problems here involved.

In 1897 Veatch,[10] from studies in Carbon County, Wyo., was led to question the validity of the current application of the term "Laramie." He endeavored to prove that Carbon County was intended by King to be the type locality for the Laramie. In this vicinity Veatch discovered the presence in the supposedly continuous Laramie section of a profound unconformity, which he thought to be similar to that found by Cross in the Denver Basin, and as the beds studied and described at Carbon by the members of the King Survey were all above the break, he contended that the name should properly be applied only to those beds and not to the beds conformable to the Cretaceous section. Veatch further held that the delimitation of the Arapahoe and Denver formations by Cross constituted a virtual redefinition of the Laramie.

Veatch's paper was answered by Cross[11] and Peale,[12] and it is sufficient to say that his view has not been adopted. Cross especially reviewed the facts relating to the application of the term "Laramie," holding that the separation of the Arapahoe and Denver did not constitute a redefinition, and finally, following out a suggestion made by himself in 1892, proposed to call these two formations and their equivalents the Shoshone group.

> It is proposed to apply the term "Shoshone group" to the deposits which unconformably succeed the Laramie and to their equivalents, and which are overlain by the Fort Union or Wasatch beds, when they are present.

In this paper Cross briefly reviewed the data bearing on the age of these post-Laramie beds and concluded as follows:

> In the preceding discussion I have avoided the suggestion as to the age of the Shoshone beds, whether Cretaceous or Eocene. I desire now to urge their reference to the Eocene. The Denver beds were originally referred by me to the Eocene, but the great weight attached to the Mesozoic affinities of the vertebrate faunas by paleontologists led to a tentative acquiescence in the assignment of the Arapahoe and Denver formations to the Cretaceous in the Denver monograph.

DAWSON ARKOSE

Dawson arkose is the name now adopted for the lower portion of the "Monument Creek group" of Hayden,[13] established in 1869 in an account of a reconnaissance study from Cheyenne, Wyo., through the Denver Basin, Colorado Springs, Canon City, and Raton fields. The group was based on "a series of variegated beds of sands and arenaceous clays, nearly horizontal, resting on the upturned edges of the older rocks, * * * of various colors * * * and of various degrees of texture." It occurs along the Front Range on the divide between the Platte and Arkansas drainage basins, where it covers an area "of about 40 miles in width from east to west and 50 miles in length north and south." From its modern appearance Hayden concluded that it was of "either late Miocene or Pliocene age."

In a "Report on the vertebrate paleontology of Colorado," published in 1873, Cope[14] took occasion to speak of the age of the "Monument Creek group," concluding that it was younger than Eocene and older than Pliocene, hence "it may be referred to the Miocene until further discoveries enable us to be more exact."

In the following year (1874) Hayden[15] again referred to the "Monument Creek group," and after describing it at some length alluded to Cope's statement regarding the vertebrate evidence, saying: "As to the real age of this group, I am inclined to regard it as Miocene, perhaps upper Miocene."

The next publication that it is necessary to notice is the Denver Basin monograph by Emmons, Cross, and Eldridge,[16] though their discussion of these rocks is brief, as in the series of beds mapped these rocks occur only as projecting tongues forming the divide between the Platte and Arkansas waters.

Emmons gave first a brief summary in which, although calling the beds the "Monument Creek formation," he noted that "two divisions have been distinguished, marked by an apparent unconformity and period of erosion." The lower division was referred tentatively to the Miocene on the basis of the previous vertebrate work of Cope; the upper division was thought probably to be referable to the Pliocene.

Eldridge devoted several pages to the discussion of the stratigraphic relations, lithology, and life of the "Monument Creek formation," writing in part as follows:

> The Monument Creek formation occurs along the southern edge of the Denver field in the steep slopes of a high mesa and also stretches from its base prairieward in thin sheets.

[10] Veatch, A. C., On the origin and definition of the geologic term Laramie: Am. Jour. Sci., 4th ser., vol. 24, p. 18, 1907; expanded under the same title in Jour. Geology, vol. 15, p. 526, 1907.

[11] Cross, Whitman, The Laramie formation and the Shoshone group: Washington Acad. Sci. Proc., vol. 11, pp. 27–45, 1909.

[12] Peale, A. C., On the application of the term "Laramie": Am. Jour. Sci., 4th ser., vol. 28, pp. 45–58, 1909.

[13] Hayden, F. V., Preliminary field report of the United States geological survey of Colorado and New Mexico, pp. 37–46, 1869; reprint, pp. 137–146, 1873.

[14] Cope, E. D., U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, p. 430, 1874.

[15] Hayden, F. V., U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1874, pp. 36, 37, 1876.

[16] Emmons, S. F., Cross, Whitman, and Eldridge, G. H., Geology of the Denver Basin in Colorado: U. S. Geol. Survey Mon. 27, pp. 38, 39, 252–254, 1896.

The floor of the lake in which the Monument Creek was deposited was more or less irregular from erosion and in one part or another consisted of the clays and sandstones of the Laramie, Arapahoe, or Denver formations. In the foothill region the Monument Creek lies in contact with the Arapahoe; between Platte River and Cherry Creek a few hundred feet of Denver beds exist, which farther to the east disappear. North and east of Coal Creek, on the eastern edge of the field, both Denver and Arapahoe are wanting, and the Monument Creek rests directly upon the clays of the Laramie.

Although the relations between the Denver and Arapahoe and the "Monument Creek" were somewhat obscure, the interpretation naturally followed that the latter was stratigraphically above the former, because it was then supposed that the lower division of the "Monument Creek" was Miocene in age, whereas the Arapahoe and Denver were then referred to the Cretaceous.

In 1902 Lee[17] discussed the "Monument Creek group" of Hayden. To the lower portion (of Emmons and others) he applied the name "Monument Creek formation," and to the upper division (the "Upper Monument Creek" of Hayden), "the youngest formation in the Castle Rock region," he gave the name "Castle conglomerate." Lee did not obtain paleontologic data bearing on the age of either of the divisions of the "Monument Creek" as recognized by him, but three years later Darton[18] obtained additional vertebrate evidence regarding the upper division, correlating it with the Chadron formation of the White River group—that is, with the Oligocene. He did not obtain evidence as to the age of the lower division but said: "The presence of the unconformity between the upper and lower members suggests that the latter may be of Wasatch or Bridger age."

The status of the "Monument Creek" problem remained as indicated above until 1910–11, when G. B. Richardson began a study of this region in preparation for a report on the geology of the Castle Rock quadrangle, which is joined by the Denver Basin on the north and by the Colorado Springs quadrangle on the south. As a result of this study Richardson[19] recognized and confirmed the twofold division of the "Monument Creek" and the separation of the two divisions by a marked unconformity. To the lower division he gave the name Dawson arkose, and to the upper division the name Castle Rock conglomerate. The Castle Rock conglomerate—that is, the "Upper Monument Creek" of Hayden and others; the so-called upper division of the "Monument Creek" of Emmons, Eldridge, Darton, and others; and the "Castle" conglomerate of Lee (Lee's name being unavailable on account of prior usage)—occurs in the south-central part of the Denver Basin, where it crops out in detached areas on the divides between the South Platte and Arkansas drainage basins from the vicinity of Elbert to Sedalia, a distance of about 30 miles. It is a remnant of a once larger formation that has been reduced by erosion. Richardson obtained additional vertebrate evidence for the correlation of the Castle Rock with the Chadron formation, the lower formation of the White River group, of Oligocene age.

In the present connection of course the greater interest attaches to the Dawson arkose, the exact age of which had been so long in question. It reaches a maximum thickness of about 2,000 feet on the west, toward its source in the mountains, and becomes thinner as it extends eastward on the plains. The Dawson arkose was described at length by Richardson,[20] who said:

> This formation is composed of a complex mass of varicolored and varitextured arkosic conglomerate, sandstone, shale, subordinate carbonaceous deposits, and clay derived chiefly from the rocks of the Front Range and deposited under various continental conditions. Sandstones comprise the greater part of the Dawson arkose. They are medium to coarse textured arkosic grits. * * * Beds and lenses of conglomerate occur throughout the formation. * * * It also includes local bodies of clay. * * * In the valley of Cherry Creek, at the north end of the quadrangle, there is an exposure of sandstone and shale composed of andesitic material.

Concerning the relation between the Dawson arkose and the Arapahoe and Denver formations Richardson wrote:

> Recent studies in the Castle Rock quadrangle have led to the recognition of previously unsuspected relations between the Arapahoe and Denver formations and the Monument Creek group of Hayden. The upper part of the "Monument Creek group" is now known to be Oligocene, and a portion of its lower part, the Dawson arkose, is known to be equivalent to the Arapahoe and Denver formations.
>
> The Dawson arkose strikes into and merges into both the Arapahoe and Denver formations. Anyone following the Dawson arkose northward along the strike from the vicinity of Dawson Butte to the area mapped as Arapahoe in the Denver monograph will find it impossible to separate these formations even at the type locality of the Arapahoe along the bluffs of Willow Creek, 3 or 4 miles southeast of the entrance to the Platte Canyon, which is only 3 miles west of the Castle Rock quadrangle.
>
> Likewise, the Dawson arkose and Denver formations merge into each other. Changes from andesitic to arkosic material occurring as interfingering lenses are common near the south end of the Denver formation, a few miles north of the Castle Rock quadrangle. * * * The marked difference in lithology between the andesitic Denver and the arkosic Dawson may be accounted for by the geographic distribution of the

[17] Lee, W. T., The areal geology of the Castle Rock region, Colorado: Am. Geologist, vol. 29, pp. 102, 103, 1902.

[18] Darton, N. H., Age of the Monument Creek formation: Am. Jour. Sci., 4th ser., vol. 20, pp. 178–180, 1905.

[19] Richardson, G. B., The Monument Creek group: Geol. Soc. America Bull., vol. 23, pp. 267–276, 1912.

[20] Richardson, G. B., U. S. Geol. Survey Geol. Atlas, Castle Rock folio (No. 198), p. 7, 1915.

rocks that supplied the sediments, the arkose being derived mainly from the Pikes Peak granite and associated rocks, whereas the Denver formation was derived, apparently simultaneously, from a local source of andesite.

MIDDLE PARK FORMATION

For many years it was supposed by the earlier geologists that there was a considerable area of Laramie rocks forming the divide between Middle and North Parks. This was the view held by Hayden,[21] who visited Middle Park in 1869 and was the first to describe the beds under consideration, but as his was only a hasty reconnaissance trip, mainly on the Colorado (formerly Grand) River near Hot Sulphur Springs, the description is necessarily brief. He mentioned especially the "Lignitic" beds, which were regarded "as of the age of the coal formations of the West—older Tertiary." The beds beneath the "Lignitic" Hayden called basalt, but they are now known to be the volcanic breccia and conglomerate of later writers. Fossil plants were collected at a number of localities.

The first adequate description of the geology of Middle Park was made by Marvine[22] in 1873. The geologic map of Colorado issued by the Hayden Survey, based largely on Marvine's work, shows the supposed Laramie occupying a large area and extending southeastward from the Continental Divide into Middle Park. The area gradually narrows and just before reaching the Colorado River divides into two arms, the eastern of which crosses the river east of Hot Sulphur Springs and terminates at a point some 4 or 5 miles south of the river. This arm is somewhat spoon-shaped, and as the beds dip inward on all sides from the rim of dark volcanic breccia it was designated the "breccia spoon" by Marvine. The western arm ends its continuous exposure at Mount Bross, on the north side of the Colorado River, though it continues interruptedly for some distance toward Mount Byers. In describing this area Cross[23] said:

> In the angle between the arms of "Laramie" appear the strata of the Cretaceous section, from the Dakota to the Fox Hills, inclusive, with a northwest-southeast strike and a northeasterly dip of 15°–25°, which carries them in apparent conformity below the strata of the "breccia spoon," while the "Laramie" beds of Mount Bross and the ridge to the southeast rest in nearly horizontal position upon Archean and the edges of the Dakota and Colorado shales. This is the unconformity discovered by Marvine.

The doleritic beds next above the Cretaceous were stated by Marvine to be 800 or 900 feet thick, and above them occurs some 5,500 feet of the "Lignitic series."

In 1877 C. A. White visited Middle Park and searched the supposed Laramie for fossils, but without avail, though he refers to a few invertebrates procured by Marvine in North Park, probably in the same formation. Concerning these White[24] said:

> Of themselves they are not sufficient to determine the age of the strata containing them or their equivalency or otherwise with those of the Laramie group. * * * The Middle Park strata contain no fossils that are certainly identical in species with any of the numerous forms found on each side of that region at the eastern and western bases, respectively, of the Rocky Mountains; and they contain, so far as known, only those imperfectly known species [from North Park] before referred to that are possibly identical with forms in the Fort Union beds of the upper Missouri.

The status of knowledge concerning the beds in Middle Park remained as indicated above for a decade or more after White's visit, but by that time the Arapahoe and Denver formations in the Denver Basin had been demonstrated to be distinct from the Laramie. From the early descriptions of the lithology and supposed stratigraphic relations of the so-called Laramie in Middle Park it was conjectured that those beds might show a similarity to the Denver formation for at least a part of the series. In order to test this suggested relation S. F. Emmons, in charge of the Colorado division of the United States Geological Survey, sent George L. Cannon, jr., to Middle Park in the summer of 1889, and his report amply confirmed this idea. Whitman Cross also visited the area in the fall of 1890 and again in 1891, at first devoting his attention to the lithologic character of the breccia and of the beds above it, as well as to evidences of unconformity. The early observations were largely of local character, but, as Cross said: "The question at issue soon expanded to one regarding the geological history of the whole Middle and North Park areas in the period following the conformable series of Cretaceous deposits." The results of this study by Cross[25] were published in 1892. He described first the so-called "doleritic breccia," which in some places rests on undoubted Fox Hills and in others apparently on Pierre shale. This series of beds is composed largely of andesitic material, with fine-grained tuff alternating irregularly with conglomerate. Where the beds are massive bold-faced cliffs are found, but where the beds

[21] Hayden, F. V., Preliminary field report of the United States geological survey of Colorado and New Mexico, pp. 80–86, 1869; reprint, 1873, pp. 181–186, 193.

[22] Marvine, A. R., U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, pp. 154–192, 1874.

[23] Cross, Whitman, The post-Laramie beds in Middle Park, Colo.: Colorado Sci. Soc. Proc., vol. 4, p. 194, 1895.

[24] White, C. A., U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1877, p. 203, 1879.

[25] Cross, Whitman, The post-Laramie beds in Middle Park, Colo.: Colorado Sci. Soc. Proc., vol. 4, pp. 192–213, 1895; separate print, pp. 1–27, 1892.

are finer grained the cliffs are broken down by cross ravines and depressions. Fossil plants occur at a number of horizons within this series. Overlying the breccia are the "lignitic" beds, which are separated by beds of transition and not by a distinct erosion interval as supposed by Marvine. They are composed of tuff, conglomerate, and sandstone and are probably over 5,000 feet thick. Fossil plants are found at various points but especially toward the base. Cross gave a list of the fossil plants then known from the post-Laramie beds in Middle Park, prepared by me, and tentatively referred these beds to the approximate age of the Denver formation. The present study confirms this reference.

PLANTS IN THE EQUIVALENT OF THE ARAPAHOE FORMATION

Before passing to the consideration of the Denver formation and its flora it is necessary to dispose of the supposed flora of the Arapahoe formation. According to Eldridge, on whom largely devolved the task of studying the Arapahoe formation in the field for the Denver Basin monograph, the Arapahoe was found to contain poorly preserved plant remains at a number of localities in the Denver region, but no determinable remains were obtained. In fact, only two localities appear to have been recorded from which determinable plants supposed to be of Arapahoe age had been reported—Sand Creek, east of Denver, and the vicinity of the old Douglas coal mine, near Sedalia, about 20 miles south of Denver.

The so-called Sand Creek locality may be first considered. The following account is taken from my report on the flora of the Laramie formation,[26] where it was necessary to consider this flora in connection with the Laramie flora:

> Some 9 or 10 species of plants are recorded as having come from the Sand Creek locality, all of which were obtained by the earlier workers in this field—that is, probably about 1873. Considerable uncertainty has existed as to the exact locality whence these plants came, but apparently important light is thrown on this point by a chance statement made by A. R. Marvine[27] in his paper on "The geology of Middle Park," which, on account of its importance, is quoted entire below.
>
> "East of Denver, in T. 4 S., and probably between Rs. 65 and 66 W., a shaft has been sunk for some depth in a high bank on the south side of Sand Creek but is now abandoned. The coal also outcrops on the bank and there appears as of very poor quality. Fossil leaves are abundant.
>
> "It was near here that the first discoveries of coal were made in Colorado, and the stream is often known at this point as Coal Creek, though called Sand Creek farther down. The latter name should be retained to prevent confusion between this and the better-known Coal Creek on the west side of the Platte.
>
> "About 4 miles to the north, near Box Elder, on the Kansas Pacific Railroad, in R. 65 W., T. 3 S., sec. 28 (?), and probably at the same horizon as the last, are two shafts which reach coal and on which work has been done now and then for some years. It is probably in one of these three shafts that the following section was made by Mr. E. B. Mally (quoted by Lesquereux in Hayden's report for 1872, p. 327), and which seems to give an idea of the strata near here. * * *
>
> "The work was abandoned on account of the poor quality of the coal."
>
> That the above-indicated plant-bearing horizon is probably the important one in the present consideration was still further indicated by Marvine, who, after mentioning a number of coal openings in another direction from Denver, said: "The only others I have heard of lie from 15 to 17 miles east of Denver City and near the Box Elder station on the Kansas Pacific Railroad." The assumption seems to be justified, therefore, that the plants labeled "Sand Creek" probably came from this area.
>
> In Lesquereux's "Tertiary flora" the following data are recorded concerning six of the species reported to have come from Sand Creek:
>
> Lastrea (Goniopteris) polypodioides. Sand Creek (W. H. Holmes).
> Gymnogramma [Gymnogramme] gardneri. Roof of a coal mine, Sand Creek (A. Gardner).
> Equisetum laevigatum. Sand Creek, 8 feet above coal (W. H. Holmes).
> Eriocaulon? porosum. Sand Creek (W. H. Holmes), with leaves of Nelumbium.
> Nelumbium tenuifolium. Sand Creek, Colo. (A. Gardner).
> Quercus viburnifolia. Sand Creek (A. R. Marvine).
>
> These species are similarly recorded in the catalogue of fossil plants in the United States National Museum, in Lesquereux's own handwriting, so it may be presumed that the statements are correct, at least so far as his information went. The species obtained by Marvine were doubtless collected on the occasion of his visit there in 1873, but no data are available as to the date on which the two species accredited to Professor Gardner were collected.
>
> W. H. Holmes assisted Marvine in his geologic work in 1873, and the plants recorded as having been collected by him were probably obtained at that time, but on consultation with Professor Holmes I find that he has now no recollection of having collected the plants, or, indeed, of having visited any coal mines east of Denver. This injects another element of uncertainty into the already sufficiently complicated matter, but we shall probably never come any nearer to a complete explanation. To sum up, it appears in its final analysis that we do not know the precise locality for a single one of these Sand Creek plants, though in all reasonable probability they apparently came from the vicinity of the coal openings on Coal or Sand Creek about 15 miles east of Denver, but as the locality is in doubt, it naturally follows that the horizon is also uncertain. It was apparently assumed by Eldridge that they came from the Arapahoe, for he stated that along Sand Creek this formation rests on the Laramie, but according to the map showing the areal geology in the Denver Basin monograph the Laramie occurs on the north bank of the creek and the Denver on the south bank, no Arapahoe being indicated. Cross,[28] in discussing the Sand Creek locality, said: "The specimens preserved in the National Museum do not satisfactorily indicate the horizon from which they came. It seems probable that a

[26] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 130, pp. 102–103, 1922.

[27] U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, pp. 120, 121, 1874.

[28] Cross, Whitman, U. S. Geol. Survey Mon. 27, p. 225, 1896.

part of them came from the Arapahoe beds and a part from the Laramie."

Up to this point, from the data available, it appeared to me that if any of the Sand Creek plants came from the Laramie they probably all did, and on this basis it was my original intention to include them provisionally in the present work [Laramie flora]. However, important observations made by W. T. Lee during the field season of 1915 put an entirely different light on the matter and have led me to exclude all the Sand Creek species from both Arapahoe and Laramie and to refer them with little or no question to the Denver. The evidence is as follows:

Lee examined the log of a deep well that has been drilled about 2½ miles northeast of Coal Creek (or Sand Creek). This well starts at the surface in sandy coal-bearing beds that are lithologically and stratigraphically identical with the beds in question along Coal Creek and are also the same as the coal-bearing beds at Scranton, which from the presence of coal are supposed to be in the upper part of the Laramie.

* * *

The facts brought out by this well record are of far-reaching significance. It shows that the Scranton coal, heretofore thought to be in the upper part of the Laramie, is about 350 feet above [the basal conglomerate of the Arapahoe formation. This conglomerate, which is about 50 feet thick, is characteristic, being made up of the usual assortment of pebbles from the older rocks]. It also appears that the Scranton coal is more than 400 feet above beds that can with reasonableness be referred to the Laramie.

The plants from the vicinity of the old Douglas coal mine (later called the Lehigh mine), nearly 4 miles west of Sedalia, have also had a varied history. They were collected by Arthur Lakes in 1890 and are recorded as coming from three localities:

325. Quarry No. 2, 3,000 feet east of Douglas coal mine.
331. Quarry No. 1, 1,900 feet east of Douglas coal mine.
332. Douglas coal mine [which is in the Laramie formation].

These localities were mentioned in the Denver Basin monograph [29] and the collections from the localities east of the coal mine were spoken of as obtained "in what are apparently Arapahoe beds." The larger part of the flora came from quarry No. 2, 3,000 feet east of the Douglas mine. The mine is about 5 miles south of the southern boundary of the Denver quadrangle and 2 miles west of the western boundary of the Castle Rock quadrangle and is very near the type locality of the Arapahoe formation, which was originally named "Willow Creek beds" from exposures on Willow Creek, 3 or 4 miles southeast of the entrance to the Platte Canyon. In the Castle Rock folio Richardson maps all the northwest corner of the quadrangle around Sedalia as Dawson arkose, and in a sketch map (fig. 5, p. 10) he shows that formation extending to the narrow band of Laramie in which the Lehigh mine is located. Another sketch map (fig. 3, p. 7) shows the areal relations of the Dawson to the Arapahoe and Denver in this vicinity. On page 8 of the text he gives a list of "plants collected by Arthur Lakes from Dawson arkose, NE. ¼ sec. 20, T. 7 S., R. 68 W., 3 miles west of Sedalia, 700 to 900 feet above base [top [30]] of the Laramie formation." This list is based on Lakes's collections from the two localities east of the Douglas mine and has since been revised. The rocks from which the plants came are in an area where the lithologic distinction between the Arapahoe and the Denver is no longer valid for drawing a stratigraphic boundary between these two formations. Nevertheless the horizon is so low in the Dawson that it is clearly within the equivalent of the Arapahoe formation as mapped along the southern boundary of the Denver quadrangle, only 5 miles away, and the species from it are designated as Arapahoe species in the general list of the flora which follows, though it may reasonably be questioned whether they are actually older than the plants from Sand Creek above discussed.

[29] U. S. Geol. Survey Mon. 27, pp. 225, 469, 1896.

THE FLORA OF THE DENVER AND RELATED FORMATIONS

LIST OF SPECIES

Before proceeding to a discussion of the flora of the Denver and Arapahoe formations, Dawson arkose, and Middle Park formation, here spoken of as the Denver and related formations, I wish to present the following as a complete list of the forms recognized. In this list the forms from the Denver formation are indicated by 1, those from the equivalent of the Arapahoe formation in the Dawson arkose by 2, those from the Dawson arkose in general by 3, and those from the Middle Park formation by 4.

1 Sclerotites rubellus (Lesquereux) Meschinelli.
3 Sclerotites? cypericola Knowlton, n. sp.
3 Sclerotites? hesperius Knowlton, n. sp.
3 Marchantites? coloradensis Knowlton, n. sp.
1 Hymenophyllum confusum Lesquereux.
4 Dryopteris integra Knowlton, n. sp.
1, 2, 4 Dryopteris lakesii (Lesquereux) Knowlton, n. comb.
2 Dryopteris richardsoniana Knowlton, n. sp.
1 Dryopteris polypodioides? (Ettingshausen) Knowlton.
2 Dennstaedtia crossiana Knowlton, n. sp.
1, 2 Woodwardia latiloba Lesquereux.
4 Woodwardia latiloba serrata Knowlton, n. var.
1 Pteris pseudopennaeformis Lesquereux.
1, 4 Diplazium crossii (Knowlton) Knowlton, n. comb.
1, 2, 4 Allantodiopsis erosa (Lesquereux) Knowlton and Maxon.
1, 3 Saccoloma gardneri (Lesquereux) Knowlton.
3 Saccoloma sp.
1 Salpichlaena anceps (Lesquereux) Knowlton.
3 Anemia mosbyensis Knowlton, n. sp.
4 Anemia lanceolata Knowlton, n. sp.
4 Anemia sp.

[30] In a personal communication Mr. Richardson states that the distance is above the top of the Laramie, not the base.

3 Lygodium coloradense Knowlton, n. sp.
3, 4 Equisetum coloradense Knowlton, n. sp.
1 Equisetum sp.
1 Equisetum sp.
1 Selaginella berthoudi Lesquereux.
4 Sequoia affinis Lesquereux.
1 Ginkgo? truncata (Lesquereux) Knowlton, n. comb.
1 Arundo? obtusa Lesquereux.
1 Carex? berthoudi Lesquereux.
1, 3 Sabalites grayanus Lesquereux.
3 Sabal? ungeri (Lesquereux) Knowlton.
3 Geonomites tenuirachis Lesquereux.
1 Geonomites? graminifolius Lesquereux.
1 Geonomites goldianus (Lesquereux) Lesquereux.
1 Geonomites? sp.
4 Chamaedorea? coloradensis Knowlton, n. sp.
1 Paloreodoxites plicatus (Lesquereux) Knowlton, n. comb.
1 Palmocarpon palmarum (Lesquereux) Knowlton.
1 Palmocarpon truncatum Lesquereux.
1 Palmocarpon? subcylindricum Lesquereux.
1 Palmocarpon? corrugatum Lesquereux.
1 Palmocarpon? lineatum Lesquereux.
1 Palmoxylon cannoni Stevens.
1 Zingiberites dubius Lesquereux.
1 Piper heerii Lesquereux.
3 Myrica sp.
1 Juglans denveriana Knowlton, n. sp.
1, 4 Juglans thermalis Lesquereux.
1 Juglans schimperi Lesquereux.
1 Juglans rhamnoides Lesquereux.
1 Juglans rugosa Lesquereux.
3 Juglans sp.
1 Hicoria antiquora (Newberry) Knowlton.
1 Pterocarya? retusa Lesquereux.
1 Alnus carpinifolia Lesquereux.
1 Alnus auraria Knowlton and Cockerell.
1 Betula schimperi Lesquereux.
1 Betula gracilis? Ludwig.
1 Betula fallax Lesquereux.
3 Castanea intermedia? Lesquereux.
1, 3, 4 Quercus viburnifolia Lesquereux.
2 Quercus? sedaliensis Knowlton, n. sp.
3 Quercus purdonensis Knowlton, n. sp.
4 Quercus whitmani Knowlton, n. sp.
1 Quercus whitei Lesquereux.
1 Quercus leonis Knowlton, n. sp.
1 Quercus celastrifolia Lesquereux.
1 Quercus coloradensis Lesquereux.
1 Populus zeilleri (Lesquereux) Knowlton, n. comb.
1 Populus nebrascensis Newberry.
1 Populus nebrascensis grandidentata Lesquereux.
1 Populus nebrascensis rotundata Lesquereux.
1 Populus nebrascensis acutidentata Lesquereux.
1 Populus nebrascensis longifolia Lesquereux.
1 Populus? sp.
1 Populus jacksoni Knowlton, n. sp.
1 Populus tenuinervata Lesquereux.
1 Populus subrotunda Lesquereux.
4 Populus zaddachi Heer?
1 Populus lacoeana Knowlton, n. sp.
3 Populus knowltoni Berry, n. sp.
1 Populus denverensis Knowlton, n. sp.
4 Populus richardsoni Heer?
1 Ulmus antecedens Lesquereux.
1 Ulmus? quercifolia Unger?
1 Ficus subtruncata Lesquereux.
2 Ficus? alata Knowlton, n. sp.
1, 3 Ficus denveriana Cockerell.
1, 3 Ficus aguilar Knowlton.
1 Ficus berthoudi Lesquereux.
1, 3 Ficus pseudopopulus Lesquereux.
3 Ficus dawsonensis Knowlton, n. sp.
3 Ficus sp.
1 Ficus sp.
1 Ficus occidentalis (Lesquereux) Lesquereux.
3 Ficus ramahensis Knowlton, n. sp.
1 Ficus? lakesii Knowlton, n. sp.
1 Ficus coloradensis Cockerell.
1 Ficus martini Knowlton, n. sp.
1 Ficus eldridgi Knowlton, n. sp.
1, 2 Ficus neoplanicostata Knowlton.
1 Ficus planicostata goldiana Lesquereux.
1 Ficus planicostata problematica Knowlton, n. var.
3 Ficus praetrinervis Knowlton.
3 Ficus puryearensis Berry?
3 Ficus sp.
3 Ficus sp.
1 Ficus sp.
1 Artocarpus pungens (Lesquereux) Hollick.
3 Artocarpus similis Knowlton.
3 Artocarpus? gigantea Knowlton, n. sp.
1, 3 Platanus rhomboidea Lesquereux.
1 Platanus guillelmae Göppert.
1 Platanus aceroides latifolia Knowlton.
1 Platanus raynoldsii Newberry.
1, 4 Platanus raynoldsii integrifolia Lesquereux.
1, 2 Platanus haydenii Newberry.
3 Platanus marginata (Lesquereux) Heer.
3 Platanus platanoides (Lesquereux) Knowlton.
4 Platanus coloradensis Knowlton, n. sp.
3 Platanus sp.?
1, 2, 3 Laurus primigenia Unger.
1?, 3 Laurus socialis Lesquereux.
3 Laurus lanceolata Knowlton, n. sp.
4 Persea brossiana Lesquereux.
3 Cinnamomum sezannense Watelet?
3 Cinnamomum linifolium Knowlton.
3 Cinnamomum? sp.
1 Cinnamomum sp.
1 Magnolia magnifolia Knowlton.
1, 2 Nelumbo lakesiana (Lesquereux) Knowlton.
1 Nelumbo tenuifolia (Lesquereux) Knowlton.
2 Nelumbo crossii Knowlton, n. sp.
3 Paleonelumbo macroloba Knowlton, n. gen., n. sp.
3 Castalia pulchella Knowlton, n. sp.
1, 2, 3, 4 Asimina eocenica Lesquereux.
1, 3 Chrysobalanus coloradensis Knowlton, n. sp.
3 Chrysobalanus? lanceolatus Knowlton, n. sp.
1 Crataegus myricoides Lesquereux.
3 Prunus denverensis Knowlton, n. sp.
3 Phaseolites coloradensis Knowlton, n. sp.
3 Sophora richardsoni Knowlton, n. sp.
3 Sophora puryearensis Berry?
1, 4 Leguminosites? arachioides (Lesquereux) Lesquereux.
3 Cassia vetusta Knowlton, n. sp.
3 Cercis coloradensis Knowlton, n. sp.
1 Celastrus gaudini Lesquereux.
1 Celastrinites artocarpidioides Lesquereux.
1 Celastrinites populifolius Knowlton, n. sp.
1 Negundo decurrens Lesquereux.
2 Acer sp.

1 Sapindus caudatus Lesquereux.
3 Sapindus berryanus Knowlton, n. sp.
1 Sapindus? obtusifolius Lesquereux?
1 Ilex? ovata Knowlton, n. sp.
1, 2 Berchemia multinervis (Al. Braun) Heer.
1 Rhamnus? praealaternoides Knowlton, n. sp.
1 Rhamnus goldianus Lesquereux.
1, 3 Rhamnus cleburni Lesquereux.
1 Rhamnus crenulatus Knowlton and Cockerell.
4 Rhamnus cannoni Knowlton, n. sp.
3 Rhamnus salicifolius Lesquereux?
1 Paliurus coloradensis Lesquereux.
1, 3 Zizyphus fibrillosus (Lesquereux) Lesquereux.
1 Zizyphus daphnogenoides Knowlton.
1 Zizyphus beckwithii Lesquereux.
1, 3 Zizyphus distortus Lesquereux.
1 Zizyphus lesquereuxii Knowlton.
1 Zizyphus hesperius Knowlton, n. sp.
3 Cissus grosse-dentata Knowlton.
3 Cissus hesperia Knowlton, n. sp.
1, 2 Cissus coloradensis Knowlton and Cockerell.
4 Cissus? cannoni Knowlton, n. sp.
1 Cissus corylifolia Lesquereux.
1, 3 Cissus lesquereuxii Knowlton.
1 Cissus obovata Knowlton, n. sp.
2, 3, 4 Cissus lobato-crenata Lesquereux.
3 Vitis olriki Heer.
1, 3 Grewiopsis tenuifolia Lesquereux.
3 Sterculia? heterodonta Knowlton, n. sp.
1? Sterculia saportanea Knowlton.
1 Sterculia libbeyi Knowlton, n. sp.
1 Pterospermites grandidentata Lesquereux.
1, 3, 4 Cornus impressa Lesquereux.
1 Cornus lakesii Knowlton, n. sp.
1 Cornus denverensis Knowlton, n. sp.
1 Cornus holmesii Lesquereux.
1, 3 Nyssa lanceolata Lesquereux.
1 Nyssa denveriana Knowlton, n. sp.
1 Nyssa? obovata Knowlton, n. sp.
1, 2, 3 Diospyros brachysepala Al. Braun.
1 Styrax? laramiensis Lesquereux.
1 Fraxinus eocenica Lesquereux.
1 Fraxinus sp.
1, 2, 3 Dombeyopsis obtusa Lesquereux.
3 Dombeyopsis magnifica Knowlton, n. sp.
2 Dombeyopsis? sedaliensis Knowlton, n. sp.
1, 2, 3 Viburnum richardsoni Knowlton, n. sp.
3 Viburnum contortum Lesquereux?
1 Viburnum? heterodontum Knowlton, n. sp.
1, 3 Viburnum lakesii Lesquereux.
3 Viburnum melaenum Knowlton and Cockerell.
1 Viburnum goldianum Lesquereux.
1 Viburnum solitarium Lesquereux.
3 Phyllites andromeda Knowlton, n. sp.
2 Phyllites aristolochioides Knowlton, n. sp.
1 Phyllites denverensis Knowlton, n. sp.
3 Phyllites sp.
3 Phyllites calhanensis Knowlton, n. sp.
3 Phyllites pellucidus Knowlton, n. sp.
1 Carpites oviformis Lesquereux.
3 Carpites quadrivalvis Knowlton, n. sp.
3 Carpites templetoni Knowlton, n. sp.
1 Carpites rostellatus Lesquereux.
1 Carpites costatus Lesquereux.
1 Carpites coffeaeformis Lesquereux.
1 Carpites minutulus Lesquereux.
1 Carpites myricarum Lesquereux.
3 Carpites coryloides Knowlton, n. sp.
1 Eriocaulon? porosum Lesquereux.
1, 3 Berrya racemosa (Knowlton) Knowlton, n. comb.

DISTRIBUTION OF THE FLORA

The complete flora as now recognized includes 222 forms, of which 145 occur in the Denver, 22 in the equivalent of the Arapahoe, 95 in the Dawson arkose in general, and 24 in the Middle Park formation. Of the 222 forms, 69 are regarded as new to science in the present paper, and 19 are not named specifically, leaving 134 species previously known, 70 of which have a distribution beyond the limits of the formations here considered.

Naturally much interest attaches to the relation between the flora of the Denver and associated formations and the floras of the underlying Cretaceous (Laramie). Only nine species, three of which are more or less in doubt, are known to cross this line, as follows:

Quercus viburnifolia.
Ficus denveriana?
Ficus coloradensis.
Ficus praetrinervis.
Platanus platanoides.
Nelumbo tenuifolia.
Dombeyopsis obtusa.
Rhamnus goldianus?
Rhamnus salicifolius?

Of the three species that are questioned two (*Ficus denveriana* and *Rhamnus goldianus*) are essentially Denver species, and their presence in the Laramie rests on single poorly preserved examples, and the other (*Rhamnus salicifolius*) is essentially Laramie with a single questionable leaf in the Dawson arkose at Templeton Gap, near Colorado Springs. As the Laramie flora of the Denver Basin includes 129 forms and the Denver and associated formations 222 forms, with only 9 in common, it shows that the relationship is not marked.

The closest relationship of the flora under consideration is undoubtedly with that of the Raton formation. The following species are held in common:

Allantodiopsis erosa.
Paloreodoxites plicatus.
Sabalites grayanus.
Sabal? ungeri.
Geonomites tenuirachis.
Geonomites goldianus.
Palmocarpon palmarum.
Juglans schimperi.
Juglans rugosa.
Castanea intermedia.
Ficus denveriana.
Ficus pseudopopulus.
Ficus aguilar.
Ficus occidentalis.
Ficus neoplanicostata.
Ficus planicostata goldiana.
Ficus praetrinervis.
Artocarpus similis.
Platanus rhomboidea.
Platanus guillelmae.
Platanus aceroides.
Platanus raynoldsii.
Platanus platanoides.
Laurus socialis.
Cinnamomum linifolium.
Magnolia magnifolia.
Nelumbo lakesiana.
Leguminosites arachioides.
Berchemia multinervis.
Rhamnus goldianus.
Rhamnus cleburni.
Zizyphus fibrillosus.

Cissus grosse-dentata.
Cissus coloradensis.
Vitis olriki.
Nyssa lanceolata.
Viburnum contortum.
Viburnum lakesii.
Berrya racemosa.

This list shows that there are 39 species, or nearly 60 per cent of the forms having an outside distribution, that are found in the Raton formation.

There is also a measure of relationship between the Denver and related formations and the Wilcox group of the Gulf region, as indicated by the following list of common species:

Pteris pseudopennaeformis.
Sabalites grayanus.
Juglans rugosa.
Hicoria antiquora.
Ficus denveriana.
Ficus pseudopopulus.
Ficus occidentalis.
Ficus neoplanicostata.
Ficus puryearensis?
Artocarpus pungens.
Leguminosites arachioides.
Diospyros brachysepala.

The Wilcox flora is a very large one, comprising over 500 species, over 350 of which are confined to the Wilcox beds. Berry has expressed the opinion that the Wilcox is slightly younger than the Raton and Denver, but a part at least of the difference in the floras is to be accounted for on the ground that the Wilcox is largely a strand flora, whereas the Raton and Denver floras are largely of inland and swamp types.

In southwestern Colorado and adjacent New Mexico the Animas formation shows a very strong relation with the Denver and associated formations, as shown by the following list of common species:

Allantodiopsis erosa.
Juglans schimperi.
Castanea intermedia.
Ficus occidentalis.
Ficus denveriana.
Ficus subtruncata.
Artocarpus pungens.
Platanus aceroides.
Platanus raynoldsii.
Laurus primigenia.
Nelumbo lakesiana.
Magnolia magnifolia.
Rhamnus cleburni.
Rhamnus goldianus.
Zizyphus fibrillosus.
Zizyphus daphnogenoides.
Cornus studeri?
Berrya racemosa.

The Animas formation has a flora of 58 species, 38 of which have been found elsewhere. As shown by the list, 18 of these species are found also in the Denver. A further comparison discloses the fact that 34 of these 38 species are found in the Denver, Raton, and Wilcox floras, which indicates that these are approximately of the same age.

Turning now to the north, we may make a comparison with the floras of the Lance and Fort Union formations. The Lance contains the following species common to the Denver and related formations:

Sabalites? grayanus.
Palmocarpon palmarum.
Juglans rugosa.
Hicoria antiquora.
Populus nebrascensis.
Populus subrotunda.
Quercus viburnifolia.
Platanus rhomboidea.
Platanus guillelmae.
Platanus raynoldsii.
Platanus raynoldsii integrifolia.
Platanus haydenii.
Platanus marginata.
Platanus platanoides?
Leguminosites? arachioides.
Berchemia multinervis.
Ficus denveriana.

The following species are common to the Fort Union formation:

Juglans rugosa.
Hicoria antiquora.
Populus nebrascensis.
Platanus raynoldsii.
Platanus haydenii.
Asimina eocenica.
Leguminosites arachioides.
Berchemia multinervis.
Diospyros brachysepala.

A final comparison can not now be made between the Lance flora and that of the Denver and related formations, for the reason that the Lance flora is much in need of critical revision. The known Lance flora numbers about 125 forms, of which over 80 occur also in the overlying Fort Union formation. Over 250 species are listed from the Fort Union formation, and it is probable that when the very large unstudied collections are fully described the number of species may approximate 500. When the Lance and Fort Union floras have been fully worked up the number of species common to the Denver flora will probably be considerably augmented. As it stands, nearly 30 per cent of the portion of the Denver flora having an outside distribution (8.5 per cent of the total flora) is found in the Lance and Fort Union.

Another flora that can not now be fully compared with the Denver and related formations is that of the Black Buttes coal group at Black Buttes, Wyo. This flora embraces about 60 species and has the following species in common with the Denver:

Diospyros brachysepala.
Ficus coloradensis.
Magnolia magnifolia.
Platanus platanoides.
Platanus raynoldsii integrifolia.
Platanus marginata.
Quercus viburnifolia.
Grewiopsis eocenica.
Juglans rhamnoides.
Sabalites grayanus.
Viburnum contortum.
Viburnum melaenum.
Carpites myricarum.
Berrya racemosa.

In all the comparisons thus far made it is believed that the formations are of approximately the same age. However, certain of the 70 species found beyond the borders of the Denver and related formations occur in Tertiary beds at higher horizons. Thus with the Green River formation we have the following in common:

Pteris pseudopennaeformis?
Geonomites goldianus?
Sapindus obtusifolius.
Juglans schimperi.

With the Hanna formation, Carbon, Wyo.:

Populus subrotunda.
Ficus coloradensis.
Platanus raynoldsii.
Platanus guillelmae.
Laurus primigenia.
Zizyphus lesquereuxii.

With the Evanston formation, Evanston, Wyo.:

Juglans rugosa.
Laurus primigenia.
Leguminosites arachioides.
Vitis olriki.

ECOLOGIC CONSIDERATIONS

The caution that is necessary to be observed in treating the probable ecologic conditions under which a flora now fossil may have lived was set forth in a former report [31] as follows:

> In drawing conclusions from individual organisms in an inquiry of this kind dependence must, of course, be placed on our knowledge of the present-day requirements of similar species, and the results must always be subject to possibility of error from two sources—first, from the incorrect placing biologically of the organism, and, second, from the fact that its requirements in past geologic time may not have been the same as these which now dominate the life activities of its supposed analogue. However, when all of the elements of a flora appear to point in the same direction the liability to serious error is minimized if not eliminated.

The flora of the Denver and associated formations numbers 222 forms. There are three species of fungi, all apparently growing on dead wood or decaying leaves and stems, but otherwise these requirements can not be determined with certainty. The single well-marked hepatic (*Marchantites*) is of the type growing on the ground or old logs in moist shaded situations.

The ferns seem to have been especially abundant, there being no less than 18 forms representing 3 families. Thus, the Hymenophyllaceae are represented by a single species with a thin filmy frond that must have required a moist, shaded habitat. Most of the ferns fall within the Polypodiaceae, and among them are some of exceptional biologic interest. The most abundant species is *Dryopteris lakesii*, which occurs mainly in the Denver beds at Golden, Colo. It is so abundant that literally hundreds of specimens have been collected. Perhaps the most interesting form is *Allantodiopsis erosa*, which is represented by a single finely fruiting specimen and by a considerable number of large, perfect fronds. *Allantodia*, with which it is undoubtedly closely related, is a monotypic genus now confined to eastern China, Malaysia, and Polynesia. Another very interesting fern is *Saccoloma*, with about eight living species in tropical America and the West Indies and in Malaysia and Polynesia. The Denver species is clearly referable to this genus and is apparently closest to *S. elegans* Kaulfuss of tropical America. A third interesting form is that described under the name *Salpichlaena anceps*. The genus *Salpichlaena*, now by some pteridologists merged with *Blechnum*, has a single tropical American species. It is a climbing fern, and the Denver species was also of similar habit. Still another interesting Denver form is a species of *Diplazium*, the numerous living species of which are widely spread over the tropical portions of both the Old and New Worlds. In addition to those above mentioned there is a small, delicate species of *Dennstaedtia* and a large, robust species of *Woodwardia*. The family Schizaeaceae is represented by three rather inadequately characterized forms of *Anemia* and a large species of *Lygodium*. Although both these genera include many tropical or subtropical living species, there are some species found in warm temperate regions. Taken altogether, the ferns of the Denver and associated formations would seem to have required a considerable degree of heat for their successful growth, perhaps as warm as subtropical.

The Equisetaceae are represented by three very poorly characterized species, and *Selaginella* by a single well-defined form, but they can have very little bearing on the climatic conditions in Denver time.

The conifers are practically a negligible factor in this flora, being represented only by a single species of *Sequoia*, and this only by two or three poorly preserved branchlets. The Ginkgoaceae are represented by a somewhat questionable fruit. No leaves have been found, and it is quite possible that the fruit has been incorrectly placed.

The monocotyledons are very poorly represented; in fact, with the exception of the palms, only three forms are recognized—a poorly preserved grass (*Arundo*), a fragmentary *Carex*, and a very questionable plant referred to *Zingiberites*. They are of little value in the present connection.

The palms, however, are a very conspicuous element, comprising 14 nominal forms, 8 of which are based on leaves, 5 on fruits, and 1 on a perfectly preserved silicified trunk. The leaves are fairly abundant, especially in the Denver beds, and some of them were of large size, perhaps reaching a diameter of 5 feet or more. The fruits, except two or three, are not so certainly placed. The trunk is very perfect. Although some living palms can withstand a few degrees of frost, the vast majority require a temperature well above 42°, and most of them would be killed at this temperature. It seems reasonable to assume, therefore, that the palms of Denver time, being of diverse types, could hardly have tolerated a temperature cooler than very warm temperate, possibly even subtropical. It is of interest in this connection to recall that palms were especially abundant in the Raton formation, where six genera and nine species are recognized. *Sabal ungeri* is probably the most abundant and widely distributed species in the Raton formation, occurring at most of the localities and at many of them in great numbers.

The amentiferous trees were apparently abundant, there being 6 species of *Juglans*, 1 each of *Hicoria* and

[31] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 101, pp. 233–234, 1917 [1918].

Pterocarya, 2 of *Alnus*, 3 of *Betula*, 1 of *Castanea*, 8 of *Quercus*, and 15 species and varieties of *Populus*. It is somewhat difficult to interpret the climatic requirements of this assemblage. Although most of the genera are most abundant in cool temperate regions at the present time, nearly all have representatives in the warmer regions of the earth, and considering the apparent requirements of the ferns and palms it is reasonable to assume that the amentiferous trees should have required similar surroundings.

The Ulmaceae are represented by two species of *Ulmus*, but they were very rare and none too well allocated.

The figs and breadfruit trees were especially abundant during Denver time, 23 forms of *Ficus* and 3 species of *Artocarpus* being recognized. They undoubtedly argue for a warm climate.

The sycamores (*Platanus*) were also an abundant element in this flora, as no less than 10 forms have been recognized, though it is possible that too many have been admitted. Many of them are large-leaved forms, and some are poorly preserved; in fact, they give evidence of having been transported for greater distances than many other types. However, if too many forms have been recognized, it will be easy enough to combine them.

The Lauraceae did not form a very prominent feature, there being three species of *Laurus*, one of *Persea*, and four of *Cinnamomum*, two of which, however, are not named specifically. The laurels and their kin are plants requiring a moist, warm habitat.

The magnolias in the Raton flora were varied and, in some forms, extremely abundant, but in the Denver flora only a single species has been noted, and this was not abundant.

The Nymphaeaceae were well developed in the Denver and associated beds, there being three genera and five species. Of these the three species of *Nelumbo* are especially well marked. Allied to this, but abundantly distinct, is *Paleonelumbo*, a new type with very large, strongly toothed leaves. The most interesting is a splendid species of water lily (*Castalia*), which is most closely related to a species now living in tropical America and the West Indies.

Passing over a number of rosaceous and papilionaceous genera (*Crataegus*, *Prunus*, *Phaseolites*, *Sophora*, *Cassia*, and *Cercis*) that are without strong climatic characters, we come to the Celastraceae, with two species of *Celastrinites* and one of *Celastrus;* the Aceraceae, with a single form each of *Acer* and *Negundo;* the Sapindaceae, with three species of *Sapindus;* and the Ilicaceae, with a single somewhat doubtful species of *Ilex*. These are mainly plants of warm regions, though with representatives in cooler lands.

The buckthorn family (Rhamnaceae) is strongly developed, having six species each of *Rhamnus* and *Zizyphus* and one each of *Berchemia* and *Paliurus*. The present-day species are mainly of temperate or warm temperate distribution.

The Vitaceae are represented by eight species of *Cissus* and one of *Vitis*, the Tiliaceae by a single species of *Grewiopsis*, the Sterculiaceae by three species of *Sterculia* and one of *Pterospermites*, and the Cornaceae by four species of *Cornus* and three of *Nyssa*.

If the apparent climatic requirements of the Denver and related floras are viewed as a whole, it appears from the above review that many of the important elements, such as the ferns, palms, figs, breadfruit trees, and laurels, argue for warm, possibly subtropical conditions. The other elements almost without exception seem to call for at least a warm or warm temperate environment; in fact, with minor exceptions there is not a type whose living representatives are exclusively temperate. Although a number, such as *Myrica*, *Magnolia*, *Cornus*, and *Ilex*, are now dominantly temperate in their distribution, they all have forms or closely related genera that extend into the Tropics. Therefore it seems safe to conclude that the local climate during Denver time was abundantly moist and warm temperate or possibly subtropical.

As the Denver and related floras are compared with those of the Raton, Wilcox, and Laramie it may be of interest to set forth the interpretation given to the apparent climatic requirements of these other floras. Concerning the Raton flora I concluded [32] as follows:

> The presence of the numerous coal veins as well as the character and luxuriance of the vegetation indicates that moisture was abundant, and the known distribution of the living representatives of the Raton flora make it more than probable that the climate was at least warm temperate.

The following conclusion was drawn as to the climate during Laramie time: [33]

> From the abundant presence of coal and the apparent requirements of the majority of the plants enumerated, it is beyond question that there must have been abundant moisture. It also appears naturally to follow from the presumed requirements of the flora that the climate was warm, at least warm temperate.

The Wilcox flora is believed by Berry to be slightly younger than that of the Raton and Denver floras. It is distinctly a strand flora. Concerning it Berry [34] wrote as follows:

> It may be noted that the Wilcox plants, almost without exception, are plants whose modern representatives inhabit the warmer parts of the earth. There is not a strictly temperate type in the whole assembly. * * * It needs but a slight acquaintance with the existing Antillean flora or that of the Florida Keys * * * to see at once that the general facies

[32] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 101, p. 240, 1917.
[33] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 130. p. 99, 1922.
[34] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, pp. 136, 137, 1916.

of the Wilcox flora is overwhelmingly that of a strand flora, some of the elements of which indicate that they grew on sandy beaches, others in muddy tidal flats, others between or behind dunes or beach ridges, and others in estuary bayous or marshes.

PHYSICAL CONDITIONS

The probable physical conditions under which the Arapahoe, Denver, Dawson, and Middle Park formations were deposited may be briefly considered. They are described by Richardson[35] as follows:

> Uplift of the Front Range region and accompanying erosion, after the deposition of the Laramie beds, marked the close of the Mesozoic and the beginning of the Cenozoic era. A great thickness of Cretaceous and older rocks was eroded from the Front Range region, and a mass of continental deposits accumulated on an uneven surface of the Laramie and older formations east of the mountains. The Dawson arkose, derived from the Pikes Peak granite and associated rocks, was laid down under various continental conditions, chiefly as wash and fluviatile deposits accompanied by local ponding. During the accumulation of the arkose this region may be conceived of as a piedmont area having a moist and temperate climate.

As already mentioned, the lower portion of the Dawson arkose appears to interdigitate on the north with the Arapahoe and Denver formations. If this interpretation is correct, as it is now believed to be, the Arapahoe and Denver are equivalent in time with the lower portion of the Dawson arkose. Although they differ markedly in lithologic composition, the physical conditions under which they were deposited appear to have been the same—that is to say, the uplift of the Front Range area started extensive erosion, and resulting débris was spread out over the adjacent plain.

The streams coming down from the highlands to the west became sluggish out on the plains and were impounded here and there into ponds and small lakes. The material brought down was spread out over the plains or deposited in the lakes and ponds. In the northern part of the Denver area and in Middle Park the material supplied by erosion was largely of volcanic origin, hence the Denver and Middle Park beds are composed mainly of andesitic materials; but to the south the streams were cutting granitic rocks, and the resulting deposits are mainly arkosic.

On the highest ridges there were doubtless conifers, but they appear to have been rare, as only a few branchlets of a single species have been detected. On the lower slopes probably grew the oaks, black walnuts, hickory nuts, and birches, with an occasional magnolia, chestnut, and maple. Along the streams were the alders, sycamores, and certain poplars and osiers. In the more open places were the viburnums, buckthorns, dogwoods, and hawthorns, with vines (*Vitis*) and bittersweet climbing over trees or other lower supports. On the low grounds were elms, sycamores, and poplars, and in the swamps was the usual tangle to be expected in such situations—the figs, sweet gums, cinnamons, magnificent palms with trunks nearly 2 feet in diameter and leaves 4 or 5 feet across, and soapberries—and underneath were *Zizyphus*, *Cissus*, *Paliurus*, and climbing ferns. In shallow water and about the margins of ponds were tufts of the tall grass *Arundo* and two apparently large equisetums, with probably smaller grasses and sedges (*Carex*) near by. On the surface of the ponds and on the slow-moving streams floated the leaves of beautiful white and yellow water lilies.

In certain parts of the area swamp conditions continued with little variation for long periods, with the result that considerable beds of coal were accumulated. So far as I have been able to interpret the facts, the available evidence indicates that this coal was not formed in any considerable part from transported material but rather was formed in place.

MATERIALS STUDIED

The material that has been available for the present study is very considerable. This study is based primarily on the early collections made by F. V. Hayden and other members of the United States Geological Survey of the Territories, mainly in the early seventies, and now preserved in the United States National Museum. Lesquereux and some of his correspondents also made collections, and all were identified and described by Lesquereux and the results published from time to time in the annual reports of the Hayden survey. In 1878 the results then available were brought together by Lesquereux.[36] Up to that time the plant-bearing beds of this general region were supposed to be similar in age and to belong to the "Lignite Tertiary," but later, when the Laramie formation was established, and still later, when the Arapahoe and Denver were separated as distinct units, considerable confusion resulted in the collections, as they were usually without specific locality labels. This is especially true of the locality "Golden, Colo.," where both Laramie and Denver are present and plant-bearing. Fortunately, however, most of the plants from Golden can be distinguished by the matrix, that of the Laramie being usually a white fine-grained sandstone and that of the Denver a yellowish andesitic material.

In 1883 Lesquereux[37] published a short "Description of species added to the flora of the Laramie

[35] Richardson, G. B., U. S. Geol. Survey Geol. Atlas, Castle Rock folio (No. 198), p. 12, 1915.

[36] Lesquereux, Leo, The Tertiary flora: U. S. Geol. Survey Terr. Rept., vol. 7, 1878.

[37] Lesquereux, Leo, The Cretaceous and Tertiary floras: U. S. Geol. Survey Terr. Rept., vol. 8, pp. 121–126, 1883.

group," enumerating 11 species, 6 of which were new. Most of these specimens are now in the museum of Princeton University, where I saw and studied them some years ago.

Arthur Lakes, a mining engineer, made a large collection of Denver plants, mainly from South Table Mountain, Golden, that became the property of the Museum of Comparative Zoology, Cambridge, Mass. They were worked up by Lesquereux,[38] who stated that the 873 specimens represented 118 species, of which 28 were described as new and 32 were recognized for the first time, thus adding 60 species to this flora. None of this material has ever been figured, and by the courtesy of Dr. Robert T. Jackson, in whose custody these plants now are, I have been permitted to borrow these types and unfigured specimens, and they are here figured for the first time. It has been necessary to revise the nomenclature somewhat, and a few of the forms supposed to be new by Lesquereux have been combined with older species or otherwise disposed of.

In 1890 Lakes was employed by S. F. Emmons to make collections of plants from the Arapahoe and Denver formations for the United States Geological Survey. These collections came mainly from South Table Mountain, Golden, and from the base of Green Mountain, in the Denver formation, and included also the collections from the equivalent of the Arapahoe in the vicinity of the old Douglas coal mine, near Sedalia, which are listed as Arapahoe plants.

Individual specimens or small but interesting and valuable collections have been submitted by many persons, among them Whitman Cross, L. F. Ward, Junius Henderson, Theo. D. A. Cockerell, A. C. Peale, and W. T. Lee. These are now mainly in the United States National Museum.

Early collections of plants from the Dawson arkose were made in 1896 by T. W. Stanton and F. H. Knowlton in the Colorado Springs area, though they were not recognized at the time as distinct from the Laramie. Small collections in the same region were also made by M. I. Goldman and A. C. Peale in 1909, but the bulk of the collections from the formation were made by G. B. Richardson or by members of the party under his direction while they were obtaining data for the Castle Rock folio. I also visited the area in 1910 and in company with Mr. Richardson made collections east of Colorado Springs; at Templeton Gap, near Calhan; on Jimmy Camp Creek; at Mosby; and elsewhere. Small collections were also made in this area in 1912 by W. T. Lee.

The plants available from Middle Park include most of the original collection made by F. V. Hayden in 1869, now preserved in the United States National Museum, and the larger collections made by George L. Cannon in 1889, together with a few procured by Whitman Cross in 1891 and 1892. The collections from Middle Park are not as complete as could be wished, though some 24 forms have been recognized. The plants are known to be abundant at a number of horizons, but it must remain for future more exhaustive exploitation to develop knowledge of this flora.

Work on the flora of the Denver formation was begun about 1895, and a number of descriptions and figures were prepared at that time, but as this was a period when views were changing on the distribution and stratigraphic relations of the Laramie, with which the Denver is more or less intimately related, it was thought expedient to lay the manuscript aside for a time until views could be more stabilized. Pressure of other interests has resulted in this long delay, but the wisdom of the delay is abundantly justified by the increased collections and stratigraphic data now available. The illustrations that were prepared when the work was started were drawn by the method then current—that is, pen drawing two-thirds enlarged for one-half reduction, which restores them to natural size. The present method consists of taking photographs natural size and retouching them to bring out the essential characters. As illustrations of these two kinds can not be mixed on the same plate, it has been necessary to arrange the plates in two series.

SYNONYMS AND CHANGES OF NAME

In the following list synonyms and former names of species here described are given alphabetically, with their equivalents in the present work.

Aralia pungens Lesquereux=*Artocarpus pungens.*

Artocarpidium olmedifolium? Unger, Lesquereux (U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, pp. 381, 400, 1874)=*Celastrinites artocarpidioides.*

Aspidium lakesii (Lesquereux) Knowlton=*Dryopteris lakesii.*

Asplenium erosum (Lesquereux) Knowlton=*Allantodiopsis erosa.*

Asplenium subsimplex (Lesquereux) Knowlton=*Allantodiopsis erosa.*

Berchemia multinervis Al. Braun, Ward (U. S. Geol. Survey Sixth Ann. Rept., p. 554, pl. 51, fig. 13, 1887; U. S. Geol. Survey Bull. 37, p. 73, pl. 33, fig. 2, 1887)=*Rhamnus goldianus.*

Berchemia parvifolia Lesquereux=*Berchemia multinervis.*

Carpolithes arachioides Lesquereux=*Leguminosites? arachioides.*

Carpolithes palmarum Lesquereux=*Palmocarpon palmarum.*

Ceanothus fibrillosus Lesquereux=*Zizyphus fibrillosus.*

Cissus laevigata Lesquereux=*Cissus coloradensis.*

Cissus parrottiaefolia Lesquereux (Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 52, 1888)=*Cissus obovata.*

Cissus spectabilis Heer, Lesquereux (Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 52, 1888)=*Chrysobalanus coloradensis.*

[38] Lesquereux, Leo, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, pp. 43–59, 1888.

Cissus tricuspidata (Heer) Lesquereux=*Cissus lesquereuxii.*
Cornus emmonsi Ward=*Cornus impressa.*
Crataegus betulaefolia Lesquereux (Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 56, 1888)=*Viburnum richardsoni.*
Daphnogene anglica? Heer, Lesquereux (Tertiary flora, p. 222, pl. 37, fig. 9, 1878)=*Zizyphus daphnogenoides.*
Diplazium mueller? Heer, Lesquereux (U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, p. 393, 1874)=*Diplazium crossii.*
Dryopteris arguta (Lesquereux) Knowlton=*Dryopteris lakesii.*
Flabellaria communis Lesquereux=*Sabalites grayanus.*
Flabellaria eocenica Lesquereux=*Sabalites grayanus.*
Flabellaria? fructifer Lesquereux=*Sabalites grayanus.*
Flabellaria? longirachis? Unger, Lesquereux (U. S. Geol. and Geog. Survey Terr. Ann Rept. for 1873, p. 396, 1874)=*Geonomites tenuirachis.*
Flabellaria zinkeni Heer, Lesquereux (Tertiary flora, p. 110, pl. 9, figs. 6–8, 1878)=*Geonomites goldianus.*
Geonomites ungeri Lesquereux=*Sabal? ungeri.*
Glyptostrobus ungeri? Heer, Lesquereux (Cretaceous and Tertiary floras, p. 139, pl. 23, figs. 1–5a, 1883)=*Sequoia affinis.*
Goniopteris polypodioides Ettingshausen, Lesquereux (U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, p. 394, 1874)=*Dryopteris polypodioides.*
Gymnogramma gardneri (Lesquereux) Lesquereux=*Saccoloma gardneri.*
Lastrea (Goniopteris) polypodioides? (Ettingshausen) Lesquereux=*Dryopteris polypodioides.*
Lathraea arguta Lesquereux=*Dryopteris lakesii.*
Laurus brossiana Lesquereux=*Persea brossiana.*
Laurus obovata? Weber, Lesquereux (U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, p. 399, 1873)=*Laurus primigenia.*
Magnolia tenuinervis Lesquereux (Tertiary flora, p. 248, pl. 44, fig. 2, 1878)=*Magnolia magnifolia.*
Nelumbium lakesianum Lesquereux=*Nelumbo lakesiana.*
Nelumbium lakesii Lesquereux=*Nelumbo lakesiana.*
Nelumbium tenuifolium Lesquereux=*Nelumbo tenuifolia.*
Nyssa? racemosa Knowlton=*Berrya racemosa.*
Orcodoxites plicatus Lesquereux=*Paloreodoxites plicatus.*
Osmunda affinis (Lesquereux)=*Salpichlaena anceps.*
Osmunda major Lesquereux=*Allantodiopsis erosa.*
Palmacites goldianus Lesquereux=*Geonomites goldianus.*
Palmocarpon commune Lesquereux=*Palmocarpon palmarum.*
Palmocarpon truncatum minor Lesquereux=*Ginkgo? truncata.*
Parrotia fagifolia Ettingshausen, Lesquereux (Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 52, 1888)=*Celastrus gaudini.*
Physagenia sp. Lesquereux (Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 43, 1888)=*Equisetum* sp.
Populus ungeri Lesquereux, Lesquereux (Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 46, 1888)=*Celastrinites populifolius.*
Protofucus zeilleri Lesquereux=*Populus zeilleri* (Lesquereux) Knowlton.
Pteris anceps Lesquereux=*Salpichlaena anceps.*
Pteris erosa Lesquereux=*Allantodiopsis erosa.*
Pteris gardneri Lesquereux=*Saccoloma gardneri.*
Pteris pennaeformis Heer, Lesquereux (U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1870, p. 384, 1871)=*Pteris pseudopennaeformis.*
Pteris pseudopennaeformis Lesquereux (Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 43, 1888)=*Salpichlaena anceps.*
Pteris subsimplex Lesquereux=*Allantodiopsis erosa.*
Pteris undulata Lesquereux=*Allantodropsis erosa.*
Rhamnus crenatus Lesquereux=*Rhamnus crenulatus.*
Sabal campbelli Newberry [part]=*Sabal? ungeri.*
Sabal communis Lesquereux=*Sabalites grayanus.*
Sabal? eocenica (Lesquereux) Knowlton=*Sabalites grayanus.*
Sabal grandifolia Newberry=*Sabal? ungeri.*
Sabal? grayana Lesquereux=*Sabalites grayanus.*
Sabal inquirenda Knowlton=*Sabalites grayanus.*
Sabalites fructier Lesquereux [part]=*Berrya racemosa.*
Sabalites fructifer Lesquereux [part]=*Sabalites grayanus.*
Salix media? Heer, Knowlton (Geol. Soc. America Bull., vol. 8, p. 141, 1897)=*Laurus primigenia.*
Sclerotium rubellum Lesquereux=*Sclerotites rubellus* (Lesquereux) Meschinelli.
Sequoia langsdorfii Brongniart, Lesquereux (U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1874, p. 310, 1875; Tertiary flora, p. 75, 1878)=*Sequoia affinis.*
Sphenopteris eocenica Ettingshausen, Lesquereux=*Dryopteris lakesii.*
Sphenopteris lakesii Lesquereux=*Dryopteris lakesii.*
Sphenopteris membranacea Lesquereux=*Dryopteris lakesii.*
Sterculia modesta Saporta, Lesquereux (Cretaceous and Tertiary floras, p. 125, pl. 20, fig. 5, 1883)=*Sterculia saportanea.*
Viburnum anceps Lesquereux (Tertiary flora, p. 227, pl. 38, fig. 11, 1878)=*Platanus rhomboidea.*
Viburnum dichotomum Lesquereux=*Viburnum melaenum.*
Viburnum marginatum Lesquereux=*Platanus marginata.*
Viburnum marginatum Lesquereux (Tertiary flora, p. 223, pl. 38, fig. 2 [not fig 3], 1878)=*Viburnum contortum.*
Viburnum platanoides Lesquereux=*Platanus platanoides.*
Viburnum whymperi? Heer, Lesquereux (Tertiary flora, p. 225, pl. 38, fig. 7, 1878)=*Viburnum melaenum.*
Woodwardia latiloba minor Lesquereux=*Woodwardia latiloba.*
Zingiberites? undulatus Lesquereux=*Zingiberites dubius.*
Zizyphus distortus Lesquereux (Tertiary flora, p. 275, pl. 51, fig. 7 [not fig. 8], 1878)=*Zizyphus fibrillosus.*
Zizyphus fibrillosus Lesquereux (Tertiary flora, p. 276, pl. 52, fig. 6 [not figs. 1–5], 1878)=*Zizyphus daphnogenoides.*
Zizyphus hyperboreus Heer, Lesquereux (Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 55, 1888)=*Zizyphus hesperius.*
Zizyphus hyperboreus? Heer, Lesquereux (Tertiary flora, p. 276, pl. 51, fig. 15, 1878)=*Zizyphus lesquereuxii.*

SYSTEMATIC PALEOBOTANY

Phylum THALLOPHYTA

Class FUNGI

Sclerotites rubellus (Lesquereux) Meschinelli

Sclerotites rubellus (Lesquereux) Meschinelli, Sylloge fungorum fossile, p. 69, 1892; Fungorum fossilium omnium, Iconcgraphia, p. 101, pl. 27, figs. 12, 13 a–f, 1898.

Sclerotium rubellum Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, p. 375, 1873; idem for 1873, p. 379, 1874; idem for 1876, p. 496, 1878; Tertiary flora, p. 35, pl. 1, figs. 2–2 f, 1878.

The type specimen of this species is preserved in the United States National Museum (No. 2), as are also other specimens of the so-called *Flabellaria zinkeni?* (Nos. 101, 102) upon which it occurs. This is by far

the best-marked fungus obtained in these formations and is in all probability correctly referred. The perithecia are oval or linear, obtuse, 1 millimeter broad, 2 to 4 millimeters long, and are placed between the striae or minute veins of the leaf.

The species has not been procured since the original collection.

Occurrence: Denver formation, Golden, Colo., on leaves of *Flabellaria.*

Sclerotites? cypericola Knowlton, n. sp.

Plate 1, Figure 7

In one of the collections from the Dawson arkose I find the single specimen of a fungus here figured. It grew on a finely striated monocotyledonous leaf about a centimeter in width, that suggests a large-leaved cyperaceous plant or possibly a segment of a palm leaf. The fungus is disposed in two or three longitudinal rows down the center of the leaf. The pustules or perithecia, if they should be so called, are more or less granular in appearance; some are nearly rectangular and others round or even kidney-shaped. There is no evidence of an opening in the top of any of these perithecia nor of the contents other than a black, carbonaceous mass.

This description is confessedly incomplete and more or less unsatisfactory, and therefore the generic reference is uncertain. The species is placed in *Sclerotites* because it seems to be like certain forms that have been so placed, but this is little assurance that the assignment is absolutely correct. It is presented mainly to direct attention to the fact that a plant of this character was present at this time.

Occurrence: Dawson arkose, east bank of Jimmy Camp Creek, 0.6 mile above Richfield Springs ranch house, 9 miles east of Colorado Springs, Colo., collected by F. H. Knowlton, July, 1910.

Sclerotites? hesperius Knowlton, n. sp.

Plate 1, Figure 6

One of the collections obtained near Ramah, Colo., contains a number of specimens showing an abundance of saprophytic fungi. The material is a red, hard-baked shale showing numerous fragments of dicotyledonous leaves and a number of stems or decorticated branches that are more or less covered with black carbonaceous pustules. These are mainly circular and of all sizes from a pin point up to a millimeter or more in diameter. The larger ones show distinctly a minute osteole in the center. Where a pustule or "perithecium" has been removed there is a circular depression like the imprint of a small shot, indicating apparently where a portion of the substance has been removed or absorbed.

The nature of the host on which this fungus was growing can not be determined with certainty, but it appears to be a monocotyledon of some kind, perhaps a cyperaceous plant or possibly a larger grass.

The proper systematic assignment for this fungus is difficult to ascertain in the absence of certain essential characters. It is therefore referred provisionally to the genus *Sclerotites.* It can be compared with *Sphaerites secretani* (Heer) Meschinelli,[30] from the Swiss Miocene and found in Austria on leaves of *Pharagmites eoningensis* Heer.

This form is certainly very distinct from the last described species and indeed may not even be congeneric with it.

Occurrence: Dawson arkose, about 4 miles south of Ramah oil well, 40 miles northeast of Colorado Springs, Colo.

Phylum BRYOPHYTA

Class HEPATICAE

Order MARCHANTIALES

Family MARCHANTIACEAE

Marchantites? coloradensis Knowlton, n. sp.

Plate 1, Figure 3

In the material from Mosby, Colo., is found the single example figured, which appears to belong to the Hepaticae. It is a mere fragment that must give only a very poor idea of the appearance of the perfect plant and ordinarily would hardly be worthy of a description and name, yet, small as it is, it exhibits a number of interesting features and can undoubtedly be recognized in future. It is interpreted as representing the under surface of the vegetative portion or frond of a hepatic. It is plainly dichotomous, consisting of a main proximad portion about 15 millimeters broad, which forks into two narrow distad portions that are 9 or 10 millimeters broad and at least 3.5 centimeters long. The most perfect of the two branches is rounded at the end, as if it were complete at this point, but this is, of course, uncertain, as it comes to the very edge of the matrix. The entire surface is strongly reticulated, the raised portions of the mesh being relatively thick and strong. The areas inclosed by the raised walls are somewhat irregular, though roughly they are quadrangular or oval. Many of them are now filled with coaly carbonaceous matter, thus proving that the frond had a considerable thick-

[30] Meschinelli, Aloysius, Fungorum fossilium omnium, Iconographia, p. 37, pl. 13, fig. 25, 1898.

ness or substance. Scattered at irregular distances over the surface are strong depressions or pits, now filled with coaly substance, which are interpreted as the points whence rhizoids once arose.

This specimen is preserved on a fine-grained sandy clay shale which retains the delicate structure very well, and it is to be regretted that so small a portion was preserved.

In some ways the fossil form suggests the living genus *Metzgeria*, though the frond has no midrib, and the cells, if they are such, are larger and much thicker walled.

Occurrence: Dawson arkose, dump of Mosby coal mine, Mosby, Colo., collected by F. H. Knowlton and G. B. Richardson, July, 1910.

Phylum PTERIDOPHYTA

Class FILICES

Order FILICALES

Family HYMENOPHYLLACEAE

Hymenophyllum confusum Lesquereux

Plate 1, Figure 4

Hymenophyllum confusum Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, p. 395, 1874; The Tertiary flora, p. 51, pl. 2, figs. 6-6a, 1878.

Frond triquadripinnate; rachis thin, flexuose; ultimate pinnae broadly lanceolate; pinnules simple or cut into two or three divisions, cuneiform, enlarged upward from a decurring base, lobed, the lobes short, oblong, obtuse, simple, emarginate or bifid; veins strong, dichotomously forked, each branch entering one of the pinnules.

This species was founded upon a mere fragment (U. S. Nat. Mus. No. 14) in which the frond is crushed and distorted in a very confusing manner, and consequently its complete habit could not be made out. Since that time, however, additional material has been collected at the type locality, and several of these specimens are fairly complete, so that it is now possible to ascertain the characters much more satisfactorily than from the type. The frond is probably tripinnate, and the pinnules are seen to be narrower than figured by Lesquereux. They are not as regularly 2-parted nor turned back as described, but are cut into two to several divisions.

Although it is of course impossible, in the absence of fruit, to be positive as to the correctness of the generic reference of any such fragments, there can be little doubt concerning these. They are, for example, very much like the living *H. fuciforme* Swartz, of South America, or *H. protrosum* Hooker, of Central America and the West Indies. Except for the spinulose-dentate margins, the frond is quite similar to *H. bivalva* Swartz, of New Zealand, and in its branches it is suggestive of *H. tumbridgense* Swartz, of northern Europe.

Occurrence: Denver formation, South Table Mountain, Golden, Colo.

Family POLYPODIACEAE

Dryopteris integra Knowlton, n. sp.

Plate 1, Figure 5

Outline of whole frond not known; apparently coriaceous, bipinnatifid; main rachis rather slender, round, not much ridged or striate; secondary rachis nearly as strong as the other and of same character; pinnae very oblique, narrowly lanceolate, cut nearly or apparently quite to the secondary rachis, the segments or pinnules contiguous, oblong, acute at apex, attached by their whole base, entire-margined; middle vein of pinnules very strong, secondary nerves obsolete; sori large, orbicular or slightly reniform, four to six pairs on each pinnule, opposite, probably on the back of a vein.

This fern is quite unlike anything heretofore described from these beds and although obscurely preserved appears to be a reasonably distinct species. The specimen is a segment, probably from the lower portion of the frond, showing parts of four pinnae. It is an impression of the under surface of the frond and brings out the fruit very clearly, or would if the matrix were better fitted to show the details. The sori are very large, almost covering the segments, and are mostly orbicular, although several are apparently slightly kidney-shaped. There is also some induration of the impressions of large sporangia disposed in circles. A slight depression in the center of many sori seems to indicate that the indusium was peltate, but this can not be demonstrated with certainty.

There seems little doubt that this species is correctly referred to *Dryopteris*. It is, for instance, quite similar to the living *Aspidium raddianum* Hooker (or *A. quitense* Christensen) from South America, though not quite so deeply cut. It is also strikingly similar to certain fossil Aspidia from Greenland that have been described by Heer under the names *Aspidium fecundum*,[40] *A. meyeri*,[41] etc. It differs from *A. meyeri* in being bipinnatifid and in having the pinnules pointed rather than obtuse. From *A. fecundum* it differs markedly in size.

Occurrence: Middle Park formation, Middle Park, Grand County, Colo., in sandy stratum just above main breccia mass in Potato Hill Gap on the Grand

[40] Heer, Oswald, Flora fossilis arctica, vol. 6, pt. 4, p. 32, pl. 29, figs. 5–9, 1882.

[41] Idem, vol. 2, p. 461, pl. 39, figs. 1–3, 1869.

[Colorado] River near Hot Sulphur Springs, collected by George L. Cannon, 1889.

Dryopteris lakesii (Lesquereux) Knowlton, n. comb.

Plate 1, Figures 1, 2

Lathraea arguta Lesquereux,[42] Am. Jour. Sci., 2d ser., vol. 45, p. 207, 1868; U. S. Geol. Survey Terr. Third Ann. Rept., p. 96, 1869; idem, reprint, p. 196, 1873.

Sphenopteris eocenica Ettingshausen. Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, p. 376, 1873; idem for 1873, p. 380, 1874.

Sphenopteris lakesii Lesquereux, The Tertiary flora, p. 49, pl. 2, figs. 1, 1*a*, 1878.

Aspidium lakesii (Lesquereux) Knowlton, Washington Biol. Soc. Proc., vol. 7, p. 154, 1892; U. S. Geol. Survey Bull. 105, p. 45, pl. 6, figs. 1–4, 1893.

Dryopteris arguta (Lesquereux) Knowlton, U. S. Geol. Survey Bull. 152, p. 91, 1898.

Sphenopteris membranacea Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, p. 394, 1874; The Tertiary flora, p. 50, pl. 2, figs. 2–3*a*, 1878.

Fronds large, of firm texture, outline uncertain, apparently broadly triangular or deltoid, at least tripinnatifid, possibly some fronds fully tripinnate; primary rachis strong, half round, usually with one or two faint ridges; pinnae large, apparently broadly deltoid, at an angle of about 45° to the rachis; secondary pinnae long, lanceolate, taper-pointed, connected along the secondary rachis by a narrow margin, provided with a large number of obliquely set segments or ultimate pinnules, which are linear or lanceolate in shape and have entire or more commonly strongly and sharply serrate margins; the pinnules are close and united from well below the middle; veins pinnate, the divisions either simple or once forked; fruit dots large, round, in pairs on opposite sides of the lateral veins or in the upper part, in a single row on each side of the midvein of the pinnules and contiguous to it; indusium apparently peltate.

This fine species is probably the most abundant and characteristic plant found in the Denver beds, being present in abundance in all collections in fragments of greater or less size. Unfortunately, few large or complete specimens have been procured, but the type specimen as figured by Lesquereux is one of the largest thus far found. It is not possible to obtain a very definite estimate as to the full size of the frond, but as nearly as can be made out certain of the larger ones must have had a spread of over 20 centimeters, and probably a still greater length. Some of the secondary pinnae, isolated fragments of which are commonly preserved, are fully 12 centimeters long in the lower part of the pinnae, but they diminish rapidly in size toward the upper part. The largest of the secondary pinnae are between 2.5 and 3.5 centimeters in width at the base; all the pinnae terminate in a slender acuminate point. Curiously enough, out of the many hundreds of specimens of greater or less size that have been collected, there appears to have been but one found in fruit. This splendid specimen, shown in Plate 1, Figure 2, appears from the label it bears to have been collected in 1876 and exhibited at the Centennial Exposition at Philadelphia, after which it came to the United States National Museum, where it has remained in storage until very recently. Its collector is unknown, but there can be no doubt as to its authenticity, for the locality—Golden, Colo.—is plainly written on the label, and, moreover, the matrix is perfectly characteristic of this well-known locality. As may be noted from the figure, there are fragments of four secondary pinnae, all of which are copiously fruiting. The lower pinna is a very broad one with the pinnules very deeply cut into triangular, acute teeth. The nervation of a pinnule consists of a very strong midvein and a series of simple or rarely forked lateral branches which terminate in the teeth. Unfortunately, the frond is preserved with the upper surface visible, so that it is difficult to make out the exact size and shape of the sori. They show through sufficiently well, however, to make it clear that they are disposed in pairs on each side of the lateral veins, or those running to the teeth of the pinnules, and there are usually two or exceptionally three pairs to each vein. In the upper pinnae as well as in the tips of the pinnae, where the pinnules are narrower and the marginal teeth reduced, the fruit dots appear in a single row on each side of the midvein. All of them appear to be circular, and from the presence of a minute dot in the center of each it is presumed that the indusium was peltate and that its stalk or support produces this central dot of organic matter. This evidence is not strong, however, and should be taken with some allowance.

In 1893, in working over material from Montana collected by A. C. Peale, I found several small fragments of a fruiting fern that seemed to be identical with the Golden species.[43] They came from a locality between the middle and north branches of Bear Creek, east of the Madison Valley, on the west side of the Madison Range, in beds supposed to be of Livingston age. These specimens represent the extreme distal portions of secondary pinnae, the pinnules with small obscure teeth and the fruit dots very small and disposed in a row on each side of the midvein. Although these specimens were small and obscure, I felt justified in transferring the Golden species to the

[42] As this is a nomen nudum and never properly described or figured, there is some uncertainty in associating it with the form under consideration. If authenticated it would be the oldest specific name applied to this species.

[43] U. S. Geol. Survey Bull. 105, p. 45, pl. 6, figs. 1–4, 1893.

genus *Aspidium* (now *Dryopteris*), and the fortunate finding of the above-mentioned fruiting example at the type locality proves this reference to have been well founded. So far as can be made out this fern belongs properly to the genus *Dryopteris*. The absence of fruit is what caused Lesquereux to place it first in the genus *Lathraea* and later in the impossible genus *Sphenopteris*. After a careful examination of Lesquereux's type specimens preserved in the United States National Museum, together with more than 100 additional specimens, collected by Arthur Lakes from a number of localities at Golden and Sedalia, Colo., I am entirely unable to distinguish more than one species. Extreme forms may be selected which appear to be very unlike, but in the large series so many intermediate forms occur that it is impossible to draw any line of demarcation between them. Indeed, Lesquereux himself seems to have been in doubt as to their specific distinctness, for he says under *S. membranacea*,[44] "This form has nearly the same characters as the preceding (*S. lakesii*) and may be a variety of it." That a plant so abundant as this must have been should show considerable variation is certainly to be expected from what we know of the variations existing in living species that have grown under varying conditions of environment. The pinnae and pinnules from different parts of a large compound frond vary considerably in certain living species, being narrower in the upper part and quite unlike the lower ones. As many of the specimens of the fossil consist only of fragments of pinnae it is impossible to tell from what part of the frond they came.

The most complete specimen that I have seen is the specimen partly figured by Lesquereux[45] as the type of *S. lakesii*. The fragment is about 14 centimeters long and fully 18 centimeters broad and represents the middle portion of the frond, neither the apex nor the base being preserved. The primary pinnae appear to be broadly deltoid, with the pinnae numerous, close, linear, rather abruptly reduced in height in the upper portion. The attachment of the primary pinnae to the main rachis is not clearly shown, but they were evidently obliquely placed. The pinnules are slightly connected at the base and are sharply serrate or toothed. The nervation, which is incorrectly shown in Lesquereux's figures, is strong, each vein forking once or twice or rarely three times.

As stated above, most of the specimens are fragments of pinnae of greater or less size, probably from various parts of the frond. Some of them, as shown in Figure 1, have the pinnae remote but connected at base by a narrow decurrent wing. Some of the pinnules, as also shown in Figure 2, are shorter and looser than in the typical forms. The nervation is invariably the same.

The principal characters upon which Lesquereux separated *S. membranacea* from *S. lakesii* were the possession of narrower decurrent pinnules and single distinct nerves. An examination of the type specimen,[46] as well as several others which are evidently like it, shows that the pinnae are very long and narrow and the pinnules smaller and more scattered than in the predominant form. It presents, as Lesquereux has said, quite a different facies from *S. lakesii*. The statement that the nerves are single and unbranched is incorrect, however, as shown not only by the type specimen but still more clearly by better-preserved specimens from the same locality recently obtained by Lakes. These specimens, some of which are typical *S. membranacea* and others merge into *S. lakesii*, all have branched nervation precisely as in typical *S. lakesii*.

The small specimen consisting of a single pinnule which is figured on Plate 2, Figures 3, 3a, of Lesquereux's report on the Tertiary flora was first called by him *Lathraea arguta* but in the report mentioned is regarded as a form or variety intermediate between *S. lakesii* and *S. membranacea*. The specimen as figured has apparently only one-half preserved, but it is fortunately contained in the National Museum collections, and an examination showed at once that the matrix on the seemingly destroyed half had not been removed. By carefully cutting it away the nearly complete half was exposed and showed, where fresh and unworn, the characteristic outline, toothing, and nervation of *S. lakesii*. Several other specimens in the National Museum recorded by Lesquereux as *S. membranacea* prove, when carefully examined, to be all nearly or quite typical *S. lakesii*.

I am therefore compelled to reduce these two species to one, which takes the name *Dryopteris lakesii* in honor of its discoverer. The most abundant form, which comes from the middle part of the frond, has the pinnae long with numerous contiguous, slightly connected pinnules. A less abundant form has shorter pinnae less thickly set with pinnules, which probably came from the lower portion of the frond. In still another form, *S. membranacea* Lesquereux, the pinnae are remote, slender, lanceolate, with the pinnules narrower, plaited in appearance, and the nerves strong.

Occurrence: Denver formation, Golden, Colo. (types), but without specific location. Later collections from Golden and vicinity are as follows: Green Mountain, quarry on northwestern base; same local-

[44] Lesquereux, Leo, The Tertiary flora, p. 50, 1878.
[45] Idem, pl. 2, fig. 1.
[46] Idem, pl. 2, fig. 2.

ity but upper seam or "fern ledge," about 20 feet above the first; South Table Mountain and about 100 feet below the lava cap. Dawson arkose, lower part (in beds equivalent to Arapahoe formation), Sedalia, Colo., about 3,000 feet east of the old Douglas coal mine. The specimens thus far enumerated were collected by Arthur Lakes in 1890. Middle Park formation, Middle Park, Grand County, Colo., from "doleritic breccia" just above main breccia mass in Potato Hill Gap on the Grand [Colorado] River, near Hot Sulphur Springs, collected by George L. Cannon, 1889.

Dryopteris richardsoniana Knowlton, n. sp.

Plate 2, Figures 3–5

Outline of whole frond not known; pinnae linear-lanceolate, the rachis extremely strong, prominently ridged; pinnules or segments nearly at right angles to the rachis, close, parallel, linear, obtuse, cut nearly or quite to the rachis; midvein of pinnules relatively strong, straight; lateral veins from 12 to about 18 pairs, at an angle of 45° or 50°, close, parallel, simple or rarely forked near the middle; fruit not known.

This form is represented by about a dozen examples. As all are merely fragments of pinnae, it is impossible to ascertain the size and outline of the whole frond, though presumably it was several times compounded. The largest fragment of a pinna is about 5 centimeters long, and neither base nor apex is shown. The width is about 2.25 centimeters. The pinnae are cut in the middle and upper parts nearly to the rachis into linear, rather obtuse segments. Near the basal portion of the pinnae the segments (or pinnules) are farther apart and appear to be nearly or quite free. The nervation consists of a relatively strong midvein and numerous pairs of simple or very rarely forked veins.

This form was at one time identified provisionally with *Dryopteris lesquereuxii* (*Lastrea* (*Goniopteris*) *goldiana* Lesquereux), from the Denver beds near Golden. Although it is of the same type (congeneric) and might possibly be shown to be identical with that species if a larger series of both were available for comparison, as the matter now stands they seem to differ in a number of essential particulars. Thus, the specimens here described as *Dryopteris richardsoniana* are much larger than the Golden species, with the pinnae cut deeper to the rachis, the segments or pinnules more nearly at right angles, and the lateral veins nearly twice the number present in *D. lesquereuxii*. The rachis is distinctly different in the two species. In *D. lesquereuxii* it is much more slender, but in *D. richardsoniana* it is exceptionally strong and very distinctly ridged. In any event, these two species are very close and may later be shown to be identical.

Dryopteris richardsoniana is also very close to *Dryopteris weedii* Knowlton,[47] from rocks of Fort Union Eocene age in the Yellowstone National Park; in fact, it is perhaps doubtful if they can be satisfactorily separated. The Yellowstone Park form appears to have the segments or pinnules narrower and more scattered and the lateral veins at a slightly lower angle, but these differences are slight, and if a series of well-preserved specimens were at hand they might disappear. As *D. weedii* was described attention was called to its undoubted affinity with *D. lesquereuxii* from Golden.

I have named this species in honor of George B. Richardson, of the United States Geological Survey, who has done so much to elucidate the geology of the region whence it came.

Occurrence: Dawson arkose, lower part (in beds equivalent to Arapahoe formation), 3,000 feet east of the old Douglas coal mine, Sedalia, Colo., collected by Arthur Lakes, June, 1890.

Dryopteris polypodioides? (Ettingshausen) Knowlton

Goniopteris polypodioides Ettinghausen. Lesquereux, U. S. Geol. Survey Terr. Ann. Rept. for 1873, p. 394, 1874.

Lastrea (*Goniopteris*) *polypodioides?* (Ettingshausen) Lesquereux, The Tertiary flora, p. 57, pl. 4, figs. 11, 12, 1878.

Dryopteris (*Lastrea*) *polypodioides* (Ettingshausen) Knowlton, U. S. Geol. Survey Bull. 152, p. 93, 1898.

The two examples upon which is predicated the presence in this country of the well-known European species are preserved in the United States National Museum (Nos. 24 and 25). As Lesquereux very well said in discussing them, "The fragments figured * * * are too obscure for positive identification." They are preserved on a soft fine-grained sandstone which has been so much worn that it is impossible to make out the margin with certainty in a single place. The largest specimen (Tertiary flora, pl. 4, fig. 11) is about 8 centimeters long and nearly 2.5 centimeters wide. There is some evidence to suggest that the margin is toothed, but this point can not be verified. Concerning the nervation Lesquereux said: "Primary veins equidistant, parallel; lateral veins at an acute angle of divergence, apparently alternate, simple, and curved inward."

As nearly as I can make out, the nervation given in Lesquereux's figures is almost totally wrong. The "primary veins," as he called them, are apparently the midveins of pinnules, which probably were free at the apices. The "lateral veins" are not simple but are thin, at an acute angle of divergence, and at least

[47] Knowlton, F. H., Fossil flora of the Yellowstone National Park: U. S. Geol. Survey Mon. 32, pt. 2, p. 669, pl. 80, fig. 8, 1899.

once forked. The whole nervation, as well as can be made out, is similar to or practically identical with that shown in the fragment from Middle Park shown on Plate 8, Figure 7, under the name *Anemia* sp.

From the foregoing statement it is apparent that there is only a remote possibility that these Sand Creek specimens can have any relation whatever with the European species described by Ettingshausen. They should probably be given a new name, but their characters are so obscure that it is doubtful if they could be so described as to permit their subsequent recognition, and under these circumstances it is perhaps as well to leave them as established by Lesquereux. I have, however, placed a question mark after the species name to indicate its extremely unsatisfactory state.

The locality whence these specimens came (Sand Creek east of Denver) has been involved in much confusion and uncertainty. They were supposed to be of either Laramie or Arapahoe age, but the latest information appears to place their horizon in the Denver formation.

Occurrence: Denver formation, Sand Creek, about 15 miles east of Denver, Colo., said to have been collected by William H. Holmes in 1873.

Dennstaedtia crossiana Knowlton, n. sp.

Plate 2, Figures 7–9

Frond bipinnate; pinnules alternate, very oblique, triangular-lanceolate, sessile, and decurrent on a slightly winged rachis, deeply pinnatifid, the segments oblong, obtuse, pointed upward and one or two toothed on the upper side, the sinuses rounded; primary vein strong; secondary veins once forked, one branch passing to the apex and the other to the sinus; sori seated on a vein at the apex of the lobes and frequently in the sinuses also.

Notwithstanding the fact that this fern is in fruit it is referred to *Dennstaedtia* with considerable hesitation, for to distinguish between this genus and *Hymenophyllum* or *Davallia* is next to impossible with material so scanty and obscure. Although it is easy to distinguish between these genera in a living state, where all the organs of fructification can be carefully examined, it is exceedingly difficult to decide in regard to fossil forms, in which the organs of reproduction are more or less obscured by the accidents of preservation. In habit, texture, division, and nervation these genera are so similar that it will usually not be possible to distinguish them without fruit, and even in the fruit much depends upon the character of the indusium, which from its delicate nature is not usually preserved.

The specimens under consideration have been referred to *Dennstaedtia* because they are, as nearly as can be made out, most like this genus. The sori are situated at the margin of the frond and always at the apex of a vein, as in the living species. The strong, thick primary rachis probably excludes them from *Hymenophyllum*, and the character of the sori seems to separate them from *Davallia*.

This is a very small, delicate fern, the longest pinnule being hardly over 1 centimeter in length and 6 to 8 millimeters in width. It was probably several times compounded, to judge from the thickness of the rachis, but the largest fragment found only shows it to be bipinnate. The outline of the whole frond can not be determined. The pinnules seem to have been easily detached, as four of them were found unconnected and not otherwise much mutilated. They are elongated, deltoid, or lanceolate, with numerous pinnatifid divisions, which are rounded at the apex and in the sinuses between them. The nervation consists of a strong central vein and once or rarely twice forking lateral veins with the fruit dots borne on them at the margin of the frond. The fruit dots are thick, globose, and seemingly somewhat cup-shaped, but they are not well enough preserved to warrant positive statements regarding the minute details.

This species is exceedingly rare, for among several hundreds of pieces of shale examined only the specimens figured were obtained. But as they are very obscure, requiring a glass for their detection, they may have been easily overlooked by the collector.

Occurrence: Dawson arkose, lower part (in beds equivalent to Arapahoe formation), Sedalia, Colo., quarry No. 2, about 3,000 feet east of the Douglas coal mine, in a gulch near the railroad, collected by Arthur Lakes, June, 1890.

Woodwardia latiloba Lesquereux

Woodwardia latiloba Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, p. 391, 1874; The Tertiary flora, p. 54, pl. 3, figs, 1, 1*a*, 1878.

Woodwardia latiloba var. *minor* Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, p. 391, 1874; The Tertiary flora, p. 54, pl. 4, figs. 9, 9*a*, 1878.

This fine and perfectly distinct species is fairly abundant at a number of localities within the Denver beds at Golden, Colo., but usually in fragments of very much smaller size than the magnificent type specimen, which is preserved in the United States National Museum (No. 15). The smaller fragments, however, retain perfectly their characteristic outline and nervation, thus rendering their identification unquestioned.

The small fragment described and figured by Lesquereux as variety *minor* is also preserved in the United States National Museum (No. 117). In the

published accounts of this form it is said to have come from Black Buttes, Wyo., but in the Museum catalogue it was recorded by Lesquereux himself as being from Golden, Colo., and an examination of the specimen leads me to believe that this statement is correct. It is said to differ from the species in having the " pinnae small; rachis narrow; lobes short, obtuse; secondary veins less divided." It represents, as Lesquereux has said, only the tip of a pinna, so it would naturally be smaller and the lobes shorter and more obtuse. It is not, however, smaller nor different in outline from what must have been the terminal portion of certain of the smaller, upper pinnae of the large type specimen of *W. latiloba*. The nervation is of precisely the same character as in the species but is, of course, less branched to accommodate the smaller size of the pinna. I therefore do not hesitate to refer it, locality and all, to the species.

The abundant but rather poorly preserved material from Sedalia, Colo., is not to be distinguished from the typical material.

Occurrence: Denver formation, Golden, Colo. Dawson arkose, lower part (in beds equivalent to Arapahoe formation), Sedalia, Colo., 1,900 feet east of the Douglas coal mine.

Woodwardia latiloba serrata Knowlton, n. var.

Plate 2, Figures 1, 2

Similar to *Woodwardia latiloba* in all particulars except that the margins of the pinnules are finely and evenly serrate.

It is perhaps doubtful if this should be considered even subspecifically distinct from the typical form, as the only observable difference is in the serrate instead of entire margins, though it may be stated that of the numerous examples of *W. latiloba* examined not one has shown a tendency to become serrate.

Occurrence: Middle Park formation, Middle Park, Grand County, Colo., from high terrace ridge between forks of Kinney Creek, in " breccia spoon " east of Hot Sulphur Springs, collected by Whitman Cross, October 6, 1891.

Pteris pseudopennaeformis Lesquereux

Pteris pseudopennaeformis Lesquereux, The Tertiary flora, p. 52, pl. 4, figs. 3, 4, 1878.
Knowlton, U. S. Geol. Survey Bull. 204, p. 22, 1902.
Hollick, Louisiana Geol. Survey Rept. for 1899, Special Rept. 5, p. 279, pl. 32, fig. 1, 1899.
Berry, U. S. Geol. Survey Prof. Paper 91, p. 168, pl. 9, fig. 6, 1916.
Pteris pennaeformis Heer. Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1870, p. 384, 1871; idem for 1873, p. 283, 1874.
?Newberry, U. S. Geol. Survey Mon. 35, p. 7, pl. 48, fig. 5, 1898.

Pinnae large, subcoriaceous, narrowly lanceolate, gradually narrowed to both base and apex; the margin entire to about the middle, obtusely dentate at and near the apex; midrib stout, more or less flexuose, grooved; veins thin, at an angle of 35° or 40°, close, straight, mostly simple or rarely once forked.

The above description is slightly modified from that given by Lesquereux, the changes being based on a reexamination of the type specimen, or rather the specimen figured by Lesquereux in the report on the Tertiary flora (U. S. Nat. Mus. No. 19) as typical. This is the only specimen I have had the opportunity of examining, as none of the recent collections from Golden seem to have included examples. The specimens from Golden in the Museum of Comparative Zoology that were identified by Lesquereux as *Pteris pseudopennaeformis* are found to belong to *Salpichlaena anceps* (Lesquereux) Knowlton.

This species was first characterized by Lesquereux, under Heer's name *Pteris pennaeformis*, from specimens collected by F. V. Hayden on Henrys Fork of Green River in Wyoming. It was also later collected by Hayden at Golden, Colo., from which came the specimen figured in the report on the Tertiary flora, Plate 4, Figure 3, notwithstanding the fact that this particular specimen is recorded in the National Museum catalogue as having come from Henrys Fork. The matrix is unmistakably that from Golden, and indeed the specimen is properly so recorded in Hayden's annual report for 1873, page 392, where this specimen was first mentioned.

This species appears to be closely related to *Pteris pennaeformis* Heer, as pointed out by Lesquereux, and may be identical with it, but in the absence of specimens from Greenland and of specimens other than the type of *P. pseudopennaeformis* I have thought best to retain Lesquereux's assignment. It is always possible that subsequent collections may contain material that will clear the matter up.

If it has been identified correctly, this species has a wide geographic range, having been reported by me [48] from the lower part of the Clarno formation at Current Creek, Oreg., and by Berry [49] from the Wilcox deposits of Louisiana and Mississippi. It appears to be a rare form and thus far is represented by only very few poorly preserved specimens, so its characters are not made out with certainty. Berry has expressed the opinion that it is more likely to be referable to the genus *Asplenium*, and he points out its resemblance to *Asplenium eoligniticum* Berry, a Wilcox species.

Occurrence: Denver formation, Golden, Colo.; early collections made by F. V. Hayden. Green River formation(?), Henrys Fork of Green River, Wyo. Lower part of Clarno formation, Current Creek, Oreg.

[48] Knowlton, F. H., U. S. Geol. Survey Bull. 204, p. 22, 1902.
[49] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 168, pl. 9, fig. 6, 1916.

Wilcox formation, Vineyard Bluff, Caddo Parish, and Naborton and Mansfield, De Soto Parish, La. Wilcox group (Grenada formation), Grenada, Miss.

Diplazium crossii (Knowlton) Knowlton, n. comb.

Plate 2, Figure 6

Asplenium (Diplazium) crossii Knowlton, U. S. Geol. Survey Bull. 152, p. 44, 1898.

Diplazium muel.eri? Heer. Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, p. 393, 1874; The Tertiary flora, p. 55, pl. 4, figs. 10, 10*a*, 1878; The Cretaceous and Tertiary floras, p. 138, 1883.

Outline of frond not known; pinnae coriaceous, narrowly lanceolate, gradually tapering upward to a long, acuminate apex, and from the lower third tapering downward to a wedge-shaped base, cut for one-fourth or one-third the width into oblong, rather obtuse segments; midvein of segments exceedingly thin and obscure; veins very thin, some arising from the midvein, others from the main rachis, all at an acute angle, once or twice forked.

This species, as indicated in the above synonymy, was doubtfully identified by Lesquereux with Heer's *Diplazium muelleri*, from the brown coal of Bornstädt. The specimen on which Lesquereux based this identification is preserved in the United States National Museum (No. 18 [by error 19]) and is before me as I write. He figured only one broken pinna, but as a matter of fact there are three pinnae on this piece of matrix, all lying in the same direction and plane. One of these, although somewhat covered with the matrix, is a more perfect specimen than the one figured in that it shows the basal portion nearly complete. A careful examination of Lesquereux's specimen, together with about 20 others since collected by Arthur Lakes near South Table Mountain, Golden, shows that they differ in at least three essential particulars from *Diplazium muelleri*, as described and figured by Heer.[50] These differences are as follows: (1) The pinnae are cut into short, entire-margined segments, but in typical *D. muelleri* the pinnae are distinctly doubly serrate. (2) They have no intramarginal nerve as figured by Lesquereux. It is difficult to see how this error of interpretation arose, for although Lesquereux's specimen is rather obscure, there is not the slightest trace of an intramarginal nerve such as that described and figured for *D. muelleri*. (3) The veins, although rather close together, do not anastomose as described and figured by Lesquereux. Even the obscure type specimen fails to show a single place where the veins anastomose, and the very well preserved new material proves still more conclusively that they do not. The fact that Lesquereux compares the anastomosing to that observed in his *Gymnogramma gardneri*[51] shows clearly that he was greatly misled concerning it, and it seems probable that his description was made entirely from the drawing, which, so far as I am able to conclude, must have been made for a different plant. The veins all arise from the secondary rachis or from the thin mid-vein and fork once or rarely twice before reaching the margin.

From this description it becomes evident that these specimens can not be considered specifically identical with *Diplazium muelleri* Heer, and it is necessary to give them a new name. The question of their generic reference may be first considered. The absence of fructification and of a knowledge of the size, shape, and habit of this form makes a generic allocation more or less uncertain. It has some resemblance to certain living species of *Diplazium*.

In this connection it may be well to clear up another misunderstanding concerning this species. In Hayden's annual report for 1873 it is stated that this species came from South Table Mountain, Golden, but in the report on the Tertiary flora it is accredited to Henrys Fork, Wyo. A comparison of the type specimen with those recently obtained by Mr. Lakes shows them to be absolutely identical lithologically. There can be no doubt that the specimens actually came from Golden and not from Henrys Fork. And upon this probably hinges a still further error. In Lesquereux's report on the Cretaceous and Tertiary floras (p. 138) *Diplazium muelleri* is enumerated from the Green River formation without mention of exact locality, being simply referred to the page of the report on the Tertiary flora in which this species is described and recorded from Henrys Fork. If, as there stated, it had come from Henrys Fork it would with very little doubt be of Green River age, and it seems probable that Lesquereux introduced it into his list of species from the Green River deposits upon this supposition. At least there is no evidence to prove the contrary, as there are no specimens extant, so far as known, that came without question from the Green River formation of Henrys Fork. It would therefore seem best to drop this species from the flora of the Green River, at least until further collections prove or disprove the correctness of the above surmise. So limited above in its distribution *Diplazium crossii* is found only in the lowest leaf-bearing stratum of the Denver beds.

Among the material obtained in Middle Park by George L. Cannon for S. F. Emmons I find a single specimen with its counterpart that belongs to this species. It is rather poorly preserved but does not differ in any particular from the Golden specimens.

Occurrence: Denver formation, Golden, Colo., on a bluff of the prairie a quarter of a mile south of the Reform School and about 500 yards southwest of South Table Mountain. Middle Park formation, Mid-

[50] Heer, Oswald, Braunkohlen Pflanzen von Bornstädt, p. 8, pl. 1, figs. 2, 2*b*, 1869.

[51] Lesquereux, Leo, The Tertiary flora, p. 58, pl. 4, fig. 2, 1878.

dle Park, Colo., on north bank of the Grand [Colorado] River near Sheriff's coal shaft, on Sheriff Creek, collected by George L. Cannon, 1889.

Genus ALLANTODIOPSIS Knowlton and Maxon

Allantodiopsis Knowlton and Maxon, U. S. Geol. Survey Bull, 696, p. 61, 1919.

Fronds simply pinnate; venation pinnate, the veins free, once or twice forked; sori dorsal, always on the upper or distal fork of a vein, short, thick, sausage-shaped, with no evidence of the presence of an indusium.

Allantodiopsis erosa (Lesquereux) Knowlton and Maxon

Plates 4, 5

Allantodiopsis erosa (Lesquereux) Knowlton and Maxon, U. S. Geol. Survey Bull. 696, p. 61, 1919.

Pteris erosa Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1871, Suppl., p. 12, 1872; idem for 1873, p. 392, 1874; The Tertiary flora, p. 53, pl. 4, fig. 8, 1878; The Cretaceous and Tertiary floras, p. 121, pl. 19, fig. 1, 1883.

Pteris subsimplex Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, p. 392, 1874; The Tertiary flora, p. 52, pl. 4, figs. 5–7, 1878.

Osmunda major Lesquereux, The Cretaceous and Tertiary floras, p. 121, pl. 18, fig. 5, 1883.

Pteris undulata Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 43, 1888.

Asplenium erosum (Lesquereux) Knowlton, U. S. Geol. Survey Bull. 152, p. 45, 1898.

Asplenium subsimplex (Lesquereux) Knowlton, U. S. Geol. Survey Bull. 152, p. 45, 1898.

Frond large, coriaceous, simply pinnate; pinnules simple, alternate or subopposite, apparently sessile, oblong-lanceolate, rounded and often very unequal-sided at base, long acuminate or taper pointed at apex; margin rarely quite entire, usually undulate, crenulate, or sharply serrate above the middle, sometimes entirely serrate; middle nerve strong, round; veins free, at an open angle of divergence, distinct, distant, very rarely simple, usually forking once near the midvein and again at or above the middle; sori dorsal, large, sausage-shaped (5.6 millimeters long, 1.5 millimeters broad), seated on the upper fork of a vein about 3 or 4 millimeters above the midvein.

After an examination of the type specimens of all the so-called species enumerated above, with the exception of *Osmunda major* (which, however, is finely figured), together with much additional material representing all the forms obtained a few years ago by Arthur Lakes, I am absolutely unable to draw any satisfactory specific lines between them. In size, general outline, and nervation they are identical, merely differing slightly in the character of the margin of the pinnules. Thus *Pteris subsimplex* is described as having the margin "entire or minutely crenulate"; *P. erosa* has the "borders obtusely dentate toward the point, irregularly crenulate-lacerate in the middle"; *P. undulata* is "regularly deeply undulate-crenate, especially in the upper part"; and *Osmunda major* is simply described as having the "borders undulate." *Pteris subsimplex* and *P. undulata* were founded on the middle and lower parts of pinnules; *P. erosa* is based on the upper parts of pinnules, and *Osmunda major* upon the basal parts of several pinnules fortunately preserved so as to indicate the position of the rachis. Further, they were all, except *O. major*, established upon fragments which give no indication of the nature of the entire frond or plant; consequently *P. subsimplex*, *P. erosa*, and *P. undulata* were thought to be entire fronds, while *O. major* was, of course, clearly pinnate. It therefore becomes reasonably clear that they all represent different parts or slightly different forms of a single species, a conclusion to which Lesquereux himself seems to have been almost forced, for in his remarks under *O. major*[52] he said: "It is, therefore, uncertain whether these fragments represent two or three species, or whether, perhaps, they may all be referable to the same."

The probability that these four nominal species are really one and the same thing is further strengthened by a knowledge of their geologic and geographic distribution. Thus, *Pteris erosa* was described from Fishers Peak, in the Raton Mountains, Colo., in beds now referred to the Raton formation, which is correlated with the Denver formation. This form is found at several places in the Raton Mesa region of Colorado and New Mexico, though it is nowhere abundant. The other forms (*Pteris subsimplex*, *Pteris undulata*, and *Osmunda major*) were all described from the andesitic beds of the Denver formation at Golden, Colo.

From a study of all the material now available it becomes apparent that we are dealing with a fern that possessed a large, simply pinnate frond with alternate or subopposite coriaceous pinnules, which are broad, linear, or oblong-lanceolate in outline (10 to 16 or 18 centimeters long and 3 to 3.5 centimeters broad), with an abruptly rounded and unequal-sided base and an acuminate or taper-pointed apex.

It is perhaps not to be wondered at that a fern as large as this should rarely be found preserved entire. The conditions for the entombment of a large frond might even be favorable, but in exhuming a specimen of this size in an easily broken matrix it would be exceedingly difficult to procure a complete fossil, even if preserved. It is but natural, therefore, that these large isolated pinnules should have been taken for entire fronds, and as even these were rarely preserved

[52] Lesquereux, Leo, The Cretaceous and Tertiary floras, p. 121, 1883.

entire there is perhaps an excuse for regarding the basal and terminal portions as representing different species, especially as they have been shown to vary from an undulate margin in the lower part to a toothed margin in the upper part. Thus in one of the most perfect examples thus far obtained the lower portions of the pinnules are of exactly the same character, indeed almost a counterpart of the type of *Osmunda major*, whereas in the upper portion of at least one of the pinnules the margin begins to be slightly toothed, showing its transition to the so-called *Pteris erosa*. This transition from a nearly or quite entire outline to a more or less pronounced toothed margin in the same frond or pinnule is by no means rare among living ferns.

The small fruiting specimen (pl. 4, fig. 1) obtained by Lakes near the Douglas coal mine, Sedalia, Colo., represents, so far as I know, the only example of the fruit of these ferns ever obtained. It is well shown in the figure and has been described at length. It is evidently in very mature condition, for all trace of the indusium has disappeared (if, indeed, it was ever present), and the sori present a pulverulent appearance under a low power, though no well-defined sporangia can be made out. Some years ago I was led to regard this fruit as indicating the genus *Asplenium*, as I then interpreted the sori to be double and contiguous on opposite sides of a vein, but after a reexamination of the specimen I can but decide that conclusive evidence for this assumption is wanting. There is no indication of a middle parting through a sorus, though some trace of it would probably be present if it ever existed, and hence the sori appear to be truly dorsal.

This fruiting specimen was submitted to the late Prof. D. C. Eaton, of Yale University, a well-known pteridologist, who at once suggested its relationship to *Allantodia brunoniana* Wallich, now known as *Diplaziopsis javanica* (Blume) Carl Christensen, a large pinnate fern native to the East Indies and Pacific islands. In the size and outline of the pinnules and in the size and position of the sori this living species is almost identical with the fossil form, but the nervation is entirely different. The veins branch at the base as in the fossil and are there only soriferous, but they anastomose into subhexagonal areoles toward the margin.

I have also submitted this material to another student of the ferns, Mr. William R. Maxon, of the United States National Museum, and have received many valuable suggestions from him. He also remarked at once the similarity of the fructification to that of *Diplaziopsis javanica*, with which, however, the fossil plant could not, on account of its free venation, be associated. He further directed my attention to the marked similarity of the fossil forms under consideration to *Coniogramme fraxinea* Don (*Gymnogramme javanica* of authors), a species of the Himalayas, Java, and Ceylon. The agreement here in size and nervation is almost perfect, but the fruiting is entirely unlike. Instead of a short, sausage-shaped sorus confined to the upper fork of a vein, we have a very long, narrow, and usually forked sorus—that is, the sori follow both forks of a vein, often for a considerable distance. As Mr. Maxon has called to my attention, the fossil under consideration appears to be excluded from all the present genera of the tribe Aspleniae by the dorsal rather than lateral position of the sori. A comparison might readily be instituted between isolated pinnae of the fossil form and numerous large-fronded living forms, such as certain species of *Pteris*, *Stenochlaena*, and *Acrostichum*, but all would be excluded on the ground of different fruit, and, following Mr. Maxon's advice, I have decided to institute a new genus for its reception.

Various relationships among fossil forms have been suggested for one or another of the so-called species here included under *Allantodiopsis erosa*, but as they were all based on a knowledge of the sterile forms only, they can now, in the light of the fruiting specimen, be regarded as of little value. Gardner and Ettingshausen, in their monograph on the British Eocene flora, stated, in connection with *Pteris eocenica*, that "The American Eocene species *P. subsimplex* and *P. erosa*, while possessing the same venation, have much broader pinnae," and later that "Although species of *Acrostichum*, *Angiopteris*, *Gymnogramme*, etc., possess similar venation, the characters furnished by this form [*Pteris eocenica*] so closely correspond to what is met with in the recent species of *Pteris* that its reference to this genus can not be doubted." If *Pteris eocenica* is really closely allied to our form, it should, of course, be considered as belonging to this new genus. So also with several other species described under the name *Pteris*, as *P. parschlugiana* Unger [53] and *P. pennaeformis* Heer.[54] But this is mere conjecture, as size, outline, and nervation are often of secondary value in determining relationship in ferns; and it is impossible, in the absence of fruit, to determine the genus of many living species.

Occurrence: Denver formation, South Table Mountain, Golden, Colo., from early collections by Hayden and Lesquereux and later by Arthur Lakes; types of *Pteris undulata* Lesquereux in Museum of Comparative Zoology, Cambridge, Mass., No. 853. Dawson arkose, lower part (in beds equivalent to Arapahoe formation), east of Douglas coal mine, near Sedalia,

[53] Unger, Franz, Chloris Protogaea, pt. 1, p. 122, pl. 36, fig. 6, 1847.
[54] Heer, Oswald, Flora tertiaria Helvetiae, vol. 1, p. 38, 1855.

Colo., collected by Arthur Lakes. Middle Park formation, Sheriff Creek, north bank of the Grand [Colorado] River, Middle Park, Grand County, Colo., collected by Geo. L. Cannon. Raton formation, Fishers Peak, Raton Mountains, Colo.

Saccoloma gardneri (Lesquereux) Knowlton

Plate 3, Figures 3–8

Saccoloma gardneri (Lesquereux) Knowlton, U. S. Geol. Survey Bull. 696, p. 560, 1919.

Pteris gardneri Lesquereux, U. S. Geol. Survey Terr. Ann. Rept. for 1873, p. 393, 1874.

Gymnogramma gardneri (Lesquereux) Lesquereux, The Tertiary flora, p. 58, pl. 4, fig. 2, 1878.

Outline of whole frond not known, but from its general resemblance to the living *Saccoloma elegans* it is presumed to have been erect, with the pinnae lanceolate and perfectly entire or slightly undulate; the texture is apparently subcoriaceous but thin. The sterile pinnae are narrowly lanceolate, acuminate at apex, and apparently abruptly rounded at base; the margin is slightly undulate.

No complete specimen has been found, but the most perfect one shown is 17 centimeters long and shows no evidence of narrowing to either base or apex. It must have been 20 to 25 centimeters in length. Midrib very strong, grooved above, finely striate below, the veins strong, at an angle of 30° to 40°, usually forking just above the midrib and often just above the middle, generally anastomosing near the margin though sometimes forking again without anastomosing. The fertile pinnae are apparently slightly smaller than the sterile ones, 2 to 3 centimeters wide, with the venation similar, forking near the midrib and again at or near the middle, not or rarely anastomosing but running free to the margin. The sori are small, close, circular, one on each vein or branch reaching the margin, slightly submarginal in position, forming a continuous row; indusium obscure, perhaps distally attached and folding over the sorus, or perhaps the margin of the frond is slightly folded over the sorus, thus simulating an indusium.

The type specimen of what for many years has been known under the name *Gymnogramma gardneri* is preserved in the United States National Museum (No. 17). It was found on Sand Creek, some 15 or 18 miles east of Denver, Colo., in beds long supposed to be Arapahoe in age but now pretty definitely settled as belonging to the Denver formation. This type specimen is very poorly preserved and consists simply of two sterile fragments representing the middle portions of pinnules or perhaps whole fronds. They lie side by side and less than 2 centimeters apart, and as they are without apex or point of attachment there is no evidence to show whether each represents a whole frond or whether they may not be pinnules of a very large compound frond. The latter interpretation is the one that was adopted by Lesquereux, who gave the following description:

> Frond large, simply pinnate; pinnae large, linear, broader in the middle, in right angle to the rachis, rounded at the base; borders deeply undulate; middle nerve broad, grooved in the middle, flattened on the borders; veins in an obtuse angle of divergence, abruptly curved downward at the base, or decurring to the rachis, forking once or twice, joined by anastomoses and forming by cross branches irregular, long areolae.

Saporta, to whom apparently Lesquereux had submitted a drawing of his so-called *Gymnogramma gardneri*, expressed the opinion that it was identical with or at least closely related to a fern from the Gypse of Aix which he regarded as referable to *Chrysodium*, a section of the genus *Acrostichum*. Gardner and Ettingshausen [55] also discuss this American fern in connection with the description of their *Chrysodium lanzeanum*, from the Lower and Middle Bagshot beds of England. It is not to be denied that *G. gardneri* has a degree of resemblance to the living *Acrostichum* (*Chrysodium*) *aureum* Linné, but it differs essentially in its looser, less anastomosing nerves. I was at one time inclined to transfer *Gymnogramma gardneri* to *Acrostichum*, but decided to retain it as placed by Lesquereux in the hope that sooner or later additional material would come to light that would help to settle its status. This new material has fortunately now been found.

In 1910 C. W. Cooke collected for G. B. Richardson some excellently preserved ferns and other plants from the basal part of the Dawson arkose near Ramah, Colo. The ferns were represented by the two examples figured, which show the sterile and fertile pinnae. The fronds are preserved on a hard baked clay shale and exhibit all the details of nervation and fructification in a high degree of perfection. The fructification as well as the shape and nervation immediately suggested reference to the genus *Saccoloma*, of which this was supposed to be the first known fossil species. Its relation to Lesquereux's *Gymnogramma gardneri* was not then suspected.

Later collections from the Dawson arkose on Jimmy Camp Creek, east of Colorado Springs, and from Mosby, El Paso County, Colo., were found to include a number of large ferns that were recognized at once as belonging to *Saccoloma*. Most of them are sterile fronds, which turn out to be indistinguishable from *Gymnogramma gardneri*. For example, a segment from the base of the large pinna shown could not be distinguished from the type of *Gymnogramma gard-*

[55] Gardner, J. S., and Ettingshausen, Constantin von, Monograph on the British Eocene flora, vol. 1, Filices, p. 28, Paleont. Soc., 1879.

neri, and it is so regarded. The reference of these Mosby specimens to *Saccoloma* is attested by a number of fruiting examples, one of which is shown in Plate 3, Figure 7. This is a mere fragment from the middle of a pinna, about 4 centimeters long and 2.5 centimeters wide. It has a broad, grooved midvein and strong forked veins as in *G. gardneri*, and the fruit is apparently more mature and forms an almost continuous row. None of the Mosby specimens show the basal portion of a pinna, but a number show an apparent narrowing toward the apex. One exhibits an irregularly erose appearance on one side, but whether this is natural or due to injury can not be determined.

The genus *Saccoloma* is a small group of davallioid polypodiaceous ferns that, with a single exception as currently accepted, is confined to tropical America. The type of the genus is *Saccoloma elegans* Kaulfuss, which inhabits tropical America from Guatemala and the West Indies southward to Rio Janeiro. Certainly congeneric with this, though of quite different form and nervation, are two other species—*S. imrayanum* Hooker and *S. wircklei* Christ, the first occurring in the West Indies and British Guiana and the second in Costa Rica. The genus is apparently in need of critical revision, but whatever the result of such study may be, the fact remains that the type of the genus and the two species above mentioned are congeneric, and with them undoubtedly belongs the fossil form here described.

Saccoloma gardneri, as it must now be called, is most closely related to *S. elegans*, with which it agrees in the shape and apparent size of the pinnae, in the position, size, and appearance of the sori, and in the indusioid character of the margin. It differs in nervation from *S. elegans*, which has the nerves mainly simple and only very rarely forked. So far as observed the veins in *S. elegans* never anastomose. There is no previous record of *Saccoloma* in a fossil state, and its presence in eastern Colorado in early Eocene time is of interest and possible importance in its bearing on the climatic conditions that prevailed at that time.

The sterile fronds of *Saccoloma gardneri* are very similar in size and appearance to *Allantodiopsis erosa* and might be confused with it unless the nervation is studied very closely. In *Allantodiopsis* the veins fork once or twice but never anastomose; in *Saccoloma* the veins fork in a similar manner but occasionally anastomose. If the specimen is poorly preserved, it may be difficult to detect the anastomosing of the veins. The degree of this anastomosing appears to differ somewhat in different specimens—that is, some show this condition very plainly and others obscurely.

Occurrence: Denver formation [type], roof of coal mine, Sand Creek, about 15 miles east of Denver, Colo., collected by A. Gardner in 1873. Dawson arkose, near Ramah oil well, in the NW. ¼ sec. 33, T. 9 N., R. 61 W., about 40 miles northeast of Colorado Springs, Colo., collected by C. W. Cooke for G. B. Richardson, September, 1910; east bank of Jimmy Camp Creek, 9 miles east of Colorado Springs, Colo., collected by A. C. Peale, 1908; dump of Mosby coal mine, Mosby, El Paso County, Colo., collected by F. H Knowlton and G. B. Richardson, July, 1910.

Saccoloma sp.

Plate 3, Figures 1, 2

The fragment of fern here figured is so poorly preserved that under ordinary circumstances its description would hardly be worth while. Yet it belongs to a type that has not previously been noted. It is very close to or possibly identical with *Saccoloma gardneri*, just described. It is a sterile frond or pinnule that was probably 6 or 8 centimeters long and is nearly 3 centimeters wide. It differs slightly from *S. gardneri* in having the margin obscurely toothed and in having the nervation at a less acute angle of divergence—both differences that might disappear if we had a series of specimens instead of a single one. The nerves fork very near the midvein and often fork again above the middle. They anastomose not far from the margin, as in the sterile frond of *S. gardneri*.

Occurrence: Dawson arkose, east bank of Jimmy Camp Creek, 0.6 mile above Richfield Springs ranch house, 9 miles east of Colorado Springs, Colo., collected by F. H. Knowlton, July, 1910.

Salpichlaena anceps (Lesquereux) Knowlton

Plate 7, Figures 1–3

Salpichlaena anceps (Lesquereux) Knowlton, U. S. Geol. Survey Bull. 696, p. 574, 1919.

Pteris anceps Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, p. 376, 1873.

Pteris affinis Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, p. 392, 1874.

Osmunda affinis (Lesquereux) Lesquereux, The Tertiary flora, p. 60, pl. 4, fig. 1, 1878.

Knowlton, U. S. Geol. Survey Mon. 32, pt. 2, p. 673, pl. 80, figs. 4, 5, 1899.

Pteris pseudopennaeformis Lesquereux. Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 43, 1888.

Fern apparently of large size, probably climbing, in effect bipinnate (primary rachis unknown), secondary rachis strong, slightly irregular or zigzag; pinnules alternate, closely sessile, narrowly lanceolate, truncate or slightly heart-shaped at base, rather obtusely acuminate at apex, margin entire or slightly undulate; midvein very strong, slightly undulate; nervation pinnate,

free, the veins relatively strong, usually at a low angle of divergence, rather remote, once or twice forked (their apices slightly thickened at the margin?); fruit unknown.

As may be seen from the above synonymy, quite diverse views have been entertained regarding the position of this fern. A mere fragment from Golden, Colo., of what was thought by Lesquereux to be this plant was first described by him under the name *Pteris anceps*.[56] In the following year he obtained more perfect material from the same locality, and, thinking he could observe slight differences between this and his *Pteris anceps*, he gave it the name *Pteris affinis*.[57] Later, when he came to prepare his report on the Tertiary flora, he had received still more perfect examples, and, considering its affinity to be rather with *Osmunda* than with *Pteris*, he described and figured it as *Osmunda affinis*. On this point he says:[58]

> The position of the pinnae (the middle one seemingly terminal), their size and form, and also the characters of the nervation of this fern seem to indicate its generic relation with *Osmunda* rather than with *Pteris*.

So the matter rested until the fortunate discovery by Lakes, in 1890, of a number of fairly well preserved large specimens which give us a much better idea of the size and probable habit of this fern than any before obtained. The best of these seems to indicate a large fern, apparently bipinnate, though the main rachis is not preserved. From the position of the pinnae on the matrix it may be presumed that they were alternate on the primary rachis, but this point is of course uncertain. The secondary rachis is very strong and slightly zigzag, as may be observed in certain living ferns of climbing habit. The position, shape, and nervation of the pinnules have been indicated in the diagnosis and need not be repeated.

By the kindness of Mr. William R. Maxon, of the United States National Museum, my attention has been drawn to the undoubted close similarity between the fossil under consideration and the living *Salpichlaena volubilis* J. Smith, or *Blechnum volubile* of authors, the name by which it was earlier known. This fern, the only known species of the genus, is widely distributed throughout Central and South America, being, for instance, especially abundant in Brazil, where it is described as climbing to the tops of the loftiest trees. It needs but a glance at a suite of specimens to show that Mr. Maxon's conjecture was well founded, for the living fern has a strong, flexuose primary rachis with the odd-pinnate pinnae disposed alternately, as they appear possibly to have been in the fossil. The pinnules, which are of approximately the same size and shape, are opposite or nearly so but, unlike those of the fossil forms, are invariably short-stalked. The nervation of the pinnules in the living species is of the same general appearance as in the fossil, but there are differences. The veins are nearly at a right angle with the midvein, closer together, and often simple, though usually forked once; their apices are slightly thickened and form a cartilaginous margin to the pinnule. The fruiting in this living species is very peculiar, the sori being linear, continuous or nearly so, parallel with the midrib and contiguous to it; they are covered by a membranous indusium, which unrolls at maturity.

Although no fruit has been found on the fossil forms, I do not hesitate to place them in the genus *Salpichlaena*, on the ground of the strong resemblances above pointed out. With the scanty material at his command Lesquereux was perhaps justified in placing them in *Osmunda*, which his best specimen does somewhat resemble, being the three terminal pinnules of a rather small pinna.

In the material belonging to the Museum of Comparative Zoology Lesquereux[59] identified two specimens as *Pteris pseudopennaeformis* Lesquereux. These specimens are before me and prove undoubtedly to belong to *Salpichlaena anceps*. The best-preserved example is figured and shows parts of five pinnae, similar in all particulars to the other figures.

Occurrence: Denver formation, South Table Mountain, Golden, Colo., collected by Arthur Lakes. Specimen identified as *Pteris pseudopennaeformis* in the Museum of Comparative Zoology, Cambridge, Mass., No. 852.

Family SCHIZAEACEAE

Anemia mosbyensis Knowlton, n. sp.

Plate 8, Figure 9

The material from the Mosby coal mine at Mosby, Colo., contains numerous fragments of an *Anemia* that it seems best to describe as new rather than to refer to a named species on what may be insufficient data. It is a rather remarkable fact that although *Anemia* appears to be widely distributed, both areally and vertically, it is uncommon to find specimens so perfectly preserved as to give a satisfactory idea of the whole frond. The present case is an example in point. There are a dozen or more fragments of pinnae but only one that gives much of an idea of the complete frond. This is shown in the figure. It is the apical portion of the frond, of which a length of about 10 centimeters is preserved, but it was undoubtedly longer

[56] U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, p. 376, 1873.

[57] Idem for 1873, p. 392, 1874.

[58] The Tertiary flora, p. 60, 1878.

[59] Lesquereux, Leo, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 43, 1888.

than this and possibly was forked. The two lower pairs of pinnae are alternate, at an acute angle with the main rachis, and narrowly linear-lanceolate. The lowest are nearly 8 centimeters long, less than 1 centimeter wide at the base, and slenderly acuminate at the apex. They are decurrent at the base and have the margins provided with remote, low, sharp teeth. The pinnae next above the two lower pairs are greatly reduced, being hardly 2 centimeters in length, and are not cut to the rachis. The others above are progressively shorter until in the extreme apical portion they are probably reduced to mere slight indentations or teeth. The nervation is characteristically that of the genus, consisting of a slender secondary rachis or midvein and numerous close, parallel, once or twice forking veins, which arise at a very acute angle.

The form here described and figured resembles more or less closely a number of fossil species. For instance, it is of the same type as and at one time was identified with *Anemia subcretacea* (Saporta) Gardner and Ettingshausen,[60] a very abundant species in the Eocene of Bournemouth, England. The European species has narrower pinnae, which are abruptly reduced in the upper portion of the frond, as in *A. mosbyensis*. The marginal teeth are also different and the veins at a less acute angle.

Anemia occidentalis Knowlton,[61] from the Raton formation, of the Raton Mesa region of Colorado and New Mexico, is also of this type but differs in the absence of a reduced apical portion—that is, the frond is cut to the tip into long, narrow pinnae. The lower pinnae are twice or more the size of the lower ones in *A. mosbyensis* and have larger, sharper teeth.

Another species of this type is *Anemia fremonti* Knowlton,[62] from the Frontier formation of southwestern Wyoming, which is very closely related to *A. subcretacea*. It is about the size of *A. mosbyensis* but is readily distinguished.

Occurrence: Dawson arkose, dump of Mosby coal mine, Mosby, Colo., collected by F. H. Knowlton and G. B. Richardson, 1910.

Anemia lanceolata Knowlton, n. sp.

Plate 8, Figure 10

Fronds apparently coriaceous, evidently of considerable size (15 to 18 centimeters long, 12 or 14 centimeters wide), probably deltoid in general outline, twice pinnatifid; main rachis strong, somewhat ridged; pinnae alternate, rather remote, very oblique, stalked or in the upper portion sessile and decurrent, narrowly lanceolate, slenderly acuminate at the apex, wedge-shaped at the base, cut nearly to the secondary rachis into numerous opposite or alternate ovate-lanceolate oblique pinnules or segments; margin of the large lower pinnules usually with a few sharp teeth, other pinnules entire; midvein of pinnules thin, obscure, formed by a very thin vein; lateral veins four or five pairs, at a very acute angle, usually only once forked in passing to the margin; fruit not known.

This form is represented by a dozen or more examples. Although they are not very completely preserved, it can be seen that the frond must have been of considerable size. So far as can be made out, the frond appears to have been broadly deltoid in outline.

It is with a good deal of hesitation that I venture to describe this form as new to science. So far as American material goes the first form to be detected that is now known to fall within this group was the *Gymnogramma haydenii* of Lesquereux,[63] which came from the south end of the Yellowstone Lake in strata believed to be of Laramie age. Some years later it was shown, apparently conclusively, that this species was identical with *Anemia subcretacea* (Saporta) Gardner and Ettingshausen, from the Eocene of Sezanne, Bournemouth, and other European localities.

Newberry stated that he had specimens of this fern collected at Point of Rocks, Wyo., Golden and Erie, Colo., and Bellingham Bay and Carbonado, Wash. I have myself collected specimens at Carbonado, Wash., but they differed so markedly from what I have supposed was typical *A. perplexa* Hollick that I was forced to give them a new name, and so with the specimens in hand. I am able to note so many differences, albeit slight, that it has seemed best to describe this fern at least tentatively as a new species. Thus from the so-called *Gymnogramma haydenii* it appears to differ in having much longer, narrower pinnae with more prominent pinnules and fewer but perhaps more distinct marginal teeth. The nervation in Lesquereux's species is very much more crowded and less distinct than in the specimens under consideration. From the specimens supposed to be identical with Lesquereux's species but recorded under the name *Anemia perplexa* Hollick[64] my material differs in the more pronounced pinnules with the margins simply instead of doubly toothed, and the nervation is very much sparser and lighter.

Occurrence: Middle Park formation, doleritic breccia just above main breccia mass at Potato Hill Gap, on the Grand [Colorado] River near Hot Sulphur

[60] Gardner, J. S., and Ettingshausen, Constantin von, Monograph on the British Eocene flora, vol. 1, Filices, p. 45, pls. 8, 9, Paleont. Soc., 1880.

[61] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 101, p. 285, pl. 54, fig. 2, 1917 [1918].

[62] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 108, p. 84, pl. 31, fig. 6; pl. 32, figs. 1–3, 1917.

[63] The Tertiary flora, p. 59, pl. 5, figs. 1–3, 1878.

[64] Hollick, Arthur, in Newberry, J. S., U. S. Geol. Survey Mon. 35, pl. 15, figs. 1, 1a, 1898.

Springs, Middle Park, Grand County, Colo., collected by George L. Cannon, 1889.

Anemia sp.

Plate 8, Figure 7

It is with considerable hesitation that I describe this form at all, as it is so fragmentary that its full character can not be made out. It has the pinnae linear-lanceolate and slightly decurrent at the base, with the margin perfectly entire or only slightly undulate in parts. The midvein is rather strong, and the finer nervation is plainly marked though rather slender. The veins arise at an acute angle and fork once or occasionally twice near the middle and thence pass up for long distances to terminate in the margin.

This form seems to approach most closely what has been called *Anemia elongata* (Newberry) Knowlton [65] (*Anemia perplexa* Hollick),[66] from which it differs mainly in the entire margins and more spreading finer nervation. It is also suggestive of what has been called *Pteris pseudopennaeformis* Lesquereux,[67] from the Denver formation, which differs in having a bi-grooved rachis, dentate margins, and mainly simple veins.

Occurrence: Middle Park formation, near Hot Sulphur Springs, Middle Park, Grand County, Colo., collected by G. L. Cannon, 1889.

Lygodium coloradense Knowlton, n. sp.

Plate 8, Figure 8

Pinnae orbicular in general outline, with a deep, rather broad sinus at base, deeply palmately cut, with about seven oblong-lanceolate, rather obtuse lobes; petiole slender, at least 3 centimeters long; nervation as in the living *L. palmatum* but proportionately rather coarser.

This species is represented by the fairly perfect specimen figured and by a number of fragments of pinnule lobes. It is of the general type of the living *Lygodium palmatum* of the eastern United States but is very much larger, the diameter of the pinnule being fully 11 centimeters in the fossil form and only 5 centimeters in the living species. The base is deeply heart-shaped, and the lobes oblong-lanceolate, with the upper ones separated to a point within 1.5 centimeters of the top of the petiole. The basal lobes are only about 1.5 centimeters long, but the central one is more than 6 centimeters long. The principal nervation is roughly dichotomous from the top of the petiole—that is, the petiole divides into two equal branches, which within a distance of 2 or 3 millimeters again fork to supply the large upper lobes, while the basal lobes are supplied by a fork from the lower of the larger ones. The fine nervation is of exactly the same type as in *L. palmatum*—that is, the nerves arise from the midnerve at an acute angle and fork usually three times before reaching the margin. Fertile fronds were not found.

Of the 25 or more living species of *Lygodium*, some 6 or 7 belong to the so-called *palmata* group, in which the nervation is palmate, or more properly dichotomous, as typified by the little climbing fern (*L. dichotomum* Swartz) of eastern North America and *L. radiatum* Prantl, of tropical America. The genus is very widely distributed and is essentially tropical.

The nominal fossil species of *Lygodium* also number about 25, but there is more or less doubt about the authenticity of certain of the forms from the older horizons. As they stand at present in the books, 2 occur in the "Upper Carboniferous," 1 in the "Jura-Trias," 2 in the Upper Cretaceous, 12 in the Eocene, 1 in the Oligocene, and 7 in the Miocene; so far as the record shows none have been found in either Pliocene or Pleistocene.

The Paleozoic forms appear to be particularly open to question. Thus, *Lygodium smilacifolium* (Sternberg) Ettingshausen, from the "Upper Carboniferous" of Saxony, was first described by Schlotheim in 1820 as a *Phyllites*. Two years later Sternberg transferred it to the genus *Osmunda*, in 1825 the same author placed it in *Neuropteris*, and in 1865 Ettingshausen again transferred it, placing it in *Lygodium*. It has the pinnate venation of the type of the living *L. scandens*, but it appears to me to be neuropteroid in its affinity and not lygodioid.

The other supposed Paleozoic species is *L. stachei* Stur, from the "Upper Carboniferous" of the central Alps. The question of its status was submitted to Mr. David White, who writes: "The specimen figured by Kerner is almost certainly a heteromorphous pinnule of a *Neuropteris* of the *N. scheuchzeri* type."

The lower Mesozoic species, *Lygodium? antiquorum* Shirley,[68] from the "Trias-Jura" of Queensland, is based on a very small, supposedly fruiting pinnule. It is not described but is discussed as follows:

> A small fragment, showing a tripartite lobule of a frond, surrounded by the characteristic plaited sori of the order, so familiar to Queenslanders through the very common *L. scandens* of our present southern flora and *L. reticulatum* and *L. japonicum* of our northern forests.

[65] Knowlton, F. H., U. S. Geol. Survey Bull. 696, p. 74, 1919.

[66] Hollick, Arthur, in Newberry, J. S., U. S. Geol. Survey Mon. 35, p. 3, pl. 16, fig. 3, 1898.

[67] Lesquereux, Leo, The Tertiary flora, p. 52, pl. 4, fig. 3, 1878.

[68] Shirley, John, Additions to the fossil flora of Queensland: Queensland Geol. Survey Bull. 7, p. 17, fig. 3, 1898.

The figure is a mere outline that in itself is hardly convincing.

Of the three supposed Cretaceous forms two are American and the other European. Of these, *L. trichomanoides* Lesquereux,[69] from the Dakota sandstone of Kansas, is a mere fragment without biologic value; in fact, Lesquereux himself stated that although he referred it to *Lygodium* he did not know any species of this genus that it resembled. It is far too doubtful to be of value in making out the phylogeny of *Lygodium*.

The other American Cretaceous species is *L. compactum* Lesquereux,[70] from the true Laramie at Marshall, Colo. It is a single small lobe, supposed to be a lobe of a pinnule of the *palmatum* type, but is too small and obscure to be of convincing value.

Lygodium cretaceum Debey and Ettingshausen,[71] the European Cretaceous form, is from the Senonian of Aachen, Prussia. The form of the frond, the nervation, and above all the fruit, which is fairly well preserved, agree in general with the *L. palmatum* type, and hence this species can probably be accepted as the oldest known representative of the genus.

By Tertiary time, however, *Lygodium* had become firmly established and widely spread in both hemispheres, as attested by fronds that no one would hesitate to pronounce congeneric with *L. palmatum*, as well as by fruit of undoubted identity. As the oldest of these (*L. gooseleti* Fritel, from the "Paleocene" of France) is still unfigured, its probable status can not be discussed.

The two forms from the Paris Basin referred by Watelet[72] to *Lygodium* (*L. crassicostatum* and *L. capillare*) appear very doubtful. They are long, lanceolate-acuminate fossils with a pinnate and conspicuously reticulate nervation quite unlike the nervation in *Lygodium*, and they should apparently be excluded from this genus.

In 1872 Saporta[73] described two species (*L. parvifolium* and *L. exquisitum*) from the Eocene of the southeast of France that although without fruit exhibit the outline and nervation characteristic of *Lygodium*. Later Saporta[74] added two more species to this flora (*L. tenellum* and *L. distractum*), which confirmed the earlier reference by the discovery of undoubted fruit.

It is hardly necessary to review the Miocene forms that have been referred to *Lygodium*, though mention may be made of the several species described by Heer[75] from the Swiss Miocene. These are of the type of the living *L. circinatum* (Burmann) Swartz, of tropical Asia and Queensland, with which some of them agree closely in form, nervation, and fructification.

We may now return to the consideration of the Colorado form here described. As already pointed out, it agrees most closely with the living *L. palmatum*, from which it differs in its much larger size, longer, narrower lobes, and slightly coarser nervation. Among American Tertiary species it approaches nearest *Lygodium kaulfussii* Heer,[76] but it differs from that species in the generally smaller size, deeply heart-shaped base, dichotomous forking of the main nerves, and somewhat more open nervation.

Occurrence: Dawson arkose, at Ramah oil well, NW. ¼ sec. 33, T. 9 S., R. 61 W., 40 miles northeast of Colorado Springs, Colo., collected by C. W. Cooke for G. B. Richardson, September 7, 1910.

Order EQUISETALES

Family EQUISETACEAE

Equisetum coloradense Knowlton, n. sp.

Plate 8, Figures 1–6

Stems of fairly robust size, 12 to 20 millimeters wide, usually strongly ribbed and furrowed, the ribs 9 to 12 on a side; length of internodes from two or three to several times the diameter of the stem; sheath short, with about 24 sharp-pointed, closely appressed teeth.

All the known examples belonging to this form have been figured. In the best-preserved stem from Middle Park (pl. 8, fig. 4) there appear to be about nine strong ribs and furrows, but in the other example (fig. 1) the stem is so poorly preserved that it is impossible to make out the furrows. The sheath in these specimens, best shown in Figure 2, is about 5 millimeters wide and provided with 24 short, sharp-pointed teeth—that is to say, about 12 teeth can be seen on the surface exposed.

The specimens from Mosby are shown in Figures 3, 5, and 6. The matrix in which they are preserved is a fine-grained sandy clay which has retained the characters with fidelity. The largest specimen is 9 centimeters long and 1.5 centimeters wide and compressed to a thickness of about 3 millimeters. It shows only one sheath with its teeth. The ribs take

[69] Lesquereux, Leo, The Cretaceous flora, p. 45, pl. 1, fig. 2, 1874.

[70] Lesquereux, Leo, The Tertiary flora, p. 64, pl. 5, fig. 9, 1878.

[71] Debey, M. H., and Ettingshausen, Constantin von, Urweltlichen Acrobryen des Kreidegeberges von Aachen und Maestricht: K. Akad. Wissensch., Math.-naturw. Classe, vol. 17, p. 18, pl. 2, figs. 18–21; pl. 3, fig. 28, 1859.

[72] Watelet, Adolphe, Description des plantes fossiles du bassin de Paris, p. 49, pl. 13, figs. 2–4, 1866.

[73] Saporta, Gaston de, Études sur la végétation du sud-est de la France à l'époque tertiaire: Annales sci. nat., 5th ser., vol. 17, p. 87, pl. 1, figs. 13, 14, 1873.

[74] Saporta, Gaston de, Flore fossile d'Aix-en-Provence, pp. 23, 24, pl. 2, figs. 7, 8, 1888.

[75] Heer, Oswald, Flora tertiaria Helvetiae, vol. 1, pp. 41–43, pl. 13, figs. 1–15, 1855.

[76] Cf. Newberry, J. S., The later extinct floras of North America: U. S. Geol. Survey Mon. 35, p. 1, pl. 62, figs. 1–4, 1898.

their origin at the line of the sheath and are double—that is, each tooth separates a wedge-shaped ridge which is composed of two appressed ribs at this point. These ribs soon separate, and within a distance of 2 or 3 centimeters they have spread so as to make double the number of ribs that arose at the sheath. The interval between the ribs is filled with fine striae. The teeth are triangular and about 2 millimeters long; they are closely appressed and fill the space between the wedge-shaped points of the ribs. It is possible that this Mosby specimen is not the same species as the specimens from Middle Park, for as well as can be made out it exhibits features not present in the others, but the general appearance is the same, though this may be due to the poor preservation of the Middle Park specimens. If material is subsequently found in sufficient quantity to be sure of the characters they can easily be separated if not found to be identical.

The specimen from Mosby, shown in Figure 3, consists of a short segment of a stem about 2 centimeters wide, showing the node as in the one first described. Lying parallel to and partly on the larger stem is a smaller one about 8 millimeters in diameter that appears to be a branch of the larger one. It does not otherwise exhibit any features not present in the specimen first described.

So far as size goes *Equisetum coloradense* seems to approach *E. haydenii* Lesquereux,[77] from the Hanna formation of Carbon, Wyo., but as *E. haydenii* is founded on underground portions of the stem with no sheaths showing, it is impossible to make any comparison except in size.

The closest relative of the form in hand appears to be *Equisetum robustum* Newberry,[78] from the "Puget Sound group" of Bellingham Bay, Wash., which, indeed, is hardly to be distinguished from it. The main points of difference are the larger size of the Washington form and the longer internodes, shorter sheaths, and less numerously furrowed stems in the Colorado specimens.

Occurrence: Middle Park formation, high terrace ridge between forks of Kinney Creek and in "breccia spoon," east of Hot Sulphur Springs, Middle Park, Grand County, Colo., collected by Whitman Cross, October 6, 1891. Dawson arkose, dump of Mosby coal mine, Mosby, Colo., collected by F. H. Knowlton and G. B. Richardson, July, 1910.

Equisetum sp.

Plate 9, Figure 4

Among the extensive material from Table Mountain, Golden, Colo., I find the specimen here figured, which represents a considerable fragment from the subterranean portion of an *Equisetum*. The stem, the transverse section of which shows as a ring in the center, is only about 7 millimeters in diameter, and from it radiate some six or seven thickened, constricted tuberous portions, which are not well enough preserved to admit of much closer definition.

The underground portion of *Equisetum* is so generally without essential characters in all forms of the genus that no attempt has been made either to identify this specimen with other so-called species based on similar fragments or to characterize it in a manner worthy of a specific name. It is simply a fragment of *Equisetum* and is presented only to call attention to the presence of the genus in these beds.

Occurrence: Denver formation, South Table Mountain, Golden, Colo.

Equisetum sp.

Physagenia sp. Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 43, 1888.

This form was described by Lesquereux as follows:

> Tubercles attached to filaments diverging in rows from a central point, composing the rhizoma of some Equisetaceae. Central point exactly round, 2 millimeters in diameter; tubercles oval, 12 millimeters long, 6 millimeters broad in the middle, strangled to 2 millimeters at the point of union, and forming a chain of which two of the tubercles are seen in close connection. They are deeply, irregularly wrinkled lengthwise.

It is with some hesitation that this form is admitted. I have examined all the supposed types in the Museum of Comparative Zoology and could find only one specimen (No. 298) that appears to be equisetaceous in character. This is a specimen showing two or three tubercles attached to a central point but so poorly preserved that it can not be figured. The remainder of the so-called types appear to be fragmentary stems or rachises of ferns, pieces of bark, etc., and of course they are without value in the present connection.

The present form is permitted to stand as above described simply to call attention to the fact that probably some sort of an equisetaceous plant was living during Denver time, but its size and aerial characters must remain for future discovery. It may be the same as the preceding form, but the characters are so obscure that this can not be ascertained.

Occurrence: Denver formation, Golden, Colo., collected by Arthur Lakes and deposited in the Museum of Comparative Zoology, Cambridge, Mass.

Equisetum perlaevigatum Cockerell, West Am. Scientist, vol. 6, No. 49, p. 154, 1889.

Equisetum laevigatum Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, p. 395, 1874; The Tertiary flora, p. 68, pl. 6, fig. 7, 1878.

One of the type specimens of this supposed species came from Sand Creek, Colo., and thus falls within

[77] Lesquereux, Leo, The Tertiary flora, p. 67, pl. 6, figs. 2–4, 1878.
[78] Newberry, J. S., U. S. Geol. Survey Mon. 35, p. 15, pl. 16, figs. 1, 2, 1898.

the scope of the present work, but an examination of this specimen shows it to be very obscure; in fact, it has more the appearance of having been a piece of dicotyledonous bark or the impression of a stem. It has the surface wrinkled irregularly rather than striately, and the so-called tubercles can hardly be made out at all. It is of no value and is excluded from systematic enumeration.

Order **LYCOPODIALES**

Family **SELAGINELLACEAE**

Selaginella berthoudi Lesquereux

Selaginella berthoudi Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, p. 395, 1874; idem for 1876, p. 499, 1878; The Tertiary flora, p. 46, pl. 5, figs. 12, 12a, 1878; Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 43, 1888.

Type: United States National Museum, No. 35.

This fine species appears to be rare, as thus far only four specimens have come to light. These include the type specimen now in the National Museum, two specimens recorded by Lesquereux in the collection of the Harvard College Museum of Comparative Zoology, and one in the Hambach collection recently acquired by the National Museum. These specimens are all recorded as having come from Golden, Colo., but are without precise locality. From the character of the matrix, however, it is thought that they came from South Table Mountain.

This species is described by Lesquereux as having a large diffuse frond which is either creeping or flattened on the ground. It has dichotomous branches with two kinds of leaves in four rows; the larger lateral leaves are open, distichous, 3 to 4 millimeters long and 1 millimeter broad and imbricated by the lower side. They are oblong-lanceolate, acute, sessile, and distinctly nerved in the middle. The intermediate leaves are small, being scarcely 1 millimeter long and 0.5 millimeter broad, oval, obtusely pointed, and marked by a middle nerve.

This is a perfectly distinct and well-marked species and resembles, as Lesquereux pointed out, the living *Selaginella mertensii* of Mexico and *S. stolonifera* of the West Indies.

Since the above account was written two additional specimens have come to light. They were collected in the Denver formation on Sand Creek near Magnolia, just northeast of Denver. They are not very well preserved, and the small intermediate leaves are made out with difficulty.

Occurrence: Denver formation, Golden, Colo., probably South Table Mountain; type specimen collected about 1873 by Capt. Ed. Berthoud, in whose honor the species was named; specimens in the Museum of Comparative Zoology collected by Arthur Lakes in 1883. The lately acquired specimens (U. S. Nat. Mus. No. 33891) were procured from Gustav Hambach, Sand Creek near Magnolia, northeast of Denver, Colo., collected by Francis W. Collins, 1909.

Phylum **SPERMATOPHYTA**

Class **GYMNOSPERMAE**

Order **CONIFERALES**

Family **PINACEAE**

Sequoia affinis Lesquereux

Sequoia affinis Lesquereux, U. S. Geol. and Geog. Survey Terr. Bull., vol. 1, p. 384, 1875 [1876]; Ann. Rept. for 1874, p. 310, 1876; The Tertiary flora, p. 75, pl. 7, figs. 3–5, 1878; The Cretaceous and Tertiary floras, p. 138, 1883. Knowlton, U. S. Nat. Mus. Proc., vol. 51, p. 248, 1916.

Sequoia langsdorfii Brongniart. Lesquereux, The Tertiary flora, p. 76, 1878.

Glyptostrobus ungeri? Heer. Lesquereux, The Cretaceous and Tertiary floras, p. 139, pl. 23, figs. 1–6a, 1883.

Following is Lesquereux's original description of this species:

Branches long, slender, pinnately branching; leaves short, oblong, imbricated and obtuse, or longer, lanceolate-acute, erect or slightly reflexed; branchlets bearing cones open; strobiles small, round-oval, obtuse; scales large, rhomboidal, with entire borders, a central oval mamilla, and wrinkles passing from it to the borders all around; male branches erect, with more acute and open leaves, resembling sterile branches of *Glyptostrobus europaeus*, with small, round catkins, covered at the top by imbricated lanceolate leaves.

In his discussion of this species in the report on the Tertiary flora (p. 75) Lesquereux stated that the leaves are "decurrent, without trace of a middle nerve," but an examination of one of the figured types shows that the leaves are provided with a clear, fairly prominent middle vein. With this exception the diagnosis appears to have been reasonably well drawn.

An examination of the history of this species shows that it was first described from Middle Park, Colo., and was later found at Costello's ranch (Florissant), South Park, Colo., and at Elko station, Nev. The specimens from the original locality do not seem to be preserved in the United States National Museum, nor have I been able to find the specimens said to have come from Elko station. Both of the specimens figured on Plate 65, Figures 2 and 4, of the report on the Tertiary flora are in the National Museum (Nos. 87, 88) and came from Florissant, Colo.

In the recent material from Middle Park I find a number of branchlets that appear to belong to this species. They are very slender branchlets with rather acute, one-nerved leaves, which correspond closely with the slenderer branchlets on the type specimen.

The question of the probable relationship of this species was commented upon by Lesquereux,[79] but as the material is so scanty it is perhaps best to defer final judgment until more can be obtained.

Occurrence: Middle Park formation (type lost), Middle Park, Colo., collected by F. V. Hayden; Mount Bross, north side of Grand [Colorado] River opposite Hot Sulphur Springs, Middle Park, Colo., collected by G. L. Cannon, 1886. Miocene, Florissant, Colo. Miocene(?), Elko, Nev.

Order GINKGOALES?

Family GINKGOACEAE?

Ginkgo? truncata (Lesquereux) Knowlton, n. comb.

Plate 9, Figure 3

Palmocarpon truncatum minor Lesquereux, The Tertiary flora, p. 120, pl. 11, figs. 8, 9, 1878.
Carpites laurineus Lesquereux, idem, p. 304, pl. 60, figs. 20, 21.

Fruits nearly spherical, averaging about 9 to 12 millimeters in diameter, sometimes slightly flattened; testa fairly rigid, hard, thin, obscurely bicarinate, seated in a fleshy, cup-shaped excavation at the summit of a stout peduncle, which is about 1 millimeter in diameter and 2 centimeters long.

Lesquereux based his *Palmocarpon truncatum* on four figured specimens, which he said might well enough represent two distinct species if based on size alone. He added: "As their characters are, however, the same, and as the difference in size may result from the relative position upon racemes of the same species but of different age, I have considered them as varieties: var. *major* and var. *minor*." The present discussion is concerned only with the variety *minor*.

All the type specimens are in the United States National Museum. A complication arises concerning the specimens supposed to represent the variety *minor* in the Museum collection. There are four specimens, all detached and all bearing the same number (517), two of which are preserved in the soft andesitic matrix characteristic of the Denver beds at Golden, Colo., and the other two in a hard ironstone matrix wholly unlike that at Golden and hence from an unknown locality. The figures given in the report on the Tertiary flora are so conventionalized that it is impossible to decide which of the four specimens served as the originals from which the figures were made. This much at least can be said: The two original specimens preserved in the andesitic matrix are undoubtedly the same as numerous additional examples from Golden collected by Arthur Lakes. All the specimens, except one of the later ones, are free and unattached; in fact, none have been observed that give any indication of a point of attachment. The exception is the specimen shown in Plate 9, Figure 3, which is believed to offer important evidence as to its possible affinity.

When Lesquereux founded his *Palmocarpon truncatum*, he compared it to the fruits of *Sabal*, especially *Sabal mexicana* Martins. It must be confessed that these globular fruits when found isolated have a strong degree of resemblance to the fruits of several genera of palms, such as *Oreodoxa*, *Sabal*, and *Thrinax*. In all these, however, the fruits are nearly sessile—that is, the supporting stalk or peduncle is very short. In the specimen here figured the peduncle is fully 2 centimeters long, and moreover the fruit appears to be seated in a cup-shaped expansion at its summit. This would seem to exclude it from the palms, or at least from those with which I am familiar, and its affinity must be sought in other directions. The requirements seem to be met in *Ginkgo*, to which consequently it has been referred.

The flowers of *Ginkgo biloba* Linné, the only living species of the genus, are dioecious and are disposed on short, lateral shoots. The male flowers are arranged in the form of a solitary, filiform, axillary catkin. The female flowers are placed among the ordinary leaves and consist of a petiole with a 2-cleft or rarely 3–6-cleft apex, each point of which supports an ovule instead of a blade of the leaf. The ovules are seated in a shallow, fleshy cup formed by the dilated apex of the petiole and consist of a bicarinate or tricarinate drupaceous seed with a thin outer "flesh" and a thin, hard shell surrounding a fleshy embryo. It frequently happens that all but one of the ovules abort, so that when mature the ovule appears solitary, though the rudiments of the blasted ovules may usually be detected by the side of or below it. At maturity the ovule is nearly spherical, with a minute apical projection.

On account of their exceedingly hard shell and resinous nature, the fruits of *Ginkgo* seem especially well fitted for preservation in a fossil state, and as a matter of fact a considerable number of species have been found in association with undoubted leaves of *Ginkgo*. Thus, *Ginkgo digitata* (Brongniart) Heer, from the Jurassic of Cape Boheman, Spitzbergen, has oval fruits terminating in a point as in the living species and was seemingly covered with a fleshy exocarp. *Ginkgo siberica* Heer, from Ust-Balei, eastern Siberia, has small globular fruits borne in twos at the summit of a slender peduncle, and *G. primordialis* Heer, of the Atane beds of Greenland, is described as having oval fruits inserted in a pronounced cup-form dilation of the oraliferous leaf.

The fruits under discussion from Golden appear to meet the requirements of a reference to *Ginkgo*, although no leaves belonging to this type have thus far

[79] Lesquereux, Leo, The Tertiary flora, p. 75, 1878.

been detected in these beds, and for this reason the generic reference has been questioned. Leaves of a number of species of *Ginkgo* occur more or less abundantly in American rocks ranging in age from Jurassic to Tertiary, but so far as I know this is the first fruit to be adequately described. As may be seen from the figure of the best specimen, it is excellently well preserved. It shows the fruiting peduncle with the cup-shaped cavity at the apex, in which is seated the small, round, slightly bicarinate fruit. There is no visible trace of an aborted ovule, which should normally be present, nor are there remains of a fleshy outer integument.

As already mentioned there are numerous detached fruits found in association with the one just described that undoubtedly belong with it. They are uniformly spherical or slightly compressed and are obscurely bicarinate or tricarinate. One of the best preserved of these detached fruits was covered when removed from the matrix with a thin film of carbonaceous matter, which possibly represented the fleshy exterior. Another is minutely and irregularly pitted, suggesting that the flesh had dried before the entombment of the specimen. Still another specimen has been cracked into two nearly equal parts, just as might result when a globular fruit with a hard, brittle shell is compressed.

It seems necessary to refer to *Ginkgo? truncata* the little fruits described by Lesquereux under the name *Carpites laurineus*.[80] These fruits, both on one piece of matrix, are present in the United States National Museum (No. 516). They were said by Lesquereux to have come from Evanston, Wyo., but in the Museum register they are recorded as coming from Golden, Colo. This record is undoubtedly correct, for the matrix is readily recognizable as that of the andesitic beds at Golden and wholly unlike anything known from Evanston. In his description of *Carpites laurineus* Lesquereux wrote as follows: "Berries small, nearly round, short-pointed, about 5 millimeters in diameter, surrounded by a thin shelly epicarp." On comparing the specimens it appears that this description must have been drawn by Lesquereux from the figures rather than the specimens. Both fruits are broken and not correctly represented by the figures. They undoubtedly belong with *Ginkgo? truncata*.

Occurrence: Denver formation (types), Golden, Colo., original collections probably made by Lesquereux about 1875; also collected by Arthur Lakes in 1890, on South Table Mountain, Golden, at a point about 100 feet below the lava cap.

[80] Lesquereux, Leo, The Tertiary flora, p. 304, pl. 60, figs. 20, 21, 1878.

Class ANGIOSPERMAE

Subclass MONOCOTYLEDONES

Order GRAMINALES

Family GRAMINEAE

Arundo? obtusa Lesquereux

Arundo? obtusa Lesquereux, U. S. Geol. and Geog. Survey Terr. Bull., vol. 1, No. 5, 2d ser., p. 385, 1875 [1876]; Ann. Rept. for 1874, p. 311, 1876; The Tertiary flora, p. 87, pl. 8, figs. 9–9c, 1878.

So far as can be ascertained, the type specimen of this species has never been in the collection of the United States National Museum, where it should be, and its present location is unknown. No additional examples have been obtained, and the status of this species must be regarded as uncertain. It was described at some length by Lesquereux, but there is no evidence other than association on the same rock to show that the organisms described as seeds and their envelopes really belong to the same plant.

Occurrence: Denver formation, South Table Mountain, Golden, Colo.

Family CYPERACEAE

Carex? berthoudi Lesquereux

Carex berthoudi Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, p. 377, 1873; idem for 1873, p. 380, 1874; idem for 1876, p. 500, 1878; The Tertiary flora, p. 92, pl. 9, figs. 3, 4, 1878.

Type: United States National Museum, No. 98.

What purport to be the type specimens of this species are preserved in the United States National Museum (No. 98; three specimens under the same number), but after a careful comparison I am not able to identify any of them with the figures given by Lesquereux. There are a number of fragments of sedgelike or grasslike leaves 3 or 4 centimeters long and 3 or 4 millimeters wide, that appear to fit the description fairly well, but the so-called seeds (perigynia) I am not able to find at all. These have either been effaced since the species was established, or more probably the wrong specimen was marked as the type. This form does not appear to have been contained in any of the more recent collections from Golden, and in fact it is doubtful if it should be continued under the name *Carex*. About all that can be said concerning it is that it resembles sedgelike leaves that are usually described under the name *Cyperacites*.

In a table in the annual report of the Hayden survey for 1872 (p. 411), showing the distribution of the fossil plants of the North American Tertiary, Lesquereux indicated the presence of *Carex berthoudi* in

the Raton Mountains, but as the column for Golden in this table is next to the one for the Raton Mountains it is probable that the cross mark was placed there in error. This is the only known mention of its coming from the Raton Mountains, and it has not been detected in the extensive collections made there in recent years.

Occurrence: Denver formation, South Table Mountain, Golden, Colo., collected by Capt. E. Berthoud in the early seventies.

Order ARECALES

Family ARECACEAE

Sabalites grayanus Lesquereux

Plate 9, Figure 5

Sabal? grayana Lesquereux, Am. Philos. Soc. Trans., vol. 13, p. 412, pl. 14, figs. 4–6, 1869. [Not Lesquereux, The Tertiary flora, pl. 12, 1878; Knowlton, U. S. Geol. Survey Bull. 163, pl. 6, fig. 5, 1900.]

Sabalites grayanus (Lesquereux) Lesquereux, The Tertiary flora, p. 112, 1878.

Berry, U. S. Geol. Survey Prof. Paper 91, p. 177, pl. 12, figs. 1–3; pl. 14, fig. 1, 1916.

Knowlton, U. S. Geol. Survey Prof. Paper 101, p. 288, 1917 [1918].

Flabellaria eocenica Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, p. 391, 1873; idem for 1873, p. 380, 1874; idem for 1876, p. 502, 1878; The Tertiary flora, p. 111, pl. 13, figs. 1–3, 1878.

Sabal communis Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1874, p. 311, 1876.

Flabellaria communis Lesquereux, U. S. Geol. and Geog. Survey Terr. Bull., vol. 1, No. 5, 2d ser., p. 385, 1876.

Sabal inquirenda Knowlton, U. S. Geol. Survey Prof. Paper 101, p. 288, pl. 56, 1917 [1918].

Sabalites fructifer Lesquereux, The Tertiary flora, p. 114, pl. 11, fig. 3 [not fig. 3[a] or the three fruits at the base of the leaf, which=*Berrya racemosa*], 1878; U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1876, p. 502, 1878.

Flabellaria? fructifer Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, p. 396, 1874.

Sabal? eocenica (Lesquereux) Knowlton, U. S. Geol. Survey Bull. 696, p. 557, 1919.

After a good deal of consideration it has seemed best to describe the palm leaves here discussed under the name *Sabalites grayanus* and to refer to that species *Sabalites eocenica* (Lesquereux), *Sabalites fructifer* Lesquereux, and *Sabal inquirenda* Knowlton. In order that the position taken may be made clear the following account is fairly full.

Sabalites grayanus was established (as *Sabal? grayana*) by Lesquereux[81] in 1869, on material from the soft white ("Eolignitic") clay of Lafayette County, Miss., and although the type specimens are now apparently lost, the exact locality is thought by Berry to be in the vicinity of Oxford, Miss. Additional material was procured from the supposed type locality by Berry, as well as from numerous localities of similar age in Mississippi, Arkansas, Tennessee, and Texas. As Lesquereux's original description was more or less incomplete the new material has enabled Berry[82] to give a much more complete description, which reads as follows:

> Leaves of large size but mostly fragmentary. Estimated diameter in some of the larger specimens, where nearly half the leaf is preserved, as great as 1.3 meters. Most of the leaves are somewhat smaller than this, no doubt because the larger the leaves the more fragmentary they would be likely to become before fossilization. Petiole long and stout, unarmed, enlarged at the base of the leaf, and tapering into an extended and gradually narrowed acumen, which is not visible on the upper surface of the leaf, where the petiole is broadly rounded and a short and inconspicuous ligule is developed. From the manner of preservation and attitude of the rays on some of the specimens it is inferred that the acumen was recurved, as it is in the existing *Sabal palmetto* (Walter) Roemer and Schultes. Rays very numerous, about 100 in number, a few reduced basal ones on each side free, the remainder united for a variable distance above the base. Their dimensions and the relative thickness of the venation are variable features dependent on the size of the leaves. The largest specimens seen have thick carinate stout-veined rays, 5 centimeters in maximum width. They increase in size from the base of the leaf upward, and individually they are narrow at their point of attachment, widening medially and becoming gradually narrowed into long acuminate tips. Venation characters variable, largely dependent on the size of the leaves and the condition of preservation of the epidermis in the fossil specimens. In well-preserved material there are four or five relatively thin intermediate veins. Between each pair of veins there are six to eight fine veinlets which are not visible except in well-preserved specimens.

The above description of *Sabalites grayanus* may be compared with Lesquereux's original description of *Flabellaria eocenica*, which reads as follows:

> Frond large, rays convex, semicylindrical toward the base, flattened in the upper part, diverging from the top of a broad rachis, distinctly nerved; primary nerves distant; intermediate veins thin, close, averaging 10 in number; rachis truncate on its upper face, rapidly narrowed to a point on its lower [face].

Flabellaria eocenica was founded by Lesquereux[82a] in 1872 on specimens from the Black Buttes coal group at Black Buttes, Wyo. The type specimens are preserved in the United States National Museum (Nos. 110, 111, 112) and were well illustrated and described by Lesquereux. It was evidently a small or medium sized leaf, probably about 1 meter in diameter.

Lesquereux stated in the report on the Tertiary flora (p. 112) that his *Flabellaria eocenica* is abundant in the Denver formation at Golden, Colo., but the National Museum does not appear to have speci-

[81] Lesquereux, Leo, Am. Philos. Soc. Trans., vol. 13, p. 412, pl. 14, figs. 4–6, 1869.

[82] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 178, 1916.

[82a] Lesquereux, Leo, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, p. 391, 1873.

mens of this form from Golden, nor has it been noted in the collections made by Lakes and others.

On again comparing the types of *Sabal inquirenda* Knowlton [83] with the types of *Flabellaria eocenica* and with the available figures of *Sabalites grayanus* I am convinced that they can not be separated. My original description of *Sabal inquirenda* reads as follows:

> Leaves relatively small, probably 1.5 meters or less in diameter, palmate, with 60 to 80 folds, which are much compressed at the point of attachment and rapidly widen out; petiole unarmed, rounded both above and below, or at least not conspicuously concave above, about 2 or 3 centimeters broad; apex of petiole rounded on the upper side and prolonged on the under side into a spine or "midrib" 6 or 8 centimeters in length.

On comparing these descriptions or, better, the several figures, it seems practically impossible to draw any satisfactory line of separation, and consequently they have been merged under the older name.

Lesquereux and others identified *Sabalites grayanus* at a number of widely separated points in Colorado, Wyoming, and Vancouver Island, British Columbia, but, as Berry [84] has well said,

> All these determinations are open to very grave doubt, not only on account of the inadequacy of the material but also because of the a priori improbability of a single species ranging from the Cretaceous Montana group to a horizon well above the base of the Eocene at such widely removed localities, in the one area associated with a subtropical coastal flora, which suggests the existing flora of the West Indies and northern South America which advanced northward in the Mississippi embayment region, and in the western area associated with a very different type of flora.

The correctness of this reasoning is shown—to mention only one instance—by the treatment of specimens from the Mesaverde formation at Point of Rocks, Wyo., referred by Lesquereux [85] to his *Sabalites grayanus*. These have now been removed under the name *Sabal montana* Knowlton.[86]

The type specimens of what Lesquereux [87] called *Sabalites fructifer* are preserved in the United States National Museum (No. 107). The best-preserved one—the original of his Figure 3—shows the distorted apex of what might be considered a pinnate leaf but without much doubt is the under surface of a leaf such as *Sabalites grayanus*. Lesquereux regarded it as a palmate leaf, writing of it as follows:

> Seems to be referable to *Sabal* by the acuminate rachis, which bears on both sides numerous rays enlarged and diverging upward. The rachis is not very distinct, but as far as can be seen it looks narrowed into a point, or with an acumen, along which very numerous rays are attached.

The fruits supposed by Lesquereux to belong to *Sabalites fructifer* are found on the same piece of matrix, but there is no evidence whatever to support the view that they belong to *S. fructifer*. They are fairly abundant in the same beds as the palm leaves, occurring either as isolated fruits or in compound racemes. At present there is no conclusive evidence to show what plant produced them. At first they were separated as *Nyssa? racemosa*, but as they can hardly belong to *Nyssa*, they have been described as new under the name *Berrya racemosa*. (See p. 134.)

Occurrence: Denver formation, Golden, Colo. Dawson arkose, Jimmy Camp Creek, 9 miles east of Colorado Springs, Colo. Black Buttes coal group, Black Buttes, Wyo. Wilcox group, Mississippi, Arkansas, and Texas. Lagrange formation, Tennessee, in beds of Wilcox age. Raton formation, Raton Tunnel, 6 miles north of Raton, and Dillon Canyon, near Blossburg, N. Mex.

Sabal? ungeri (Lesquereux) Knowlton

Sabal campbelli Newberry (in part), Boston Jour. Nat. Hist., vol. 7, p. 515, 1863.

Sabal campbelli Newberry. Lesquereux, Illustrations of Cretaceous and Tertiary plants, pl. 10, U. S. Geol. and Geog. Survey Terr., 1878.

Geonomites ungeri Lesquereux, The Tertiary flora, p. 118, pl. 11, fig. 2, 1878.

Sabal grandifolia Newberry, U. S. Geol. Survey Mon. 35, p. 28, pl. 63, fig. 5 [possibly not pl. 25 nor pl. 64, figs. 2, 2 a], 1898.

Sabal? ungeri (Lesquereux) Knowlton, U. S. Geol. Survey Prof. Paper 101, p. 289, pls. 57, 59, 1917 [1918].

Leaves large, probably 2.5 to 3 meters in diameter, with 70 to 90 folds; petiole 3 to 4.5 centimeters wide, flat or slightly ridged above but without a keel above or below; margins of petiole unarmed, terminating on the upper side in an arch from which the folds radiate, on the under side prolonged into a spine or midrib 15 to 20 centimeters or more in length.

The above description is with some essential modifications that given by Newberry for his *Sabal grandifolia*, of which he figured one specimen from the Fishers Peak region, in southern Colorado. Whether or not the other specimens figured and described by Newberry under this name are really conspecific is not here considered, but there can be no doubt that his Fishers Peak specimen is identical with Lesquereux's *Geonomites ungeri*, from the same region, and as Lesquereux's specific name has priority over the other that is the name it must bear.

The fragment upon which Lesquereux based his *Geonomites ungeri* (U. S. Nat. Mus. No. 106) came,

[83] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 101, p. 288, pl. 56, 1917 [1918].

[84] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 177, 1916.

[85] Lesquereux, Leo, The Tertiary flora, p. 112, pl. 12, figs. 1, 2, 1878.

[86] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 101, p. 253, pl. 32, fig. 3, 1917 [1918].

[87] Lesquereux, Leo, The Tertiary flora, p. 114, pl. 11, fig. 3 (in part), 1878.

as is now known, from the under side of a large leaf and shows the spikelike prolongation of the petiole. He mistook this for the upper side of the leaf and hence concluded that the shape of the perfect leaf was flabellato-pinnate, or broadly linear-lanceolate. It was for this reason that he placed it in *Geonomites*, as in the living genus *Geonoma* the leaves are somewhat of this character.

Notwithstanding the fact that a comparatively large number of specimens of what is believed to be a single species of palm are now available for study it is extremely difficult to reach definite conclusions regarding many of them. On this point Newberry[88] had the following to say:

> In the great number of the remains of palms found in the Tertiary and Cretaceous rocks of the West—trunks, leaves, and fruit—it has been very difficult to define distinct species, and it is probable that many years will elapse before perfect order can be brought out of the present confusion. The species under consideration may, however, be identified by the large size of its leaf, its plain unkeeled petiole drawn into a long acute spine on the under side, the very numerous folds, and the crowded, subequal nervation.

With these limitations in mind, *Sabal ungeri* is thought to be one of the most abundant forms in the Raton formation of the Raton Mesa region. It occurs abundantly from one end of this region to the other, and at two localities it has been found in the top of the underlying Vermejo formation, thus apparently crossing the line between Cretaceous and Tertiary. In the Dawson arkose along Jimmy Camp Creek there are great numbers of remains of palms, but they are so fragmentary, or rather they break into pieces so small when excavated from the bank, that it is difficult to identify them with certainty. These specimens are absolutely indistinguishable from the type of this species and also from the large leaves figured in my paper on the flora of the Vermejo and Raton formations.[89]

A few words may be said regarding the probable affinity and interrelationships of *Sabal? ungeri*. The species from outside the Rocky Mountain area to which the present form is most closely related is *Sabalites grayanus* (Lesquereux) Lesquereux. This was described originally,[90] under the name *Sabal*, from the "Eolignitic" (Wilcox group) of Mississippi, and although a mere fragment is distinguished from *Sabal? ungeri* with difficulty if at all. Subsequently leaves that have been identified as *Sabalites grayanus* have been reported from many localities ranging in age from Montana to Eocene, but most of these are fragmentary, and it is extremely doubtful if they have been correctly referred to this species.

The segment of a huge petiole from the Denver formation near Golden, Colo., figured by Lesquereux[91] as *Sabalites grayanus* is preserved in the United States National Museum (No. 109). There is, however, no valid reason for referring it to this species. If this strongly keeled petiole could really be proved to belong to *Sabalites grayanus*, the keel would in itself be a sufficient character to separate it from *Sabal? ungeri*, in which there is no evidence that the petiole was either grooved or keeled.

In my "Flora of the Vermejo and Raton formations"[92] I have made the following statement regarding the relationships of *Sabal? ungeri:*

> It undoubtedly approaches most closely to *Sabal inquirenda* Knowlton, and unless specimens are of sufficient size and perfection to show well their character they can not be separated with absolute certainty. *Sabal inquirenda*, however, may be known in general by its small size—not exceeding 1.5 meters in diameter—and its 40 to 50 instead of 70 to 90 folds. *Sabal rugosa* is smaller and has more strongly ribbed and plicated rays, which do not exceed 40 in number. *Sabal leei*, also a large-leaved form, may be distinguished from *S. ungeri* by its wedge-shaped base and its great number of very closely appressed, obliquely inserted rays.

Occurrence: Raton formation (types), abundant and widely distributed in the Raton Mesa region of Colorado and New Mexico. Dawson arkose, east bank of Jimmy Camp Creek, 0.6 mile above Richfield Springs ranch house, 9 miles east of Colorado Springs, Colo., collected by F. H. Knowlton and W. T. Lee, July, 1910. Vermejo formation, near top of formation, Ponil Canyon, N. Mex., and near Shumway, Colo.

Geonomites tenuirachis Lesquereux

Plate 6; Plate 9, Figures 1, 2, 6

Geonomites tenuirachis Lesquereux, The Tertiary flora, p. 117, pl. 11, fig. 1, 1878.
Knowlton, U. S. Geol. Survey Prof. Paper 101, p. 291, pl. 62, 1917 [1918].
Flabellaria longirachis Unger. Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, p. 396, 1874.

Type: United States National Museum No. 105.

This species appears to be rare. The type and only example known to Lesquereux came from the Raton Mountains of New Mexico and is a mere fragment from near the middle of a leaf of considerable size. This fragment is so small that the character of the leaf can not be made out satisfactorily. It is not improbable that if the complete leaf were known it would be

[88] Newberry, J. S., The later extinct floras of North America: U. S. Geol. Survey Mon. 35, p. 28, 1898.
[89] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 101, p. 289, pls. 57, 59, 1917 [1918].
[90] Lesquereux, Leo. Am. Philos. Soc. Trans., vol. 13, p. 412, pl. 14, figs. 4–6, 1869.
[91] Lesquereux, Leo, The Tertiary flora, p. 112, pl. 12, figs. 1, 2, 1878.
[92] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 101, p. 290, 1917 [1918].

found to be referable to some of the other species described from beds of this age. In the absence of conclusive evidence, however, it seems best to retain this form under the name given by Lesquereux.

The collections from the Dawson arkose on Jimmy Camp Creek contain a large number of remains of palms, but they are so fragmentary that it is difficult to find determinable specimens. The fragment here figured is a segment from the middle of a leaf of considerable size. It is not distinguishable from the type specimen of *Geonomites temuirachis* and is referred to that species.

Occurrence: Dawson arkose, about 0.6 mile north of Richfield Springs ranch, on east bank of Jimmy Camp Creek, 9 miles east of Colorado Springs, Colo., collected by W. T. Lee and F. H. Knowlton, July, 1910. Raton formation (type), Raton Mountains, N. Mex., ridge east of Yankee mine, near Yankee, N. Mex.

Geonomites? graminifolius Lesquereux

Geonomites graminifolius Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 44, 1888.

Following is Lesquereux's description and discussion of this species:

> Broken or separated rays of a palm, varying in width from 5 to 10 millimeters, marked in the middle by a broad nerve, the borders thinly regularly striate by 10 to 15 thin veins scarcely distinct even with a lens.
>
> These fragments may belong to leaves of *Calamopsis danai* Lesquereux [now *Chamaedorea danai*] or to a species much like it. One leaf in a better state of preservation has the rays narrowed to a point of connection to a broad, thinly lineate rachis, united three to five together, either connate part of their length or disconnected to the base like the fragments described above. Though the likeness to *Calamopsis danai*, figured and described in Trans. Am. Philos. Soc., vol. 13, p. 411, pl. XIV, figs. 1–3, is marked, I have never seen the rays divide into narrow laciniae as in this species, generally found in small, narrow segments.

I have studied the type specimens of this supposed form in the Harvard College Museum of Comparative Zoology, but they are so fragmentary that it is impossible to reach any final conclusion. They are simply what Lesquereux described them as being—"broken or separated rays of a palm"—and there is no means of knowing what the complete leaf was like. It should probably be merged with some other species or discarded altogether, but I have finally decided to let it stand as established by Lesquereux in the hope that subsequent discoveries may resolve its status one way or the other.

Occurrence: Denver formation, Golden, Colo., types in Museum of Comparative Zoology, Cambridge, Mass., collected by Arthur Lakes.

Geonomites goldianus (Lesquereux) Lesquereux

Plate 10, Figure 2

Geonomites goldianus (Lesquereux) Lesquereux, The Tertiary flora, p. 115, pl. 9, fig. 9, 1878; U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1876, p. 502, 1878; Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 44, 1888.

Palmacites goldianus Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1874, p. 311, 1876.

?Flabellaria zinkeni Heer. Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, p. 377, 1873; idem for 1873, p. 380, 1874; idem for 1876, p. 502, 1878; The Tertiary flora, p. 110, pl. 9, figs. 6–8, 1878.

The type and illustrated specimens as recorded under all the above names are in the United States National Museum collections and are before me. The specimen first called *Palmacites goldianus* and later transferred to the genus *Geonomites* (No. 103) is the best-preserved example. It remained unique for a long time, but the collection made by Lakes for the Museum of Comparative Zoology, Cambridge, and determined by Lesquereux contained 10 specimens. The recent collections include a few examples, and I have also found in the National Museum collection another example (No. 2059) that seems properly referable to it.

The type specimen is almost too small for careful description, yet it can probably be recognized in future. Following is Lesquereux's description:

> Leaves flabellate; rays flat and without carinae; joined in an acute angle of divergence and by their whole base to a narrow, linear, flat rachis, with narrow furrows marking the line of separation; primary veins generally distinct, with 10 intermediate veinlets.

The exact size and shape of this leaf are not known, as it is found only in fragments, but it can perhaps be recognized by the slender rachis to which the narrow, apparently flat rays are joined by their whole bases, the angle being about 20°. Lesquereux's statement that the rays are "without carinae" is not quite correct, as may be seen from the specimen. The carinae are undoubtedly present, but the whole leaf was apparently thin, and hence the carinae are not strongly apparent.

The new specimen above referred to, shown in Plate 10, Figure 2, appears to belong to this species. It is about 15 centimeters long and about 8 centimeters in extreme width and represents the distal extremity of the leaf. The rays are united to a point within some 10 centimeters of the periphery, where they split into long, narrowly acuminate segments, as in many living palms of this type. The rays are distinctly though not prominently keeled and are separated by 7 to 9 or 10 distinct, often very distinct veinlets. It is of course impossible to be absolutely certain that this specimen is identical with *Geonomites goldianus*, as it does not show the connection of the rays with the

rachis, but the general appearance, number of intermediate veinlets, and other features lead me to believe that it is.

The specimens identified by Lesquereux with the European *Flabellaria zinkeni* Heer (U. S. Nat. Mus. Nos. 101, 102) came from the exact spot that furnished the type specimens of *Geonomites goldianus*. They are mere fragments, the largest of which is less than 7 centimeters in length, and are entirely without essential characters. Indeed, the European original is said by Schenk [93] to be so fragmentary as to be unidentifiable—that is to say, although there can be little doubt as to its being a palm, it is not sufficient for adequate generic determination. If this is true it is still more true for the American examples under discussion, and I have referred them as above indicated. They are said by Lesquereux to be characterized by two to four indeterminate thin veinlets, whereas *Geonomites goldianus* is said to have as many as ten. A reexamination of all the specimens proves this character to be unreliable, and in the absence of others it has seemed best to unite them with *G. goldianus*. It is possible that these American specimens identified as *Flabellaria zinkeni* should be referred to *Flabellaria* sp., but, as pointed out under that form, it is too indefinite to be placed with certainty anywhere.

Occurrence: Denver formation, South Table Mountain, Golden, Colo. Green River formation(?), Barrel Springs, Wyo.

Geonomites? sp.

Plate 10, Figure 1

Leaves evidently large (rachis and attachment of rays unknown); rays very strong, approximately 4 centimeters in width, strongly or moderately carinate; primary nerves distinct but rather slender, with as many as 10 intermediate veinlets.

This is undoubtedly a very inadequate description, and perhaps the material is so fragmentary that it does not merit mention, but, as pointed out under *Flabellaria eocenica* and *Geonomites goldianus*, Lesquereux has apparently confused the broad rays of the present form with one or the other of these species, and it seems necessary to separate them. Lesquereux was of the opinion that *Geonomites goldianus* was a rather small leaved species, but it is beyond question that the present form had very large leaves. Thus, in the fragment figured there are portions of only three rays which show a width of over 8 centimeters, and the length, with little decrease in the size of the rays, is about 25 centimeters. Other fragments consist of single rays many of which show a width of 3.5 or 4 centimeters and give no indication of narrowing or approaching the extremity. They are always distinctly and sometimes strongly carinate, with the primary and finer veinlets as indicated in the diagnosis.

It is possible that the fragments of palm leaves from these beds referred by Lesquereux to *Flabellaria zinkeni* Heer should be placed with this form, but they appear smaller and more grasslike and, moreover, are in general so unsatisfactory that it makes little difference where they are referred, and I have placed them provisionally with *Geonomites goldianus*.

At least a part of the material provisionally placed under *Cyperus chavannesi* Heer should be referred to the present form.

Occurrence: Denver formation, Golden, Colo., collected by Arthur Lakes, 1890.

Chamaedorea? coloradensis Knowlton, n. sp.

Plate 10, Figure 3

Leaves pinnate, evidently of considerable size, hardly less than 60 or 70 centimeters in length; rachis slender, striate; leaflets remote, narrow, and grasslike, probably subopposite, decurrent for some distance down the rachis, perhaps reaching the leaflet below; leaflets narrowed at base, with about seven or eight rather strong parallel nerves, apparently with finer striae between the stronger ones, but their number and character can not be made out with certainty.

This form, which is represented by the single fragment figured, is really too fragmentary to admit of adequate characterization, but it is of such exceptional interest in the present connection that I have ventured to describe and figure it. It represents a portion of a slender rachis about 6 centimeters in length, which bears the basal portions of three leaflets. These leaflets are much narrowed and long decurrent at the base but rapidly become wider above. The length of the leaflets is not known, but at the point where they are broken they are about 1.5 centimeters in width. The nervation appears to be uniform—that is, there is no conspicuously larger midrib nor secondary veins.

In a specimen as fragmentary as this, with so many of the characters obscure or unknown, it is naturally impossible to discuss with satisfaction its possible or probable affinities. In many respects this seems to approach most closely a feather palm from the "Eolignitic" (Wilcox group) of Mississippi, which was described by Lesquereux [94] under the name *Calamopsis danai* but later transferred by Berry [95] to the genus *Chamaedorea*.

[93] Schenk, August, in Zittel, Karl von, Handbuch der Palaeontologie, Abt. 2, p. 372, 1890.

[94] Lesquereux, Leo, Am. Philos. Soc. Trans., vol. 13, p. 411, pl. 14, figs. 1–3, 1869.

[95] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 179, pl. 12, fig. 4; pl. 13, figs. 1–3, 1916.

The genus *Calamopsis* was founded by Heer [96] on a single species from the Tortonian of Baden, with the following generic characterization:

Frondes magnae, pinnatae, inermes, pinnis gramineis, nervis primariis omnino aequalibus, interstitialibus pluribus, subtilibus; nervis transversalibus nullis.

The type species of *Calamopsis* (*C. bredana*) is seen to be a large-leaved form with numerous narrow opposite leaflets without obvious midrib and not decurrent at the base.

The Mississippi form was removed from *Calamopsis* by Berry on the ground that the leaflets are not opposite and have a decurrent base and a "fairly prominent" midrib and was referred to the living American genus *Chamaedorea*, the 60 or more species of which range from central Mexico well into South America.

The specimen from Middle Park under discussion seems to combine certain of the characters of both these genera—that is, it has the decurrent base of *Chamaedorea* but lacks the obvious midvein, like *Calamopsis*. More and better material will be necessary to settle its status, but under the circumstances reference to the American genus seems most logical, with a question mark.

Occurrence: Middle Park formation, from south face of Mount Bross, Middle Park, Grand County, Colo., about 1,000 feet above base of mountain, collected by George L. Cannon, 1889.

Genus PALOREODOXITES Knowlton, n. gen.

Paloreodoxites plicatus (Lesquereux) Knowlton, n. comb.

Plate 11, Figures 1–4

Orcodoxites plicatus Lesquereux, The Cretaceous and Tertiary floras, p. 122, pl. 18, figs. 1–4, 1883.
Knowlton, U. S. Geol. Survey Prof. Paper 101, p. 287, pl. 63, fig. 1, 1917 [1918].

The genus *Oreodoxites* was established by Göppert [97] in 1864 and is based on a rather obscure seed or fruit from the Permian of Braunau, Bohemia. The type and only species was *Oreodoxites martianus;* it has not been subsequently reported in the literature.

When Lesquereux [98] established his *Oreodoxites plicatus* he did not give a generic diagnosis, nor did he in any way indicate that he considered his leaves congeneric with Göppert's *Oreodoxites*, and there is every reason to suppose that he considered he was founding it anew on the living *Oreodoxa*, which, he pointed out, it is supposed to resemble. As it is highly improbable, not to say impossible, that any relationship can exist between the Permian *Oreodoxites* of Göppert and the Eocene *Oreodoxites* of Lesquereux, it seems best to give the latter a new name. I have therefore called it *Paloreodoxites.*

Following is Lesquereux's original description of his *Oreodoxites plicatus:*

Leaves acute at both ends, deeply plicate lengthwise in numerous rays converging at the base and apex, obscurely marked toward the base by a median nerve [midrib]; rays distinctly veined; primary nerves distinct, separated by three or four intermediate ones.

The type specimens of this very characteristic species are preserved in the museum of Princeton University and are apparently the most perfect that have been found. The best-preserved example is absolutely perfect except for a slight break at the point of attachment. It is about 17 centimeters long and a little less than 6 centimeters wide. The largest specimen is fully 7 centimeters wide and must have been nearly or quite 20 centimeters long when living. In the best-preserved specimen there is little indication of the presence of a midrib, but in the others it is very pronounced, extending up for nearly one-third of the length.

Only a very few additional specimens have been found at the type locality, and these are even less perfect than the least perfect of the type, hence they do not throw further light on the habit and relationship of this species.

The generic name *Paloreodoxites* has been selected so as to preserve its connection with the *Oreodoxites* of Lesquereux, rather than the implication of its ancestry of the modern *Oreodoxa;* in fact, it is much to be doubted if there is any real relationship between the living genus and the present fossil form.

Occurrence: Denver formation (types), Golden, Colo., subsequently collected by Arthur Lakes, L. F. Ward, and others on south face of South Table Mountain, 100 feet below the lava cap, Golden, Colo.

Palmocarpon palmarum (Lesquereux) Knowlton

Carpolithes palmarum Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1871, Suppl., p. 13, 1872; idem for 1872, pp. 382, 398, 1873.
Palmocarpon commune Lesquereux, The Tertiary flora, p. 119, pl. 13, figs. 4–7, 1878.
Palmocarpon palmarum (Lesquereux) Knowlton, U. S. Geol. Survey Bull. 152, p. 158, 1898; Washington Acad. Sci. Proc., vol. 11, p. 204, 1909; U. S. Geol. Survey Prof. Paper 101, p. 292, 1918.

The type specimens of this species came from the Raton formation at Fishers Peak, Raton Mountains, Colo., and it has since been found at numerous localities in this formation in southern Colorado and northern New Mexico. It is also abundant in the Denver formation at Golden, Colo., and vicinity.

[96] Heer, Oswald, Flora tertiaria Helvetiae, vol. 3, p. 169, pl. 149, 1859.
[97] Göppert, H. R., Die fossile Flora der permischen Formation: Palaeontographica, vol. 12, p. 147, pl. 26, fig. 5, 1864.
[98] Lesquereux, Leo, The Cretaceous and Tertiary floras, p. 122, pl. 18, figs. 1–4, 1883.

Notwithstanding the number of these fruits now known, very little has been ascertained concerning their mode of growth and probable affinities. On these points Lesquereux wrote as follows:

These fruits, about 3 centimeters in diameter, and nearly globular when covered with the outer envelope, are broadly oval and a little smaller—2.5 centimeters long and 2 centimeters across—when deprived of their exocarp. This shelly covering is thin, straw-colored or yellowish, smooth, and easily crushed; the endocarp appears also thin and, like the kernel, soft and easily yielding to compression; therefore few of these fruits are preserved in their original form. The endocarp is very thinly lined in the length, a character which is remarked only with the glass; and on one side they are indistinctly marked by scars resembling the point of a chalaza with the raphis and hilum, as seen in the endocarp of some seeds. * * * They are found very numerous in certain localities of limited areas, as if they were derived from a common support or a raceme. At least the specimens of Golden and of Raton are mixed with cylindrical fragments, like branches and branchlets or clustered peduncles half destroyed by maceration, and to which these fruits seem to have been originally attached; even with pieces of textile filaments, like remnants of decomposed spathes.

Occurrence: Raton formation (types), Fishers Peak, Raton Mountains, Colo., and at many localities in this formation in southern Colorado and northern New Mexico. Denver formation, Golden, Colo., and numerous localities. Lance formation, Weston and Converse Counties, Wyo.

Palmocarpon truncatum Lesquereux

Palmocarpon truncatum Lesquereux, The Tertiary flora, p. 120, pl. 11, figs. 6–9, 1878.

All the figured types of this species are preserved in the United States National Museum (No. 517) and have been carefully reexamined. They were fairly well described by Lesquereux, but the figures are rather poor and more or less misleading. Lesquereux's description reads as follows: "Fruit subglobose, slightly flattened, truncate on one side, covered with a brownish, smooth shaly envelope." On the basis of size Lesquereux divided this species into two varieties—*major* and *minor*. Concerning them he writes as follows:

The largest specimen of var. *major* (fig. 7) measures 17 millimeters across from side to side and 10 millimeters only from the truncate base to the top; one specimen, which seems intermediate between both varieties, is only 14 millimeters broad and 8 millimeters high. The variety *minor* (figs. 8 and 9) is represented by nutlets 10 millimeters across the widest part and 5 or 6 millimeters in the other direction, generally in a better state of preservation, but with the same thin pericarp of the same color. The characters of these small nuts refer them to *Sabal*.

Occurrence: Denver formation, South Table Mountain, Golden, Colo., early collections.

Palmocarpon? subcylindricum Lesquereux

Palmocarpon subcylindricum Lesquereux, The Tertiary flora, p. 121, pl. 11, fig. 12, 1878.

Following is Lesquereux's description:

Fruit oblong or subcylindrical, truncate at one end, split at the other in two diverging or slightly recurved, pointed lobes. distantly and obscurely veined near the base.

The figured types of this species are in the United States National Museum (No. 518), but the figure in the report on the Tertiary flora is not quite accurate. There is no evidence to show that the scar at the base is as pronounced as the figure would make out, nor is there indication that the ribs or costae are so apparent. The base in some of the more recently collected specimens is truncate, but the point of attachment seems to have been smaller than figured.

At first sight it seemed that these fruits could be nothing but examples of *Palmocarpon palmarum* that had been split at the apex by pressure, but an examination of the types, as well as a number of additional specimens, makes it reasonably certain that they were actually bilobed nearly to the middle. The pericarp is, as Lesquereux has pointed out, the same as in *Palmocarpon palmarum* and is found in the same beds with that species.

Occurrence: Denver formation, Golden, Colo.

Palmocarpon? corrugatum Lesquereux

Palmocarpon corrugatum Lesquereux, The Tertiary flora, p. 121, pl. 11, figs. 10, 11, 1878; U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1876, p. 503, 1878.

The larger of the figured types of this species (original of fig. 11) is preserved in the United States National Museum (No. 522). The other does not appear to have belonged to the Museum and is now lost. The species has not since been found.

Occurrence: Denver formation, Golden, Colo.

Palmocarpon? lineatum Lesquereux

Plate 11, Figure 5

Palmocarpon lineatum Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 44, 1888.

This species is described by Lesquereux as follows:

Seeds small, oval or oblong, obtuse at apex, subtruncate at base, regularly thinly but distinctly striate. The seeds, 4 millimeters long, 2.5 millimeters in diameter, are very numerous, apparently derived from racemes.

I have studied the types of this species and have nothing to add to Lesquereux's description. It is extremely doubtful if they are properly referred to the palms, but on the other hand no other relationship is suggested, and so they are permitted to remain as left by Lesquereux, but with the genus questioned.

Occurrence: Denver formation, Golden, Colo. Types in Museum of Comparative Zoology, Cambridge, Mass., Nos. 103 and 1616, collected by Arthur Lakes.

Palmoxylon cannoni Stevens

Palmoxylon cannoni Stevens, Am. Jour. Sci., 5th ser., vol. 1, p. 442, text figs. 11–16, 1921.

Described by the author as follows:

Fibrovascular bundles scattered, usually about 10 per square centimeter, 0.8 to 1 millimeter in diameter. Bast region rounded in outline, flattened where it joins the vascular portion. No marked difference in size, shape, or arrangement of fibrovascular bundles in different parts of the specimen. No axillary sclerenchyma bundles. Fundamental tissue composed of irregular, rather thin-walled cells, with large intercellular spaces, and also beset by groups of thicker-walled "stone" cells varying greatly in size, thickness of wall, and number of cells to the group. Stone-cell groups usually measure from 0.1 to 0.3 millimeter in diameter.

This species is based on a silicified trunk of large size and is remarkably well preserved with the exception of the phloëm, which had apparently disappeared before silicification. Stevens states that the fundamental tissue is rather specialized.

Like that of *P. cellulosum* Knowlton it has large intercellular spaces, but scattered among the typical parenchymatous cells, usually in groups of 3 to 10, are much thicker "stone" cells. These stone cells vary considerably in size, in number associated in a single group, and thickness of walls, while some seem to be pitted.

Occurrence: Denver formation, western suburbs of Denver, Colo., in lower part of formation, collected by G. L. Cannon, for whom it is named. Type in Yale Museum, New Haven, Conn.

Order ZINGIBERALES

Family ZINGIBERACEAE

Zingiberites dubius Lesquereux

Zingiberites dubius Lesquereux, The Tertiary flora, p. 95, pl. 16, fig. 1, 1878; U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1876, p. 501, 1878.

Zingiberites? undulatus Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, p. 396, 1874. [Homonym, *Zingiberites undulatus* Heer, Miocene baltische Flora, p. 64, 1869.]

A part of the type specimen of this species is in the collection of the United States National Museum (No. 136). It is a mere fragment, the nature of which, as Lesquereux said, is open to grave doubt. In his original characterization Lesquereux wrote as follows:

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 six or seven 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 a rachis to which the fragments of an evidently large leaf may have been attached.

A poorly preserved specimen is present in the later collections made by Lakes, but it is not large enough to throw any additional light on the nature or habit of this peculiar plant. Schenk [99] has suggested that this plant should probably be referred to the genus *Musophyllum*, but in the absence of material which makes this relationship plain I have thought it best to retain it under the name given it by Lesquereux.

Occurrence: Denver formation (type), Golden, Colo., collected by Leo Lesquereux, 1873. The recent specimen is from the south face of South Table Mountain, Golden, 100 feet below the lava cap, collected by Arthur Lakes, 1890.

Subclass DICOTYLEDONES

Order PIPERALES

Family PIPERACEAE

Piper heerii Lesquereux

Plate 11, Figure 6

Piper heerii Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 44, 1888.

Described by Lesquereux as follows:

Leaves subcoriaceous, round or oval, entire, palmately nerved from the base, nerves very curved, the outer following the borders up to the middle of the leaf, the inner acrodrome.

The fragment, the half of one leaf cut lengthwise or along the median nerve, is, in all its characters, identical with the leaf described by Heer [1] as *Piper antiquum*. As the leaf is fragmentary, the petiole being absent, I can not well identify it with that of the Miocene of Sumatra, though I am unable to see any marked difference. The leaf described by Heer is unequilateral and long-petioled, and none of these characters can be seen from the American fragment. The nerves are distinct; the outer primary follows the borders at a small distance, its branches, nearly at right angles, forming, by anastomosing curves, a series of areolae along the borders from the middle downward, and the areas are traversed by nervilles at right angles.

This leaf has been well described by Lesquereux, though, as he says, it is very fragmentary, lacking all of one side and a portion of the apex. It does closely resemble *Piper antiquum* Heer, but it is so fragmentary that certain essential features can not be compared satisfactorily. This leaf also suggests certain species of *Ficus*, such as *Ficus pseudopopulus* Lesquereux, which is especially abundant in the Raton formation, but it differs essentially in the nervation.

Occurrence: Denver formation, South Table Mountain, Golden, Colo., collected by Arthur Lakes. Type

[99] Schenk, August, in Zittel, Karl von, Handbuch der Palaeontologie, Abt. 2, p. 387, 1890.

[1] Heer, Oswald, Beiträge zur fossilen Flora von Sumatra, p. 11, pl. 1, fig. 7, 1880.

in Museum of Comparative Zoology, Cambridge, Mass., No. 1037.

Order MYRICALES

Family MYRICACEAE

Myrica sp.

Plate 11, Figure 7

The specimen here figured is all that was found in the interesting collection from reddish baked shale near Ramah, Colo., and, although it is rather fragmentary, it is so distinctive that it must be described. It is a medium-sized leaf, clearly lanceolate, and probably acuminate at both base and apex, though both are now wanting. It was presumably about 8 or 9 centimeters long and just 3 centimeters wide. The margin is perfectly entire. The nervation is distinctive, consisting of a fairly strong midrib, a very distinct intramarginal vein or connected series of loops well inside the margin, and numerous fine irregular veins connecting the midrib and the marginal vein. Some of the stronger veins fork, and all are united into a fine mesh or network of finer nervation.

In size, shape, and nervation this species agrees very closely with *Myrica torreyi* Lesquereux,[2] but it differs in having the margin perfectly entire instead of strongly serrate.

Occurrence: Dawson arkose, red baked shale near oil well south of Ramah, Colo., collected by C. W. Cooke for G. B. Richardson, 1910.

Order JUGLANDALES

Family JUGLANDACEAE

Juglans denveriana Knowlton, n. sp.

Plate 12, Figures 1, 2; Plate 13, Figures 2–4

Leaves very large, probably at least 50 centimeters long and 30 centimeters broad, coriaceous, pinnate; terminal leaflet lanceolate, long, wedge-shaped, and equal-sided at the base, rather abruptly narrowed above to the slenderly acuminate apex; margin slightly undulate but otherwise practically entire; midrib very strong, with about 12 pairs of strong, subopposite secondaries, which emerge at an angle of 20° or 25° and curve upward strongly, each joining the one next above by a long curve just inside the border; nervilles numerous, strong, mainly unbroken; finer nervation irregularly quadrangular. Lateral leaflets large, the upper ones about 15 centimeters long and 5 centimeters wide, elliptical-lanceolate, strongly unequal-sided at the base, petioled, margin obscurely serrate, apex slenderly acuminate; nervation similar to that of the terminal leaflet. Basal leaflets smaller, about 12 centimeters long and 3.5 centimeters wide; nervation similar to that of other leaflets.

If this form has been interpreted correctly, it was a very large leaved species. It is represented by a considerable number of well-preserved specimens, a few of which are figured. What is presumed to be the terminal leaflet is shown in Plate 12, Figure 1. This was not less than 19 centimeters long and 6 centimeters wide. Whether it was petioled is not known, as this portion is missing, but it probably was. It is remarkable for its lanceolate shape, slenderly acuminate tip, and numerous strong, camptodrome secondaries. There are two or three intermediate secondaries between most of the secondaries.

Two of the lateral leaflets are shown in Plate 12, Figure 2. They are not attached to the common petiole, but they lie in the same plane, and there is little doubt that they are in the same relative positions they held when living. Each has a slender petiole about 1 centimeter long. The upper leaflet is best preserved and shows well the unequal-sidedness of the base, but the external tip is not preserved. The margin is entire at the base, but above it is obscurely serrate. The nervation is of exactly the same type as that in the supposed terminal leaflet.

The leaflet shown in Plate 13, Figure 3, is the counterpart of the upper leaflet in Plate 12, Figure 2. It is figured because its preservation is such that the marginal teeth are more clearly brought out. The manner in which the secondaries arch and send fine branches to the teeth is also well shown.

Smaller leaflets are shown in Plate 13, Figures 2 and 4. They are presumed to be the lower leaflets of the large leaf. They agree perfectly in shape and nervation with those last described but differ from them in the absence of marginal teeth. In view of this difference the question is raised whether all these leaflets should be regarded as conspecific. On the other hand, there are so many points of agreement among them that the presence or absence of slight teeth is not considered to be a sufficient warrant for separating them. The probable correctness of this view is substantiated by the finding of occasional slight teeth in leaflets that have the margin apparently entire, which shows it to be a variable character.

The probable relationship of this species may now be considered. The smaller leaflets, such as those shown in Plate 13, Figures 2 and 4, have a very strong resemblance to certain of the leaflets referred to *Juglans rugosa* Lesquereux;[3] in fact, one of these specimens was identified as this species by Lesquereux. In general, however, the leaflets of *J. rugosa* are smaller, more equal-sided at the base, more obtuse at the apex, and always—so far as the published figures show—without marginal teeth or a trace of a petiole. Although the figures given by Lesquereux

[2] Lesquereux, Leo, The Tertiary flora, p. 129, pl. 16, figs. 3–10, 1878.

[3] Idem, pl. 55, figs. 2, 4.

all show detached and isolated leaflets, it seems probable that some evidence of a petiole should be observable if one had been present. The same argument applies to the marginal teeth, but, on the other hand, it is to be remembered that all the smaller leaflets of *J. denveriana* have entire margins. In the leaflets of *J. denveriana* the nervation is deeply impressed, producing the rugose appearance described as characteristic of *J. rugosa*, and it will be extremely difficult to allocate some specimens—that is, to distinguish the one from the other. However, it is believed that with adequate material they may be distinguished without much difficulty.

There are also some points of agreement between the smaller leaflets of *Juglans denveriana* and a leaflet described by Lesquereux[4] under the name *Sapindus caudatus*. That leaflet differs, however, in being relatively shorter, much broader, and more abruptly narrowed to the slender tip, in having entire instead of obscurely serrate margins, and in minor particulars of nervation.

Occurrence: Denver formation, Golden, Colo., probably all from South Table Mountain, collected by Arthur Lakes.

Juglans thermalis Lesquereux

Plate 13, Figure 5

Juglans thermalis Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1871, Suppl., p. 17, 1872; idem for 1873, p. 389, 1874; idem for 1876, p. 517, 1878; The Tertiary flora, p. 287, pl. 56, figs. 3, 4, 1878.

Types: United States National Museum, Nos. 464, 464a.

The larger of the two type specimens, the original of Plate 56, Figure 3, of the "Tertiary flora," is from Middle Park, Colo., and is preserved on a hard conglomerate characteristic of a well-known horizon at that locality. The other specimen, the original of Lesquereux's Figure 4, is from the andesitic beds at Golden, Colo. It is much smaller than the Middle Park example, and, as Lesquereux pointed out, it differs somewhat in nervation and may belong to a different species. In the absence of additional material that throws light on this point it is left as designated by Lesquereux.

In the material collected by G. L. Cannon in Middle Park there is a single specimen that appears to be the same as the original example from this region. It is a little smaller and lacks some of the finer nervation but otherwise does not differ essentially.

Occurrence: Middle Park formation (type), Middle Park, Grand County, Colo.; Sheriffs Creek, Middle Park, collected by G. L. Cannon, 1889. Denver formation (type), Golden, Colo.

[4] Lesquereux, Leo, The Tertiary flora, p. 264, pl. 48, fig. 6, 1878.

Juglans schimperi Lesquereux

Juglans schimperi Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1871, Suppl., p. 8, 1872; The Tertiary flora, p. 287, pl. 56, figs. 5–10, 1878.

Knowlton, U. S. Geol. Survey Mon. 32, pt. 2, p. 688, 1899; U. S. Geol. Survey Bull. 204, p. 34, 1902; U. S. Geol. Survey Prof. Paper 101, p. 296, pl. 64, fig. 1, 1917 [1918].

Hollick, Louisiana Geol. Survey, Rept. for 1899, Special Rept. 5, p. 280, pl. 33, figs. 1, 2, 1899.

Penhallow, Report on the Tertiary flora of British Columbia, p. 60, 1908.

Berry, The flora of the Wilcox formation: U. S. Geol. Survey Prof. Paper 91, p. 182, pl. 18, figs. 3–5, pl. 19, fig. 4, 1916.

Juglans rugosa Lesquereux. Lesquereux, U. S. Nat. Mus. Proc., vol. 11, p. 11, 1888.

Berry[5] gives the following description of this species as based on the fuller material from the Wilcox group:

> Leaves ovate-lanceolate and somewhat inequilateral in outline. Apex gradually acuminate. Base broadly cuneate or rounded, inequilateral. Size variable; length ranges from 10 to 18 centimeters; maximum width, in middle or lower half of the leaf, from 2 to 4.8 centimeters. Margins entire, slightly undulate. Petiolule generally not preserved; in some of the specimens from Wyoming it ranges from 3 to 7 millimeters in length. Midrib stout, usually curved. Secondaries thin, numerous, rather evenly spaced, subparallel, about 14 or 15 subopposite to alternate pairs; they branch from the midrib at wide angles and curve upward close to the margins in a camptodrome manner. Tertiaries mostly percurrent and distinct. Areolation subquadrate.

Juglans schimperi was well described and figured by Lesquereux.[6] The type specimens came from the Green River formation at Green River, Wyo., but in the report on the Tertiary flora Lesquereux figured also (pl. 56, fig. 9) a single leaflet from the Denver formation at Golden, Colo. This leaflet differs slightly from the Green River specimens, and it may sometime be removed, but without further material for comparison I think best to leave it under *Juglans schimperi*.

This species was found at a number of localities in the Raton formation and by both Hollick and Berry in the Wilcox group of the Gulf States. It has also been reported from the Miocene of the Yellowstone National Park and with some doubt from the upper part of the Clarno formation of Oregon.

As regards the propriety of referring these leaflets to the genus *Juglans*, Berry well says that, although the reference is not above question, "no better disposition of them has suggested itself."

Occurrence: Green River formation (types), Green River, Wyo. Denver formation (type), Golden, Colo.

[5] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 182, 1916.

[6] Lesquereux, Leo, The Tertiary flora, p. 287, pl. 56, figs. 5–10, 1878.

Raton formation, southern Colorado and adjacent New Mexico.

Juglans rhamnoides Lesquereux

Juglans rhamnoides Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1871, p. 294, 1872; idem for 1872, pp. 382, 400, 402, 1873; idem for 1874, p. 307, 1876; idem for 1876, p. 517, 1878; Bull., vol. 1, p. 370, 1876; The Tertiary flora, p. 284, pl. 54, figs. 6–9, 1878; The Cretaceous and Tertiary floras, p. 235, 1883.

Dawson, Roy. Soc. Canada Trans., vol. 4, sec. 4, p. 31, 1886.

Lesquereux, U. S. Nat. Mus. Proc., vol. 11, p. 32, 1888; Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 56, 1888.

Knowlton, U. S. Geol. Survey Bull. 105, p. 58, 1893; U. S. Geol. Survey Prof. Paper 101, p. 294, pl. 66, fig. 1, 1917 [1918].

A rather complete history of *Juglans rhamnoides* has already been given [7] and need not be repeated here except in barest outline. This species appears to have been first described in 1871 from fragments said to have come from Evanston, Wyo., below the main coal. In the following year it was mentioned by Lesquereux as occurring at Golden, Colo., and Black Buttes and Evanston, Wyo., and in 1875 a single leaflet from Point of Rocks, Wyo., was referred to it. None of these specimens—at least under this name—are now to be found in the collections of the United States National Museum, and it seems likely that they were transferred to other forms without a record being made of such transfer, as was Lesquereux's occasional custom. In the report on the Tertiary flora, which was supposed to represent Lesquereux's mature judgment regarding all previously described forms falling within its scope, the only two localities mentioned are Spring Canyon, Mont., and Point of Rocks, Wyo. Of the four examples he figured, all of which I have seen, three came from Black Buttes and one from Spring Canyon. No specimen was found then in the collections, nor subsequently from Point of Rocks, and hence *Juglans rhamnoides* was excluded from my report on the flora of the Montana formation. It was also reported by Lesquereux as present in Tertiary beds at Cherry Creek, Oreg., but in working over his material I failed to find it, and it was consequently excluded from my bulletin on the fossil flora of the John Day Basin. It was, however, recognized as present in my report on the flora of the Livingston formation.

Juglans rhamnoides was reported a number of times by Lesquereux from Golden, Colo., but these specimens have not been recognized in the later studies. Its presence in these beds rests on the three specimens so identified by Lesquereux in the material belonging to the Harvard College Museum of Comparative Zoology. It was also admitted to the flora of the Raton formation on the basis of a single leaflet collected by W. T. Lee in Spring Canyon, north of Vermejo Park, N. Mex.

Occurrence: Denver formation, Golden, Colo. Black Buttes coal group, Black Buttes, Wyo. Raton formation, Spring Canyon, Vermejo Park, N. Mex. Livingston formation, "Spring Canyon," Mont. [Hodson's coal mine on Meadow Creek, 12 miles southeast of Bozeman].

Juglans rugosa Lesquereux

Plate 14, Figure 1

Juglans rugosa Lesquereux, Am. Jour. Sci., 2d ser., vol. 45, p. 206, 1868 [nomen nudum]; U. S. Geol. Survey Terr. Ann. Rept. for 1869, p. 96; reprint, 1873, p. 196; U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1871, pp. 287, 298, 1872; idem, Suppl., pp. 10, 12, 1872; idem for 1872, pp. 382, 390, 398, 404, 407, 1873; idem for 1876, p. 517, 1878: The Tertiary flora, p. 286, pl. 54, figs. 5. 14; pl. 55, figs. 1–9, 1878; U. S. Nat. Mus. Proc., vol. 11, pp. 13, 22, 31, 1888.

Dawson, Roy. Soc. Canada Trans., vol. 3, sec. 4, p. 30, 1886.

Ward, Geol. Soc. America Bull., vol. 1, p. 529, 1890.

Cross, Colorado Sci. Soc. Proc., vol. 4, p. 211, 1892.

Knowlton, U. S. Geol. Survey Bull. 105, p. 53, 1893; U. S. Geol. Survey Bull. 163, pp. 13, 17, 1900; U. S. Geol. Survey Mon. 32, pt. 2, pp. 687, 690, 779, 1899; in Merriam, California Univ. Dept. Geology Bull., vol. 2, p. 289, 1901: U. S. Geol. Survey Bull. 204, pp. 34, 90, 102, 103, 1902.

Stanton and Knowlton, Geol. Soc. America Bull., vol. 8, pp. 141, 148, 1897.

Hollick, Louisiana Geol. Survey Rept. for 1899, Special Rept. 5, p. 280, pl. 35, figs. 1, 2, 1900.

Juglans acuminata? Al. Braun. Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1871, Suppl., p. 8. 1872.

The history of *Juglans rugosa*, which is somewhat complicated, has recently been given at length in the discussion under *Juglans praerugosa* Knowlton.[8] A portion of that history is here transcribed.

Juglans rugosa Lesquereux was named in 1868 from material obtained from the Marshall mine, Marshall, Colo., but it was neither described nor figured at that time. The only note of explanation then given [9] is as follows: "Very nearly related to *J. acuminata* Al. Braun, a species extensively distributed in the European Miocene." This note was copied without change by F. V. Hayden in the Third Annual Report of the Geological Survey of the Territories, published in 1869, page 96, and the species was alluded to in several of the later Hayden reports, but it was not

[7] Knowlton, F. H., Flora of the Raton formation: U. S. Geol. Survey Prof. Paper 101, pp. 294–295, 1917 [1918].

[8] Knowlton, F. H., Flora of the Laramie formation: U. S. Geol. Survey Prof. Paper 130, pp. 121–122, 1922.

[9] Lesquereux, Leo, Am. Jour. Sci., 2d ser., vol. 45, p. 206, 1868.

until 1878 that it was really validated by being properly described and figured.[10] Now, another complication was introduced with the figuring and describing of this species. The original locality of Marshall for *Juglans rugosa* is nowhere mentioned in the "Tertiary flora," and, so far as known, none of the original specimens are extant. The diagnosis and figures in the report on the Tertiary flora are based in the main on material from Evanston, Wyo., coming from "above the coal." Of the 13 figured specimens of *Juglans rugosa*, 11 are now in the collection of the United States National Museum. The missing types are the originals of Lesquereux's Plate 54, Figure 5, and Plate 55, Figure 1, both, it is said, from Golden, Colo., though whether from Laramie or Denver beds can not now be determined.

From this account it appears that, although named from material of Laramie age at Marshall, *Juglans rugosa* as currently accepted is based on material from higher or post-Laramie horizons. There is thus no means of knowing just what the original Marshall leaves were like beyond the statement already mentioned that they are said to resemble *Juglans acuminata*. It is for these reasons that *Juglans rugosa* is excluded from the Laramie flora. The *Juglans* from the Laramie formation at Marshall was named *Juglans praerugosa*, though there is, of course, no certainty that the leaflets on which it is based are of the same type as those to which Lesquereux gave the name *Juglans rugosa*.

In the synonymy given at the head of this discussion I have noted practically all the published references to *Juglans rugosa*, from which it appears to have been reported from many localities. As a large proportion of the specimens upon which this record was made are preserved in the United States National Museum, it was of interest to examine them with a view of ascertaining if possible the correctness of the identifications. The following list shows the illustrations of the types of *Juglans rugosa* in the volume on the Tertiary flora and the corresponding numbers in the United States National Museum catalogue:

	Catalogue No.
Plate 54, Figure 14	454
Plate 55, Figure 1	851
Figure 2	455
Figure 3	455a
Figure 4	456
Figure 5	457
Figure 6	458
Figure 7	461
Figure 8	460
Figure 9	459
Plate 56, Figure 1	463

[10] Lesquereux, Leo, The Tertiary flora, p. 286, pl. 54, figs. 5, 14; pl. 55, figs. 1-9, 1878.

Of these specimens Nos. 455, 455a, 457, 458, 461, and 851 are from Evanston, Wyo. No. 460 is recorded in the Museum catalogue as having come from Golden, Colo., but attached to the specimen is a small original label which gives its locality as Evanston, Wyo.. and as the matrix agrees perfectly with that of the other Evanston specimens this label is assumed to be correct. No. 455 is from Black Buttes, Wyo., and No. 456 is said to be from Point of Rocks, Wyo. The matrix of No. 456 appears to be identical with that of the specimens from Evanston and unlike that ordinarily found at Point of Rocks, and on the strength of this finding I excluded it from my bulletin on the flora of the Montana formation.[11] However, it is but fair to state that this specimen has an original label attached to it, similar to that above mentioned, which records it as from Point of Rocks. In spite of this evidence I can not escape the feeling that the label is in error, the more so because the abundant recent collections from Point of Rocks did not include specimens referable to *J. rugosa*. As a further point it may be noted that Lesquereux did not give Point of Rocks in his list of localities for this species in the report on the Tertiary flora, this list reading as follows:

> Six miles above Spring Canyon, near Fort Ellis, Mont.; Evanston, Wyo.; very abundant at these localities. Plate 55 is mostly composed of Evanston specimens. Black Buttes, Wyo., and Golden, Colo.; less common. One of the specimens, communicated by Dr. A. R. Marvine, bears the label "South borders of North Park," a locality whose geological station is not known to me.

From this it appears that most of the specimens came from Evanston and Spring Canyon, though none from Spring Canyon are figured, nor can any of them now be found in the Museum collections. However, in my report on the fossil plants of the Bozeman coal field I recorded the fact[12] that "a number of good specimens were obtained." These came from Hodson's coal mine, in beds supposed to be of Livingston age.

We may now turn to some of the other localities whence *Juglans rugosa* has been reported. In 1886 Dawson[13] reported this species from the Upper Laramie of Porcupine Creek, Alberta, Canada. He did not figure these specimens, nor have I seen them, but from the fact that Dawson at one time identified them with *Juglans nigella* Heer, a species which is really quite unlike the present one, it is presumed that this determination requires confirmation.

In 1888 Lesquereux,[14] in a paper giving the determinations of a miscellaneous lot of material that had been sent him from the National Museum, mentioned

[11] Knowlton, F. H., U. S. Geol. Survey Bull. 163, 1900.

[12] Knowlton, F. H., U. S. Geol. Survey Bull. 105, p. 53, 1893.

[13] Dawson, J. W., Roy. Soc. Canada Trans., vol. 4, sec. 4, p. 30, 1886.

[14] Lesquereux, Leo, U. S. Nat. Mus. Proc., vol. 11, pp. 22, 31, 1888.

two specimens from Cherry Creek, Crook County, Oreg., as referable to *Juglans rugosa*. I studied these specimens when preparing my paper on the fossil flora of the John Day Basin [15] and wrote of them as follows: "Represented by two fragments that are more or less obscure and doubtful." In his paper of 1888 Lesquereux mentioned a single specimen from Lassen County, Calif., but this also is fragmentary and not well authenticated.

Hollick [16] reported *Juglans rugosa* from beds of "Eolignitic" (Wilcox) age near Coushatta, La., but the species was not accepted by Berry [17] in his paper on the flora of the Wilcox formation. In the Yellowstone National Park [18] I detected this species at a number of localities in beds supposed to be of Fort Union age. *Juglans rugosa* was found to be fairly abundant in the Raton formation of the Raton Mesa region of Colorado and New Mexico.[19]

Occurrence: Denver formation, Sand Creek near Magnolia, northeast of Denver, Colo., collected by Francis W. Collins, 1909.

Juglans sp.

Plate 14, Figure 5; Plate 15, Figure 1

The Dawson arkose at a locality on Jimmy Camp Creek has afforded the example here figured. It is a segment from near the middle of what appears to be an elliptical-lanceolate leaflet. It must have been 12 or 13 centimeters long and is very nearly 6 centimeters wide. Margin entire; petiole strong and perfectly straight; secondaries numerous, mainly alternate, emerging nearly at a right angle, considerably curved upward, camptodrome; nervilles strong, very oblique to the secondaries.

This is undoubtedly very close to *Juglans denveriana*, above described, and may be identical with it.

Occurrence: Dawson arkose, east bank of Jimmy Camp Creek, 0.6 mile above Richfield Springs ranch house, 9 miles east of Colorado Springs, Colo., collected by F. H. Knowlton, July, 1910.

Hicoria antiquora (Newberry) Knowlton

Hicoria antiquora (Newberry) Knowlton, U. S. Geol. Survey Bull. 152, p. 117, 1898.

Carya antiquorum Newberry, New York City Lyceum Nat. Hist. Annals, vol. 9, p. 72, 1868.

Lesquereux, The Tertiary flora, p. 289, pl. 57, figs. 1–5; pl. 58, fig. 2, 1878; Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 56, 1888.

Newberry, U. S. Geol. Survey Mon. 35, p. 35, pl. 31, figs. 1–4, 1898.

In the material from the andesitic beds at Golden, Colo., identified by Lesquereux for the Museum of Comparative Zoology, he reports a single example of this species. It is a small, rather obscurely preserved leaf or leaflet, and its identification is more or less doubtful. However, as it seems to differ from any other leaves found in the same locality, it may be permitted to stand until further evidence is available. It was not noted in the extensive material from this locality that has been passed in review.

Occurrence: Denver formation, Golden, Colo., specimen in the Museum of Comparative Zoology, Cambridge, Mass.

Pterocarya? retusa Lesquereux

Plate 14, Figures 2–4; Plate 15, Figure 5

Pterocarya retusa Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 56, 1888.

Described as follows by Lesquereux:

Terminal leaflet large, ovate-lanceolate; the lateral [leaflets] small, linear-oblong, blunt at apex, rounded-subtruncate at base; lateral nerves close, parallel, at a broad angle of divergence, branching near their ends; surfaces rugose. The leaflets are thick, denticulate or crenulate on the recurved borders; the lateral nerves, at an angle of 50°, are not more than 5 millimeters distant in the small leaves; deeply marked.

This species is said by Lesquereux [20] to be "closely allied to *Pterocarya americana* Lesquereux, differing by the open proximate nerves." It is also said to show relationship with *Juglans corrugata* Ludwig [21] "by its rugose surface and its nervation, * * * differing especially by the leaves being blunt or obtuse, not acuminate as in the European species."

Pterocarya americana Lesquereux is said by Lesquereux to have come from Middle Park, Colo., from beds presumed to be in the approximate position of the Denver formation, but an examination of the type specimen in the National Museum proves unmistakably that it came from the Miocene lake beds at Florissant, Colo.

Pterocarya? retusa is represented by six specimens, four of the best of which are here figured and may be regarded as the types. None of them are very well preserved. The one taken by Lesquereux to be the terminal leaflet (pl. 15, fig. 5) is about 7.5 centimeters long and nearly 3.5 centimeters wide. It is said by Lesquereux to be blunt at the apex, but on removal of more of the matrix it was found to be fairly acute. The margin is curled under to such an extent that it is almost impossible to determine the character of the teeth or crenulations, but they appear to be short and rather blunt. Another specimen (pl. 14, fig. 4) is fully

[15] Knowlton, F. H., U. S. Geol. Survey Bull. 204, p. 34, 1902.

[16] Hollick, Arthur, Fossil plants from Louisiana: Louisiana Geol. Survey Rept. for 1899, Special Rept. 5, p. 280, pl. 35, figs. 1, 2, 1899.

[17] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, 1916.

[18] Knowlton, F. H., U. S. Geol. Survey Mon. 32, pt. 2, p. 687, 1899.

[19] Knowlton, F. H., Flora of the Raton formation: U. S. Geol. Survey Prof. Paper 101, p. 293, pl. 112, fig. 4, 1917 [1918].

[20] Lesquereux, Leo, The Tertiary flora, p. 290, pl. 58, fig. 3, 1878.

[21] Ludwig, Rudolph, Palaeontographica, vol. 8, p. 178, pl. 70, figs. 11, 12, 1861.

7 centimeters long and about 3 centimeters wide and shows the apex to be rather long and slender. The base is destroyed, and the margin is very obscure though apparently only undulate. The third specimen (pl. 14, fig. 3) has the base preserved but lacks all of the apical portion; it was probably about 5.5 centimeters long and 1.75 centimeters wide. The margin is certainly entire at and near the base, but in the upper part it can not be determined. The best-preserved example (pl. 14, fig. 2) shows a terminal leaflet and a lateral leaflet in place. The terminal leaflet was probably about 10.5 or 11 centimeters long and 7 centimeters wide, and the lateral leaflet must have been about 7 centimeters long and 2.5 centimeters wide. The margin in both leaflets is so much turned under (whence the specific name *retusa*) that it is very difficult to determine whether or not there were teeth, though the margin was probably crenulate, as Lesquereux states. The nervation consists of a very strong midrib and numerous, mainly alternate, irregularly spaced secondaries that arise at a very low angle, curve upward more or less, and are apparently craspedodrome. The nervilles are strong, are mainly at right angles to the secondaries, and produce a distinctly rugose appearance.

It is doubtful if these leaves are correctly referred to the genus *Pterocarya*. They have much more the appearance of being leaflets of a *Juglans*; in fact, on Lesquereux's original label with one of the specimens it was placed in *Juglans*, but later it was referred to *Pterocarya*. The resemblance to *Pterocarya americana* Lesquereux is shown by the lateral leaflet and not by the terminal one, which is, of course, very different. On the whole it would probably be better to place this form in the genus *Juglans*, but as so many features are obscure it has been retained as left by its author, simply questioning the generic reference.

Occurrence: Denver formation, South Table Mountain, Golden, Colo., collected by Arthur Lakes. Types in Museum of Comparative Zoology, Cambridge, Mass., Nos. 414, 1558, 1559, and 1561.

Order FAGALES

Family BETULACEAE

Alnus carpinifolia Lesquereux

Plate 15, Figure 2

Alnus carpinifolia Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 45, 1888.

Leaves comparatively small, ovate-acute, narrowed and abruptly short-decurving to the petiole, entire to the middle, denticulate above; lateral nerves equidistant, the lower pair much branching, all parallel, at an acute angle of divergence, craspedodrome.

The relation of this leaf is with that of *Alnus cycladum* Unger,[22] differing essentially by the base, which is rounded and abruptly turned down to the petiole. The lower lateral nerves are joined to the midrib a little above the base of the leaf.

Occurrence: Denver formation, South Table Mountain, Golden, Colo., collected by Arthur Lakes. Type in Museum of Comparative Zoology, Cambridge, Mass., No. 1056.

Alnus auraria Knowlton and Cockerell

Plate 15, Figure 6

Alnus auraria Knowlton and Cockerell, U. S. Geol. Survey Bull. 696, p. 63, 1919.

Alnus rugosa Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 45, 1888. [Homonym, Koch, 1872.]

Lesquereux's description reads as follows:

Leaves membranous [membranaceous], elliptic-ovate, narrowed to the base, undulate on the borders, pinnately nerved; lateral nerves equidistant, parallel, straight, craspedodrome, with few branches; surface rugose. The leaves are about of the same size as those of *Alnus nostratum* Unger,[23] and the nervation is of the same type, but the leaves are narrowed, not rounded to the base.

This species was based on two specimens, the best preserved of which is here figured. It must have been about 10 centimeters long (the apex is wanting) and is a little over 5.5 centimeters broad. It has a very strong midrib, especially below, and six or seven pairs of alternate secondaries. The lowest pair of secondaries are very thin and run for only a short distance, but the next pair are strong and have several branches on the outside. The secondaries and their branches are all craspedodrome, ending in the margin, which is in places slightly undulate-toothed.

Occurrence: Denver formation, South Table Mountain, Golden, Colo., collected by Arthur Lakes. Types in Museum of Comparative Zoology, Cambridge, Mass., No. 1057.

Betula schimperi Lesquereux

Plate 15, Figures 3, 4

Betula schimperi Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 45, 1888.

Described by Lesquereux as follows:

Leaves small, as broad as long, round or subcordate at base; ovate, acute, simply or doubly dentate; lateral nerves thick, five pairs, the three lower opposite, the lowest more or less branching outside, all craspedodrome, as well as the divisions, entering the larger teeth directly when simple, and the intermediate short ones by branches; curved in traversing the areas at a broad angle of divergence. The leaves measure 2 to 3 centimeters across, both ways, and are deltoid-acute at the apex. The teeth, like the veins, are somewhat distant, turned outside, sharply pointed, triangular. The base of the median nerve is pressed into the stone, and thus the leaves appear subcordate; but the base is really rounded and abruptly turned down to the pedicel [petiole]. The surface is rugose by the deep impression of the nerves and the nervilles, these being

[22] Unger, Franz, Die fossile Flora von Kumi, p. 23, pl. 3, fig. 19, 1867.

[23] Unger, Franz, Chloris Protogaea, pl. 34, fig. 1, 1847.

simple or branching in the middle. The relation of this species is with *Betula angulata* Göppert.[24]

This species is represented by two specimens, both of which are figured. It appears to be a good species and has been well described by Lesquereux.

Occurrence: Denver formation, South Table Mountain, Golden, Colo., collected by Arthur Lakes. Types in Museum of Comparative Zoology, Cambridge, Mass., Nos. 1035, 1036.

Betula gracilis? Ludwig

Betula gracilis Ludwig, Palaeontographica, vol. 8, p. 99, pl. 32, figs. 3–6, 1861.

Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, pp. 380, 397, 1874; The Tertiary flora, p. 138, pl. 17, fig. 20, 1878.

The only specimen upon which the presence of this European species in American strata depends is in the United States National Museum (No. 158). It is a small, poorly preserved leaf, and its identification is, as Lesquereux indicated, open to grave doubt. It does resemble *Betula* somewhat but is too imperfect to be of much value.

Occurrence: Denver formation, Golden, Colo.

Betula fallax Lesquereux

Plate 15, Figures 7–10; Plate 16, Figures 1, 2

Betula fallax Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 45, 1888.

Lesquereux's original description and discussion are as follows:

> Leaves rhomboidal-ovate, cuneate to the base and narrowed in the same degree from the middle to the apex, penninerved; lower pair of secondaries attached to the midrib above the base of the leaves and opposite, the others, five to six pairs, parallel, at variable distance, at an acute angle of divergence, somewhat curved in passing toward the borders; border distantly dentate in the upper part of the leaves, the teeth short and turned up, being marked only at the apices of the lateral nerves, which are most simple, the lower ones only with few branches.
>
> The species resembles *Betula nigra* Linné in the form of the leaves. The leaves vary from 3.5 to 5.5 centimeters in length; from 2.5 to 3.5 centimeters in width in the middle. The angle of divergence of the nerves is only 30°, and therefore the leaves are only dentate in the upper part, at the points entered by the secondaries.

This species, according to Lesquereux, is represented by no less than 32 specimens in the Harvard College Museum of Comparative Zoology. I have studied all this material and have selected six specimens to be figured, the remainder being largely fragmentary. There is so considerable a range in the appearance of these types as almost to lead to the conclusion that they can not be conspecific. For example, take the question of size. Lesquereux gives the length as being between 3.5 and 5.5 centimeters, but in the specimen shown in Plate 16, Figure 1, the length is little less than 8 centimeters. The width is said to be between 2.5 and 3.5 centimeters, but the width of the specimen in Plate 16, Figure 7, is fully 4 centimeters. In the marginal toothing there is also considerable range. Thus, in most of the specimens the teeth are small and obscure, but in Plate 15, Figure 9, the teeth are all relatively large and oaklike. This particular specimen closely resembles certain of the leaves referred to *Crataegus betulaefolius* Lesquereux, from the same horizon, and is also suggestive of small leaves of *Quercus viburnifolia* Lesquereux.

Occurrence: Denver formation, South Table Mountatin, Golden, Colo., collected by Arthur Lakes. Types in Museum of Comparative Zoology, Cambridge, Mass., Nos. 1034, 1043, 1044, 1045, 1058, 1620.

Family FAGACEAE

Castanea intermedia? Lesquereux

Castanea intermedia Lesquereux, U. S. Geol. and Geog. Survey Terr. Bull., vol. 1, 2d ser., No. 5, p. 386, 1876; U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1874, p. 313, 1876; The Tertiary flora, p. 164, pl. 21, fig. 7, 1878.

Knowlton, U. S. Geol. Survey Prof. Paper 101, p. 297, pl. 68, fig. 2, 1917 [1918].

This species is said to have come from Middle Park, Colo., from beds thought to be of Green River age, but it apparently has not been since reported from that locality, and later knowledge of the geology of Middle Park makes it seem reasonably probable that it came from beds of Denver age. A single example referred to this species was reported from the Raton formation at Wootton, Colo., by me. It is a little larger and broader than the type but does not otherwise differ essentially.

In one of the small collections made near the Purdon mine there is a leaf that is most like the specimen figured in the Raton flora, but it differs slightly in being proportionately broader and less conspicuously toothed, though the margin is not very well preserved. The nervation is the same in both leaves.

Occurrence: Dawson arkose, a quarter of a mile east of Purdon mine, sec. 27, T. 11 S., R. 61 W., Colo., collected by G. B. Richardson, 1910.

Quercus viburnifolia Lesquereux

Plate 16, figures 3–8; Plate 17, Figure 1

Quercus viburnifolia Lesquereux, The Tertiary flora, p. 159, pl. 20, figs. 11, 12, 1878; U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1876, p. 505, 1878; Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 46, 1888.

Ettingshausen, Royal Soc. London Proc., vol. 30, p. 232, 1879–80.

Knowlton, Washington Acad. Sci. Proc., vol. 11, p. 207, 1909; U. S. Geol. Survey Prof. Paper 130, p. 127, 1922.

[24] Göppert, H. R., Tertiäre Flora von Schossnitz, p. 10, pl. 3, fig. 3, 1855.

Quercus triangularis Göppert [part]. Lesquereux, U. S. Geol. and Geog. Survey Terr. Rept. for 1872, p. 377, 1873.

Quercus attenuata? Göppert. Lesquereux, U. S. Geol. and Geog. Survey Terr. Rept. for 1873, p. 381, 1874.

Populus crenata Unger. Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 48, 1888.

Crataegus betulaefolia Lesquereux [part], Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 56, 1888.

Crataegus antiqua Heer. Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 57, 1888.

Leaves membranaceous, ovate or ovate-oblong, 3.5 to 9 centimeters long, 3 to 5.5 centimeters broad, broadest near or just below the middle, whence they are abruptly narrowed to the obtusely wedge-shaped base and above to the rather obtuse apex; margin entire below, sharply and somewhat irregularly toothed above; petiole slender; nervation pinnate, consisting of a rather slender, slightly irregular midrib and four or five pairs of slender subopposite or alternate secondaries, which end in the marginal teeth, lower secondaries often with several outside branches, craspedodrome; nervilles numerous, strong, about at right angles to the secondaries.

One of the figured types of this species—the original of Plate 20, Figure 11, in the report on the Tertiary flora—is preserved in the United States National Museum (No. 186), together with a number of others that were the basis of Lesquereux's discussion of this form. This type specimen was found on Sand Creek, about 15 miles east of Denver, Colo., in beds long supposed to be of Arapahoe age but now known with reasonable certainty to be in the Denver formation. Other specimens not figured that are in the Museum collection came from the andesitic beds at Golden, Colo., and the red-baked shale at Black Buttes, Wyo. In a later publication Lesquereux [25] recorded the presence of nearly a dozen examples from Golden. It has also been reported from beds of Denver age on Mount Bross, Middle Park, Colo.; from the Lance formation of Converse County, Wyo., and somewhat questionably from the true Laramie on Crow Creek east of Greeley, Colo.

In the Dawson arkose at Mosby, Colo., was found the specimen with its counterpart shown in Plate 16, Figure 5. It is intermediate in size between the two figured types as given by Lesquereux. It is about 6.5 centimeters long and a little over 5 centimeters wide. It is proportionately a little shorter than the larger of Lesquereux's types but otherwise agrees with it in all essential particulars.

Another specimen from the vicinity of Calhan is shown in Plate 17, Figure 1. It agrees very closely in size, shape, and marginal teeth with the larger of the figured types and differs only in having the nervation somewhat stronger, though of the same disposition.

Lesquereux [26] established *Crataegus betulaefolia* on specimens from Golden, Colo., in the Harvard College Museum of Comparative Zoology. I have examined most of them and am unable to draw any line of separation except in size between these and *Quercus viburnifolia* Lesquereux.[27] The two types of *Quercus viburnifolia* are 4 and 9 centimeters long, and the range in size in the leaves of *Crataegus betulaefolia* is given as from 3.5 to 7 centimeters. On a single piece of matrix (Mus. Comp. Zoology No. 1631) there are four leaves, two of which are types of *Crataegus betulaefolia* and two were referred by Lesquereux himself to *Quercus viburnifolia;* all are here figured. Of course, close association on the matrix does not necessarily prove identity, but it does suggest that they came from the same vicinity and might well enough have come from the same tree.

Lesquereux states that his *Crataegus betulaefolia* is "trinervate from the base," but an examination of the specimens shows that the lowest secondaries are opposite and arise at a distance above the base of the blade, thus producing a sort of false trinervate appearance. This character is to be noted in both types of *Quercus viburnifolia* as well as in the specimens so identified by Lesquereux and in many others subsequently studied. In the wedge-shaped slightly decurrent base, sharp-toothed margin, and craspedodrome secondaries these leaves are all apparently conspecific and are combined under *Quercus viburnifolia.*

The specimens identified by Lesquereux [28] as *Crataegus antiqua* Heer and now in the Museum of Comparative Zoology (Nos. 1563, 1564) are also referred to *Quercus viburnifolia;* it has not been thought necessary to figure any of them.

In 1888 Lesquereux [29] also referred no less than 17 specimens from the Denver to *Populus crenata* Unger. I have now seen these specimens, though the present remarks are based on a single leaf (U. S. Nat. Mus. No. 51083) so identified by him in the Lacoe collection. This is a small leaf about 5 centimeters long and 3.5 centimeters wide and has the margin above the middle provided with few large sharp teeth. The secondaries number three or four pairs; the lowest pair arise just above the base of the blade and end in large teeth, and each has several branches on the outside. So far as I can determine, this leaf is not essentially different from the smaller of the two leaves fig-

[25] Lesquereux, Leo, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 46, 1888.

[26] Lesquereux, Leo, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 56, 1888.

[27] Lesquereux, Leo, The Tertiary flora, p. 159, pl. 20, fig. 11, 1878.

[28] Lesquereux, Leo, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 57, 1888.

[29] Idem, p. 48.

ured by Lesquereux [30] as the types of *Quercus viburnifolia*, though it has rather larger teeth and the upper secondaries at a slightly more acute angle. Whether all the specimens identified by Lesquereux as Unger's *Populus crenata* are referable to *Quercus viburnifolia* I am not now able to say.

Occurrence: Denver formation (type), Sand Creek, about 15 miles east of Denver, Colo., collected by A. R. Marvine in 1873; South Table Mountain, Golden, Colo., collected by Leo Lesquereux about 1872 and by Arthur Lakes in 1885. Middle Park formation, Mount Bross, Middle Park, Colo., collected by Whitman Cross. Dawson arkose, dump of Mosby coal mine, Mosby, El Paso County, Colo., collected by F. H. Knowlton and G. B. Richardson, July, 1910; Rice's clay pit, 1 mile southwest of Calhan, Colo., collected by F. H. Knowlton, 1910. Lance formation, gulch south of Lightning Creek, Converse County, Wyo., collected by T. W. Stanton, July, 1896. Black Buttes coal group, Black Buttes, Wyo. Laramie formation, ?Canfield ranch, about 25 miles northeast of Greeley, Colo., collected by T. W. Stanton and F. H. Knowlton, June, 1896.

Quercus? sedaliensis Knowlton, n. sp.

Plate 17, Figure 4

Leaf large, evidently of fine texture, broadly elliptical, apparently rounded or possibly obtusely wedge-shaped at the base and probably obtusely acuminate at the apex; margin undulate-toothed throughout, the teeth small, low, rounded, and separated by similar shallow sinuses; midrib very thick, especially below, perfectly straight; secondaries evidently 10 or 12 pairs, rather slender, alternate, somewhat curving upward, all unbranched and camptodrome.

This was a large leaf, probably not less than 15 centimeters in length and possibly longer, and the width in the middle is about 7 centimeters. Unfortunately, it lacks both base and apex, but, so far as can be made out, the shape was broadly elliptical and apparently abruptly rounded to the base, though it may have been obtusely wedge-shaped. The most marked character is the margin, which is provided with numerous small, rounded teeth that are separated by similar shallow sinuses.

This leaf is referred with hesitation to the genus *Quercus* solely on the ground of its evident resemblance to what has been called *Quercus haidingeri* Ettingshausen rather than the conviction that it actually belongs to this genus. Broadly considered its facies is hardly that of an oak, yet it seems fair to assume that if Ettingshausen's species is correctly referred this must also be correct; in any event it is so well characterized by its large size and peculiar margin that it can be easily recognized in the future.

As stated above, it is nearest to *Q. haidingeri*, from which it differs in its much larger size, thicker midrib, and evidently more rounded base. Additional examples, however, may show that the size and supposed difference in shape are not constant, and it may then be referred to Ettingshausen's species.

Occurrence: Dawson arkose, lower part (in beds equivalent to Arapahoe formation), 3,000 feet east of the Douglas coal mine, Sedalia, Colo.

Quercus purdonensis Knowlton, n. sp.

Plate 17, Figure 2

Leaf small, evidently thick and coriaceous, elliptical, rounded and entire below, strongly few-toothed above, the teeth relatively large, sharp-pointed, apparently bristle-tipped, apex acuminate; petiole stout; midrib very strong; secondaries four or five pairs, strongly alternate, at an angle of about 45°, craspedodrome, ending in the marginal teeth; finer nervation not well preserved.

This little leaf is nearly perfect and is the only one noted in the collections. It is 3 centimeters long and a little less than 2 centimeters wide. It is remarkable for the large, sharp-pointed teeth.

This species is of the type of a number of species living at the present time in the Rocky Mountain and Pacific coast regions, being not greatly unlike small leaves of *Quercus engelmanni* Greene, *Quercus chrysolepis* Liebmann, or *Quercus wislizeni* A. de Candolle.

Occurrence: Dawson arkose, a quarter of a mile east of the Purdon mine, sec. 27, T. 11 S., R. 61 W., Colo., collected by G. B. Richardson.

Quercus whitmani Knowlton, n. sp.

Plate 17, Figure 5

Leaf relatively large, evidently coriaceous, rather broadly lanceolate, wedge-shaped at the base, apparently rather narrowly acuminate at the apex; margin obscurely toothed, the teeth remote, very low, the sinuses very shallow; midrib fairly strong, straight; secondaries about 10 pairs, alternate below, subopposite above, slightly curved upward, occasionally forked, the lower ones camptodrome, arching along the margin and sending nervilles from the outside to the marginal teeth, upper secondaries craspedodrome, entering the teeth; nervilles numerous, strong, mainly percurrent, approximately at right angles to the secondaries.

It is with some hesitation that this species has been described as new. It is not a perfect specimen, lacking both base and apex and a considerable portion of one side. So far as can be determined, it must have been about 15 centimeters in length and about 6 centi-

[30] Lesquereux, Leo, The Tertiary flora, pl. 20, fig. 12, 1878.

meters in width. The margin can be made out in several places and shows the teeth to be very low and the sinuses correspondingly shallow. One or two of the teeth appear to have been spinescent or possibly bristle-tipped, and if this appearance has been correctly interpreted it is probable that all the teeth were thus terminated. The strong nervation is well shown in the figure.

In some respects the present leaf is similar to what is described above as *Quercus sedaliensis* Knowlton, but it differs in a number of minor particulars. Thus, the teeth are of a different character, the secondaries are less numerous, and the finer nervation is much more broken up.

Quercus whitmani is also in a way suggestive of *Quercus paucidentata* Newberry,[31] from the upper part of the Clarno formation at Bridge Creek, Oreg. The Oregon leaf is slightly smaller than the one under consideration and moreover has the teeth aggregated in the upper part of the leaf.

Occurrence: Middle Park formation, Middle Park, Grand County, Colo., from high terrace ridge between forks of Kinney Creek, in the "breccia spoon," east of Hot Sulphur Springs, collected by Whitman Cross, October, 1891.

Quercus whitei Lesquereux

Plate 17, Figure 3; Plate 18, Figure 1

Quercus whitei Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 46, 1888.

Leaves of medium size, membranous [membranaceous], ovate-lanceolate, cuneiform to the base, short-petioled, regularly more or less deeply dentate; secondaries straight, oblique, equidistant, simple, parallel, each entering one of the teeth, which are gibbous on the back. The secondaries at an angle of 40° are straight, the upper ones only slightly curved. The teeth, short upon some leaves, as long as 0.5 centimeter upon others, are always distant and bossed on the back. The leaves average 7 centimeters long and 4 centimeters broad in the middle.

This fine species is closely allied to *Quercus etymodrys* Massalongo,[32] especially with the variety described as *castellinensis* by Capellini.[33] It is also allied to *Quercus furcinervis* Rossmassler, differing from both by the subdentate or umbonate teeth.

Two of the best preserved of the types of this species are here figured. The one shown in Plate 18, Figure 1, was nearly half concealed in the matrix, but on removing this it is found to be nearly perfect. It is broadly ovate-lanceolate, with a very obtusely wedge-shaped base and an acuminate apex. The margin is entire for about one-fourth the length of the blade and thence provided with large obtuse teeth. The midrib is relatively strong, with about five pairs of subopposite secondaries. This leaf is about 7.5 centimeters long and nearly 4 centimeters broad.

Occurrence: Denver formation, Golden, Colo., collected by Arthur Lakes, 1883, for the Museum of Comparative Zoology, Cambridge, Mass., types Nos. 1072, 1056, 1628.

Quercus leonis Knowlton, n. sp.

Plate 18, Figures 2, 3.

Quercus haidingeri Ettingshausen. Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 46, 1888.

Two specimens from Golden were referred by Lesquereux to this species without comment. The best preserved of these is shown in Plate 18, Figure 2, and is a leaf that must have been about 9 centimeters long when perfect, but it now lacks practically all of the margin except for the length of about 1 centimeter near the middle. The margin here is seen to be distinctly toothed, the teeth low, sharp-pointed, and regular. The nervation consists of a slender straight midrib and some 8 or 10 pairs of very slender secondaries that are at irregular distances and much curved upward and apparently camptodrome. The finer nervation is not preserved.

In shape and size the leaf here figured resembles the smaller of the two leaves figured by Lesquereux[34] under the name *Quercus haidingeri* Ettingshausen, but it differs strongly in the secondary nervation. The leaf originally figured by Ettingshausen from the Miocene of Austria is narrower than either of the leaves figured or identified by Lesquereux and has sharp, upward-pointing teeth, whereas the American leaves have the margin closely serrate with the teeth outward-pointing.

There is another complication regarding the leaves figured in the report on the Tertiary flora. When they were first mentioned[35] they were said to have come from Green River, Wyo., but subsequently they were vaguely thought to have come from the Denver at Golden, Colo. They are certainly not the same as the European type of this species and considering the uncertainty of their locality are of little value.

The leaf from Golden under discussion that was identified by Lesquereux as *Quercus haidingeri* Ettingshausen is not identical with the European type, nor is it the same as the American leaves discussed above. It seems best, therefore, to give it a new name, especially as it appears to be different from anything previously noted.

Occurrence: Denver formation, Golden, Colo., collected by Arthur Lakes. Type in Museum of Com-

[31] Newberry, J. S., U. S. Geol. Survey Mon. 35, pl. 43, fig. 1, 1898.

[32] Massalongo, A. B., Synopsis flora fossilis Senegalliensis, p. 26, 1858.

[33] Capellini, T. F. G., La formazione gessosa di Castellina, p. 572, pl. 5, fig. 1, 1874.

[34] Lesquereux, Leo, The Tertiary flora, pl. 20, fig. 9, 1878.

[35] U. S. Geol. and Geog. Survey Terr. Bull., vol. 1, p. 387, 1875 [1876].

parative Zoology, Cambridge, Mass., No. 1625; one in United States National Museum, No. 1278.

Quercus celastrifolia Lesquereux

Plate 18, Figures 4–7

Quercus celastrifolia Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 46, 1888.
Quercus stramineus? Lesquereux. Lesquereux, op. cit., p. 46.

Lesquereux's description and remarks concerning this species are as follows:

Leaves subcoriaceous, oval, equally narrowed at both ends, obtusely pointed; secondaries very oblique, distant, parallel from the base, curving in passing toward the borders, ascending along them, nearly simple, passing upward under the teeth and joining them by short branches. The teeth are acute, turned upward, one at the end of each of the secondaries, which are subopposite in five or six pairs; nervilles thin, at right angles to the median nerve, except near the borders, where they turn upward like thin tertiary nerves. The leaves are 5 to 6 centimeters long, 3 to 3.5 centimeters broad; the angle of divergence 30° to 35°.

This species is based on four specimens, all of which are here figured. The best-preserved one is shown in Figure 6 and is nearly perfect. It is slightly more than 5.5 centimeters long and 3.5 centimeters wide. It is entire for the lower third and thence provided with few low, apparently spine-tipped teeth separated by very shallow sinuses. There are five pairs of nearly opposite secondaries at an angle of about 60°, which end in marginal teeth. The specimen shown in Figure 7 is nearly 6 centimeters long and fully 3.5 centimeters wide. It has the lower secondaries branched but does not otherwise differ from the one just described. The smallest specimen, Figure 5, is but little more than 4 centimeters long and about 3 centimeters wide; it shows the base well preserved.

A single small leaf from Golden that was referred by Lesquereux [36] with question to *Quercus stramineus* Lesquereux is shown in Figure 4. He says of it:

The leaf which I refer to this species is oval, apparently denticulate near the apex, and narrower than those figured in the United States Geological Survey of the Territories [Tertiary flora], VII, Plate 19, Figures 6, 7. It may therefore belong to a different species.

On comparing this leaf with the types of *Quercus celastrifolia* I am unable to note any essential difference. It is smaller, being only about 4.5 centimeters long and 2.5 centimeters wide, but has the same low, sharp teeth and the same kind of nervation.

The type locality of *Quercus stramineus* is in the Laramie formation at Golden, Colo., and so far as known it has not been found at any other horizon.

[36] Lesquereux, Leo, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 46, 1888.

Occurrence: Denver formation, Golden, Colo., collected by Arthur Lakes about 1883 for the Museum of Comparative Zoology, Cambridge, Mass.; types, Nos. 1071, 1075, 1626.

Quercus coloradensis Lesquereux

Quercus coloradensis Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 46, 1888.

Leaves subcoriaceous, entire, oblong, obtuse, rounded at the base, abruptly decurring in joining [to join] the petiole (broken); secondaries five to six pairs, at an acute angle of divergence, camptodrome, the lower ones branching, all connected by distant though thin nervilles and running high up along the borders, which are parallel in the middle.

By the size and form of the leaves—5 to 6 centimeters long, 3 to 4 centimeters broad in the middle, where they are somewhat contracted—the species is related to *Quercus oreadum* Saporta.[37]

This species is based on two examples supposed to be in the Harvard College Museum of Comparative Zoology, but only one has been located, and this is so fragmentary that it was not thought worth figuring.

Occurrence: Denver formation, Golden, Colo., collected by Arthur Lakes in 1883 for the Museum of Comparative Zoology, Cambridge, Mass.

Order SALICALES

Family SALICACEAE

Populus zeilleri (Lesquereux) Knowlton, n. comb.

Plate 18, Figure 8; Plate 19, Figures 1–3

Protoficus zeilleri Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 50, 1888.

Following is Lesquereux's original description and discussion:

Leaves of medium size, coriaceous, rugose on the surface, enlarged and round-cordate at base, deltoid at the acute apex, palmately 3-nerved to 5-nerved from the top of the petiole; lateral nerves much branched; borders crenulate. The leaves, deeply rugose by the impression of strong nervilles, are 6 to 7 centimeters long, 5 to 5.5 centimeters broad below the middle; primary nerves three or more, generally five, the lower at a broad angle of divergence, following the borders, the inner ascending in a curve somewhat inclined to the midrib; secondaries two or three pairs at a great distance from the base. The borders, mostly destroyed, are seen crenulate at the few places where they are preserved.

This species was based on five specimens, all of which are before me and four of which are here figured. Three of these specimens are undoubtedly conspecific, but the other (pl. 19, fig. 1) is less certainly so. Lesquereux states that the leaves are "palmately 3-nerved to 5-nerved from the top of the petiole," but

[37] Saporta, Gaston de, Flora de Cumi: École normale supérieure Annales sci., 2d ser., vol. 2, p. 337, pl. 2, fig. 11, 1873.

a glance at the four specimens above mentioned shows that they are essentially 3-ribbed, with a strong, straight midrib and a single pair of nearly as strong lateral ribs that curve upward and nearly parallel the midrib, each with secondary branches on the outside, the lowest arising near the top of the petiole and thus producing a sort of false 5-ribbed appearance. In the fourth specimen, however (pl. 19, fig. 1), there are five distinct ribs, the lowest with three or four secondary branches on the outside. The inner pair of ribs do not parallel the midrib, like the others, and their secondary branches, four or five in number, arise some distance above the base.

The margin in all these leaves is very obscurely preserved. It is described by Lesquereux as undulate or crenate, but in most cases its character is extremely difficult to determine. In one specimen (pl. 19, fig. 1), which happens to be the anomalous one above mentioned, the margin is provided with scattered low teeth which are entered by the secondaries or by nervilles from them. The only other example in which the teeth are preserved is that shown in Plate 18, Figure 8, and in this only for a short distance just above the base; the teeth seem to be more rounded than in the other one mentioned.

The question of the generic reference for these leaves may be considered. The genus *Protoficus* was established by Saporta[38] on four species from the travertines of Sézanne, the type apparently being *Protoficus sezannensis* (Watelet) Saporta (*Ficus sezannensis* Watelet). This a large, broadly oblong leaf with entire margins. It is evidently wedge-shaped at the base and pinnate, with an extremely strong midrib and numerous mainly alternate secondaries which emerge nearly at a right angle.

A second species, *Protoficus insignis* Saporta, is of the same type as *Protoficus sezannensis*, from which it differs in its more oval shape and upward-curving secondaries.

A third species, *Protoficus crenulata* Saporta, is greatly different and can hardly be congeneric with the others, being ovate with a finely crenulate margin and 3-ribbed from the top of the petiole. It was evidently this species that Lesquereux had in mind when he referred the Golden leaves to *Protoficus*, but these leaves differ so widely from the French species that they can not possibly be congeneric. In *Protoficus crenulata* the lateral ribs arise at an angle of about 45° and pass with very little upward curving to the border, being together with the secondary branches distinctly camptodrome, whereas the Golden leaves have the ribs arising at a more acute angle and curve abruptly upward to parallel the midrib, ending, as to the secondary and tertiary branches, in the margin. These Golden leaves are of course totally unlike the type of *Protoficus*.

The question next arises as to the generic reference of the leaves described by Lesquereux as *Protoficus zeilleri*. In size, shape, margin, and particularly in the manner in which the lateral ribs curve upward and parallel the midrib, they are at once suggestive of certain Tertiary species of *Populus*, such as *Populus speciosa* Ward,[39] *P. nebrascensis* Newberry,[40] and *P. smilacifolia* Newberry,[41] all from the Fort Union formation. In fact, I do not see how they can be separated from the genus *Populus*, nor is it apparent how they can be adequately distinguished from the type leaves of *Populus nebrascensis*. However, as the margin is so obscurely preserved in the leaves under consideration it may be as well to refer them to *Populus* but let the species stand under Lesquereux's name.

Comparison has been made with the genera *Grewia*, *Grewiopsis*, *Ficus*, *Zizyphus*, *Smilax*, etc., and although there are certain points of resemblance with all these genera the Golden leaves differ in some essential manner.

Occurrence: Denver formation, South Table Mountain, Golden, Colo., collected by Arthur Lakes. Types in Museum of Comparative Zoology, Cambridge, Mass., Nos. 1671, 1672, 1674, 1675.

Populus nebrascensis Newberry

Populus nebrascensis Newberry, New York Lyceum Nat. Hist. Annals, vol. 9, p. 62, 1868; Illustrations of Cretaceous and Tertiary plants, pl. 12, figs. 4, 5, 1878; U. S. Geol Survey Mon. 35, p. 47, pl. 27, figs. 4, 5, 1898.

Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol 16, p. 47, 1888.

Populus crenata Unger. Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 48. 1888.

Following is Newberry's original description:

Leaves long-petioled, 2 to 3 inches long, ovate, pointed, regularly rounded at base, coarsely and irregularly toothed except near the base, where the margins are entire; nervation strong, radiating from the base of the leaf; medial nerve straight, simple (or supporting very small nerves), except near the summit, where two or three larger branches arise from it; lateral nerves, two pairs on each side, springing from a common point of origin; lower pair arched upward, nearly parallel with the margin of the leaf, to which they send off one or more simple branches; second pair of laterals diverging from these at an angle of 30°, arching upward, and parallel with the midrib, terminating in the margin near the summit, each giving off about three exterior branches, which curve upward and terminate in the dentations of the border.

[38] Saporta, Gaston de, Prodrome d'une flore fossile des travertins anciens de Sézanne: Soc. géol. France Mém., 2d ser., vol. 7, p. 355 (67), 1868.

[39] Ward, L. F., Synopsis of the flora of the Laramie group: U. S. Geol. Survey Sixth Ann. Rept., p. 550, pl. 34, figs. 1–4, 1885.

[40] Newberry, J. S., The later extinct floras of North America: U. S. Geol. Survey Mon. 35, p. 47, pl. 27, figs. 4, 5, 1898.

[41] Idem, pl. 29, fig. 5.

This is one of the most abundant and widely distributed Fort Union species and has been well described and figured by Newberry. Curiously enough, this species is extremely rare, or rather extremely local, in its occurrence in the Denver formation; in fact, it has been found at only a single locality, though from this place about 300 specimens of it were procured. Although excavations were made only a few rods away, not a single specimen of it has been found among the many thousands that have been collected. This seems to prove, as Lesquereux has pointed out, that the leaves were not transported from any distance but, as he says, had "fallen from trees either around woody swamps or on the borders of shallow lakes."

From the fact that only a single very circumscribed locality in the Denver Basin has thus far been noted for these leaves it seems a reasonable inference that they all came from a single tree or at most a small clump of trees and presumably represent a single species. There is so much diversity to be noted in these leaves, however, that Lesquereux has seen fit to divide them up into a number of varieties, some of which are indeed so different from what may be called the typical form that had they been found at different localities and horizons they would probably have been designated as full species.

Lesquereux's names and descriptions of these varieties[42] are given below. None of them have previously been figured.

Populus nebrascensis var. grandidentata Lesquereux

Plate 19, Figures 4–7; Plate 20, Figures 2, 6, 7

Leaves broader, rounded, and undulate toward the base; borders cut from the middle upward in large deltoid obtuse gradually longer teeth. Some of the leaves are subtruncate at apex with long irregular teeth; others are rapidly narrowed to an obtuse apex. The nervation is the same in the varieties as in the normal form, 3 to 5 palmate from the base, with the inner pair of primary nerves curved inward and ascending to near the apexes and the secondary ones at a great distance from the base.

This form was represented by 85 specimens in the collection studied by Lesquereux for the Harvard College Museum of Comparative Zoology. The National Museum possesses about a dozen specimens in the Lacoe collection, obtained by Arthur Lakes at the same locality. Two nearly perfect specimens have been figured. The larger one is fully 11 centimeters long and a little over 8 centimeters wide. It is rounded and nearly truncate at the base and has the margin cut above into numerous large irregular teeth. The nervation is very strongly marked, especially the midrib and the inner pair of secondaries or ribs. On one side there are two strong secondaries springing from near the top of the petiole, thus making the leaf in effect 6-ribbed. Another example figured is considerably smaller, being only about 7.5 centimeters long and 7 centimeters wide; it has fewer but relatively larger teeth and is 5-ribbed from the top of the petiole.

Populus nebrascensis var. rotundata Lesquereux

Plate 20, Figures 1, 3, 4, 5, 8

Much like the preceding, differing by its broader leaves broadly rounded and enlarged at the base.

This was represented by 48 specimens in the collection studied by Lesquereux and by two specimens, both of which are figured, in the National Museum. The smaller specimen (fig. 1) is 5 centimeters long and 5.5 centimeters wide and has the petiole preserved for a length of 4.5 centimeters; it has rather few small sharper-pointed teeth. The other specimen (fig. 8) is about 7 centimeters long and 6.5 centimeters wide. It is nearly circular and has rather small sharp teeth.

Three additional examples from the original collection in the Harvard College Museum of Comparative Zoology are also figured.

Populus nebrascensis var. acutidentata Lesquereux

Plate 21, Figures 1, 2

Leaves oval, narrowed at base, lanceolate above, generally palmately trinerved, teeth of the borders large, equal, sharply pointed.

This form is represented by 13 specimens in the original collection now in the Harvard College Museum of Comparative Zoology but was not noted in the National Museum material. Two of the best preserved of the types are figured. Both are large leaves, the one shown in Figure 1 being about 8.5 centimeters long and 7 centimeters wide. It is nearly entire for the lower third and thence cut into large, equal, sharp teeth. The nervation does not differ from that of the other forms. The other specimen (fig. 2) is about 8 centimeters long and a little over 5 centimeters wide; it has the same large, sharp teeth.

Populus nebrascensis var. longifolia Lesquereux

Plate 21, Figures 3–5

Leaves large, oblong-ovate, rounded at base, 5-nerved; lateral primary nerves ascending to above the middle; second curved inside, much branching; secondary nerves three or four pairs, at a great distance from the base, camptodrome or craspedodrome, with their divisions effaced at the borders, which are cut in obtuse large teeth. The leaves are long, lanceolate from below the middle, 7.5 to 11 centimeters long, 4 to 7 centimeters broad below the middle; the teeth are large, round, equal, marked from near the base; the petiole is long and slender.

[42] Lesquereux, Leo, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, pp. 47, 48, 1888.

This form, according to Lesquereux, is represented by 13 specimens in the collections of the Museum of Comparative Zoology, three of which are here figured. The one shown in Figure 5 is broadly ovate, 7.5 centimeters long and a little over 6 centimeters wide below the middle. It is a little prolonged above and has the marginal teeth large, regular, and rather obtuse. With a base of much the same shape but with the upper portion more elongated is the leaf shown in Figure 4, which is 8.5 centimeters long and less than 6 centimeters broad; it has very few teeth. The other specimen, shown in Figure 3, is a very narrow leaf 7.5 centimeters long and only about 4 centimeters wide; it also has few teeth.

Lesquereux referred a number of leaves, in the collection studied by him for the Harvard College Museum of Comparative Zoology, to *Populus crenata* Unger,[43] from the Miocene of Sotzka. On comparing the original figures of this species with the leaves from Golden it is seen that they agree somewhat as to size and outline but differ absolutely in nervation. *Populus crenata* is distinctly pinnate, but the leaves under consideration from Golden are distinctly palmate and 3-ribbed from the top of the petiole. So far as I can determine they are referable to *Populus nebrascensis*.

In 1888 Lesquereux[44] established *Cissus duplicato-serrata* on some seven specimens from Golden, Colo., in the Museum of Comparative Zoology. After characterizing the species he stated:

> The leaves are referable to *Cissus*, though they have a degree of affinity with some varieties of *Populus nebrascensis* Newberry. They differ essentially by the primary lateral nerves not incurved, much branched, all the divisions craspedodrome, the teeth acute, the substance of the leaves thick.

I have studied these specimens carefully and am at a loss to find any essential character by which they can be separated from certain of the forms of *Populus nebrascensis*. The type specimens of *Cissus duplicato-serrata* are all fairly well preserved, so there is little difficulty in comparing their characters. Four of the best have been figured. In regard to shape and size they have, it may be seen, the same appearance as *Populus nebrascensis*—that is, they fall easily within the limits of one or another of the forms of this species. The absence of incurving in the primary lateral nerves is not more marked than in many leaves of *Populus nebrascensis*, nor is the secondary branching of these ribs more marked.

Of the four figured types of *Cissus duplicato-serrata*, the one shown in Plate 20, Figure 2, is referred to *Populus nebrascensis grandidentata*, and the others (pl. 20, figs. 3–5) are referred to *Populus nebrascensis rotundata*.

At least two of the specimens identified by Lesquereux[45] as *Cissus parrottiaefolia* Lesquereux, from Golden, Colo, are also referred to *Populus nebrascensis rotundata*. They are small leaves that do not otherwise differ from this form.

Occurrence: Fort Union formation, mouth of Yellowstone River (type locality). Denver formation, South Table Mountain, Golden, Colo., collected by Arthur Lakes; a few specimens in the Lacoe collection, now in the United States National Museum, and a large number in the Museum of Comparative Zoology, Cambridge, Mass. The specimens figured are all from the Denver formation and are as follows: *Populus nebrascensis* var. *rotundata*, Nos. 1219, 1223, 1226; var. *acutidentata*, Nos. 1210, 1262; var. *longifolia*, Nos. 1239, 1244, 1245. Types of *Cissus duplicato-serrata* Lesquereux=*P. nebrascensis rotundata* (Nos. 1498, 1499, 1505) and *P. nebrascensis grandidentata* (No. 1683).

Populus? sp.

Plate 21, Figure 9

Populus attenuata Al. Braun. Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 48, 1888.

Leaf very thick and coriaceous, broadly elliptical or broadly ovate, apparently truncate at the base, truncate at the apex; margin with about seven large, low, rounded teeth or lobes separated by shallow sinuses; 5-ribbed from the base, the midrib very strong below, much more slender above, with a single pair of secondary branches; next (inner) pair of ribs very strong, at an angle of about 50°, straight, ending in marginal lobes, each with several slender secondary branches; lower (outer) ribs strong, at an angle of about 35°, perfectly straight, craspedodrome; nervilles numerous, light, forming large rectangular areas.

Lesquereux identified two leaves in the Harvard College Museum of Comparative Zoology as *Populus attenuata* Al. Braun, the one here figured and another which is totally different and belongs with what he called *Cissus duplicato-dentata*. The present specimen is fragmentary in that it lacks all of the basal portion. It was evidently a very thick leaf, with five extremely strong, straight ribs apparently from the top of the petiole. It appears to have been about 4.5 centimeters long and 5.5 centimeters or more broad. It has only a few broad, low, rounded lobes, each of

[43] Unger, Franz, Fossile Flora von Sotzka, p. 36 (166), pl. 15 (36), figs. 2–5, 1851.

[44] Lesquereux, Leo, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 52, 1888.

[45] Idem, p. 52.

which is entered by a rib or a secondary branch from a rib.

Populus attenuata Al. Braun, with which this was identified by Lesquereux, is a common and widely distributed species in the European Miocene—for instance, in the Swiss Miocene. Heer [46] has figured more than 20 specimens in his Swiss flora. Although there is considerable range in variation, some of them somewhat resemble the present specimen in the shape of the upper portion, though the marginal teeth are small and numerous, but they differ absolutely in nervation. *Populus attenuata* is essentially pinnate, though in some specimens the lowest pair of secondaries is somewhat strengthened and produces a pseudo 3-ribbed aspect. The present leaf, however, is distinctly palmately 5-ribbed from the top of the petiole, and all the ribs are distinctly craspedodrome, instead of being largely camptodrome, as in *P. attenuata*. It can not possibly be referred to *P. attenuata*, and there is much doubt as to its even belonging to *Populus*. It suggests certain forms of *Hedera*, but as it is so fragmentary that its full character can not be made out it is permitted to remain with question in *Populus*.

Occurrence: Denver formation, South Table Mountain, Golden, Colo., collected by Arthur Lakes. Type, originally under the name *Populus attenuata* Al. Braun, in the Museum of Comparative Zoology, Cambridge, Mass., No. 1286.

Populus jacksoni Knowlton, n. sp.

Plate 21, Figures 6–8; Plate 22, Figure 7

Populus arctica Heer. Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 47, 1888.

Leaves coriaceous, small, nearly circular or broadly ovate, truncate or slightly heart-shaped at the base, rounded or obtusely pointed at the apex; margin from nearly entire to crenulate or fairly well toothed, the teeth obtuse; petiole long and slender; 5-nerved from the base, midrib with two or three secondary branches in the extreme upper part, next pair of ribs arching inward and reaching the margin near the apex, usually with several outside branches; outer ribs slender, those and all branches craspedodrome; nervilles numerous, very strong.

This species, under the name *Populus arctica* Heer, is said by Lesquereux to be represented in the Harvard College Museum of Comparative Zoology by 15 specimens. Of these, four have been selected to show the range in size, marginal configuration, and nervation. They are all small leaves from 2 to 4 centimeters in length and about the same in width. The petiole, preserved in only one specimen, was at least 2 centimeters long and very slender.

[46] Heer, Oswald, Flora tertiaria Helvetiae, vol. 2, p. 15, pl. 57, figs. 8–12, 1856.

This species is undoubtedly closely related to—indeed, possibly identical with—certain leaves that have been referred to *Populus arctica* Heer. For example, Lesquereux [47] stated that except that these leaves

> are generally more distinctly crenulate, nothing in the characters indicates a difference from those which I have figured in United States Geological Survey of the Territories [Tertiary flora], Plate 23, Figures 1–6, or of those in Heer, Flora fossilis arctica, vol. 1, pl. 4, fig. 6a.

Examination of the specimens figured by Lesquereux shows that there is very considerable diversity in size, shape, and nervation, and it has been necessary to separate them into two and possibly three species; moreover, it is to be doubted if any should be regarded as true *Populus arctica*. The present species seems to me to be abundantly distinct from any figured by Lesquereux as *Populus arctica;* in fact, it is much closer to certain leaves of *Populus decipiens* Lesquereux [48] (now called *P. arctica decipiens* by Cockerell), except that the latter has the leaves always entire and more wedge-shaped at the base.

Populus jacksoni is suggestive of certain very small leaves of *Populus arctica*, such as that shown in Heer's Plate 4, Figure 6a (Flora fossilis arctica), but from the ordinary leaves of this species, such as shown by Heer on his Plate 5, there is marked divergence.

Populus arctica was described originally from the Miocene of Greenland and has since been found to be very widely distributed throughout the Arctic lands. It is especially abundant in the Kenai formation of Alaska and has been reported from the Eocene of Canada and the Fort Union and Lance formations of Montana and Wyoming. It is probable, however, that when all this material is critically studied more than one species will be found confused under this name.

I take pleasure in naming this species in honor of Dr. Robert T. Jackson, of Harvard University, who, as custodian of the fossil plant collections, has generously placed this Golden material at my disposal.

Occurrence: Denver formation, South Table Mountain, Golden, Colo., collected by Arthur Lakes. Types in the Museum of Comparative Zoology, Cambridge, Mass., Nos. 1077, 1083, 1084, 1085, 1441.

Populus tenuinervata Lesquereux

Plate 22, Figures 1–4, 6

Populus tenuinervata Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 48, 1888.

Lesquereux's original description and remarks concerning this species are given on page 59.

[47] Lesquereux, Leo, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 47, 1888.

[48] Lesquereux, Leo, The Tertiary flora, p. 179, pl. 23, figs. 7–11, 1878.

Leaves comparatively small, round or ovate, broadly cuneate or rounded at base, palmately 5-nerved; inner primary nerves curving inward and ascending near the apex; those of the outside also curving and ascending to the middle, all camptodrome, thin but distinct; borders irregularly dentate, the teeth unequal and pointed; nervilles distinct, obliquely joined to the midrib.

The leaves resemble those of a *Ficus*, being, in their facies, like those of *Ficus crenata* Unger, which, however, has not distinct nervilles. They have a still more marked likeness to those of *Populus latior-transversa* Heer, as figured by Ludwig in Palaeontographica, vol. 5, pl. 26, fig. 3. The petiole is thick.

According to Lesquereux this form is represented in the collections of the Museum of Comparative Zoology by no less than 34 specimens. I have seen and studied these specimens and have selected for illustration five examples that seem best to show the range in size and general appearance. They are all nearly circular. The smallest one, shown in Figure 2, is about 2.75 centimeters long and the same in width. It is entire for at least the lower third of the margin and thence provided with few, apparently sharp teeth. The next in point of size, shown in Figure 6, is 4.5 centimeters long and about 4 centimeters broad. It has a few scattered teeth below and larger ones above, all sharp-pointed. A small portion of the petiole preserved is rather thick for the size of the leaf. The specimen represented in Figure 4 is of about the same size as the last and was selected because the larger pair of ribs diverge with little incurving in passing to the upper margin. The leaf shown in Figure 1 was 5 centimeters or more long and about 4.5 centimeters broad; its petiole is apparently preserved entire and is 3.5 centimeters long and very slender. The largest leaf observed, shown in Figure 3, is nearly 6 centimeters long and 5 centimeters wide. It is entire-margined below and has a few relatively very large sharp teeth in the upper portion.

This species is undoubtedly most closely related to *Populus nebrascensis* Newberry; in fact, it is in certain respects doubtful if they should be separated. For instance, it is almost impossible to separate this species from certain of the smaller leaves referred to *Populus nebrascensis rotundata* Lesquereux, as may be seen on comparing the two sets of figures. In general, however, the present species may be known by its small size, nearly circular shape, few, equal sharp-pointed marginal teeth, and thin, rather delicate nervation. In the diagnosis Lesquereux states that the nerves are camptodrome, but so far as I can determine they are all craspedodrome and end in the marginal teeth. The petiole is slender in the only specimen in which it is fully preserved.

Occurrence: Denver formation, Golden, Colo., collected by Arthur Lakes. Types in Museum of Comparative Zoology, Cambridge, Mass., Nos. 1252, 1256, 1266, 1274, 1513.

Populus subrotunda Lesquereux

Plate 22, Figure 9

Populus subrotunda Lesquereux, Am. Jour. Sci., 2d ser., vol. 45, p. 205, 1868; U. S. Geol. Survey Terr. Ann. Rept. for 1869, p. 196, 1869; idem for 1870, p. 380, 1871; idem for 1876, p. 506, 1878.

Populus attenuata Al. Braun. Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, pp. 386, 389, 392, 1873.

Populus subrotundata Lesquereux [apparently a misspelling for *subrotunda*], The Tertiary flora, p. 173, pl. 24, figs. 6–8, 1878.

Dawson, Canada Geol. Survey Rept. Progress for 1877–78, p. 186B, 1879.

Two of the figured types of this fine species—the originals of Plate 24, Figures 6 and 8, in the "Tertiary flora"—from Carbon, Wyo., are preserved in the United States National Museum (Nos. 220, 221). The other specimen—the original of Figure 7—said to have come from Evanston, Wyo., can not be located, nor can the specimens reported to have come from "Rock Creek on the Laramie Plains."

As Lesquereux has pointed out, *Populus subrotunda* is apparently closely related to *Populus attenuata* Al. Braun, especially as figured by Heer[49] from the Tertiary of Switzerland. The American leaves, however, are more nearly round, with a less pointed apex, sharper, upturned teeth, and more truncate base; the nervation is the same in both. *Populus attenuata* has been reported by Lesquereux[50] from the Denver formation at Golden, Colo., but I have not seen the specimens, two of which are mentioned.

Among the specimens more recently procured from the Denver formation there is a single much broken example which appears to belong to *Populus subrotunda*. It is smaller than either of the figured types and appears to have only two pairs of secondaries on the midrib, in this respect agreeing with one of Heer's figures of *P. attenuata*.

Among various specimens from the Lance formation of Converse County, Wyo., is a single very perfect example that I am unable to distinguish from certain leaves of *Populus subrotunda*. In this diagnosis of this species Lesquereux stated that "the nervation is tripalmate, camptodrome." In the specimen under consideration the nervation is distinctly tripalmate, but it is not camptodrome, nor for that matter is at least one of the type specimens (Tertiary flora, pl. 24, fig. 6), for although rather faint the

[49] Heer, Oswald, Flora tertiaria Helvetiae, vol. 2, p. 15, pl. 57, figs. 8–12, 1856.

[50] Lesquereux, Leo, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 48, 1888.

secondary branches may be seen distinctly entering the marginal teeth. The Converse County leaf is intermediate in size between those of Figures 6 and 7, above mentioned, but the basal secondaries arise at a lower point than in Figure 7, though not lower than in Figure 6, and the branches from the lower side of the ribs clearly enter the marginal teeth. Otherwise it is not possible to distinguish between them.

Occurrence: Hanna formation, Carbon, Wyo. (types). Evanston formation, Evanston, Wyo. (type). Denver formation, northwestern base of Green Mountain, Golden, Colo. Lance formation, gulch south of Lightning Creek and opposite Box Creek, Converse County, Wyo.

Populus zaddachi Heer?

Plate 22, Figure 8

Populus zaddachi Heer, in Zaddach, Phys.-ökon. Gesell. Königsberg Schriften, vol. 1, p. 29, pl. 4, 1860 [1861].
Heer, Flora fossilis arctica, vol. 1, p. 98, pl. 6, figs. 1–4, 1868.
Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1871, p. 292, 1872; Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 47, 1888.

In the material collected in Middle Park, Colo., I have found a leaf with its counterpart—the one here figured—that appears to belong to this species. It was at one time identified by Ward as *Zizyphus meekii* Lesquereux, which is not referred to *Populus*, but it seems in both shape and nervation to be more like *Populus zaddachi*. It is about 5 centimeters long and 3.5 centimeters wide, is rather deeply heart-shaped at the base, and has the margin provided with strong, rounded teeth. The nervation is strongly marked and is well shown in the figure.

Populus zaddachi is essentially a Miocene species, though it has been reported from beds somewhat older. For instance, in the Hayden annual report for 1871 Lesquereux reported the probable presence of *Populus zaddachi* at Evanston, Wyo., "below the coal." It was omitted by Lesquereux in his final report on the Tertiary flora, however, and has not since been detected with certainty at Evanston.

Populus zaddachi is an abundant and characteristic species in the auriferous gravel of California [51] and has also been reported by Lesquereux [52] from Florissant, Colo. Considering the fact that the specimen under discussion is somewhat obscure, its positive identification as *Populus zaddachi* should perhaps be questioned.

[51] Lesquereux, Leo, Harvard Coll. Mus. Comp. Zoology Mem., vol. 6, pl. 8, figs. 1–8, 1878.
[52] Lesquereux, Leo, The Cretaceous and Tertiary floras, p. 158, pl. 31, fig. 8, 1883.

Occurrence: Middle Park formation, Mount Bross, Middle Park, Grant County, Colo., débris on slope, collected by Geo. L. Cannon. Miocene (auriferous gravel), California.

Populus lacoeana Knowlton, n. sp.

Plate 22, Figure 5

Leaf coriaceous, very broadly ovate or almost circular, broadly truncate and slightly cordate at the base, abruptly rounded above to obtusely acuminate apex; margin strongly and somewhat irregularly toothed, the teeth obtuse and rounded and separated by shallow or deep rounded sinuses; petiole very strong, of unknown length but 3 centimeters preserved, splitting at the very base of the blade into three nearly equal ribs; of these ribs the central or midrib is straight and terminates in the tip of the blade; the midrib has one or two secondary branches in the extreme upper part; the lateral ribs arise at an angle of about 45°, then turn upward, and run nearly parallel to the midrib and terminate in large marginal lobes; each rib has about six secondary branches on the outside, the two lower ones arising together at the extreme base, thus simulating a semiribbed appearance; the secondary branches are strong, the lower ones camptodrome and the upper ones craspedodrome; nervilles numerous, strong, often arched but mainly unbroken.

The type specimen—the one here figured—has the basal portion showing the petiole and the origin of the primary ribs, as well as one side of the blade, very perfectly preserved. It is about 9 or 10 centimeters long and 8 centimeters wide. At first sight it seems to be semiribbed, but it is probably best explained as being 3-ribbed, with two secondary branches on the lateral ribs arising together and so low down as to simulate ribs. The ribs are very strong, the lateral ones being perhaps slightly stronger than the midrib. They are somewhat irregular.

Populus lacoeana is closely related to a number of described forms—so closely, in fact, that it is somewhat difficult to draw specific lines. It is undoubtedly of the same type as a large group of species from the Fort Union formation, some of which are also reported from the Denver formation. It is especially like *Populus nebrascensis* Newberry [53] as regards the primary nervation but differs in being much larger and much broader and above all in having only a few large obtuse teeth instead of numerous small relatively sharp teeth. *Populus nebrascensis* is identified in the

[53] Newberry, J. S., The later extinct floras of North America: U. S. Geol. Survey Mon. 35, p. 47, pl. 27, figs. 4, 5, 1898.

Denver flora by Lesquereux,[54] who reports a large number of specimens in the collection studied for the Museum of Comparative Zoology. Lesquereux has divided these into a number of varieties, among them one (*grandidentata*) which may include the form under discussion but which is a larger leaf with fewer and larger teeth than are to be observed in a number of specimens in the Lacoe collection identified as this variety by Lesquereux.

Populus lacoeana is also like certain of the larger leaves of *Populus amblyrhyncha* Ward,[55] a well-known Fort Union species, but differs in being much larger and in having fewer, larger teeth and the primary ribs at a more acute angle.

Occurrence: Denver formation, south face of South Table Mountain, Golden, Colo., about 100 feet below the lava cap, collected by Arthur Lakes, 1890.

Populus knowltoni Berry, n. sp.[56]

Plate 23, Figures 1–4

Leaves apparently of thin but firm texture, broadly or some narrowly obovate, broadest about the middle, whence they narrow below to a wedge-shaped base and above to a narrow tip; petiole relatively very strong, apparently several centimeters long; margin entire for about one-fourth the length of the blade above the base, thence strongly and somewhat irregularly toothed, the teeth obtuse and separated by shallow sinuses; nervation palmately 3-ribbed, or in effect 5-ribbed, from the base of the blade; midrib slightly the stronger, straight, with usually about three pairs of strongly alternate secondaries above the middle, the lower ones often forked, all craspedodrome; lateral ribs straight, at an angle of about 70°, ending in marginal teeth; each with five or six secondary branches on the outside, the lowest arising very near the base of the blade and thus producing the 5-ribbed appearance; secondaries all craspedodrome; nervilles numerous, strong, both broken and percurrent, finer nervation very perfectly preserved, irregularly quadrangular.

There are numerous specimens of this well-marked species in the collection, and although comparatively few were perfect when entombed, they retain the nervation in the parts present with the greatest degree of fidelity. There is considerable range in size and outline, though all have the wedge-shaped base, strongly toothed margin, and five ribs from the top of the petiole. The larger ones are some 8 centimeters long and 5 centimeters or more wide, and the smallest one observed (pl. 23, fig. 4) is about 5 centimeters long and scarcely 2 centimeters wide. The majority, however, are perhaps 6 or 7 centimeters long and about 4 centimeters wide. The petiole, which is relatively very strong, has not been observed actually attached to the blade for a greater length than 1.5 centimeters, but in one specimen a petiole which seems to have been broken off this particular blade is not less than 5 or 6 centimeters long.

The species under consideration has a greater or less resemblance to a number of described forms, such as *Platanus rhomboidea* Lesquereux,[57] a well-known Denver plant. This differs, however, in its much longer size, broader, less wedge-shaped base, less acute-angled primary ribs, and above all relatively larger but sharp-pointed teeth. They can hardly be even congeneric, and as a matter of fact the present generic reference for the so-called *Platanus rhomboidea* is perhaps open to some question.

Occurrence: Dawson arkose, south of oil well near Ramah, Colo., collected by C. W. Cooke in 1910.

Populus denverensis Knowlton, n. sp.

Plate 23, Figure 5

Leaf small, evidently coriaceous, elliptical-ovate, rounded or almost truncate at the base, apparently rather long pointed at the apex; margin obscurely undulate-toothed above the lower fourth of the blade; midrib relatively very strong, straight; secondaries about five pairs, the two lower pairs arising at practically the same point at the base of the blade and together with the midrib producing an obscurely 5-ribbed appearance; lowest pair of secondaries slender, perhaps best considered as in part tertiary branches of the second pair, which are far stronger and run upward for nearly half the length of the blade, each with several branches on the outside that enter the obscure teeth; upper secondaries alternate, sometimes branched, craspedodrome; nervilles numerous, strong, very much broken.

The little leaf here figured is slightly elliptical-ovate, with a rounded base and an apparently acuminate apex. Its length was about 5 centimeters and its width 2.5 centimeters. The margin is obscurely toothed.

It is with some hesitation that this leaf is described as new to science. It is, for instance, very similar to what Lesquereux has identified as *Populus mutabilis ovalis* Heer,[58] from the Livingston formation of Montana, but differs in being more nearly oval and in having fewer secondaries. It is even nearer to

[54] Lesquereux, Leo, Fossil plants collected at Golden, Colo.: Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 47, 1888.

[55] Ward, L. F., Flora of the Laramie group: U. S. Geol. Survey Sixth Ann. Rept., p. 550, pl. 35, fig. 6, 1886.

[56] Knowlton failed to suggest a specific name for this species, and I have therefore named it after him.—E. W. B.

[57] Lesquereux, Leo, The Tertiary flora, p. 186, pl. 26, figs. 6, 7, 1878.

[58] Idem, p. 177, pl. 24, fig. 4.

Populus mutabilis crenulata Heer,[59] from the Swiss Miocene, and might almost be identified with that species, but I recall what Lesquereux once said on this point: "These varieties [of *Populus mutabilis*] are so numerous and so intimately allied by their characters that it is extremely hazardous to identify single leaves with one of the eight subdivisions of this species." For these reasons I have ventured to give this leaf a new name, although it is acknowledged to be close to the forms above mentioned.

Occurrence: Denver formation, south face of South Table Mountain, 100 feet below the lava cap, Golden, Colo., collected by Arthur Lakes, 1890.

Populus richardsoni Heer?

Plate 23, Figures 6, 8

Populus richardsoni Heer, Flora fossilis arctica, vol. 1, p. 98, pl. 4, figs. 1–5; pl. 6, figs. 7, 8; pl. 15, fig. 1c, 1868.
Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, p. 411, 1874; The Tertiary flora, p. 177, pl. 22, figs. 10–12, 1878.

In the material from Middle Park I find three or four leaves of a *Populus* that seem to belong to Heer's *Populus richardsoni*,[60] especially as figured from the Atane beds of North Greenland. The best of these leaves is shown in Figure 6 and is precisely similar in shape and nervation to the figure above referred to, though it is much smaller. It is not, however, smaller than many leaves that have been referred to this species, notably by Heer himself. The leaf under consideration is seen to be strongly 7-ribbed from the top of an extremely thick and evidently flattened petiole. The blade is deeply heart-shaped at the base, and the lower pair of ribs is deflected much below a right angle to supply these lower lobes. Although this leaf and the others found with it appear to belong to *Populus richardsoni*, it has been thought best to question the identification, as even the best-preserved leaf lacks the upper portion and considerable of the margin.

Occurrence: Middle Park formation, Mount Bross, opposite Hot Sulphur Springs, Middle Park, Grand County, Colo., collected by George L. Cannon, 1889.

Order URTICALES

Family ULMACEAE

Ulmus antecedens Lesquereux

Plate 23, Figure 7

Ulmus antecedens Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 49, 1888.

This species is described by Lesquereux as follows:

Leaves small, thickish, oblong-lanceolate, acute, subcordate and subequilateral at base, doubly or triply dentate; teeth short, curved upward; secondaries thick, parallel, strong and straight, generally simple, sometimes forking in the middle, with thick oblique nervilles.

The leaf has the same character as that of *Ulmus crassifolia*, of Texas. The substance is thick, the size is the same, 4 centimeters long, 2 centimeters broad in the middle, the widest part; the lateral nerves are 12 or 13 pairs.

This is a splendid species and has been well described by Lesquereux. As he says, it resembles very closely *Ulmus crassifolia* Nuttall, the so-called cedar elm, which ranges from Mississippi through southern Arkansas into western Texas.

Occurrence: Denver formation, South Table Mountain, Golden, Colo., collected by Arthur Lakes. A single specimen known; type in the Museum of Comparative Zoology, Cambridge, Mass., No. 1692.

Ulmus? quercifolia Unger?

Plate 23, Figure 10

Ulmus quercifolia Unger, Chloris Protogaea, p. lxxx (nomen nudum), 1845; p. 96, pl. 25, fig. 5, 1847.
Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 49, 1888.

The presence of this species in the Denver flora, as determined by Lesquereux, rests on the single fragmentary specimen here figured. It is the basal part of a leaf that must have been some 8 or 9 centimeters in length and a little over 5 centimeters wide. It is very obtusely wedge-shaped and entire below but becomes sharply serrate above. Lesquereux says: "The borders are sharply dentate, the lateral nerves distant oblique, parallel from the base, passing in a curve toward the borders, where they become effaced."

Lesquereux compares this fragment with leaves figured by Unger[61] from the Miocene of Parschlug, Styria, and it does closely resemble them, though they are considerably smaller. One is nearly entire at the base, but the other is sharply serrate nearly to the petiole. The base is practically equilateral and the margin sharply serrate throughout.

It is extremely doubtful if the generic reference for these leaves is correct; in fact, Unger himself casts some doubt on it. They do not have the aspect of elm leaves and seem much more likely to belong to *Quercus*. As the leaf from Golden is so broken I have hesitated to refer it to another genus and have simply questioned both genus and species pending the discovery of more complete material.

Occurrence: Denver formation, South Table Mountain, Golden, Colo., collected by Arthur Lakes. Specimen now in the Museum of Comparative Zoology, Cambridge, Mass., No. 1422.

[59] Heer, Oswald, Flora tertiaria Helvetiae, vol. 2, pl. 61, fig. 15. 1856.

[60] Heer, Oswald, Flora fossilis arctica, vol. 2, pl. 55, fig. 3b, 1871.

[61] Unger, Franz, Iconographia plantarum fossilium, p. 115, pl. 43. figs. 24, 25, 1852.

Family MORACEAE

Ficus subtruncata Lesquereux

Ficus subtruncata Lesquereux, The Tertiary flora, p. 205, pl. 30, figs. 7–9, 1878.

Ficus auriculata Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, p. 379, 1873; The Tertiary flora, p. 206, pl. 30, figs. 4–6, 1878. [Homonym, Lour, 1834.]

Ficus truncata? Heer. Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, p. 400, 1874.

Leaves variable in size (from 4 to 10 centimeters long, 2.5 to 5.5 centimeters wide), entire, ovate-lanceolate or oblong-obovate, obtuse or sometimes almost acutely pointed at the apex, truncate-cordate or deeply cordate, almost auriculate, at the base; basilar veins three or four pairs, the upper more remote, all camptodrome.

This species is most widely known under the name *Ficus auriculata* Lesquereux, but this name proves to be preoccupied by a living species and it becomes necessary to restore the name next in order, *Ficus subtruncata* Lesquereux.

The type specimens on which *Ficus auriculata* Lesquereux was based came from Golden, Colo., and are preserved in the United States National Museum (Nos. 266, 266a, 267). The matrix shows them to have come from the andesitic material so characteristic of the Denver formation. Lesquereux[62] also reports this species from the region north of Grand River, Colo., the exact locality being described by Peale[63] as follows:

> On Grand River, near the mouth of Roan Creek, there are bluffs in which about 500 feet of sandstones outcrop. These sandstones are probably the upper part of the Laramie group, the variegated beds just above representing the Wasatch group. In the Grand Hogback range, just east of Cactus Valley, the following fossil plants were obtained, the identifications being by Professor Lesquereux.

Then follows the enumeration of species, among them being *Ficus auriculata*.

From Peale's description of the stratigraphic relations it appears that the plants mentioned must have come from beds in the approximate position of the Denver formation, but the species has not since been found in that portion of Colorado, and the exact stratigraphic position must remain in question.

In the report in which *Ficus auriculata* was named Lesquereux recorded it from Spring Canyon, near Bozeman, Mont. The specimens so recorded are not now to be found in the National Museum collections, but the species is present in collections made in the same place by A. C. Peale and me during the years 1885–1890. They came from the upper part of the series of rocks comprising the so-called Bozeman coal field, in what has been called the Livingston formation, which in my opinion corresponds in position and age to the Denver formation of Colorado.

The recent collections from Golden, Colo., contain a few leaves clearly belonging to this species, but as they have only the bases preserved they add nothing to our knowledge of the species.

The specimens originally mentioned by Lesquereux under the name *Ficus truncata?*, later changed to *Ficus subtruncata*, are fortunately all preserved in the United States National Museum (Nos. 268, 269, 270). They came from exactly the same place as those described as *Ficus auriculata*, and they do not seem to differ from that species sufficiently to warrant their separation. Lesquereux described this species as follows: "Leaves comparatively small, entire, truncate-cordate at the more or less inequilateral base, ovate or oblong, acuminate; borders undulate." Size, it is well known, is a very unreliable character. A glance at the figures of both species shows that the smallest leaf of *F. subtruncata* is larger than the smallest leaf of *F. auriculata*,[64] therefore relative size can not be used to separate them. The shape is approximately the same, ovate or ovate-lanceolate. *F. subtruncata* is said to be "truncate-cordate" at the base, as shown in Lesquereux's Plate 30, Figure 7, but an examination of the type specimen of this form (U. S. Nat. Mus. No. 270) revealed the fact that the matrix had not been all removed from the base. When this had been done the base proved to be of the same shape as that shown in Figure 4 of the same plate—that is, distinctly cordate. It is also described as "more or less inequilateral," presumably as shown in Figure 9 of Plate 30. This specimen (U. S. Nat. Mus. No. 268) had not been properly excavated from the matrix, and when this had been done it showed that the two sides of the leaf were approximately equal, thus destroying this supposed character. It was also said to be "undulate" on the margins, but on examining the type of Figure 7, which is shown in the plate as undulate, it is found that neither of the margins is preserved, the drawing being wrong. Figure 9 is also wrong as to the leaf being undulate. The leaf does not lie flat on the matrix, which causes it to appear undulate. The nervation is precisely the same in both of these forms, as can be seen by comparing the figures on Plate 30. It therefore seems justifiable to regard them as representing a single species.

Occurrence: Denver formation (types), South Table Mountain, Golden, Colo. Formation uncertain, Grand [Colorado] River near the mouth of Roan Creek, Colo., collected by A. C. Peale, 1876. Livingston

[62] Lesquereux, Leo, The Tertiary flora, p. 207, 1878.

[63] Peale, A. C., U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1876, p. 181, 1878.

[64] Lesquereux, Leo, The Tertiary flora, pl. 30, 1878. Cf. figs. 4 and 7.

formation (?), Hodson's coal mine on Meadow Creek, 14 miles southeast of Bozeman, Mont., collected by A. C. Peale in 1872 and by Peale and Knowlton in 1888.

Ficus? alata Knowlton, n. sp.

Plate 23, Figure 9

Leaf small, very thick, oval or elliptical-oblong, rather abruptly rounded to the base and thence narrowly decurrent on the thick, strong petiole, apex destroyed; midrib very strong, straight; secondaries alternate, thin, at a low angle, camptodrome, arching and joining well inside the margin; nervilles obscure, apparently percurrent and at right angles to the secondaries; finer nervation not retained.

This species is apparently represented by the single example figured, which lacks nearly all of the upper portion. So far as can be made out it is oblong or elliptical-oblong with perfectly entire margins and a rounded base, which passes into a narrow wing down the thick petiole. The leaf was probably 3.5 or 4 centimeters in length and slightly more than 2 centimeters in width. The petiole is about 1 centimeter long and gives evidence of having been somewhat longer when perfect. The wing to the petiole appears to diminish downward, if the conditions are correctly interpreted, and at the base had probably entirely disappeared. This leaf as it is preserved exhibits the dorsal surface and is seen to be very thick and probably coriaceous, as the secondaries and nervilles show but faintly.

I am much in doubt as to the proper generic reference for this little leaf. The contour, coriaceous texture, thick petiole, and midrib suggest many species of *Ficus*, but the presence of a decided wing on the petiole can hardly be considered a character of this genus, yet certain fossil forms having this feature have been so placed. Thus *Ficus ovalis* Lesquereux[65] has approximately the same shape of blade and what appears to be a slight winglike broadening of the petiole; it differs in size and somewhat in nervation. In shape, size, and nervation it also suggests *F. tenuinervis* Lesquereux,[66] and there is even a slight indication of the presence of a wing on the short petiole in this species. The species in hand has some resemblance to what I have called *Cinchonidium? turneri* Knowlton,[67] from the Esmeralda formation of Nevada. The size and winged petiole are somewhat the same, but in the Nevada form the base is strongly unequal-sided and the nervation much closer and more irregular. The genus *Sapindus* is also suggested, but from this it appears to be excluded by the long and winged petiole. I am therefore constrained to place it under *Ficus*, premising, however, that this reference may not be the correct one.

Occurrence: Dawson arkose, lower part (in beds equivalent to Arapahoe formation), 3,000 feet east of the Douglas coal mine, Sedalia, Colo.

Ficus denveriana Cockerell

Plate 24, Figures 1–3

Ficus denveriana Cockerell, Torreya, vol. 10, p. 224, 1910.
Berry, U. S. Geol. Survey Prof. Paper 91, p. 198, 1916.
Knowlton, U. S. Geol. Survey Prof. Paper 101, p. 302, pl. 75, figs. 1, 2, 1917 [1918].

Ficus spectabilis Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, p. 379, 1873; The Tertiary flora, p. 199, pl. 33, figs. 4–6; Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 50, 1888. [Homonym, Kunth and Bouché, Annales sci. nat., 3d ser., vol. 7, p. 235, 1847.]

Populus ungeri Lesquereux, The Tertiary flora, p. 175, pl. 24, fig. 5, 1878; U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1876, p. 507, 1878.

Populus heliadum Unger. Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, pp. 380, 397, 1874; idem for 1876, p. 507, 1878.

Cissus primaeva Saporta. Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 51, 1888.

In one of the collections from the Dawson arkose of Jimmy Camp Creek I find the large leaf here figured, which apparently belongs to this species. It is rather broader and more truncate at the base than is usual in this species, but otherwise it does not appear to differ essentially.

The collection from Mosby, Colo., also includes this species, though it is represented by only the upper portion of a rather small individual. It has not been figured.

A small collection made by Francis M. Collins for Dr. A. C. Peale on Sand Creek near Magnolia, a short distance northeast of Denver, includes a very good specimen of this species.

In 1878 Lesquereux[68] described, under the name *Populus ungeri*, a single leaf from the andesitic beds at Golden, Colo. This specimen (U. S. Nat. Mus. No. 222) is before me and needs but little study to show that it has been very incorrectly figured and interpreted by Lesquereux. According to the figure it is nearly circular and about equally rounded at base and apex, but as a matter of fact neither is represented by true margin. By removing the matrix it is found that the base is obtusely wedge-shaped and the apex prolonged for several centimeters beyond the point where it is shown in the figure. That it was prolonged far beyond this point is still further shown

[65] The Tertiary flora, p. 198, pl. 30, fig. 2, 1878.
[66] The Cretaceous and Tertiary floras, p. 164, pl. 44, fig. 4, 1883.
[67] U. S. Geol. Survey Twenty-first Ann. Rept., pt. 2, p. 218, pl. 30, figs. 9–11, 1900.
[68] Lesquereux, Leo, The Tertiary flora, p. 175, pl. 24, fig. 5, 1878.

by the fact that the midrib is little if any reduced in thickness at the point where it enters the supposed margin. The margin, shown in the figure as slightly undulate on one side, is really practically entire, and the nervation is likewise incorrectly figured. The secondaries on one side show a number of branches, and the finer nervation is well preserved in one or two places and is seen to consist of numerous strong, often broken nervilles.

Populus ungeri Lesquereux is undoubtedly a medium-sized leaf of *Ficus denveriana* Cockerell, being, for example, of the same shape and general appearance as one of Lesquereux's figures of this species,[69] though a little longer.

In the collection of Golden specimens studied by Lesquereux for the Museum of Comparative Zoology *Populus ungeri* is said to be represented by three examples, but I have not seen them.

In the material from Golden elaborated by Lesquereux for the Museum of Comparative Zoology there is a single fragmentary specimen that he identified as *Cissus primaeva?* Saporta, a species which came from the travertines of Sezanne. On comparing this leaf with Saporta's figure[70] it is seen that they agree in size and shape but differ in marginal dentition and in the secondaries, which are camptodrome in the Golden leaf but craspedodrome in the French leaf.

Comparison of the leaf from Golden with figures of *Ficus denveriana* Cockerell shows that it agrees closely with the original figure by Lesquereux, and it is consequently referred to this species.

Occurrence: Denver formation (types), Golden, Colo., specimen in Museum of Comparative Zoology, Cambridge, Mass. (identified by Lesquereux as *Cissus primaeva?* Saporta), No. 1500; Sand Creek near Magnolia, northeast of Denver, Colo., collected by Francis M. Collins. Wilcox formation, Arkansas and Louisiana. Lagrange formation, Kentucky, in beds of Wilcox age. Raton formation, Raton Mesa region of Colorado and New Mexico. Laramie formation, Popes Bluff, west of Pikeview, Colo. [identification questioned]. Dawson arkose, east bank of Jimmy Camp Creek, 1 mile above Richfield Springs ranch house, 9 miles east of Colorado Springs, Colo., collected by F. H. Knowlton, July, 1910; dump of Mosby coal mine, Mosby, Colo., collected by F. H. Knowlton and G. B. Richardson, 1910; Coal Gulch, about 2 miles northeast of Ramah, Colo., in sandstone above coal, collected by W. T. Lee, 1914; a quarter of a mile east of Purdon mine, sec. 27, T. 11 S., R. 61 W., Colo., collected by G. B. Richardson.

[69] Lesquereux, Leo, The Tertiary flora, pl. 33, fig. 4, 1878.

[70] Saporta, Gaston de, Prodrome d'une flore fossile des travertins anciens de Sézanne, pl. 11, fig. 2, 1868.

Ficus aguilar Knowlton

Plate 24, Figure 4

Ficus aguilar Knowlton, U. S. Geol. Survey Prof. Paper 101, p. 300, pl. 71, fig. 1, 1917 [1918].

This species was described from the Raton formation of southern Colorado and is based on a single example which lacks the upper portion. The present specimen permits a knowledge of the apical portion of the blade, and the description may be modified to read as follows: Leaves large, very thick and coriaceous, oblong, rather abruptly rounded below to the thick petiole and above to an obtusely acuminate apex; margin perfectly entire; midrib unusually thick, perfectly straight but becoming thinner above; secondaries numerous, about 10 or 15 pairs, at somewhat irregular distances, emerging at a low angle, considerably curved upward, ending very near the margin or camptodrome; nervilles apparently numerous, unbroken, and at right angles to the secondaries.

The present specimen is much smaller than the type but is nearly perfect. It is about 11 centimeters long and nearly 7 centimeters wide. It has the petiole preserved for a short distance only.

In the collection of Denver plants identified by Lesquereux for the Museum of Comparative Zoology I find a single leaf under the name *Populus ungeri* Lesquereux. It represents only the lower portion of a large oval-lanceolate leaf that must have been about 12 centimeters long and nearly 7 centimeters wide. It is rounded truncate at the base and has a very strong midrib. The secondaries are at a slightly lower angle than in the specimen of *Ficus aguilar* figured, but it does not otherwise differ and has been referred to that species; it is not figured.

Occurrence: Dawson arkose, a quarter of a mile east of Purdon mine, sec. 27, T. 11 S., R. 16 W., Colo., collected by G. B. Richardson. Denver formation, South Table Mountain, Golden, Colo., collected by Arthur Lakes, specimen (under the name *Populus ungeri* Lesquereux) in the Museum of Comparative Zoology, Cambridge, Mass., No. 1087. Raton formation (type), Aguilar, Colo.

Ficus berthoudi Lesquereux

Plate 25, Figures 1, 2, 6

Ficus berthoudi Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 49, 1888.

Leaves thick and coarse, broadly cordate at base, ovate-lanceolate, acuminate above, entire, enlarging toward the base and rounding to the petiole, descending lower than its top, sometimes auriculate, the basilar border in one leaf overlapping the top of the petiole; primary nerves deep and broad; lower lateral nerves opposite, the upper alternate, all very deeply curving toward the borders and following them in a series of areoles; nervilles deep, close, parallel, cut by branches at right angles, forming a square distinct areolation.

Two of the four specimens referred to this species are here figured as the types. The more perfect one, Figure 2, is a small leaf about 7 centimeters long and nearly 5 centimeters broad. The other, Figure 1, is much larger, probably about 11 centimeters long and at least 8 centimeters broad. They are, as Lesquereux says, rather thick coarse leaves with strongly impressed nervation.

I have also referred to this species a leaf identified by Lesquereux[71] as *Ficus tiliaefolia* (Al. Braun) Heer; it is shown in Figure 6. It is intermediate in size between the other specimens but does not seem to differ essentially from them.

Ficus berthoudi is undoubtedly most closely related to *Ficus subtruncata* Lesquereux[72] (which includes *Ficus auriculata* Lesquereux); in fact, it is perhaps doubtful if they should be maintained as distinct. It is possibly a slightly coarser leaved species, with somewhat larger leaves which are more abruptly narrowed above, but these differences are certainly slight.

Occurrence: Denver formation, South Table Mountain, Golden, Colo., collected by Arthur Lakes. Types in Museum of Comparative Zoology, Cambridge, Mass., Nos. 1089b, 1440, 1443.

Ficus pseudopopulus Lesquereux

Plate 25, Figures 3–5; Plate 26, Figures 2–4

Ficus pseudopopulus Lesquereux, U. S. Geol. and Geog. Survey Terr. Bull., vol. 1, 2d ser., No. 5, p. 387, 1876; U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1874, p. 313, 1876; The Tertiary flora, p. 204, pl. 34, figs. 1a, 2, 1878.

Berry, U. S. Geol. Survey Prof. Paper 91, p. 200, pl. 37, figs. 3–5; pl. 113, fig. 3, 1916.

Knowlton, U. S. Geol. Survey Prof. Paper 101, p. 304, pl. 72, figs. 2–4; pl. 73, figs. 1, 2; pl. 112, fig. 3, 1917 [1918].

Ficus andraei Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 50, 1888.

Ficus pseudopopulus was described by Lesquereux from an unknown locality which was conjectured to be in the Green River formation, but the point remains unsettled. The species was subsequently found in beds of lower Tertiary age at Evanston, Wyo., and still later in the Raton formation of the Raton Mesa region of Colorado and New Mexico, in the Wilcox formation of Louisiana, and in the Lagrange formation of Tennessee, in beds of Wilcox age. It is perhaps most abundant in the Wilcox beds. Berry gives the following description:

> Palmately veined leaves of medium size, broadly ovate in general outline, narrowed and acuminate at the apex, broadly rounded or truncate, and more or less decurrent at the base. Length about 12 or 13 centimeters. Maximum width, at or below the middle, about 6 or 7 centimeters. Texture subcoriaceous. Petiole stout, curved, about 1.5 centimeters in length. Primaries [ribs] three, curved, the midrib stouter than the laterals. Lateral primaries [ribs], one on each side, diverging from the midrib just above the top of the petiole at angles of about 20°, ascending, and camptodromely joining a secondary two-thirds or more of the distance from the base to the tip. Secondaries from the upper half of the midrib, four or five alternate curved pairs, diverging from the midrib at acute angles, becoming subparallel with the lateral margins distad, and arching along them in a camptodrome manner. Secondaries from the outer side of the lateral primaries [ribs], about seven on each side, thin and camptodrome, the lowest on each side longer, stouter, and more ascending than the others, diverging at or just above the top of the petiole. Tertiaries [nervilles] thin, percurrent, at right angles to primaries and secondaries.

The example figured in this paper, although fragmentary, is undoubtedly identical with leaves of this species as figured by Berry from Shandy, Tenn. A more perfect specimen from Mosby, Colo., has also been figured. It has the petiole preserved for a length of over 2 centimeters and altogether is indistinguishable from leaves in the Raton formation of the Raton Mesa region.[73]

The type specimen of *Ficus andraei* Lesquereux,[74] the property of the Harvard College Museum of Comparative Zoology, is before me and is shown on Plate 26, Figure 4. It needs but a glance to show that it is identical with *Ficus pseudopopulus* Lesquereux. It is, for instance, indistinguishable from figures given by Berry[75] from the Lagrange formation of Tennessee, in beds of Wilcox age, and by Knowlton[76] from the Raton formation of Colorado and New Mexico. It has the petiole preserved for a length of 2 centimeters.

Occurrence: Dawson arkose, east bank of Jimmy Camp Creek 0.6 mile above Richfield Springs ranch house, 9 miles east of Colorado Springs, Colo., collected by F. H. Knowlton and W. T. Lee, July, 1910; same locality but 1 mile above ranch house, collected by F. H. Knowlton, July, 1910; dump of Mosby coal mine, Mosby, Colo., collected by F. H. Knowlton and G. B. Richardson, 1910; Rice's clay bank, 1 mile southwest of Calhan, Colo., collected by F. H. Knowlton, 1910. Raton formation, Raton Mesa region of Colorado and New Mexico. Wilcox formation, Louisiana. Lagrange formation, Tennessee. Denver formation, Sand Creek near Magnolia, northeast of Denver, Colo., collected by Francis M. Collins, 1909; South Table Mountain, Golden Colo., collected by Arthur Lakes. Type of *Ficus andraei* Lesquereux, Museum of Comparative Zoology, Cambridge, Mass., No. 1677.

[71] Lesquereux, Leo, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 49, 1888.

[72] Lesquereux, Leo, The Tertiary flora, pl. 30, figs. 4–6, 7–9 [not fig. 6a, which = *Carpites oviformis*].

[73] See Knowlton, F. H., U. S. Geol. Survey Prof. Paper 101, p. 304, pl. 73, figs. 1, 2, 1917 [1918].

[74] Lesquereux, Leo, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 50, 1888.

[75] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 200, pl. 37, figs. 4, 5, 1916.

[76] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 101, p. 304, pl. 72, fig. 4; pl. 73, figs. 1, 2, 1917 [1918].

Ficus dawsonensis Knowlton, n. sp.

Plate 26, Figure 1

Leaf thick, broadly ovate, rounded and deeply heart-shaped at the base, rounded and obtuse at the apex; margin absolutely entire; midrib rather slender, with about four pairs of thin secondaries, the lowest pair opposite, arising at the top of the petiole and giving the leaf a 3-ribbed aspect, each with five or six camptodrome branches on the outside, upper pairs of secondaries alternate, subcamptodrome; nervilles obscure, thin, apparently unbroken.

This form is represented by a single example with its counterpart. It is about 9 centimeters long and 7 centimeters wide.

This species is of the type of *Ficus leei* Knowlton,[77] from the Vermejo formation of the Raton Mesa region; in fact, it is distinguished from that species with difficulty. It appears to differ in being rather broader in proportion to the length and above all in the absence of the nervilles, which are so prominent in *F. leei*. It is to be regretted that there are not more specimens of *F. dawsonensis* available for comparison, for then it might be determined whether this is a valid species.

Occurrence: Dawson arkose, Mosby coal mine, Mosby, Colo., collected by F. H. Knowlton and G. B. Richardson, 1910.

Ficus sp.

Plate 27, Figures 1–3

The material obtained near Ramah, Colo., includes a number of fragmentary leaves that appear to belong to *Ficus*, but they are hardly well enough preserved to admit of specific identification. They are large leaves, probably not less than 12 or 14 centimeters long and 8 centimeters or more wide. As nearly as can be made out these leaves were elliptical-lanceolate or perhaps slightly ovate-lanceolate, with a very obtusely wedge-shaped or rounded base and apparently a rather acuminate apex. The margin is perfectly entire. The nervation consists of a very thick midrib and numerous pairs of strong secondaries, which emerge at an angle of about 35° or 40°.

This form appears to be most closely related to what is now known as *Ficus uncata* Lesquereux and is perhaps identical with it. It is especially suggestive of certain leaves now referred to *Ficus uncata* but described and figured by Lesquereux under the name *Ficus arenacea brevipetiolata*.[78] About the only difference to be noted is in the base, which is rather more wedge-shaped than in *Ficus uncata*. It would probably be well within the bounds of probability to identify the present form directly with *Ficus uncata*, but in view of its fragmentary representation it has seemed best to refrain from a specific determination.

Occurrence: Dawson arkose, near oil well 1 mile south of Ramah, Colo., collected by C. W. Cooke for G. B. Richardson, 1910.

Ficus sp.

Ficus tiliaefolia Al. Braun. Lesquereux, The Tertiary flora, p. 203, pl. 32, fig. 2, 1878.

In the report on the Tertiary flora Lesquereux gave the figures of three fragmentary leaves that he referred to the European *Ficus tiliaefolia* Al. Braun. He said (p. 204) that he had identified this species "from the lowest stage of the lignitic Eocene to the highest Tertiary measures," the localities enumerated being Washakie Station, Wyo.; Spring Canyon near Fort Ellis, Mont.; Yellowstone Lake, Point of Rocks, Wyo.; Fishers Peak, Sand Creek, Golden, and near Colorado Springs, Colo.; Black Buttes, Wyo.; and the auriferous gravel of California. Lesquereux states that the specimens are always more or less broken and the identification uncertain. Wherever the flora of the above-mentioned localities has been critically reviewed in recent years, *Ficus tiliaefolia* has usually been rejected, and the leaves so determined have been referred to other species.

One of the specimens figured in the report on the Tertiary flora (pl. 32, fig. 2) is from Golden, Colo. It is No. 282 of the United States National Museum collection and is preserved in the andesitic matrix characteristic of the Denver formation. It undeniably resembles certain leaves referred to the European *Ficus tiliaefolia* Al. Braun, such as some from the Swiss Miocene as figured by Heer,[79] but the Old World specimens are all figured as strongly unequal-sided, and the specimen under consideration is so fragmentary that it is impossible to determine this point. It lacks both base and apex and all of one side, and although it may have been unequal-sided there is no positive indication of it.

This particular specimen is also of about the same size and shape as the typical leaves of *Ficus planicostata goldiana* Lesquereux,[80] except that it is slightly more wedge-shaped at the base and has a somewhat stronger nervation. Under the circumstances it seems best to refer this leaf to *Ficus* sp., as it can not be positively referred to *F. tiliaefolia* or to any of the varieties of *F. planicostata*.

The National Museum contains a specimen (No. 284) that appears to be the counterpart of the leaf figured

[77] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 101, p. 261, pl. 39, figs. 1–6; pl. 40, figs. 1, 2, 1917 [1918].

[78] Lesquereux, Leo, The Tertiary flora, p. 195, pl. 29, figs. 2, 3, 5, 1878.

[79] Heer, Oswald, Flora tertiaria Helvetiae, vol. 2, p. 68, pl. 84, figs. 1–6, 1856.

[80] Lesquereux, Leo, The Tertiary flora, p. 202, pl. 33, figs. 1–3, 1878.

in the report on the Tertiary flora, Plate 32, Figure 1, as *Ficus tiliaefolia*. It is recorded as having come from Sand Creek, Colo., but to judge from the matrix this can hardly be true. In any event it is a fragment lacking both base and apex and has no positive evidence of having been unequal-sided. It is not accepted as *Ficus tiliaefolia*.

Occurrence: Denver formation, Golden, Colo., probably collected by Arthur Lakes in the early seventies.

Ficus occidentalis (Lesquereux) Lesquereux

Plate 26, Figure 5; Plate 27, Figure 4

Ficus occidentalis (Lesquereux) Lesquereux, The Tertiary flora, p. 200, pl. 32, fig. 4, 1878; Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 50, 1888.
Penhallow, Report on Tertiary plants of British Columbia, p. 55, 1908.
Knowlton, U. S. Geol. Survey Prof. Paper 101, p. 302, pl. 72, fig. 1, 1917 [1918].
Berry, U. S. Geol. Survey Prof. Paper 91, pp. 12, 197, pl. 28, fig. 3, 1916.
Dombeyopsis occidentalis Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, p. 380, 1873.

The type of this species is from the Denver formation at Golden, Colo., and is preserved in the United States National Museum (No. 281). It was described by Lesquereux in part as follows:

Leaves comparatively thick, coriaceous, truncate-cordate at the base, narrowed upward into an obtuse acumen, palmately triple-nerved; lateral veins equidistant, parallel, camptodrome.

Ficus occidentalis appears to be rather rare, though in his original discussion Lesquereux said, "A number of finely preserved specimens of this species have been obtained from the same locality, all, however, deprived of the petiole." He also recorded [81] the presence of five specimens in the large collections he identified for the Harvard College Museum of Comparative Zoology. The large collections made by Lakes and now for the most part studied for the first time contain only a single example that differs from the type in being much smaller.

In the collections from the Raton formation made in Dillon Canyon, N. Mex., I noted the presence of two leaves of this species.[82] The better preserved of these was figured and, except for being a little larger than the figured type, agrees perfectly with it.

Ficus occidentalis was recorded by Berry [83] from the Midway(?) formation at Earle, Tex., and the Ackerman formation of the Wilcox group at Hurleys, Benton County, Miss. The leaves from Mississippi were described as being somewhat smaller than those from the Rocky Mountain region, averaging about 8 centimeters in length and 6 centimeters in maximum width.

This species is thought to be most closely related to *Ficus planicostata* Lesquereux, from which it differs in its generally larger size, broadly ovate rather than elliptical outline, and thicker nerves. It is also apparently related to *Ficus harrisiana* Hollick,[84] a species from the Wilcox formation of Louisiana, which is widest in the middle instead of at the base. The venation, Berry states, "though of the same general character shows well-marked differences of detail."

Occurrence: Denver formation (type), Golden, Colo. Raton formation, Dillon Canyon, near Blossburg, N. Mex. Wilcox group (Ackerman formation), Hurleys, Benton County, Miss. Midway(?) formation, Earle, Tex. Eocene, Stanley Park, Vancouver Island, British Columbia.

Ficus ramahensis Knowlton, n. sp.

Plate 27, Figure 5

Leaf large (about 23 centimeters long and 13 centimeters wide), evidently thick, broadly ovate, broadest near or just below the middle, from which it is rounded to the very obtusely wedge-shaped base and upward to a relatively long, slender apex; margin entire; midrib very strong, especially below, straight; secondaries about 15 pairs, mainly alternate, strong, parallel, at an angle of about 40°, not much curved upward, camptodrome, arching very close to the margin; finer nervation not retained.

This species as represented by the example figured is apparently the largest-leaved *Ficus* found thus far in the Denver or related formations. It seems to be most closely related to *Ficus occidentalis* Lesquereux,[85] a fairly abundant form in the andesitic beds at Golden, but it is much larger and does not have the lower secondaries branched, nor are the upper secondaries so much curved upward. The largest of the type specimens of *Ficus occidentalis* is only about 15 centimeters long and 8.5 centimeters wide, and the other types are much smaller. *Ficus occidentalis* has been identified by Berry in the Wilcox group, but these leaves are smaller than the Rocky Mountain specimens.

Ficus ramahensis is also like *Ficus monodon* (Lesquereux) Berry,[86] especially as figured by Berry from the Wilcox group. That species, however, is relatively broader, is more truncate at the base, and has

[81] Lesquereux, Leo, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 50, 1888.
[82] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 101, p. 302, pl. 72, fig. 1, 1917 [1918].
[83] Berry, E. W., The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, pp. 12, 197, pl. 28, fig. 3, 1916.
[84] Hollick, Arthur, Louisiana Geol. Survey Rept. for 1899, Special Rept. 5, p. 281, pl. 46, fig. 2, 1899.
[85] Lesquereux, Leo, The Tertiary flora, p. 200, pl. 32, fig. 4, 1878.
[86] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 201, pl. 32, fig. 2; pl. 33, fig. 2, 1916.

conspicuously undulate margins. It is also like certain of the leaves that have been referred to *Ficus uncata* Lesquereux, from the Raton formation of Colorado and New Mexico, especially the large leaf figured by Lesquereux[87] under the name *Populus monodon*.

Occurrence: Dawson arkose, half a mile west of Ramah, Colo., collected by W. T. Lee, 1915.

Ficus? lakesii Knowlton, n. sp.

Plate 28, Figure 1

Leaf small, narrowly obovate, rounded or almost truncate at the apex, obtusely wedge-shaped at the base; petiole relatively rather long, slender; margin entire or slightly undulate; nervation strongly 3-ribbed from the base of the blade; midrib exceedingly strong for the size of the leaf, nearly straight, with one pair of alternate, very strong secondary branches in the upper portion; lateral ribs nearly as strong as the midrib, passing up to near the apex; there curving inward, each with five or six secondary branches on the outside, these camptodrome and arching just at the margin; nervilles numerous, strong, mainly broken.

The little leaf here figured is rather narrowly obovate, being slightly under 2.5 centimeters in length exclusive of the petiole, which is itself nearly 1 centimeter in length. The width at the broadest point, somewhat above the middle, is a little less than 1.5 centimeters.

This leaf is referred to the genus *Ficus* with hesitation and mainly on the ground of its resemblance to certain of the smaller leaves of *F. planicostata* Lesquereux.[88] It differs, however, in being obovate instead of ovate or elliptical, with only one pair of secondaries and somewhat different nervilles, etc.

Occurrence: Denver formation, Golden, Colo., south face of South Table Mountain, collected by Arthur Lakes, for whom it is named.

Ficus coloradensis Cockerell

Ficus coloradensis Cockerell, Torreya, vol. 10, p. 223, 1910.
Knowlton, U. S. Geol. Survey Prof. Paper 130, p. 134, pl. 22, fig. 1, 1922.

Ficus irregularis (Lesquereux) Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1874, p. 304, 1876; U. S. Geol. and Geog. Survey Terr. Bull., vol. 1, p. 368, 1876; The Tertiary flora, p. 196, pl. 34, figs. 4–7, 1878; Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 50, 1888.
Ward, U. S. Geol. Survey Sixth Ann. Rept., p. 552, pl. 44, fig. 4 [not fig. 5, which=*Rhamnus goldianus*], 1886; U. S. Geol. Survey Bull. 37, p. 38, pl. 20, fig. 4 [not fig. 5, which=*Rhamnus goldianus*], 1887.
Knowlton, U. S. Geol. Survey Bull. 163, p. 51, 1900.

Ulmus? irregularis Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, p. 378, 1873.

Occurrence: Denver formation, Golden, Colo. (types). Laramie formation, Marshall and 1¼ miles south of Golden, Colo. Hanna formation, Carbon, Wyo. (doubtful).

Ficus martini Knowlton, n. sp.

Plate 40, Figure 5

Leaf fairly large, ovate, with a broadly rounded-truncate, slightly auriculate base and a pointed tip. Margins entire and texture apparently coriaceous. Length about 15 centimeters; maximum width, below the middle, about 9.25 centimeters. Petiole missing. Midvein stout, prominent on the under side of the leaf. Secondaries stout, about seven somewhat irregularly spaced pairs, diverging from the midvein at angles of about 45°, camptodrome close to the margins. Tertiaries not seen.

This species, of doubtful generic relationship, is based upon the single specimen figured and is named for the collector, George C. Martin.

Occurrence: Denver formation, dump of abandoned mine at Scranton, about 22 miles east of Denver, Colo.

Ficus eldridgi Knowlton, n. sp.

Plate 59, Figure 4

Leaf relatively small, ovate, with a slightly cordate base and abruptly pointed tip. Margins entire. Length about 7 centimeters; maximum width, below the middle, about 4.25 centimeters. Petiole missing. Midvein relatively stout, straight, and prominent. Secondaries stout, about seven, mostly alternate, camptodrome pairs, diverging from midvein at wide angles and all except the basal pair rather straight in their courses. Tertiaries obsolete in the coarse matrix.

This small form, apparently new, is tentatively referred to the genus *Ficus*, although this relationship is somewhat uncertain. It is not unlike *Ficus subtruncata* Lesquereux. It is named for the late George H. Eldridge.

Occurrence: Denver formation, dump of abandoned mine at Scranton, about 22 miles east of Denver, Colo.

Ficus neoplanicostata Knowlton

Plate 28, Figures 3, 4, 6, 7; Plate 29, Figures 3, 4

Ficus neoplanicostata Knowlton, U. S. Geol. Survey Prof. Paper 101, p. 303, pl. 73, fig. 4; pl. 74, figs. 2, 3; pl. 76, fig. 4, 1917 [1918].

Leaves thick, ovate, broadest at or just below the middle, whence they are rounded to the obtusely wedge-shaped or nearly truncate base and above to the acuminate apex; margin perfectly entire; nervation strong, pinnate, the lowest pair of secondaries nearly

[87] Lesquereux, Leo, The Tertiary flora, p. 180, pl. 24, fig. 1, 1878.
[88] Lesquereux, Leo, The Tertiary flora, p. 201, pl. 31, figs. 1–8, 10–12, 1878.

as strong as the midrib and arising just above the base or sometimes nearly at the base, thus producing a pseudo 3-ribbed appearance; midrib with three or four pairs of secondaries, which are slightly curved upward and arch just inside the margin; basal pair of secondaries (ribs) with some seven or eight camptodrome branches on the outside; nervilles numerous, strong, mainly unbroken.

This species was described originally from the Raton formation of southern Colorado and was based on specimens that ranged in length from 4 to 10 centimeters and in width from 3 to 5.5 centimeters. The specimens referred to this species from the Denver formation average smaller than the original specimens. The smallest example is only about 3 centimeters long and 2.5 centimeters wide but does not otherwise differ.

As pointed out in the original discussion this species is undoubtedly of the type of and most closely related to *Ficus planicostata* Lesquereux,[89] of the Black Buttes coal group of Black Buttes, Wyo., regarded by the author as of post-Laramie age. It differs from this, however, in a number of minor though apparently constant particulars, being ovate-acuminate instead of elliptical with a rounded apex, and having the basal secondaries or ribs arising slightly above the base of the blade instead of at the top of the petiole. The finer nervation is practically the same in both forms.

Occurrence: Denver formation, Golden, Colo. Dawson arkose, lower part (in beds equivalent to Arapahoe formation), 3,000 feet east of the Douglas mine, Sedalia, Colo. Raton formation, near Walsenburg, Colo. Wilcox formation, De Soto Parish, La.

Ficus planicostata goldiana Lesquereux

Plate 28, Figure 5

Ficus planicostata goldiana Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, p. 399, 1874; The Tertiary flora, p. 202, pl. 33, figs. 1–3, 1878.

Ficus planicostata clintoni (Lesquereux) Knowlton, U. S. Geol. Survey Bull. 152, p. 103, 1898; U. S. Geol. Survey Prof. Paper 101, p. 303, pl. 76, fig. 3, 1917 [1918].

This form is of the type of *Ficus planicostata* Lesquereux but differs by its larger size and above all by its thinner texture and lighter nervation. The leaves are elliptical or oval, approximating 12 centimeters in length and 6 or 7 centimeters in width, contracted above into a short acumen and round-cuneate or almost truncate at base. These leaves are conspicuously 3-ribbed from the base of the blade or the very top of the petiole, all being of about the same strength. The midrib has about three pairs of camptodrome secondary branches in the upper part, and the lateral ribs are at an acute angle and have six or eight branches on the outside. The nervilles are thin and often broken.

Only one of the three figured types of this form—the original of Plate 33, Figure 2, of the report on the Tertiary flora—is now to be found in the United States National Museum. This specimen and those represented by the other figures are seen to be larger than the usual leaves of *Ficus planicostata*, and in this one the leaf substance is thinner and the nervation lighter. It may be, as Lesquereux once suggested, that this form should have full specific rank and might even be placed in a different genus. In this connection he called attention to its resemblance to *Sterculia variabilis* Saporta, from the "Paleocene" of Sezanne.

Some misunderstanding appears to have arisen in connection with Lesquereux's reference of his *Ficus clintoni* to *F. planicostata goldiana*. *Ficus clintoni* was described[90] in 1872, and the description is on the same page as that of *F. planicostata*. It was described as a small species with leaves only 3 to 6 centimeters long. In 1878, when Lesquereux published his report on the Tertiary flora, he appears to have intended to merge his *Ficus clintoni* with *Ficus planicostata goldiana*, which has large leaves about 12 centimeters long. He stated that four of the small leaves (figs. 7, 8, 11, 12 of pl. 31), which he described as small, undeveloped leaves of *F. planicostata* and which were probably the types or at least typical of *F. clintoni*, may be referable to this variety, *F. planicostata goldiana*. If this view were accepted it would require a complete redefinition of *F. planicostata goldiana*, and this I am not able to accept. The small leaves above mentioned were all found at Black Buttes mixed with the typical leaves of *F. planicostata*, and according to present understanding should be left with the typical form. When Lesquereux labeled the specimens now in the National Museum he did not record the presence of either *F. clintoni* or *F. planicostata goldiana* at Black Buttes, and hence it may be assumed that his final intention was to relegate his *Ficus clintoni* to *Ficus planicostata*.

The above explanation has been made especially because of the effect on the matter of nomenclature. If *Ficus clintoni* is to be merged with *F. planicostata goldiana*, it would be necessary to replace *goldiana* by *clintoni*, on the ground of priority of publication. This is the disposition I made of the matter when I restored *clintoni* in the several publications indicated in the synonymy at the head of this form.

Ficus planicostata goldiana is not a very abundant form, though several leaves identical with the type specimens have been found in the recent collections

[89] Lesquereux, Leo, The Tertiary flora, p. 201, pl. 31, figs. 1–8, 10–12, 1878.

[90] Lesquereux, Leo, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, p. 393, 1873.

from Golden. There are several well-marked leaves referred to this form from the Raton formation at Trujillo, Colo.

Occurrence: Denver formation (types), Golden, Colo. Raton formation, Trujillo, Colo.

Ficus planicostata problematica Knowlton, n. var.

Plate 28, Figure 2

Leaf small and evidently rather thin, ovate-elliptical, very slightly unequal-sided, rounded about equally to both base and apex; nervation palmately 3-ribbed from the base, midrib slender, straight, with two pairs of alternate, thin secondaries which curve upward, the apical pair curving in until they nearly or quite reach the extreme apex of the leaf; lateral ribs of about the same strength as the midrib, slightly curving upward and reaching within a short distance of the apex, each with six or seven light secondary branches on the outside only, these curving upward and disappearing just within the margin; nervilles numerous, approximately at right angles to the midrib; finer nervation obsolete.

The single example figured is all that has been found thus far. It is a small ovate-elliptical leaf, about 5.5 centimeters in length and 3.3 centimeters wide near the middle, and slightly unequal-sided. This leaf was at first supposed to be referable to *Ficus planicostata* Lesquereux, with which it is undoubtedly most closely related, but it is evidently a much thinner leaf, is slightly more elliptical, and has only two pairs of secondary branches on the midrib, the upper pair curving inward rather more than is usual in the former species. As regards apparent texture it is nearer *F. planicostata goldiana*, but it is hardly one-fourth the size of leaves of that form and moreover has a different facies. It is quite possible, however, that additional material may show that this leaf should be referred to one or the other of the above-mentioned forms, but in the meantime it may be referred as above.

Occurrence: Denver formation, south face of South Table Mountain, 100 feet below the lava cap, Golden, Colo., collected by Arthur Lakes, 1890.

Ficus praetrinervis Knowlton

Plate 28, Figures 8–10

Ficus praetrinervis Knowlton, U. S. Geol. Survey Prof. Paper 101, pp. 263, 304, pl. 41, figs. 1–4; pl. 42, fig. 1, 1917 [1918].

Following is the original description of this species:

Leaves of firm texture, broadly ovate in shape, more or less abruptly rounded below to the decurrent base, and apparently rather obtuse above; margin perfectly entire; 3-ribbed from the base of the decurrent or wedge-shaped basal portion of the blade; central rib (midrib) straight, terminating in the tip of the blade, with two or three pairs of secondaries in the upper portion; lateral ribs nearly or quite equal in size to the midrib, equally dividing the distance between the midrib and the margin of the blade, curved and becoming approximately parallel to the midrib, thin above and apparently lost before reaching the upper third of the blade, each with two to four secondary branches on the outside, these being camptodrome and arching well inside the margin.

The type locality for *Ficus praetrinervis* is in the Vermejo formation of the Canon City field of Colorado, and it was subsequently determined to be abundant and widely distributed throughout the Raton Mesa area of Colorado and New Mexico. The Canon City material studied had passed through Lesquereux's hands, this species being identified by him as *Cinnamomum affine* Lesquereux. There is a considerable range in size. The larger examples are about 10 centimeters long and about 7 centimeters wide; smaller ones not more than 6 or 7 centimeters long and 4 centimeters wide. An average size is about 8 by 5 centimeters. The petiole is especially well preserved in some of the Canon City material and is from a third to almost half as long as the blade; the three principal ribs run clear to the very base and are compressed and lie side by side in the lower part.

Ficus praetrinervis was also found at several localities in the Raton formation of southern Colorado, thus proving to be one of the few species crossing the line between Cretaceous and Tertiary.

The collections made in the Dawson arkose on Jimmy Camp Creek, east of Colorado Springs, contain a dozen or more examples that undoubtedly belong to *Ficus praetrinervis* and show the same range in size as the types from Canon City, or even a greater range. These specimens also show more details of the finer nervation than the types. Four pieces of matrix have been figured, depicting six leaves. The smallest leaf (fig. 10) was about 4 centimeters long and 2 centimeters wide. Figure 9 is given because it shows the upper portion of a leaf of a form which for some reason appears to be infrequently preserved. It is rather more pointed than the type specimens seem to have been. The nervation of these specimens is well brought out in the figures.

Occurrence: Dawson arkose, east bank of Jimmy Camp Creek 0.6 mile above Richfield Springs ranch house, 9 miles east of Colorado Springs, Colo., collected by F. H. Knowlton and W. T. Lee, July, 1910. Raton formation, near Cokedale and Dean, Colo. Vermejo formation, abundant in the Raton Mesa region of Colorado and New Mexico.

Ficus puryearensis Berry? [91]

Plate 29, Figures 1, 2

Ficus puryearensis Berry, U. S. Geol. Survey Prof. Paper 91, p. 205, pl. 27, figs. 4, 5; pl. 28, fig. 5; pl. 30, figs. 4, 5, 1916.

This species is described by Berry as follows:

Leaves of medium size, smooth and coriaceous, oblong-lanceolate in outline. Apex shortly pointed. Base broadly rounded, slightly cordate, or very broadly pointed. Length ranges from 9 to 11 centimeters. Maximum width ranges from 3.3 to 5 centimeters at or somewhat below the middle. There is considerable variation in the appearance of these leaves, well illustrated in the specimens figured. The widest leaf has full, regularly curved margins and is shortly and broadly pointed distad and still more broadly pointed proximad. From this extreme the leaves vary toward forms that have a rounded, almost truncate base and a somewhat extended tip. The extreme form as regards the extended tip has a slightly cordate base, with full and rounded lower lateral margins, nearly straight sides, and an elongated narrowed tip. Petiole short and stout. Midrib stout, prominent on the lower side of the leaf. Secondaries relatively thin, 10 to 12 subopposite to alternate pairs, remote and somewhat irregularly spaced, diverging from the midrib at wide angles, nearly 90°, nearly straight until they reach the marginal region, where they turn abruptly upward and form a wide arch to the secondary next above. Tertiaries mostly obsolete. Margins entire.

As may be noted from this description and from the several figures given, there is considerable variation in the size, shape, and nervation in this species, and it seems not impossible that two forms may have been confused. The most abundant and most strongly marked form—shown in Berry's Plate 27, Figures 4 and 5, and Plate 30, Figures 4 and 5—is oblong-ovate and has the secondaries very conspicuously at a low angle, each joining the one next above by a broad bow far inside the margin. The other form—shown in Berry's Plate 28, Figure 5—is longer and more sharply pointed and has the secondaries, especially the lower ones, at a more acute angle and passing up nearer the margin.

The leaf here figured is most nearly like that shown in Berry's Plate 28, Figure 5, as mentioned above. It lacks the base and much of one side, but it has the apical portion well preserved. It was about 12 centimeters long and slightly over 4 centimeters wide. It has the fairly strong midrib and numerous alternate or subopposite low-angled secondaries, as in Berry's specimen, though if anything they seem to pass up for a greater distance near the margin before sending branches to join the secondary next above.

Occurrence: Dawson arkose, Rice's clay pit, 1 mile southwest of Calhan, Colo., collected by F. H. Knowlton, 1910. Wilcox group (types), Grenada and Hurleys, Miss. Lagrange formation, Puryear, Tenn., in beds of Wilcox age.

[91] This determination is extremely doubtful.—E. W. B.

Ficus sp.

Plate 29, Figure 5

The collection from the Dawson arkose on Jimmy Camp Creek, 9 miles east of Colorado Springs, Colo., contains a large leaf that is here figured. It lacks all or nearly all of the margin and hence can not be positively determined. It was probably not less than 18 centimeters long and 15 centimeters wide and was apparently more or less heart-shaped at the base. It is 5-ribbed, apparently from the top of the petiole. The midrib is slightly the stronger and has a pair of opposite secondaries at a great distance above the base. The next pair of ribs is at an angle of about 45° and has secondary branches on the outside. The lowest pair of ribs is approximately at right angles to the midrib and probably had branches on the lower side. The nervilles are strong and mainly unbroken.

This leaf resembles a number of described forms, but its fragmentary condition makes its full identification a matter of doubt. Thus, it suggests *Ficus speciosissima* Ward,[92] from the Mesaverde formation at Point of Rocks, Wyo., but it is apparently a larger leaf with a stronger primary nervation. Without the details of the basal configuration I can not compare this part with named species.

The leaf under consideration is very much like certain large leaves from the true Laramie of the Denver Basin [93] that have been described as *Ficus cockerelli*, but it can not be compared fully on account of its fragmentary condition. It also suggests a very large leaf of *Ficus planicostata latifolia* Lesquereux.[94]

This is so large a leaf that it perhaps merits a figure, although it is so fragmentary that its full character can not be made out. But there is probably enough of it to permit its identification if found in the future.

Occurrence: Dawson arkose, east bank of Jimmy Camp Creek 0.6 mile above Richfield Springs ranch house, 9 miles east of Colorado Springs, Colo., collected by F. H. Knowlton and W. T. Lee, July, 1910.

Ficus sp.

Plate 30, Figure 1

The specimen here figured lacks so much of being perfect that ordinarily it would hardly merit recognition, but it evidently represents so large and striking a leaf that I venture to include it. It was apparently ovate and could hardly have been less than 18 centimeters long and 14 centimeters wide. It is truncate below, with the base slightly decurrent down the peti-

[92] Ward, L. F., U. S. Geol. Survey Sixth Ann. Rept., p. 552, pl. 65, fig. 1, 1886.

[93] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 130, p. 132, 1922.

[94] Lesquereux, Leo, The Tertiary flora, p. 202, pl. 31, fig. 9, 1878.

ole. It is palmately 5-ribbed; the midrib is considerably stronger than the others and has at least one pair of strong opposite secondaries at a considerable distance above the base. The inner pair of ribs is at an angle of about 50°, straight and with several tertiary branches on the outside. The outer pair of ribs emerges at an angle of about 40° and also has a few outside branches. The finer nervation is not well preserved.

Occurrence: Dawson arkose, east bank of Jimmy Camp Creek 1 mile above Richfield Springs ranch house, 9 miles east of Colorado Springs, Colo., collected by F. H. Knowlton, July, 1910.

Ficus sp.

Ficus asarifolia Ettingshausen. Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 50, 1888.

This specimen is so fragmentary that ordinarily it would not be figured except for the fact that it was identified by Lesquereux as *Ficus asarifolia* Ettingshausen. The American leaves originally referred to this species were found in the Mesaverde formation at Point of Rocks, Wyo., and are small leaves not exceeding 4 centimeters in width and 3.5 centimeters in length, whereas the present leaf was fully 12 centimeters wide and probably not less than 10 centimeters long. It appears to have been broader than long and was rounded and obtuse at the apex. The margin apears to have been entire. The nervation is very coarse and strongly reticulated but very unlike the areolation in the Point of Rocks leaves.

Occurrence: Denver formation, South Table Mountain, Golden, Colo., collected by Arthur Lakes. Specimen identified as *Ficus asarifolia* Ettingshausen in the Museum of Comparative Zoology, Cambridge, Mass., No. 1441a.

Artocarpus pungens (Lesquereux) Hollick

Plate 30, Figure 2; Plate 31; Plate 32, Figures 1, 2

Artocarpus pungens (Lesquereux) Hollick, Louisiana Geol. Survey Rept. for 1899, Special Rept. 5, p. 281, pl. 38, figs. 1, 2, 1899.

Berry, U. S. Geol. Survey Prof. Paper 91, p. 195, pl. 25, fig. 1; pl. 27, fig. 1; pl. 29, fig. 1, 1916.

Aralia pungens Lesquereux, The Cretaceous and Tertiary floras, p. 123, pl. 19, figs. 3, 4, 1883.

Leaves thick and coriaceous, very large, probably reaching a length of 30 centimeters and a width of 18 or 20 centimeters, oblong in general outline, deeply pinnately lobed above and almost if not quite pinnate below; lobes opposite, lower and middle lobes directed outward at an angle of 45° or less, the upper ones directed upward; lobes long, oblong-lanceolate, taper-pointed, slightly broadest in the middle and lower portion, separated by more or less broad rounded sinuses, the sinuses separating the lower lobes extending nearly or quite to the midrib; margins entire; midrib very thick and stout, straight, secondaries proportionately thick, of two orders, the main ones strong, subopposite, ascending to the point of the lobe and several times branched on either side, the others smaller, emerging from the midrib between the large ones, passing up to the sinus, where they divide into two branches that arch around the sinus just inside the margin and follow the borders of the lobes in festoons, anastomosing with the tertiaries; tertiaries several in each lobe, alternate, curved slightly or markedly in passing to the margin, along which they often form long festoons just inside the border; ultimate areolation in the main quadrangular, formed by divisions at right angles to the tertiaries.

These were fine large leaves, but leaves of large size are rarely preserved complete, and although this species has been known for many years and has been found at a number of widely separated localities, we are still without a really perfect specimen. The middle and upper parts of the leaf are known from many specimens, but the basal portion is still somewhat in doubt. The lobes are separated by broad, rounded sinuses, and the extent to which the indentation approaches the midrib increases from the apex downward, until what is perhaps the lowest set of lobes is separated from the midrib by only a very narrow wing, and still below this there is a pair of apparently distinct leaflets. This condition is well brought out in the specimen shown in Plate 31. The upper part of this leaf is indistinguishable in shape and nervation from the figures of the type specimens. It may also be noted that the third pair of lobes from the apex of the leaf has the sinus on one side cutting almost to the midrib, but on the other side it is nearly a centimeter wide. These lobes are oblong-lanceolate—that is, they are slightly constricted near the base. Fully 2 centimeters below the pair of lobes just described there is seen a single small, oblong, wedge-shaped and apparently free leaflet, and so far as can be made out there is no wing along the midrib connecting it with the pair of lobes next above. An exactly similar condition is seen in the specimen shown in Plate 32, Figure 2, although it is considerably broken. In this specimen the third pair of lobes is about a centimeter below the pair next above, with no evidence of a connecting wing along the midrib (or rachis). These lobes (or leaflets) are deeply cut into on the upper side and expanded on the lower side. Two centimeters below is a small petioled leaflet (there was undoubtedly a pair, but the opposite one is destroyed) that is in undoubted organic connection with the axis (rachis), which extends for more than

2 centimeters below its point of attachment. This is probably the real base of the leaf, though there may be a still smaller and lower pair of leaflets that is not preserved.

Berry reported the presence of *Artocarpus pungens* in Wilcox beds at several localities in Louisiana and Arkansas, but neither in his figures nor in his discussion of the species is there an indication of free basal leaflets such as just described for the Denver specimens. Berry mentioned the difficulty of getting good specimens on account of the friable nature of the matrix in which they are preserved. His best example is a splendid specimen from Coushatta, La.[95] It represents the upper part of a leaf that was probably 30 centimeters in length. Two other specimens[96] from Benton, Ark., are apparently from near the middle portion of the leaves, and although there is no indication of a reduction of the lobes to leaflets, they do show the sinus cutting pretty close to the axis. So far as can be judged from the specimens figured there is no reason to question the correctness of the reference of the Wilcox material to *Artocarpus pungens*, but this is confessedly without a knowledge of the configuration of the base of the leaves.

The species under consideration was first described by Lesquereux[97] under the name *Aralia pingens* from specimens obtained at Golden, Colo. The types are the property of Princeton University and should be preserved in the university museum, but at the present time only one of them, the original of Figure 3 of Lesquereux's plate, can be found. This specimen, by the kindness of William Libby, jr., the curator of the museum, I was permitted to study. It has been redrawn and is shown on Plate 32, Figure 1. In the figure of it as published by Lesquereux the right-hand upper lobe is not represented, but an examination shows that what is given as true margin is not correct, and there is every reason to suppose that it was extended into a lobe similar to the one on the opposite side. Its restoration is shown by the dotted lines. The other type specimen possessed the two upper lobes, as do all specimens that are well enough preserved for this feature to be made out.

In referring these leaves to the genus *Aralia* Lesquereux apparently interpreted them as being the upper parts of very large palmately divided leaves with the segments deeply cut into large lobes, such for instance as may be seen in *Aralia dissecta* Lesquereux,[98] from the Green River formation. Lesquereux recognized the resemblance of *Aralia pungens* to his earlier *Myrica? lessigiana* (now *Artocarpus lessigiana*), but, evidently depending on the drawings rather than a study of the specimens, he decided that the nervation differed sufficiently to separate them generically. In this connection he said:[99]

> This species is allied to what has been described in volume 7 as *M[yrica] lessigii*, but the nervation differs. In *M. lessigii* the tertiary veins directed toward the sinuses divide under them into two branches, passing along on both sides and following the borders of the lobes, while in this leaf [his *Aralia pungens*] the tertiary veins do not divide but appear merely to pass up on one side without forking. Though this difference may be marked, it is scarcely possible to doubt that these fragments represent the same group or the same genus of plants, and, as I have remarked it in the description of *M. lessigii*, Saporta and other authors refer plants of this kind to the Araliaceae.

A glance at the figure of *Aralia pungens* as redrawn (pl. 32, fig. 1) shows the nervation about the sinuses to be of the same character as that in the so-called *Myrica lessigiana*, and therefore this supposed distinctive character fails.

It is now necessary to consider further the relation between *Artocarpus pungens* and *Artocarpus lessigiana*. They are undoubtedly very close, and at one time I was inclined to place them together,[1] but Berry[2] regards them as distinct and recognized both in the Wilcox group. He said:

> This species [*Artocarpus pungens*] differs from *Artocarpus lessigiana* (Lesquereux) Knowlton, with which it is often confused, by its more orbicular general form and the great elongation and narrowness of the lobes, which are also more ascending and are separated by more open sinuses.

I have accepted this disposition and in my paper on the Laramie flora[3] have kept them distinct, the more so because it proved that in the Denver Basin *A. lessigiana* is confined to the Laramie and *A. pungens* to the Denver. The peculiar reduced and free lobes or leaflets just described as occurring in *A. pungens* might prove an additional and very marked point of difference between the two species if we were able to compare this feature in them, but unfortunately no specimen of *A. lessigiana* is known which has the basal portion preserved. In the type of *A. lessigiana* the lowest lobe present is very broad and blunt, and it seems improbable, from the size and configuration of the whole leaf, that there could have been any reduced lobes or leaflets below that lobe, but this is of course purely conjectural.

Occurrence: Denver formation, South Table Mountain, Golden, Colo. Wilcox group, Grenada, Miss., Benton, Ark., and Coushatta and Naborton, La.

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[95] Berry, E. W., The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, pl. 25, 1916.

[96] Idem, pl. 27, fig. 1; pl. 29, fig. 1.

[97] Lesquereux, Leo, The Cretaceous and Tertiary floras, p. 123, pl. 19, figs. 3, 4, 1883.

[98] Idem, pl. 35.

[99] Idem, p. 123.

[1] Knowlton, F. H., Catalogue of the Cretaceous and Tertiary plants of North America: U. S. Geol. Survey Bull. 152, p. 42, 1898.

[2] Berry, E. W., The lower Eocene floras of southeastern North America: U. S. Geol. Survey Prof. Paper 91, p. 195, 1916.

[3] Knowlton, F. H., Laramie flora of the Denver Basin: U. S. Geol. Survey Prof. Paper 130, p. 128, 1922.

Artocarpus similis Knowlton

Plate 32, Figure 4

Artocarpus similis Knowlton, U. S. Geol. Survey Prof. Paper 101, p. 306, pl. 77; pl. 78, figs. 1, 2, 1917 [1918].

The type of this species comes from the Raton formation of the Raton Mesa region of southern Colorado, where it was found at a number of localities. It was shown to be most closely related to forms from the Denver Basin, which are now believed to represent two species. These are *Artocarpus lessigiana* (Lesquereux) Knowlton (originally described as *Myrica? lessigiana*) and *Artocarpus pungens* (Lesquereux) Knowlton (first named *Aralia pungens*). *Artocarpus similis* is, in a way, intermediate between the two Denver Basin forms, having the narrow, acute-pointed lobes of *A. pungens* and the ovate, obtuse terminal lobe of *A. lessigiana*.

The example here figured is almost exactly the same as the type figured on Plate 77 of the Raton Mesa report except that it is much smaller. It is only a little more than 7 centimeters wide between the points of the upper lobes and could hardly have been much if any over 12 centimeters in length.

Occurrence: Dawson arkose, Rice's clay bank, 1 mile southwest of Calhan, Colo., collected by F. H. Knowlton, July, 1910. Raton formation, southeastern Colorado.

Artocarpus? gigantea Knowlton, n. sp.

The collection from Jimmy Camp Creek, east of Colorado Springs, Colo., contains the remains of a leaf that, although very imperfectly preserved, is so gigantic and so striking in appearance as to warrant a name and description. Very little, if any, of the margin is retained, yet the portion of the leaf present is 30 centimeters long and about 15 centimeters wide. It was probably at least 40 centimeters long, and, to judge from the thickness of the midrib where it is broken at the base and apex, it might well have reached a length of 50 centimeters. It appears to have been elliptical or oblong in general outline, though the absence of the margin makes this uncertain. There appears to be a shallow, rounded sinus near the base on the right-hand side, giving indication of the presence of a large lobe, and that there were probably other lobes is suggested by the exceedingly strong secondaries in the middle and upper part of the blade. The secondaries number at least five or six pairs. They are very strong, alternate, and at irregular distances.

The fragmentary character of this leaf makes a knowledge of its generic reference uncertain. Its size and apparent shape, the probable lobe in the lower portion, and the character of the nervation suggest at once the genus *Artocarpus*. It is perhaps nearest to what Berry [4] has identified as *Artocarpus lessigiana* (Lesquereux) Knowlton, from the Wilcox formation at Shreveport, La.[5] I am not certain that the Wilcox leaves are conspecific with the type specimens of *A. lessigiana*, which came from the Laramie of the Denver Basin, though they may be. The leaves of *Artocarpus* are sometimes identified with difficulty. They are such large leaves that it is unusual to find them wholly preserved, and moreover they are usually very rare, thus making in difficult to procure material for comparison. Berry states that the Wilcox specimens are large leaves having a maximum length of 30 centimeters and a maximum width of 20 centimeters. In the figure given by Berry the secondaries are seen to be at a low angle with the midrib, whereas in the leaf under discussion the secondaries are at an angle of about 45° and do not curve downward, so far as can be made out. The lower lobe, if it is such, in the present species is separated by a deeper sinus than in Berry's figured specimen, and there are some differences in the details of nervation. But none of these differences are great, and it is possible that they might be shown to be closer if a sufficient series were available for comparison. For this reason I have decided to give the leaf under consideration a new name and trust to the future to settle its status.

It has some resemblance to *Artocarpus pungens* (Lesquereux) Hollick, which has just been discussed, though it is very much larger and of course gives no evidence of the presence of the basal characters described in that species.

The specimen of this form is so fragmentary that I have not been able to figure it.

Occurrence: Dawson arkose, east bank of Jimmy Camp Creek 0.6 mile north of Richfield Springs ranch house and 9 miles east of Colorado Springs, Colo., collected by F. H. Knowlton and W. T. Lee, July, 1910.

Order PLATANALES

Family PLATANACEAE

Platanus rhomboidea Lesquereux

Plate 32, Figure 3

Platanus rhomboidea Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, p. 400, 1874; The Tertiary flora, p. 186, pl. 26, figs. 6, 7, 1878; Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 49, 1888.

Knowlton, Washington Acad. Sci. Proc., vol. 11, p. 204, 1909; U. S. Geol. Survey Prof. Paper 101, p. 324, 1917 [1918].

Viburnum anceps Lesquereux, The Tertiary flora, p. 227, pl. 38, fig. 11, 1878.

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[4] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 194, pl. 26, 1916.

[5] It is undoubtedly identical with the Louisiana material.—E. W. B.

Leaves small or medium sized (7 to 12 centimeters long, 5 to 9 centimeters broad), subcoriaceous, rhomboidal, 3-ribbed and in some specimens slightly trilobate, being broadest at about the middle, from which point they are narrowed and entire to the wedge-shaped base and about equally narrowed above, where they are more or less deeply, usually sharply dentate; lateral nerves (secondaries) at an acute angle of divergence, parallel, the lower pair a little the longer and entering short acute lobes, each with three or four branches on the outside, which also pass to marginal teeth; nervilles nearly at right angles to the midrib, mostly percurrent; finer nervation quadrangular.

The two figured type specimens of *Platanus rhomboidea* are preserved in the United States National Museum (Nos. 245, 246) and are from the characteristic andesitic material of the Denver formation at Golden, Colo. They were the only specimens recorded in the Museum catalogue that were so identified by Lesquereux, but in the large lot of specimens belonging to the Museum of Comparative Zoology that were studied by Lesquereux in 1888 no less than six additional examples were recorded, and in the large collection from Golden procured by Arthur Lakes in 1890 and studied by me a number of characteristic specimens were found. This species has since been detected in the Lance formation in Weston County, Wyo., and in certain beds southwest of Rawlins, Wyo., in beds regarded by me as of post-Laramie age. It has also been found at a number of localities in the Raton formation of Colorado and New Mexico.

In 1878 Lesquereux described and figured in the report on the Tertiary flora (pl. 38, fig. 11) a single leaf under the name *Viburnum anceps*. After a careful examination of the type (U. S. Nat. Mus. No. 326) I am unable to find any character that will separate it from *Platanus rhomboidea*. It is based on the upper portion of a leaf of the same size as the smaller of the two types of *P. rhomboidea*. The general shape of the leaves, as well as the nervation, is precisely the same, the only difference being that in the so-called *Viburnum anceps* the teeth are not quite so prominent nor sharp.

Occurrence: Denver formation (types), Golden, Colo.; subsequently collected by Arthur Lakes from South Table Mountain, Golden. Dawson arkose, a quarter of a mile east of the Purdon mine, sec. 27, T. 11 S., R. 61 W., Colo., collected by G. B. Richardson. Raton formation, near Raton and mouth of York Canyon, N. Mex., and several localities near Wootton, Colo., all collected by W. T. Lee. Lance formation, Weston County, Wyo. Hanna formation, near Rawlins, Wyo.

Platanus guillelmae Göppert

Plate 33, Figure 2; Plate 34, Figure 1

Platanus guil elmae Göppert. Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1871, p. 289, 1872; The Tertiary flora, p. 183, pl. 25, figs. 1–3, 1878.
Knowlton, U. S. Geol. Survey Prof. Paper 101, p. 322, pl. 93, fig. 1, 1917 [1918].

In discussing certain platanoid leaves from the Raton Mesa region of Colorado and New Mexico, I took occasion to say [6] that I found a number of well-preserved leaves that were indistinguishable from the usual figures given for *Platanus guillelmae*, such as those given by Heer [7] from the Tertiary of Greenland. The same statement applies to certain leaves from the Denver formation. The one here figured (pl. 33, fig. 2), for example, is not to be distinguished from the figured specimen from the Raton formation, except that it is slightly larger. It is about 11 centimeters long and 12.5 centimeters wide, truncate at the base, and with margins entire for some distance and thence with small sharp teeth. It is distinctly 3-lobed, with the lateral lobes small and rather obtuse. The lateral ribs arise some distance above the base of the blade.

These leaves somewhat resemble small leaves of *Platanus aceroides latifolia* Knowlton,[8] but they differ in being more nearly truncate at the base, in having shorter lateral lobes, and in having the lateral ribs arising well above the base instead of at the top of the petiole.

Occurrence: Denver formation, South Table Mountain, Golden, Colo., collected by Arthur Lakes. Raton formation, Raton Mesa region of southern Colorado and adjacent New Mexico. Hanna formation, Carbon, Wyo. Fort Union formation, Glendive, Mont. Lance formation, near Glendive, Mont., and Dayton and Kubey, Wyo.

Platanus aceroides latifolia Knowlton

Plate 33, Figure 1

Platanus aceroides latifolia Knowlton, U. S. Geol. Survey Prof. Paper 101, p. 321, pl. 92; pl. 93, fig. 3; pl. 94, 1917 [1918].
Berry, U. S. Geol. Survey Prof. Paper 91, p. 13, 1916.

This variety is similar to the type but is proportionately broader and shorter, the margin provided with numerous small, rather blunt teeth. It is of the type of the living *Platanus occidentalis* and may be described as being of medium size, 3-ribbed and 3-lobed, the base truncate, slightly cordate or rarely more or less subcuneate, the lobes broadly triangular

[6] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 101, p. 322, 1917 [1918].
[7] Heer, Oswald, Flora fossilis arctica, vol. 7, p. 96, pl. 97, fig. 6; pl. 99, fig. 1, 1883.
[8] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 101, p. 321, pl. 93, fig. 3, 1917 [1918].

with the margins dentate, the middle lobe with two to four teeth and the lateral lobes with a few more, the teeth usually strong, in many specimens curved or even slightly hooked, and invariably sharp pointed.

This form is probably the most abundant member of the genus in the Raton formation of the Raton Mesa region of Colorado and New Mexico. In a single collection obtained near Wootton, Colo., there are more than a hundred specimens, some of them absolutely perfect. It is discussed at some length in my paper on the flora of the Raton formation.[9]

In the material from the Denver formation at Golden, Colo., there are a number of specimens that clearly belong to this variety. They are smaller than many from the Raton formation but agree with some of the smaller leaves. Thus, the specimen figured seems indistinguishable from the one shown on Plate 94 of the paper above mentioned.

Platanus aceroides latifolia was found by Berry[10] in the Midway(?) formation at Earle, Bexar County, Tex.

Occurrence: Denver formation, South Table Mountain, Golden, Colo. Raton formation, Raton Mesa region of Colorado and New Mexico. Midway(?) formation, Earle, Bexar County, Tex.

Platanus raynoldsii Newberry

Plate 35, Figure 1

Platanus raynoldsii Newberry, New York Lyceum Nat. Hist. Annals, vol. 9, p. 69, 1868; Illustrations of Cretaceous and Tertiary plants, pl. 18, U. S. Geol. and Geog. Survey Terr., 1878 [plates prepared by Newberry; names assigned by Lesquereux]; U. S. Geol. Survey Mon. 35, p. 109, pl. 35, 1898.

Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, pp. 379, 399, 1873; idem for 1873, p. 381, 1874; idem for 1876, p. 507, 1878; The Tertiary flora, p. 185, pl. 27, fig. 2, 1878; Illustrations of Cretaceous and Tertiary plants, pl. 18, U. S. Geol. and Geog. Survey Terr., 1878 [plates prepared by Newberry; names assigned by Lesquereux]; Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 49, 1888.

Knowlton, U. S. Geol. Survey Prof. Paper 101, p. 324, pl. 95, fig. 1, 1917 [1918].

The following is the original description given by Newberry:

> Leaves of large size, suborbicular or rudely triangular in outline, more or less rounded below, three-pointed above, often decurrent on the petiole; margins at base entire, on the sides and above coarsely and obtusely doubly serrate, the lobes of the upper margin short and broad, less produced than in most other species; nervation strong but open, having the usual character of *P. occidentalis* and of the fossil species *P. aceroides*.

The type specimens came from the Fort Union formation near the mouth of the Yellowstone River, Montana. It was reported as abundant in the collections examined by Newberry and was found by Ward[11] in approximately the same locality 20 years later. In recent years it has been collected from a great number of localities in Montana and the Dakotas; in fact, it proves to be one of the most abundant and widely distributed Fort Union species.

Soon after *Platanus raynoldsii* was described from the Yellowstone region it was reported by Lesquereux as occurring at Black Buttes, Wyo., and Golden, Colo. The specimens from Black Buttes were said to have come from the saurian bed, but they are now lost, and none have since been obtained.

Platanus raynoldsii appears to be closely related to *Platanus haydenii*, and unless the specimens are fairly well preserved it is sometimes very difficult to distinguish between them. As defined by Newberry they could be separated by the characters of the marginal dentition, being simply toothed in *P. haydenii* and doubly serrate in *P. raynoldsii*, but an examination of the figured type specimen of *P. raynoldsii*,[12] now in the National Museum, discloses the fact that it is simply toothed like the other. On removing the matrix it was found that what appeared to be smaller teeth on the large ones were due entirely to the manner in which the matrix was fractured along the margin of the leaf. The two species may be distinguished, however, by characters drawn from the shape and nervation of the basal part of the leaf. In *Platanus raynoldsii* the base of the blade is rounded to a wedge-shaped portion decurrent on the petiole, and the lowest pair of lateral ribs arise a considerable distance above the base of the blade. In *P. haydenii* the base is nearly or quite truncate, with no decurrent portion along the petiole, and the large ribs arise with the midrib at the very base of the blade. This shows why in the absence of complete leaves it is so difficult to distinguish between these species.

Platanus raynoldsii is one of the most abundant species in the Denver formation at Golden, Colo. So far as can be made out, all the specimens that passed through Lesquereux's hands up to the time of the publication of his report on the Tertiary flora (1878) he intended to refer to his variety *integrifolia*, though this is by no means certain, as is explained on a subsequent page. In any event, in the list of specimens identified for the Museum of Comparative Zoology the 23 specimens found were recorded under the original specific name only. It is therefore doubtful whether it was Lesquereux's intention to abandon the

[9] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 101, p. 321, 1917 [1918].

[10] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 13, 1916.

[11] Ward, L. F., U. S. Geol. Survey Bull. 37, p. 37, 1887.

[12] Newberry, J. S., The later extinct floras of North America: U. S. Geol. Survey Mon. 35, pl. 35, 1898.

so-called varietal form, or whether all the specimens happened to belong to the species and not the variety. It is certain that among the recent collections there are a number of specimens that belong to the specific form as well as some that might be referred to the varietal form. It is to be noted, however, that the leaves referred to *P. raynoldsii* from Golden, Colo., are in general much smaller than the specimens from the Fort Union. Thus the specimen figured by Lesquereux[13] is absolutely identical with the type as figured by Newberry.[14] In Newberry's text it is stated that this is one-half the linear size of the largest specimen obtained.

In the material obtained at Carbon, Wyo., by Ward, I find several fragments of a large *Platanus* leaf, among them being one (U. S. Nat. Mus. No. 1080) having the decurrent basal portion and a part of the petiole fairly well preserved. For some distance the margin appears to be perfectly entire, but soon it becomes obscurely toothed, the teeth being low and separated by shallow sinuses. The upper part of the leaf is not preserved, but so far as can be made out it was probably 3-lobed. The basal portion of this leaf is undoubtedly like that of typical *P. raynoldsii*, and it is so considered.

Platanus raynoldsii is also present in the Raton formation of the Raton Mesa region of Colorado and New Mexico.[15]

Occurrence: Fort Union formation (types), near mouth of Yellowstone River, Mont.; abundant and widely distributed in the Fort Union formation. Denver formation, south face of South Table Mountain, Golden, Colo. Hanna formation, Carbon, Wyo., collected by Lester F. Ward, 1883. Raton formation, Raton Mesa of southern Colorado and adjacent New Mexico.

Platanus raynoldsii integrifolia Lesquereux

Plate 34, Figure 2

Platanus raynoldsii integrifolia Lesquereux, The Tertiary flora, p. 185, pl. 26, figs. 4, 5, 1878.

There is some confusion and uncertainty regarding the status of this form, as it is difficult to make out just what Lesquereux intended to do. It was established on material said to have come from Golden, Colo., and Black Buttes, Wyo., but a study of the matrix of the figured types now preserved in the United States National Museum does not bear out its presence at Black Buttes. In the report on the Tertiary flora, where the variety *integrifolia* was established, Lesquereux first employs the heading *Platanus raynoldsii* and under it places all the plate references, yet the description follows the introduction of the varietal name. In the discussion of this form given by Lesquereux it is not clear whether he intended to call all the specimens *integrifolia* or whether a part were to be regarded as referable to the species. In the explanation of the plates the figures on Plate 26 are referred to as *Platanus raynoldsii* var. *integrifolia*, but on Plate 27 the figures are all given to the species, and they are all recorded in the Museum catalogue under the same designation.

Lesquereux's description of the variety is as follows:

> Leaves of large size, suborbicular or obscurely triangular in outline, more or less rounded and entire toward the decurrent base, dentate, serrate or undulate, even entire, subcoriaceous.

This description, it will be observed, agrees with the characterization of the species given by Newberry, except as regards the margin. Four of the five specimens figured by Lesquereux in the report on the Tertiary flora are now in the National Museum. They are all preserved in the andesitic material characteristic of the Denver formation at Golden, Colo., although one of them—the original of Plate 26, Figure 4—is said by Lesquereux (p. 186) to have come from Black Buttes, Wyo. These leaves are all imperfect, and it is difficult if not impossible to determine the exact character of the margin, and I strongly suspect that Lesquereux's description was prepared largely from the drawings and not from the actual specimens. For example, take the specimens shown on Lesquereux's Plate 26 under the designation *Platanus raynoldsii* var. *integrifolia*. The larger leaf is Figure 4 (U. S. Nat. Mus. No. 243), which is shown as if practically the whole margin were preserved and were entire or slightly undulate; but with the exception of a small basal portion below the lowest tertiary branch of the basal rib the margin of the entire left-hand side of the leaf is missing, and the margin of the right-hand side is indefinite except for perhaps a distance of 5 centimeters near the base. Figure 5 of this plate is described as perfectly entire. This specimen (No. 244) is very poorly preserved, especially the margin; in fact, it is doubtful if any margin at all is retained. If any of it is true margin it appears to be undulate-toothed rather than perfectly entire.

On Plate 27 of the report on the Tertiary flora there are three figures referred to *Platanus raynoldsii* without the varietal designation. Two of these specimens (figs. 1 and 2) are before me; the better-preserved one is that shown in Figure 2 (U. S. Nat. Mus. No. 248). In the figure the margin is shown on practically the whole of the left-hand side, but the specimen does not bear this out, for with the exception of the entire-margined decurrent basal portion of the blade with perhaps a length of 4 centimeters adjacent, the whole margin of this side is either absent or so imperfectly

[13] Lesquereux, Leo, The Tertiary flora, p. 185, pl. 27, fig. 2, 1878.
[14] Newberry, J. S., op. cit., pl. 35.
[15] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 101, p. 324, pl. 95, fig. 1, 1917 [1918].

preserved that its presence is impossible to determine certainly. The other specimens are even more fragmentary and afford no additional information regarding the character of the margin.

Among the specimens recently collected at Golden are a considerable number that from the configuration of the base should be referred to *Platanus raynoldsii*, but unfortunately there is not one that shows the complete outline or gives positive evidence regarding the marginal teeth. I think Lesquereux was probably right in believing that these leaves from Golden are more nearly entire than the types from the Fort Union formation, but they are not so entire-margined as the figures would imply. On account of the conditions above set forth it has been thought best to retain the variety *integrifolia* as established by Lesquereux and to leave to the future the determination of its exact status.

In the collections from Converse County, Wyo., I find a single fragmentary leaf that appears to belong to *Platanus raynoldsii integrifolia*. It is of about the same size as the specimens figured by Lesquereux, being 14 or 15 centimeters long and about 13 centimeters wide, and has a portion of a strong petiole preserved. Unfortunately only a very small portion of the margin is preserved, but so far as can be made out it was not a 3-lobed leaf and has the margin rather coarsely undulate-toothed—that is, both teeth and sinuses appear to be rounded. It is certainly not doubly dentate, as described for the type specimens, but seems to agree more with Lesquereux's so-called variety *integrifolia*. It is possible that if more material were available differences would be observable.

In the material from Middle Park, Colo., I also find a single small, much broken leaf that appears to be referable to this variety. Only a portion of the margin near the base of the blade is preserved, and this is entirely without teeth.

Occurrence: Denver formation [types], South Table Mountain, Golden, Colo., collected by Arthur Lakes in the early seventies and in larger numbers about 1890. Middle Park formation, Sheriff Creek, north bank of Grand [Colorado] River, Middle Park, Colo., collected by George L. Cannon. Lance formation, Lightning Creek opposite mouth of Box Creek, Converse County, Wyo., collected by J. B. Hatcher.

Platanus haydenii Newberry

Plate 36, Figure 1

Platanus haydenii Newberry, New York Lyc. Nat. Hist. Annals, vol. 9, p. 7, 1868; Illustrations of Cretaceous and Tertiary plants, pls. 19, 20, U. S. Geol. and Geog. Survey Terr., 1878 [plates prepared by Newberry; names assigned by Lesquereux]; U. S. Geol. Survey Mon. 35, p. 103, pls. 36, 38, pl. 56, fig. 3, 1878.

Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1871, pp. 287, 289, 290, 1872; idem for 1872, p. 379, 1873; idem for 1873, p. 381, 1874; idem for 1876, p. 507, 1878; Illustrations of Cretaceous and Tertiary plants, pls. 19, 20, U. S. Geol. and Geog. Survey Terr., 1878 [plates prepared by Newberry; names assigned by Lesquereux]; Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 48, 1888.

This species was described by Newberry as follows:

> Leaves large, long-petioled, when mature three, perhaps rarely five lobed; lobes nearly equal, long-pointed, acute; on either side of the middle lobe five to eight obtuse teeth; margins of the lateral lobes sinuately toothed to near the base; younger leaves ovate, acuminate, coarsely toothed throughout, except near the base, which is slightly decurrent; nervation strong, radiate from the base, primary nerves three, which are nearly straight and terminate in the three lobes of the border. From the midrib spring seven or eight pairs of lateral nerves above the basilar pair; these diverge at an angle of about 35°, are slightly flexed at the base, straight or nearly so above, where they are somewhat truncated, their branches terminating in the marginal teeth. The basilar nerves diverge from the midrib at an angle of about 35° and run nearly straight to the extremities of the lateral lobes. They each give off on the lower side seven or eight branches, of which the second or third is straight. These are more or less curved and branched, the branches terminating in the teeth of the margin. Fruit 2–3 lines long, prismatic, clavate.

This is the original and most complete description that has been given of this species, which was first obtained on the banks of the Yellowstone River near its mouth. It is said by Newberry to be well represented by specimens, though but few of these are present in the collections of the United States National Museum. Ward, who collected extensively in the same general area as the type locality in 1883, did not procure any of the large mature leaves, though he did procure a number of leaves identical with those referred by Newberry to the young forms of this species.

I have studied the two leaves figured by Newberry as the young, immature leaves of *P. haydenii* and am inclined to doubt his conclusion. The one shown on his Plate 38 is said to be "probably a young or abnormal state of this species, as it occurs with the ordinary trilobate form." This leaf is certainly platanoid in appearance, but it is very different from *P. haydenii*, especially as regards the nervation at the base of the leaf. Without a series connecting this with the normal form it seems to me to be very doubtful if they should be placed together.

The small leaf shown in Newberry's Plate 56, Figure 3, is also platanoid in appearance and may well enough have been the immature leaf of one of the large-leaved species, but its association with *Platanus haydenii* seems to me questionable. It is 3-lobed, with a large central lobe and smaller lateral lobes, in this respect agreeing with *P. haydenii*. The basal nervation consists of a fairly strong midrib and two lighter

lateral ribs which arise at some distance above the base of the blade and end in the lateral lobes. In this feature this leaf agrees with *Platanus raynoldsii*, which has the basal ribs arising well above the base of the blade, and differs from *P. haydenii*, in which the basal ribs arise at the top of the petiole, with the midrib.

There are several described and figured Fort Union species that seem to be identical with the small leaf referred by Newberry, as indicated above, to *Platanus haydenii*. *Populus nervosa elongata* Newberry,[16] from the Yellowstone River at or near the type locality for *Platanus haydenii*, is smaller than the leaf of *Platanus haydenii* but does not appear to differ essentially. The form identified by Ward[17] as *Platanus guillelmae* Göppert is even more like *Platanus haydenii* than the *Populus* just mentioned. Ward described two other species that strongly suggest this small leaf referred to *Platanus haydenii*. These are *Grewiopsis viburnifolia*[18] and *G. populifolia*,[19] both, like the specimen identified as *Platanus guillelmae*, from the lower Yellowstone River near the locality that supplied *P. haydenii*. When the flora of the Fort Union formation comes to be fully worked up it may be possible to arrive at a definite conclusion regarding the status of the leaves mentioned above, but until that time it is perhaps best to leave them as fixed by the authors quoted.

Platanus haydenii has been reported from a number of localities in Wyoming and Colorado, in beds then supposed to be of Laramie age, as well as in certain overlying beds. Thus in the United States National Museum collection I find a single example (No. 912) recorded as having come from Evanston, Wyo. This appears to be the same that was alluded to by Lesquereux[20] as *Platanus nobilis* Newberry, as it agrees perfectly with the description and moreover is the only large *Platanus* leaf now in the Museum collection from this place. This specimen is of much importance, for if authenticated it would be an instance of *P. nobilis* found in beds not now recognized as Fort Union; but doubt attaches to it, as it was referred by Lesquereux in his later work to *P. haydenii*. An examination of this specimen shows it to be a mere fragment from the middle of a large leaf, and it is without a trace of margin or any character by which it can be positively identified. It is without doubt a piece of a large *Platanus* leaf, but beyond this it is absolutely impossible to go with certainty. It might have belonged as well to any large-leaved species, and this uncertainty is well shown by the fact that it was first referred to *P. nobilis* and later to *P. haydenii*.

There is a specimen in the National Museum (No. 914) from Sand Creek, Colo., that was referred by Lesquereux to *Platanus haydenii*. It is a fragment showing the lower left-hand side of a medium-sized leaf. The margin was not exposed at first, but by removing some of the matrix it could be made out with difficulty. The specimen has large simple teeth and is probably correctly named, though more material will be needed for confirming this identification.

The Museum collection contains a number of specimens of *P. haydenii* from the Denver formation at Golden, Colo. One of these (No. 242) is the original of Plate 25, Figure 6, of the report on the Tertiary flora. The others (Nos. 843, 909) are broken leaves, one of them of larger size, but they do not have the margin preserved.

In the collections from the Denver formation studied by Lesquereux[21] for the Museum of Comparative Zoology of Harvard College no less than 16 specimens were found. They seem to be the young form described above, for the most perfect example was compared by Lesquereux with *Populus nervosa* Newberry, the variety of which has already been shown to be probably identical with the young leaf of *Platanus haydenii*.

The recent large collections from the Denver formation at Golden, Colo., also include a number of more or less perfect leaves that I have referred to *P. haydenii*, but these leaves approach *P. raynoldsii* Newberry so closely in size and nervation as to be separated with difficulty. This collection contains a great many large leaves of *Platanus*, but they are so fragmentary that it is next to impossible to differentiate them.

According to the catalogue of the National Museum there should be specimens of *Platanus haydenii* from Bridger Pass, Wyo., the Raton Mountains, N. Mex., the vicinity of Colorado Springs, Colo., and elsewhere, but they can not now be found.

Occurrence: Fort Union formation (types), Yellowstone River near its mouth, Montana; now known to be abundant and widely distributed in the Fort Union. Denver formation, Golden and Sand Creek, about 12 miles east of Denver, Colo. Lawson arkose, lower part (in beds equivalent to Arapahoe formation), Sedalia, Colo.

[16] Newberry, J. S., The later extinct floras of North America: U. S. Geol. Survey Mon. 35, p. 49, pl. 28, fig. 1, 1898.

[17] Ward, L. F., Types of the Laramie flora: U. S. Geol. Survey Bull. 37, p. 37, pl. 20, fig. 1, 1887.

[18] Idem, p. 89, pl. 40, fig. 2.

[19] Idem, p. 90, pl. 40, figs. 3–5.

[20] Lesquereux, Leo, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1871, p. 295, 1872.

[21] Lesquereux, Leo, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 48, 1888.

Platanus marginata (Lesquereux) Heer

Plate 36, Figures 2, 3

Viburnum marginatum Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, p. 395, 1873; idem for 1873, pp. 382, 401, 1874; idem for 1874, p. 306, 1876; idem for 1876, p. 510, 1878; U. S. Geol. and Geog. Survey Terr. Bull., vol. 1, p. 380, 1875; The Tertiary flora, p. 223, pl. 38, figs. 1, 4 [not figs. 2, 3, 5], 1878; Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 51, 1888.

Knowlton, Geol. Soc. America Bull., vol. 8, p. 145, 1897; Jour. Geology, vol. 19, p. 361, 1911.

Platanus marginata (Lesquereux) Heer, Flora fossilis arctica, vol. 7, p. 97, pl. 98, figs. 3–5; pl. 99, figs. 2, 3; pl. 101, fig. 5, 1883.

Jankó, Engler's bot. Jahrb., vol. 11, p. 454, 1889.

Cross, Colorado Sci. Soc. Proc., vol. 4, p. 211 [25 of reprint], 1892.

This species, under the name *Viburnum marginatum*, was first described from abundant material collected in 1872 at Black Buttes, Wyo. Of the great number of specimens present Lesquereux was inclined to refer a considerable variety to this species, writing as follows:

> So different, indeed, are some of these leaves that but for the permanent character of their nervation it would be impossible to consider them as representing the same species. The small leaves are about 5 centimeters long, half as broad in the upper part, or above the middle, tapering downward to the petiole. The largest are 12 to 14 centimeters long, fully as broad below the middle, abruptly contracted to the petiole, rounded upward, or often merely truncate to a short point entered by the median nerve.

Lesquereux compared these leaves especially with such living species as *Viburnum pubescens* Pursh, *V. dentatum* Linné, and *V. lantanoides* Michaux.

In later publications additional material from the type locality was mentioned by Lesquereux, and he also reported this species as present at Point of Rocks, Wyo., and Golden, Colo. All but one of the figured types of *Viburnum marginatum* are present in the United States National Museum, but there are no examples preserved from either of these additional localities, nor apparently have any been subsequently obtained.

In 1883, when Heer studied and described the Tertiary flora of Greenland, he found what he presumed to be the same as the *Viburnum marginatum* of Lesquereux, but after fully considering the case he decided that they should be properly referred to the genus *Platanus*, and he consequently called them *Platanus marginata*. This view is sustained by Jankó,[22] who is an authority on the genus *Platanus*, both living and fossil.

I have studied carefully the material, both figured and unfigured, in the National Museum, and while I am prepared to admit the correctness of referring a portion of them to *Platanus*, I do not think that all belong to a single species or even to the same genus. What I assume to be *Platanus* are well shown in Figures 1 and 4 of Plate 38 in the report on the Tertiary flora, and these are evidently the forms that were principally in the minds of Heer and Jankó when they transferred Lesquereux's species from *Viburnum*.

The type of leaf that I would ascribe to *Platanus marginata* may be described as follows: Leaf of medium or small size (12 to 15 centimeters broad and about the same in length), broadly ovate or obovate, obtusely wedge-shaped at the base, not divided into lobes but rather abruptly rounded and entire above or with a short acuminate point; margin entire below, becoming sparsely denticulate above, the teeth small, acute; petiole relatively long and strong; primary nerves three, strong, the central or midrib straight, ending in the tip or apex, with about four pairs of strong, subopposite secondaries which usually fork once or twice, the branches passing to the marginal teeth; lateral ribs arising at the very base of the blade and at the same angle as the secondaries on the midrib, each with four or five secondary branches on the lower or outer side, the lowest of which bears numerous camptodrome branches, while the upper branches are once or twice forked and craspedodrome, ending in marginal teeth; nervilles numerous, strong, both broken and percurrent.

These leaves from the type locality at Black Buttes are usually very perfectly preserved, the matrix being a light-yellowish fine-grained sandstone on which the outline and nervation of the leaves stand out in black lines.

The other type of leaf that was included by Lesquereux in his *Viburnum marginatum* is shown in Plate 37, Figure 1, and Plate 38, Figures 2 and 3, of the report on the Tertiary flora. It is nearly elliptical or slightly elliptical-obovate, being about the same at both base and apex, with the margin entire below and slightly toothed above. The nervation, it seems to me, differs essentially in not being strongly 3-ribbed from the base of the blade but having a strong midrib with some five or six pairs of rather light secondaries. The branches from the lower secondaries are camptodrome in the lower part of the blade and craspedodrome in the upper part, a feature in which they agree with the leaves of *Platanus marginata*. In my opinion these leaves should be given a new specific name but retained in the genus *Viburnum*.

Viburnum marginatum was reported by Lesquereux from Point of Rocks, Wyo., but as no specimens can now be found to substantiate this report it is impossible to say whether they belong to what is now referred to *Platanus* or to the leaves it is proposed to

[22] Jankó, H., Engler's bot. Jahrb., vol. 11, p. 454, 1889.

retain in *Viburnum*. This locality must therefore be dropped, at least for the present.

Platanus marginata has been identified in Carbon County, Wyo., where it occurs in the "Lower Laramie" [Medicine Bow formation], believed by me to be the stratigraphic equivalent of the Laramie of the Denver Basin. The specimens are fairly well preserved and are probably correctly determined.

This species has also be found in the Lance formation in the Cheyenne Indian Reservation of South Dakota.

A specimen with its counterpart from the Dawson arkose at Mosby, Colo., is here figured. (Pl. 36, figs. 2, 3.) It is unfortunately not very perfect, but enough is present to make its identification certain. It appears indistinguishable from Figure 1 in Plate 38 of the report on the Tertiary flora, though it is slightly smaller. The counterpart shows the perfect petiole, which is about 2.5 centimeters long and shows the enlargement at the end under which the bud for the following year's growth was concealed. This is a well-known character of *Platanus* leaves, and this leaf confirms the reference to this genus.

Occurrence: Black Buttes coal group (types), Black Buttes, Wyo. Dawson arkose, dump of Mosby coal mine, Mosby, Colo., collected by F. H. Knowlton and G. B. Richardson, 1910. Lance formation, Cheyenne Indian Reservation, S. Dak. "Lower Laramie" [Medicine Bow formation], Carbon County, Wyo.

Platanus platanoides (Lesquereux) Knowlton

Plate 36, Figure 5

Platanus platanoides (Lesquereux) Knowlton, U. S. Geol. Survey Bull. 152, p. 171, 1898; Jour. Geology, vol. 19, p. 370, 1911; U. S. Geol. Survey Prof. Paper 101, p. 323, pl. 95, fig. 4, 1917 [1918].

Viburnum platanoides Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1874, p. 314, 1876; The Tertiary flora, p. 224, pl. 38, figs. 8, 9, 1878.

The fragmentary specimen from the Dawson arkose on Jimmy Camp Creek here figured appears to be identical with a specimen from the Raton formation [23] figured under this name. It is a little more wedge-shaped at the base than the type specimens but does not differ otherwise to a marked degree.

Occurrence: Dawson arkose, east bank of Jimmy Camp Creek 1 mile above Richfield Springs ranch house, 9 miles east of Colorado Springs, Colo., collected by F. H. Knowlton, July, 1910. Black Buttes coal group, Black Buttes, Wyo. Lance (?) formation, sec. 20, T. 14 N., R. 10 E., S. Dak. Laramie (?) formation, Erie, Colo. Raton formation, Rouse, Colo.

[23] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 101, p. 323, pl. 95, fig. 4, 1917 [1918].

Platanus coloradensis Knowlton, n. sp.

Plate 37, Figures 1, 2

Leaves of medium size, evidently coriaceous and firm, ovate, lateral lobes slight if any; rather obtusely wedge-shaped at the base and obtusely acuminate at the apex; margin entire below, undulate-toothed above, the teeth low and separated by very shallow sinuses; midrib of moderate strength, straight; nervation subpalmate—that is, the lowest pair of strong secondaries arise at an angle of about 45° well above the base of the blade, thence running to the margin, though probably not into lobes, each provided on the lower or outer side with some five or six tertiary branches, which curve slightly upward and are apparently camptodrome; below the strong pair are one or two pairs of much thinner secondaries, one of which is usually provided with several thin camptodrome tertiary branches; above the strong pair of secondaries there are six or seven pairs of well-marked secondaries that run nearly straight to the margin, which they enter at the low teeth, the lower ones with one or two forks, which also enter the margin; nervilles numerous, strong and deeply impressed, usually curved but unbroken.

This species is represented by several examples, of which two of the best are figured. They are of medium size, the length being about 15 centimeters and the width about 10 centimeters; the petiole is not preserved. It is probable that the leaves are simply ovate, though there may have been slight lateral lobes. The lower portion of the blade is perfectly entire, but from a point near the middle it becomes undulate-toothed. The nervation is strongly marked, as may be seen from the figures.

The most perfect of these leaves, shown in Plate 37, Figure 1, was found in the collection of the United States National Museum under No. 1057, and in the catalogue Lesquereux has recorded the fact that it was a new species. This specimen was collected in 1875 by E. A. Barber, who was at that time associated with the Hayden survey. It came from Middle Park, Colo., but is without specific locality. It is, however, identical with leaves since obtained by Whitman Cross on a high terrace ridge between the forks of Kinney Creek, a tributary of the Colorado River east of Hot Sulphur Springs, in Middle Park. The matrix is also similar in the two examples, and it is fair to assume that the Barber specimen came from practically the same place as the others.

It is with some hesitation that I venture to describe this as a new species, yet it does not appear to be very closely related to previously named species. In size and shape it perhaps approximates most closely what

has been called a young leaf of *Platanus haydenii* Newberry,[24] but the margin and basal nervation are somewhat different. If there were slight lateral lobes in the leaves under consideration, a point which, as above stated, it is impossible to demonstrate, this species might come near to several species such as P. *heerii* or *P. newberryana*, but these may be dismissed without further consideration.

Occurrence: Middle Park formation, on high terrace divide between forks of Kinney Creek, a tributary of Grand [Colorado] River on the north, east of Hot Sulphur Springs, Middle Park, Grand County, Colo., collected by Whitman Cross, October 6, 1891; also specimen collected by E. A. Barber in Middle Park but without specific locality.

Platanus sp.?

Plate 38, Figure 2

In the collection from Mosby, Colo., was the specimen here figured. It is only a fragment of the lower side of a leaf with a strong nervation and sharply toothed margin. It is a *Platanus* of the type of *P. guillelmae* Göppert or *P. aceroides* Göppert, as figured, for instance, by Lesquereux in the report on the Tertiary flora, Plate 25, Figures 1–5. As the origin of the strong lateral ribs is not shown in this specimen it is not possible to distinguish between these two species, though if anything it appears to approach more closely *P. guillelmae*. This specimen is, of course, of comparatively little value except as indicating the presence of this type of leaf in the formation under consideration.

Occurrence: Dawson arkose, dump of Mosby coal mine, Mosby, Colo., collected by F. H. Knowlton and G. B. Richardson, 1910.

Order THYMELEALES

Family LAURACEAE

Laurus primigenia Unger

Plate 38, Figures 3, 5, 6

Laurus primigenia Unger, Genera et species plantarum fossilium, p. 423, 1850.

Heer, Acad. Nat. Sci. Philadelphia Proc., vol. 10, p. 265, 1858.

Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, p. 406, 1873; idem for 1874, p. 385, 1876; idem for 1876, p. 510, 1878; The Tertiary flora, p. 214, pl. 36, figs. 5, 6, 8, 1878; Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 50, 1888; U. S. Nat. Mus. Proc., vol. 11, p. 36, 1888.

Ward, U. S. Geol. Survey Sixth Ann. Rept., p. 553, pl. 46, figs. 8–10, 1885; U. S. Geol. Survey Bull. 37, p. 47, pl. 23, figs. 8–10, 1887.

Knowlton, U. S. Geol. Survey Mon. 32, pt. 2, p. 722, pl. 91, figs. 4, 5, 1899; Geol. Soc. America Bull., vol. 8, p. 154, 1897.

Hollick, Louisiana Geol. Survey Rept. for 1899, Special Rept. 5, p. 284, pl. 41, figs. 1, 2, 1899.

Laurus obovata? Weber. Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, p. 399, 1874.

Salix media? Heer. Knowlton, Geol. Soc. America Bull., vol. 8, p. 141, 1897.

Laurus primigenia is a common and widely distributed species in the European Tertiary, being apparently most abundant in the upper Eocene, Oligocene, and lower Miocene. Its presence in North American strata appears to have been first noted by Heer in 1858, when he reported on a number of drawings of fossil plants from the Dakota sandstone of Nebraska, submitted to him by Meek and Hayden.[25] This determination was not accepted by either Lesquereux or Newberry, for neither mentioned it, though many years later Lesquereux procured a specimen from the Dakota sandstone of Pipe Creek, Cloud County, Kans., that he at first inclined to regard as a variety of *L. primigenia* but later decided to be more closely allied to *Ficus*.[26]

In point of time the next mention of *Laurus primigenia* in North America is by Lesquereux,[27] who reported it from Spring Canyon (now Rocky Canyon), Mont., but the specimens upon which this identification rests were later, according to a statement in the report on the Tertiary flora (p. 214), discarded as unworthy of notice. This species was not detected when I studied the recent collections from the Bozeman coal field and may well be dropped from this locality.

In 1874 Lesquereux[28] reported with question the presence of *Laurus obovata* Weber in the so-called saurian bed at Black Buttes, Wyo., but on the page of the report on the Tertiary flora above cited he abandoned this also as being based on too imperfect material for certain identification.

Apparently the first authentic material referred to *Laurus primigenia* came from Evanston, Wyo. It was described and figured by Lesquereux[29] in 1878, but none of this material, figured or otherwise, can now be found in the collections of the United States National Museum, where presumably it should be located. Dependence must therefore be placed entirely upon Lesquereux's figures. The specimens are said to have been found in the same beds with *Laurus socialis*

[24] Newberry, J. S., U. S. Geol. Survey Mon. 35, p. 103, pl. 38, 1898.

[25] Meek, F. B., and Hayden, F. V., Acad. Nat. Sci. Philadelphia Proc., vol. 10, pp. 257, 265, 1858.

[26] U. S. Geol. Survey Mon. 17, p. 85, 1895.

[27] Lesquereux, Leo, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, p. 406, 1873.

[28] Idem for 1874, p. 385, 1876.

[29] Lesquereux, Leo, The Tertiary flora, p. 214, pl. 36, figs. 5, 6, 8, 1878.

Lesquereux and are certainly very close to it, differing, according to Lesquereux, in being "narrowly lanceolate, more distinctly acuminate, and narrowly cuneate," all comparative or relative characters of little weight. Although *Laurus primigenia* is a very polymorphous species, to judge from the forms that have been referred to it by various European students, it is hard to reconcile Lesquereux's figures with any of them. Thus Figure 6 of his Plate 36 is quite clearly a *Laurus*, as it has the peculiar arching camptodrome secondaries, but Figures 5 and 8 of the same plate may not be the same—that is, if they have been correctly drawn. Figure 6 approaches certain of the narrow leaves of the European form, such for instance as those figured by Unger [30] from Sotzka, but the other figures do not, and I should incline to exclude them from this species. They may be lauraceous, but I doubt very much if they belong to *Laurus primigenia*.

Ward [31] figured three specimens that he referred to *L. primigenia*. Of these the one from Carbon, Wyo. (fig. 8), may be correctly referred on the basis of Lesquereux's figures, but the others that came from Point of Rocks, Wyo., almost certainly belong to another species. Indeed, with Ettingshausen,[32] I must regard Figure 9 at least as more like *Laurus ocateaefolia* Ettingshausen and quite unlike typical forms of *L. primigenia*.

In 1888 Lesquereux [33] reported the presence of *Laurus primigenia* in beds of the Denver formation at Golden, Colo., and one of the best preserved is here figured. I have not been able to detect it among the large recent collections from Golden. In the same year Lesquereux [34] also mentioned this species as being present in a small collection from Selma, Cherokee County, Tex., but this is extremely doubtful.

The next in order are two fragmentary examples from the Cretaceous of Staten Island more doubtfully referred to *L. primigenia* by Hollick.[35] These leaves can not possibly belong to this species, and it is even doubtful if they belong to the genus *Laurus*. Nearly the same stricture may be passed on the two leaves from the Wilcox formation at Coushatta, La., referred without question by Hollick [36] to *L. primigenia;* in fact, Berry,[37] who has recently revised this flora, has relegated the two figures to separate and distinct species—that is, Hollick's Figure 1 is referred to *Oreodaphne mississippiensis* Berry, and his Figure 2 to *Nectandra pseudocoriacea* Berry.

In my Flora of the Yellowstone National Park [38] I figured as doubtfully referable to *Laurus primigenia* two rather fragmentary examples from rocks of Fort Union age at a point on the Yellowstone River just below the mouth of Elk Creek. This assignment was based largely on their resemblance to the leaf from Carbon, Wyo., that was referred by Ward to this species, and as that has been accepted it is probable that the Yellowstone Park specimens should also be accepted as referable to *L. primigenia*.

In 1900 [39] I admitted *Laurus primigenia* as present at Point of Rocks, Wyo., but as set forth above, it is now believed that the specimen was incorrectly identified.

In the material obtained near the Douglas coal mine, Sedalia, Colo., I find the single example here figured, which is referred with some question to *Laurus primigenia*. It is relatively longer and narrower than the figures given by Lesquereux, but the shape and nervation are identical.

In 1905 A. C. Veatch, of the United States Geological Survey, made some small collections from the Evanston area, and at mine No. 7, Almy, he found several leaves that are identical with Lesquereux's figures of *Laurus primigenia*. Almy is a small mining camp and is probably very near, perhaps identical with, the locality that afforded Lesquereux's specimens.

The material from the Mosby coal mine, east of Colorado Springs, Colo., includes several leaves that agree well enough with the figures of *Laurus primigenia*.

Occurrence: Dawson arkose, Jimmy Camp Creek, near Richfield Springs ranch house, 9 miles east of Colorado Springs, Colo., collected by F. H. Knowlton, 1910. Dawson arkose, lower part (in beds equivalent to Arapahoe formation), 3,000 feet east of old Douglas coal mine, near Sedalia, Colo., collected by Arthur Lakes, 1895. Denver formation, South Table Mountain, Golden, Colo., collected by Arthur Lakes; specimens in Museum of Comparative Zoology, Cambridge, Mass., No. 1466. Evanston formation, mine No. 7, near Almy, Evanston, Wyo. Hanna formation, Carbon, Wyo. Beds of Fort Union age, Yellowstone River near mouth of Elk Creek, Yellowstone National Park, collected by F. H. Knowlton, 1888.

[30] Unger, Franz, Fossile Flora von Sotzka, pl. 19, figs. 1–4, 1851.

[31] Ward, L. F., U. S. Geol. Survey Sixth Ann. Rept., p. 553, pl. 46, figs. 8–10, 1886; U. S. Geol. Survey Bull. 37, p. 47, pl. 23, figs. 8–10, 1887.

[32] Cf. Ward, L. F., op. cit. (Bull. 37), p. 48.

[33] Lesquereux, Leo, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 50, 1888.

[34] Lesquereux, Leo, U. S. Nat. Mus. Proc., vol. 11, p. 36, 1888.

[35] Hollick, Arthur, New York Acad. Sci. Trans., vol. 12, p. 33, pl. 2, fig. 20; pl. 3, fig. 3, 1892.

[36] Hollick, Arthur, Louisiana Geol. Survey Rept. for 1899, Special Rept. 5, p. 284, pl. 41, figs. 1, 2, 1899.

[37] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, pp. 303, 311, 1916.

[38] Knowlton, F. H., U. S. Geol. Survey Mon. 32, pt. 2, p. 722, pl. 91, figs. 4, 5, 1899.

[39] Knowlton, F. H., Flora of the Montana formation: U. S. Geol. Survey Bull. 163, p. 58, 1900.

Laurus socialis Lesquereux

Plate 38, Figure 4

Laurus socialis Lesquereux, The Tertiary flora, p. 213, pl. 36, figs. 1–4, 7, 1878; Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 50, 1888.
Knowlton, U. S. Geol. Survey Bull. 105, p. 56, 1893; U. S. Geol. Survey Prof. Paper 101, p. 317, pl. 91, fig. 5, 1917 [1918].

This species is closely allied to the American specimens identified by Lesquereux as *Laurus primigenia* Unger, as Lesquereux stated, and was even regarded by him at one time as identical with it. Saporta, however, to whom figures had been submitted, considered them distinct, the present species "having larger leaves, more obtuse at the base, less distinctly acuminate than any of those referred to *L. primigenia*." The nervation is of the same character in both.

Most of the type specimens of *Laurus socialis* are preserved in the United States National Museum (Nos. 306, 307, 308). They were found at the same locality and some of them even on the same pieces of matrix as those of *L. primigenia*, but as no additional examples have come from that locality we must depend upon the figured types.

Laurus socialis was reported by Lesquereux [40] from the Denver formation at Golden, Colo., but I have not seen these specimens, nor have I been able to detect any specimens in the recent collections from this locality.

Laurus socialis was also reported by Lesquereux [41] from Lassen County, Calif., and this was apparently the species largely relied upon to prove the Eocene age of the beds whence they came. Only three broken examples were procured from this locality, all of which are preserved in the United States National Museum. However, they do not seem to me to belong to *Laurus socialis*. They are of about the same size and shape as leaves of this species, but the nervation appears quite different. The finer nervation is well preserved, and although like that of *L. socialis*, it is also as near to some of the species of *Persea* from California, such as *P. dilleri* Lesquereux.[42] One of the Lassen County leaves is rounded exactly as in *P. dilleri*. These leaves are also much like *Persea punctulata* Lesquereux,[43] from Corral Hollow, Alameda County, Calif.

Laurus socialis was also reported by Lesquereux [44] from Campbell's quarry, Cross Lakes, La. Only one leaf was found at this locality, a small example (U. S. Nat. Mus. No. 2501) which lacks both base and apex. This specimen has been studied by Berry,[45] who refers it to his *Mespilodaphne pseudoglauca*, a species that has been found to be abundant and widely distributed in beds of Wilcox age in Louisiana, Mississippi, and Kentucky.

In the Livingston formation near Chestnuts, in the Bozeman coal field, Montana, I found [46] a number of examples that were referred to *Laurus socialis*. They are fairly well preserved and appear to be correctly referred.

Laurus socialis was identified [47] in beds of the Raton formation at several localities in southern Colorado and northern New Mexico.

Occurrence: Evanston formation [types], Evanston, Wyo. Denver(?) formation, Golden, Colo. Dawson arkose, Mosby coal mine, Mosby, Colo., collected by F. H. Knowlton and G. B. Richardson, 1910. Livingston formation, Chestnuts, near Bozeman, Mont. Raton formation, Delagua and near Aguilar, Colo., and York Canyon, N. Mex., collected by G. B. Richardson.

Laurus lanceolata Knowlton, n. sp.

Plate 38, Figure 9

Leaf narrowly lanceolate and slightly falcate, slightly inequilateral, with about equally acuminate apex and base; petiole missing. Midvein stout, slightly flexuous, prominent on the under side of the leaf. Secondaries stout, six or seven subopposite to alternate pairs, prominent, diverging from the midvein at acute angles, sweeping upward in long ascending curves, eventually camptodrome. Tertiaries thin, mostly immersed in the coriaceous leaf substance. Length between 9 and 10 centimeters; maximum width 4 centimeters.

This species resembles the Wilcox species *Nectandra pseudocoriacea* Berry [48] in size and form but is somewhat less acuminate and has fewer and more ascending secondaries.

Occurrence: Dawson arkose.

Persea brossiana Lesquereux

Persea brossiana Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, p. 407, 1874.
Laurus brossiana (Lesquereux) Lesquereux, The Tertiary flora, p. 216, pl. 36, fig. 9, 1878.

The original and so far as known the only specimen of this very fine species is preserved in the collections of the United States National Museum (No. 309) and has been well described and figured by Lesquereux.

[40] Lesquereux, Leo, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 50, 1888.
[41] U. S. Nat. Mus. Proc., vol. 11, p. 29, 1888.
[42] Idem, p. 27, pl. 13, figs. 2–4.
[43] Idem, p. 26, pl. 14, fig. 1.
[44] Idem, p. 24.
[45] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 306, pl. 80, fig. 4, 1916.
[46] Knowlton, F. H., U. S. Geol. Survey Bull. 105, p. 56, 1893.
[47] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 101, p. 317, pl. 91, fig. 5, 1917 [1918].
[48] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 311, pl. 88, figs. 1–3, 1916.

This leaf was first placed in the genus *Persea* by Lesquereux but was later transferred by him to *Laurus*, as he regarded it as closely related to his *Laurus utahensis*. A comparison of the leaf under consideration and the living *Persea carolinensis* Nees, from the southeastern United States, shows them to be so similar that it is almost impossible to separate them. This leaf is also closely similar to the living *Laurus canariensis* Weber, as Lesquereux pointed out, and this fact, together with the presence of undoubted glands in the axils of the secondary nerves, was probably what induced him to transfer it to *Laurus*. But as it was first called *Persea* and bears so striking a resemblance to the living *Persea carolinensis* I have thought best to retransfer it.

The glands that appear so prominently in the type illustration are certainly present but hardly seem as pronounced as would be supposed from the figure. It is the possession of these glands, together with the fact that the leaf is much broader and more obtuse than most of the leaves of *Persea carolinensis*, that separates the fossil from the living species.

Occurrence: Middle Park formation, Mount Bross, Middle Park, Grand County, Colo.

Cinnamomum sezannense Watelet?

Plate 38, Figures 7, 8; Plate 59, Figure 2

Cinnamomum sezannense Watelet, Description des plantes fossiles du bassin de Paris, p. 175, pl. 50, fig. 2, 1866.

The specimen with its counterpart that is here figured I am not able to distinguish from *Cinnamomum sezannense* as described and figured by Watelet and others from the Eocene of the Paris Basin. It is a narrowly lanceolate leaf 10 or 12 centimeters in length and a little less than 4 centimeters in width. The petiole is retained for a length of about 12 millimeters and is not complete. The midrib is strong for the size of the blade and has two or three secondary branches in the upper third of the leaf. The lateral ribs are strong, though lighter than the midrib; they arise well above the base and run along well inside the margin probably nearly to the apex. There is a single series of very light tertiary branches or strong nervilles on the outside of the ribs, these forming a series of loops just inside the margin. The nervilles are numerous, strong, often broken, and at right angles to the midrib.

This leaf was at first thought to be referable to *Cinnamomum affine* Lesquereux,[49] but closer inspection discloses a number of differences. Thus *C. affine* is distinctly ovate or ovate-elliptical, whereas the present leaf is proportionately much narrower or more nearly lanceolate. The primary nervation, including both midrib and lateral ribs, is very much stronger in the leaf under consideration than in *C. affine*, and there appear to be fewer secondary branches on the midrib. It is possible that this is only a narrow, strongly veined leaf of *C. affine*, but I have not seen other similar specimens that could be so interpreted. On the other hand, I can not see any essential characters by which this leaf can be separated from *C. sezannense* as figured by Watelet, Saporta and Marion, and others. In spite of this seeming agreement it is with some hesitation that a European species is identified as present in the Rocky Mountain region, and the reference has been questioned.

Occurrence: Dawson arkose, east bank of Jimmy Camp Creek 1 mile above Richfield Springs ranch house, 9 miles east of Colorado Springs, Colo., collected by F. H. Knowlton, July, 1910.

Cinnamomum linifolium Knowlton

Plate 59, Figure 3

Cinnamomum linifolium Knowlton, U. S. Geol. Survey Prof. Paper 101, p. 319, pl. 88, figs. 3–7, 1917 [1918].

This species was found in the Raton formation of the Raton Mesa region of Colorado and New Mexico, where it appears to have been rather uncommon. It was described as follows:

> Leaves firm in texture, from linear to linear-lanceolate, long and narrowly wedge-shaped at base, apparently rather obtuse at apex; nervation triple-ribbed from the very top of the petiole, midrib the stronger, straight; lateral ribs more slender, ascending nearly or quite to the apex of the blade.

The single example here figured from the Dawson arkose is referred to *Cinnamomum linifolium* with a considerable degree of certainty. It is a small leaf only about 4 centimeters long and 1.5 centimeters wide, and although proportionately a little broader than in the types it agrees in its obtuse apex and in the ribs arising from the top of the petiole. The firm nervation is obscure, as it is in the type specimens, though there appear to be one or two secondary branches on the outside of the lateral ribs and the nervilles seem to be numerous, close, and approximately at right angles to the midrib.

Cinnamomum linifolium is apparently closely related to *Cinnamomum oblongatum* Berry,[50] from the Lagrange formation (in beds of Wilcox age) at Puryear, Tenn. The size and shape are practically identical in the two forms, the most notable difference being in the point of origin of the lateral ribs. In *C. linifolium* the lateral ribs arise at the top of the petiole, but in *C. oblongatum* the ribs originate a short distance above the base of the blade.

[49] Lesquereux, Leo, The Tertiary flora, p. 219, pl. 37, figs. 1–5, 7, 1878.

[50] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 297, pl. 79, figs. 1, 2, 1916.

The leaf here figured from the Dawson arkose is also suggestive of one of the small leaves of *Cinnamomum vera* Berry,[51] from the Wilcox group at Oxford, Miss. It is not quite so broad, however, and differs as regards the origin of the lateral ribs, as it does from *C. oblongatum*.

Occurrence: Dawson arkose, east bank of Jimmy Camp Creek 0.6 mile above Richfield Springs ranch house, 9 miles east of Colorado Springs, Colo., collected by F. H. Knowlton and W. T. Lee, July, 1910. Raton formation, near Starkville, Colo., and Vermejo Creek, near Dawson, N. Mex.

Cinnamomum? sp.

Plate 36, Figure 4

The material from Templeton Gap includes a single specimen—the one here figured—that appears to belong to *Cinnamomum*, but as it lacks both base and apex it can not be placed with certainty. It is a small leaf about 6 centimeters long and 3.5 centimeters wide. It is presumably regularly elliptical, with a wedge-shaped base and an obtuse apex. The midrib is rather strong, with two or three pairs of secondaries in the upper portion. The lateral ribs are but little lighter than the midrib and pass up to at least the upper third of the length of the blade. Each has several secondary branches on the outside. The manner in which the lateral ribs join the midrib can not be ascertained. The matrix is so coarse grained that the finer nervation is obscured. This leaf may belong to *Cinnamomum affine* Lesquereux,[52] but it is rather narrower than that species usually is. It also suggests some of the narrower leaves of *Ficus trinervis* Knowlton and *Ficus praetrinervis* Knowlton, but absence of the base makes it impossible to determine this point. It seems more likely to belong to *Cinnamomum* than to *Ficus* of the type of the above-mentioned species.

Occurrence: Dawson arkose, Templeton Gap, 4 miles northeast of Colorado Springs, Colo., collected by F. H. Knowlton, July, 1910.

Cinnamomum sp.

Plate 39, Figure 1

In the material from the Denver beds at Golden, Colo., I have found a single leaf that appears to be a *Cinnamomum*. Unfortunately it is fragmentary, lacking all of the basal portion and most of the sides, but it has more of the apical portion preserved, showing that it was extended into a rather sharp-pointed apex. So far as can be made out it is similar to what was identified by Lesquereux [53] as *Cinnamomum polymorphum* Al. Braun, later separated as *Cinnamomum ellipticum* Knowlton,[54] but it is too fragmentary to be positively identified. This type specimen of *C. ellipticum* was said by Lesquereux in the report on the Tertiary flora to have come from Golden, Colo., and in the catalogue it is recorded from the Bozeman coal field, Montana. An examination of the specimen, which is preserved in the United States National Museum (No. 316), proves clearly that it did not come from Golden but from the Montana locality.

The specimen under consideration might be referred to what has been identified with *Cinnamomum sezannense?* Watelet, or possibly with *Cinnamomum* sp., but as it is so broken that its full character can not be made out, it should be held apart from other forms until more nearly perfect material can be procured.

Occurrence: Denver formation, Golden, Colo., associated with *Diplazium crossii*.

Family MAGNOLIACEAE

Magnolia magnifolia Knowlton

Magnolia magnifolia Knowlton, U. S. Geol. Survey Prof. Paper 101, p. 311, pl. 84, 1917 [1918].

Magnolia tenuinervis Lesquereux, The Tertiary flora, p. 249, pl. 44, figs. 5, 6, 1878.

Magnolia magnifolia as at present understood is perhaps the most abundant and widely distributed species thus far observed in the Raton formation. It is apparently the largest-leaved fossil magnolia yet described from American rocks, the maximum length observed being approximately 30 centimeters and the width 10 or 12 centimeters. It may be known by its large size, rather obtuse apex, wedge-shaped base, and especially by the irregular spacing of the secondaries near the middle of the leaf.

Magnolia magnifolia was established in large part to take the place of *Magnolia tenuinervis* of Lesquereux, which is found to be so complicated as regards specific limitation and vertical range that it was thought best to abandon the use of the name in large part and start afresh. The history of *Magnolia tenuinervis*, both nomenclatorial and distributional, has been set forth at length in Professional Paper 101 and need not be repeated in full at this time. The species was named, though not adequately described, by Lesquereux in 1868 from material said to have been obtained in "lignitic beds near Golden City, Colo.," and hence presumably in the true Laramie formation, as the Denver formation has not been found coal bearing at this locality. For more than 10 years after it was named it remained a nomen nudum, and even where it was described and figured it was based on such a heterogeneous assemblage of

[51] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, pl. 79, fig. 3, 1916.

[52] Lesquereux, Leo, The Tertiary flora, p. 219, pl. 37, figs. 1–5, 7, 1878.

[53] Idem, p. 221, pl. 37, fig. 10.

[54] Knowlton, F. H., U. S. Geol. Survey Bull. 152, p. 68, 1898.

forms that are obviously not conspecific and may not all be congeneric, from unknown or doubtful localities, that it seemed best to abandon the current acceptance of the "species." The difficulties into which this miscellaneous assemblage has led subsequent writers are shown by the fact that it was supposed to have a vertical range from the Mesaverde formation to the Denver formation, or even later. But, as the rules of nomenclature do not permit the abandonment of a name so long as it can not be clearly referred to another earlier species, it is proposed hereafter to restrict the name *Magnolia tenuinervis* to Figure 6, Plate 45, of the report on the Tertiary flora, for this, so far as can be made out, is the figure of the specimen from "Golden City, Colo.," upon which the "species" was based. It is a mere fragment of the upper portion of a leaf that can not be positively identified with anything and may not be a *Magnolia*. The type specimen itself is lost, and it can not be determined whether it belongs to the Laramie or the Denver formation.

Although several of the forms figured by Lesquereux as *Magnolia tenuinervis* are said to have come from the Denver formation at Golden, Colo., only one—that of Figure 2, Plate 45—is known positively to have come from Golden. This is No. 367 of the National Museum collection and is preserved on the characteristic andesitic matrix. It is fragmentary, lacking both base and apex and all of the margin on one side. It was probably about 15 centimeters long and less than 6 centimeters wide, thus being smaller than most of the examples from the Raton Mesa region. Several other specimens from Golden obtained in recent years are also smaller than the average of those from the Raton formation, but otherwise they do not differ essentially. The originals of Figures 3 and 6 of Lesquereux's Plate 44 are with little doubt from Black Buttes, Wyo., and not from Golden, Colo.

There is a specimen in the duplicate collection of the National Museum (No. 926) from Golden, Colo., that was questionably referred by Lesquereux to *Magnolia lesleyana* Lesquereux. It is only a fragment from the middle of a leaf that must have approached in size the large leaves of *M. magnifolia* from the Raton formation and should probably be referred to this species.

Occurrence: Denver formation, andesitic beds at Golden, Colo. Raton formation, known from a great number of localities in the Raton Mesa region of Colorado and New Mexico; for specific localities see United States Geological Survey Professional Paper 101, pages 312, 313. Black Buttes coal group, Black Buttes, Wyo.

Order RANALES

Family NYMPHAEACEAE

Genus NELUMBO

The leaves of this genus are in general so characteristic that with adequate material there is little or no difficulty in placing them with a great degree of certainty. The genus comprises only two living species—*Nelumbo lutea* (Willdenow) Persoon, the American lotus or water chinquapin of eastern and southern North America from Ontario to Oklahoma, and *Nelumbo nelumbo* (Linné) Karsten, the Indian or sacred lotus of Asia and Australasia. The American species has leaves from 30 to 60 centimeters (1 to 2 feet) in diameter, and the Oriental species has still larger leaves, from 60 to 90 centimeters (2 to 3 feet) in diameter. In both species the margins of the leaf are entire and there are 19 to 23 strong, radiating ribs which fork some distance below the margin.

Although now comparatively restricted in its range, the genus *Nelumbo* has had an interesting geologic history which takes it over a wide area where it is not now present. Nearly 30 fossil species have been described, of which about half are known from North America, including Greenland. As certain of these species are based on a single specimen, often a mere fragment, it is more than probable that the number of recognizable forms will be somewhat reduced when larger series are available for comparison.

There is a difference of opinion as to when and where this type originated. If Berry is correct in views recently expressed, it may have had its origin, in company with the oldest known dicotyledons, in the Lower Cretaceous (Patapsco formation of the Potomac group) of the Atlantic Coastal Plain. In 1911 Berry [55] established the genus *Nelumbites* based on the species originally referred by Fontaine to *Menispermites*. Concerning these Berry wrote as follows:

> While the Potomac species have the characteristic peltate leaves they are not radially symmetrical as are the later species but have the petiole attached nearer to one margin, giving them an appearance much like that of a number of supposed species of *Menispermites*. The venation is, however, nearer that of *Nelumbo* and its allies, the secondaries being prominent on the lower surface, obsolete on the upper surface, and forking after the manner of the Nymphaeaceae.

These leaves are orbicular or somewhat elliptical in shape and 10 or 15 centimeters in diameter. They are distinctly peltate, but the pelta is excentric, being much nearer one side than the other. When they are oriented with the pelta on the lower side it appears

[55] Berry, E. W., Maryland Geol. Survey, Lower Cretaceous, p. 462, 1911.

that there is a slight tendency for the leaves to be heart-shaped at the base and slightly pointed at the apex. It also appears that there is a more or less distinct midrib with from two to four pairs of secondaries, the lower of which are joined by broad arches with branches from the next lateral ribs. The margin of the leaves is often undulate or obscurely crenulate.

It appears to me that the characters enumerated above tend to make these leaves ancestral to *Castalia* rather than to *Nelumbo*. In *Castalia* there is always a distinct midrib with a greater or less number of secondary branches on each side, and the base has the margin cut to the point of attachment of the petiole. If the indentation already indicated in these leaves is continued to the point of attachment of the petiole, they would undoubtedly be referable to the living *Castalia*. In order that *Nelumbites* could be developed into *Nelumbo* it would be necessary to suppress the obvious tendency to basal lobation, to move the point of petiolar attachment to a central position, and to eliminate the midrib or modify it into an ordinary forked rib. This evolutionary process, while perhaps possible, seems a far greater modification than simply deepening the basal lobation that is already outlined, which would permit its allocation in *Castalia*. In this connection it is also pertinent to point out that this basal lobation may have been more pronounced than is now recognized. In discussing *Nelumbites virginiensis* (Fontaine) Berry, which is the type of the genus, Berry [56] stated that the type of the species is a fragment of a large leaf about 15 centimeters in diameter.

The preservation is such that its peltate character can not be made out with certainty, the specimen having the appearance of having a deeply auriculate overlapping base, but this is probably due to maceration or folding, as the additional specimens since found which resemble it very closely are distinctly peltate.

Berry also calls attention to the undoubted resemblance betwen *Nelumbites virginiensis* and certain Dakota forms referred to *Menispermites*, such as *M. grandis* Lesquereux [57] and *M. cyclophyllus* Lesquereux.[58] It is, indeed, difficult to escape the conviction that the Dakota forms are congeneric with the Potomac forms, but even so it shows that there was but little evolution between Potomac and Dakota time. The leaves referred to *Menispermites grandis*, for example, are of the same shape and have the incipient basal indentation, excentric pelta, and above all the distinct midrib that are characters in *Nelumbites virginiensis*. In other words, it seems to me impossible that either *Nelumbites* or the above-mentioned species of *Menispermites* can be in the direct ancestral line of the modern genus *Nelumbo*.

Saporta [59] recorded the presence of two species of *Nelumbo* (*Nelumbium hesitanicum* and *N. choffati*) in the supposed Albian of Portugal. This is in approximately the same stratigraphic position as the Patapsco formation, whence came the forms referred to *Nelumbites*. As neither of Saporta's species is figured or adequately described it is impossible to compare them critically with the American forms, though from his comments it is to be inferred that he regarded them as pretty closely related to the living *Nelumbo*. He did not state that the point of attachment of the ribs, of which there are 9 in *N. choffati* and 20 in *N. hesitanicum*, is excentric, but the material is fragmentary and perhaps this feature could not be ascertained. With one of the forms he found portions of the flowers, which were not unlike those of the living species.

Up to this point we are somewhat in doubt as to the value of the evidence pointing to the presence of *Nelumbo* or its probable ancestors in the Lower Cretaceous. I have pointed out the reasons why in my opinion the two species of *Nelumbites* do not offer convincing proof on this point, and the two forms from the Albian of Portugal are still too imperfectly known to permit a final estimate of their value. However this may be, when we take into account the strong resemblance if not actual identity between the dicotyledonous flora of the Patapsco of Atlantic America and the Albian of Portugal it would not be surprising to find the four forms at least congeneric. It must be left to the future to settle these points.

We may now turn to the fossil forms which with little question should be regarded as ancestral or directly referable to the living genus *Nelumbo*. So far as available knowledge goes the genus with its modern characteristics was already established in Greenland in early Upper Cretaceous time. This form was described by Heer [60] under the name *Nelumbium arcticum* (*Nelumbo arctica* (Heer) Tuzson) from the lower Atane beds of Greenland. It is a fragment from the central portion of a leaf and shows the pelta with the bases of 12 strong radiating ribs. None of the margin was preserved. This species is obviously closely related to and perhaps identical with *Nelumbo kempii* (Hollick) Hollick,[61] from the Magothy formation of Long Island. The Atane beds are of practically the same age as the Magothy formation of New York and

[56] Berry, E. W., Maryland Geol. Survey, Lower Cretaceous, p. 463, 1911.

[57] Lesquereux, Leo, The Cretaceous and Tertiary floras, p. 80, pl. 15, figs. 1, 2, 1883.

[58] Idem, pl. 15, fig. 3.

[59] Saporta, Gaston de, Nouveaux détails concernant les Nymphéinées infracrétacées: Compt. Rend., vol. 119, pp. 835–837, 1894.

[60] Heer, Oswald, Flora fossilis arctica, vol. 6, pt. 2, p. 92, pl. 40, fig. 6, 1882.

[61] Hollick, Arthur, Additions to the paleobotany of the Cretaceous formation of Long Island, No. 2: New York Bot. Garden Bull., vol. 3, p. 412, pl. 74, figs. 1, 2; pls. 75, 76; pl. 77, fig. 1, 1904.

New Jersey, and there is thus abundant reason for the probability of this being identical. Hollick has described *N. kempii* as having leaves approximately 40 centimeters in diameter. The only difference that can be noted between them is in the number of ribs, *N. kempii* having from 15 to 19 and *N. arctica* only 12.

Under the name *Nelumbo primaeva* Berry[62] described a small form from the Magothy formation at Cliffwood, N. J., later found in beds of the same age at Round Bay, Md. Available material of this form is so fragmentary that it is still imperfectly known. So far as can be made out, however, these leaves ranged in diameter from 3 or 4 to about 10 centimeters. They are peltate, orbicular or broadly elliptical, and with entire margins. The ribs are eight in number, "generally straight, prominent in the lower surface of the leaf, forking dichotomously at variable distances from their origin, and giving off thin, transverse, more or less curved secondaries."

Berry[63] has recently transferred this species to his genus *Nelumbites* with the statement that it is "probably a descendant of *Nelumbites virginiensis*," which has already been discussed. He also expresses the opinion that *Nelumbo kempii* should probably be referred to *Nelumbites*. It does not seem to me that this position is well taken, especially as regards *Nelumbo kempii*. This species certainly had a large centrally peltate leaf, with numerous, equally strong, evenly disposed ribs and no particular evidence for selecting one that could be interpreted as a midrib. These are characters of *Nelumbo* and not of *Nelumbites*.

The status of *Nelumbo primaeva* is not quite so clear, for the reason that the available material is so scanty. So far as can be seen from the published figures this form also has centrally peltate leaves and no midrib such as that seen in the type species of *Nelumbites*. Until more conclusive evidence is supplied this should be retained in *Nelumbo*.

A small but very well characterized species is *Nelumbo intermedia* Knowlton,[64] described from the Mesaverde formation at Point of Rocks, Wyo. This species has thin leaves 2 to 4 centimeters in diameter, with slightly undulate margins and 12 or 13 rather weak, tortuous, forking ribs.

Another species that is evidently closely related to the last and is of approximately the same stratigraphic position is *Nelumbo dawsoni* Hollick[65] (originally named *Brasenia antiqua* by Dawson but that name preoccupied by the earlier *B. antiqua* of Newberry), from the Belly River formation near Medicine Hat, Alberta. This is similar is size and appearance to *N. intermedia* but has 18 strong ribs. Still another of these small species is *Nelumbo laramiensis* Hollick,[66] from the Vermejo formation at Florence, Colo. It has leaves 4 centimeters in diameter and with about 12 relatively strong ribs that branch rather than fork, thus differing from *N. intermedia*.

I recently[67] described under the name *Nelumbo* sp. a form from the Montana group (Fruitland formation) in the San Juan Basin, N. Mex. It was based on a segment from the center of a leaf that is at least 12 centimeters in diameter and was probably twice this size when living. It is concave and evidently thick in substance. The ribs are somewhat indistinct, but apparently there are 18 or 20. This leaf is of the type of the living *Nelumbo lutea*.

Passing still higher geologically we have *Nelumbo tenuifolia* (Lesquereux) Knowlton (*Nelumbium tenuifolium* Lesquereux[68]), from the Laramie and Denver formations of the Denver Basin of Colorado. This species has a rather thin leaf 9 or 10 centimeters in diameter and 13 thin ribs. It is very closely related to *Nelumbo lakesiana* (Lesquereux) Knowlton (*Nelumbium lakesii* Lesquereux[69]) and *Nelumbo crossii* Knowlton (p. 93), both from the Denver formation. The first of these has leaves of about the same size as *N. tenuifolia*, but the leaf substance appears to have been firmer and the 13 or 14 ribs much stronger. In *N. crossii* none of the margin is preserved and there are only 7 or 8 ribs. This, it will be recalled, is the same number as in *Nelumbo primaeva*. The three species mentioned in this paragraph are discussed at length in the following pages.

Dawson described but did not figure a small leaf from the Canadian Upper Laramie under the name *Nelumbium saskatchuense*.[70] It is said to have only seven ribs. The last American species to be mentioned is *Nelumbium pygmaeum* Dawson,[71] from beds supposed to be of Miocene age on the Similkameen River, British Columbia. This form is so poorly described and figured that it is difficult to place satisfactorily. Dawson says it is about 2 centimeters in diameter, with the "petiole subcentral" and about 14 thin ribs "netting toward the margin." If this is really a *Nelumbo*, the petiole should be approximately central, in which case it would be at least 4 centimeters in diameter and the ribs probably as many as 18. It is

[62] Berry, E. W., New York Bot. Garden Bull., vol. 3, p. 75, pl. 43, fig. 1, 1903.

[63] Berry, E. W., Maryland Geol. Survey, Upper Cretaceous, p. 840, pl. 75, fig. 4, 1916.

[64] Knowlton, F. H., The flora of the Montana formation: U. S. Geol. Survey Bull. 163, p. 53, pl. 13, figs. 3–5, 1900.

[65] Hollick, Arthur, A new fossil *Nelumbo* from the Laramie group at Florence, Colo.: Torrey Bot. Club Bull., vol. 21, p. 309, 1894.

[66] Idem, p. 308, fig. in text.

[67] Knowlton, F. H., Flora of the Fruitland and Kirtland formations: U. S. Geol. Survey Prof. Paper 98, p. 341, 1916.

[68] Lesquereux, Leo, The Tertiary flora, p. 253, pl. 46, fig. 3, 1878.

[69] Idem, p. 252, pl. 46, figs. 1, 2, 1878.

[70] Dawson, J. W., Roy. Soc. Canada Trans., vol. 5, sec. 4, p. 35, 1887.

[71] Idem, vol. 8, sec. 4, p. 87, text fig. 22, 1890.

obvious that further data are needed concerning this form.

Since the above account was written Berry[72] has described a splendid new species—*Nelumbo protolutea*—from the upper part of the Wilcox group (Grenada formation) at Meridian, Miss. It is a large species with leaves ranging from 25 to 35 centimeters in diameter, and associated with it are fragments of rootstocks showing traces of roots with leaf cushions and rootlet scars. There are numerous rootlets in the clays which show that the plants grew in the exact spot where they are now preserved. Associated with the other remains are some poorly preserved oblate-spheroidal seeds, about 1.3 centimeters in diameter, that are considered to be the seeds of this species. It may be added that the number of ribs in the leaves appears to be about 25. Berry considers his *Nelumbo protolutea* to be wholly unlike any American Tertiary species heretofore known. It is, however, obviously very closely related to *Nelumbium protospeciosum* Saporta[73] from the Aquitanian of southern France; in fact, he adds: "If the two occurred at the same horizon it would be impossible to distinguish them by their foliage alone." This French species was considered by Saporta to be descended from *Nelumbium provinciale* Saporta,[74] of the Aturian of southern France, and in turn to have led to the living sacred lotus (*Nelumbo nelumbo*) of India.

Paralleling this line of descent in Europe, Berry now considers that *Nelumbo kempii* of the Magothy formation of Long Island and New Jersey was the "logical ancestor" of *Nelumbo protolutea* of the Wilcox, which in turn gave rise to the living *Nelumbo lutea* of eastern North America.

Nelumbo lakesiana (Lesquereux) Knowlton

Plate 41, Figure 1; Plate 42, Figure 2

Nelumbo lakesiana (Lesquereux) Knowlton, U. S. Geol. Survey Prof. Paper 101, p. 308, 1917 [1918].

Nelumbium lakesianum Lesquereux, U. S. Geol and Geog. Survey Terr. Ann. Rept. for 1873, p. 403, 1874.

Nelumbium lakesii Lesquereux, The Tertiary flora, p. 252, pl. 46, figs. 1, 2, 1878; U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1876, p. 514, 1878; Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 53, 1888.

The type specimens of this beautiful species are preserved in the United States National Museum (Nos. 370, 371), together with a number of others more recently found. They were collected about 1875 by Arthur Lakes and were named by Lesquereux in his honor. The original description by Lesquereux is as follows:

> Leaves coarse, thickish, peltate, exactly round, with the petiole central; borders turned down; center concave, regular; all the ribs (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.**

Lesquereux added that "this species is represented by three specimens of the same form, two small leaves and a much larger one." The two figured specimens are the only ones of the original specimens that are present in the Museum collection.

In the living species of *Nelumbo* the ribs are usually if not always dichotomously forked some distance below the margin. In discussing *Nelumbo lakesiana* in the report on the Tertiary flora Lesquereux called attention to the fact that the ribs appear to be branched rather than forked.

> The ribs are deeply impressed and thick, sparingly branching and, so far as can be seen, only on one side, and not by dichotomous divisions. * * * It is scarcely possible to see a difference in the size and in the directions of the nerves [ribs], which are more or less turned on one side; none of them has dichotomous divisions, and thus the leaves of this species seem far different from those of our time, and also from those described from the European Tertiary.

A restudy of the type specimens appears to substantiate the above contention, but both are so fragmentary that not all the characters can be made out. The original of Lesquereux's Plate 46, Figure 1, does not have any portion of the margin preserved, and that of Figure 2 has only a small portion which shows the ribs complete. Each of these ribs is curved to the right and has on the opposite side two or three secondary branches, which are camptodrome and arch just inside the margin. This manner of branching is certainly different from the dichotomous forking that is normal in the living and in many fossil species. In this character *Nelumbo lakesiana* approaches the remarkable lobed form described in this report under the name *Paleonelumbo macroloba*, except that the latter has the ribs straight with secondary branches on both sides. In the original of Lesquereux's Figure 2 the margin is retained for only about 3 centimeters, and while there is some slight evidence that it may be lobed as in *Paleonelumbo*, the evidence is not conclusive.

Lesquereux stated that the leaves of *Nelumbo lakesiana* appear to be about 12 centimeters in diameter, but an examination of the type of his Figure 1 discloses the fact that a portion of the leaf is folded over and is not shown in the figure. Even this does not reach the margin, but it permits a measurement of over 8 centimeters for the length of the rib, which

[72] Berry, E. W., U. S. Geol. Survey Prof. Paper 108, p. 64, pls. 24–26, 1917.

[73] Saporta, Gaston de, Recherches sur la végétation du niveau aquitanien de Manosque, p. 17, pl. 1, figs. 2, 3; pl. 4, figs. 1, 2, 1891.

[74] Saporta, Gaston de, Le *Nelumbium provinciale*: Soc. géol. France Pal. Mém. 5, 1890.

would make the whole leaf at least 16 centimeters in diameter. It was probably not less than 20 centimeters in diameter. The type (Lesquereux's fig. 2), in which a portion of the margin is retained, is about 12 centimeters in diameter, and this is probably the one on which Lesquereux based his statement of size. The range in size of the leaves of *Nelumbo lakesiana* is thus shown to be from 12 to 18 or 20 centimeters.

The types of *Nelumbo lakesiana* are preserved in the coarse andesitic matrix characteristic of South Table Mountain, Golden, Colo. It appears, however, to be a rare species, for in the numerous collections from Golden and vicinity that have passed through my hands in recent years no trace of it has been detected. In the collection made by Lakes and now the property of the Museum of Comparative Zoology Lesquereux noted the presence of two specimens but made no comment on them.

In the collection made by Lakes near the Douglas coal mine, Sedalia, Colo., I find no less than five more or less perfect fragments that are referred with much certainty to *Nelumbo lakesiana*. They have the same thick ribs, which produce, when preserved on similar matrix, the rough appearance described by Lesquereux for the type specimens. The number of ribs is usually 14, though one has but 13, the number described as present in *Nelumbo tenuifolia*. One specimen shows the under surface of a leaf with a small portion of the petiole preserved. The petiole is about 3.5 millimeters in diameter, which is about the size of the petiole in the living *Nelumbo lutea*. The margin is not well enough preserved to show with certainty the manner in which the ribs approach the border.

Nelumbo lakesiana seems to be rather closely related to *Nelumbo arctica* (Heer) Tuzson,[75] from the lower Atane beds of Greenland. The Arctic species is based on a small fragment from the center of a leaf, but so far as can be made out it appears to agree closely with *N. lakesiana*. It has 13 thick ribs radiating from the common center, but all finer nervation is obsolete.

Occurrence: Denver formation (types), South Table Mountain, Golden, Colo., collected by Arthur Lakes, for whom the species is named, about 1875; also collected at about the same locality by Lakes in 1883 and now in the Museum of Comparative Zoology, Cambridge, Mass. Dawson arkose, lower part (in beds equivalent to Arapahoe formation), Sedalia, Colo., 3,000 feet east of the old Douglas coal mine, collected by Arthur Lakes, 1890. Raton formation, Fishers Peak mine, 3 miles southeast of Trinidad, Colo., collected by G. B. Richardson.

[75] Tuzson, J., Magyar tudom. akad. Math. termész. ért., vol. 29, No. 5, p. 827, 1911.

Nelumbo tenuifolia (Lesquereux) Knowlton

Plate 41, Figure 2

Nelumbium tenuifolium Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, p. 402, 1874; idem for 1876, p. 514, 1878; The Tertiary flora, p. 253, pl. 46, fig. 3, 1878.

The type specimen of this species came from Sand Creek, a few miles east of Denver, Colo., and is preserved in the United States National Museum (No. 372). It is the only specimen in the Museum collection under this name, although Lesquereux, in the report on the Tertiary flora (p. 254) mentioned having two leaves, one of which was "obtained from a different locality." It is not now possible to determine the source of this unfigured specimen.

The type specimen of *Nelumbo tenuifolia* is preserved on a soft, friable sandstone and is very indistinct. Lesquereux's figure of it is far from accurate. The only part of the true margin retained is a fragment hardly more than 3 centimeters in extent in the upper left-hand portion of the figure. A careful examination fails to show the margin on the lower portion, although it is represented in the figure. This seems to prove that the leaf was larger than is shown in the figure—that is, it was at least 12 centimeters in diameter instead of the 8 or 9 centimeters stated by Lesquereux. It has relatively thin ribs as described by Lesquereux and altogether appears to have been a thin leaf, but otherwise it approaches *Nelumbo lakesiana* closely. The number of ribs (13) is probably not of specific value, as some undoubted leaves of *N. lakesiana* have only 13. The manner in which the ribs turn to one side and have branches rather than a distinct fork are also characters common to the two forms, as was pointed out by Lesquereux. He concluded, however, that "the great difference in their substance seems sufficient to authorize a separate specification," and it is largely on this basis that they are retained as distinct.

The stratigraphic position of the locality on Sand Creek which supplied the type specimen of *Nelumbo tenuifolia* has long been more or less in doubt. It was supposed to be in the Arapahoe formation, but data recently procured place it without much doubt in the Denver formation. The complication regarding the stratigraphic position of this locality is fully discussed in the introductory part of this report (p. 6).

In a collection made some years ago from the Laramie rocks at Erie, Colo., there was a single example that has been referred with considerable certainty to

Nelumbo tenuifolia.[76] It was folded around on both sides of a thin piece of matrix and appears to have been a thin, delicate leaf. Its diameter is about 10 centimeters. It has the same number of ribs as the type specimen, and the ribs tend to be turned to one side and to branch rather than fork as in *N. lakesiana.* The finer nervation is obscure.

Occurrence: Denver formation (type), Sand Creek, about 15 miles east of Denver, Colo., collected by A. Gardner about 1873. Laramie formation, Erie, Colo., collected by N. L. Britton about 1885.

Nelumbo crossii Knowlton, n. sp.

Plate 41, Figure 3

Leaf of thin texture, subcircular, centrally peltate, seven or perhaps occasionally eight ribs, the ribs rather thin, diverging with approximate regularity, forking above; nervilles strong, a few percurrent but mainly broken in the middle; finer nervation producing irregular areas.

It is with some doubt and hesitation that this leaf is described as new. It is found associated in the same beds with *Nelumbo lakesiana* and was at first thought to belong to this species, but it has only 7 or possibly 8 ribs, whereas the other always has 13 or 14, and this is thought to be too great a difference to be reconciled with our recognized knowledge of specific variation. The number of ribs in the living *N. lutea* is usually 21 but may vary from 19 to 23. So far as is known to me no living leaves which showed a reduction to half of the normal number of ribs have been found. Therefore it is upon this considerable difference in the number of ribs as compared with its nearest relative that this species is proposed.

As shown in the figure, *N. crossii* is founded upon a mere fragment of the center of a peltate leaf. At no point is the margin preserved, yet from the longest fragment of a rib retained it appears that the leaf must have been at least 8 centimeters in diameter, and, as the ribs still appear strong at the point where broken, it was probably considerably larger. The two best-preserved ribs are forked as in typical *Nelumbo*, and the intermediate nervation is also similar. It is therefore an undoubted *Nelumbo*, but its specific status must remain in more or less doubt pending the discovery of more perfect material.

Dawson [77] has described under the name *Nelumbium saskatchuense* a small species from the so-called Canadian Upper Laramie of the North Saskatchewan. This species was described as "orbicular, peltate, with seven ribs" and a diameter of 2 centimeters or a little more. This agrees with *N. crossii*, it will be observed, in the number of ribs, but the size is so small as apparently to put out of consideration the question of specific identity.

Occurrence: Dawson arkose, lower part (in beds equivalent to Arapahoe formation), 3,000 feet east of the Douglas coal mine, Sedalia, Colo.

Genus PALEONELUMBO Knowlton, n. gen.

Similar to the living *Nelumbo* but with the leaves provided with high, obtuse teeth or lobes, one for each rib.

Paleonelumbo macroloba Knowlton, n. sp.

Plate 39, figure 3; Plate 42, Figures 3, 4

Leaf very thick and firm, circular, centrally peltate, concave, about 30 centimeters in diameter; marginal lobes the same number as the ribs, very obtuse and rounded at the tips, about 4 centimeters long and 3 or 3.5 centimeters wide at the base, separated by deep, rounded sinuses; ribs 12 or 13, very thick and strong, each terminating in a lobe, with three or four pairs of strong secondary branches in the upper portion, these arching upward and joining, producing a loop just within the margin of the lobes; nervilles numerous, especially in the central portion of the leaf, strong, unbroken, approximately at right angles to the ribs.

This large and very striking species is represented in the collection by several specimens, three of which are here figured. The most perfect of these (pl. 39, fig. 3) is an impression of the under side of the leaf which brings out the strong ribs and other nervation in an admirable manner. The specimen is cupped around the matrix, showing that it was deeply concave above, after the manner of the living lotus (*Nelumbo nelumbo*). The others figured show the central part of leaves with strong, radiating ribs, but no part of the margin is retained.

These leaves belong undoubtedly to the Nymphaeaceae and are most closely related to the genus *Nelumbo*, which comprises only two species, *Nelumbo lutea* (Willdenow) Persoon, the American lotus or water chinquapin of southeastern and eastern North America, and *Nelumbo nelumbo* (Linné) Karsten, the well-known Indian lotus of Asiatic and Australasian countries. Both have entire, more or less concave leaves 1 to 3 feet in diameter and more numerous ribs which fork into equal or nearly equal branches well below the margin. The fossil form differs from the living *Nelumbo* in the fewer ribs, pronounced marginal lobes as many as and entered by the ribs, and secondary branches in the upper portion of the ribs instead of equal forks. These differences are so marked as to appear to entitle it to generic rank.

[76] Knowlton, F. H., The Laramie flora of the Denver Basin: U. S. Geol. Survey Prof. Paper 130, p. 141, pl. 26, fig. 7, 1922.

[77] Dawson, J. W., Roy. Soc. Canada Trans., vol. 5, sec. 4, p. 35, 1887.

Occurrence: Dawson arkose, about a quarter of a mile east of Purdon mine, sec. 27, T. 11 S., R. 61 W., Colo., in sandstone about 25 feet above the Purdon coal, collected by G. B. Richardson, 1910.

Castalia pulchella Knowlton, n. sp.

Plate 42, Figure 1; Plate 57, Figure 3

Leaf evidently rather thin and membranaceous, apparently nearly circular, fissi-cordate, the lobes rather short, rounded, the sinus acute; margin conspicuously toothed, the teeth low, obtuse, separated by shallow rounded sinuses; ribs, including the midrib, 11, radiating from a central point or pelta; midrib little if any stronger than others, with three or four slender pairs of branches; lower ribs turning down into the lobes, the others disposed at equal distances, all splitting into two equally strong branches which join in a broad loop, with two or three series of progressively smaller loops until the margin is reached; nervilles fairly strong, mostly unbroken, at right angles between the ribs.

This remarkably fine and distinct species is represented only by the specimen figured and its restoration. The central part of the leaf is preserved, showing the radiating ribs or primary veins, as Caspary called them, in a high degree of perfection, but the margin is retained in only a few places. As nearly as can be made out the leaf was nearly circular or perhaps a little broader than long. The width is approximately 8.5 centimeters, and the preserved length only about 7 centimeters, but both base and apex are not wholly preserved. The teeth are conspicuously large for so small a leaf of this genus. There is some evidence of the presence of smaller slight protuberances on the main teeth, but this is not very conclusive.

This leaf exhibits distinctively and unmistakably the outline and peculiar forking and anastomosing of the ribs that are characteristic of *Castalia*, and there can be no doubt about its being correctly referred to this genus. *Castalia* (*Nymphaea* of authors) comprises about 35 living species and is found here and there almost all over the world. As they hybridize freely a large number of hybrids and garden varieties are known and prized in cultivation. The genus was monographed in 1905 by H. S. Conard,[78] of the University of Pennsylvania, and from this splendid publication it is possible to make a number of comparisons with the fossil form under consideration. Thus in some ways this suggests *Castalia rudgeana* (*Nymphaea rudgeana* Myer), a species living in tropical America and certain West Indian Islands, except that the living leaf is much larger than the fossil. In marginal dentition the living *Castalia stellata* (*Nymphaea stellata* Willdenow), of wide distribution in southern and southeastern Asia and neighboring islands, approaches the fossil leaf but differs markedly in the number and strength of the ribs. Another species with similarly toothed, though much larger leaves is *Castalia flavo-virens* (*Nymphaea flavo-virens* Lehmann).

This is the fourth fossil species to be described from this country, though neither of the others can be considered as being so well established as the present one. These are *Castalia stantoni* Knowlton,[79] from the Judith River formation of Montana; *Castalia? duttoniana* Knowlton,[80] from the Montana group of the Laramie Plains, Wyoming; and *Castalia leei* Knowlton,[81] from the Raton formation of southern Colorado. These are all very unlike *Castalia pulchella*.

Several species were described by Heer [82] from the Tertiary of Greenland, but they are either based on seeds or so fragmentary as to be of little comparative value in the present connection. Thus his *Nymphaea arctica* is a mere fragment that may or may not have been correctly placed.

A dozen or more European species have been described, most of them being correctly referred to *Castalia* (*Nymphaea*), but none approach closely the fossil form here described.

Although it may perhaps seem a wide generalization to make on the data available, it seems not unlikely that what is here described as *Castalia pulchella* may be in the direct line from which *Castalia rudgeana* has been derived.

Occurrence: Dawson arkose, left bank of Jimmy Camp Creek 0.7 mile above Richfield Springs ranch house, about 9 miles east of Colorado Springs, Colo., collected by F. H. Knowlton and W. T. Lee, 1910.

Family ANONACEAE

Asimina eocenica Lesquereux

Plate 40, Figure 4; Plate 43, Figures 1, 2, 4, 6

Asimina cocenica Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, p. 387, 1873; idem for 1876, p. 514, 1878; The Tertiary flora, p. 251, pl. 43, figs. 5–8, 1878.

Only a part of the type specimens of this fine species appear to be preserved in the collections of the United States National Museum [No. 362 ("Ter-

[78] Conard, H. S., The water lilies, a monograph of the genus *Nymphaea*: Carnegie Inst. Washington Pub. 4, 1905.

[79] Knowlton, F. H., in Stanton, T. W., and Hatcher, J. B., Geology and paleontology of the Judith River beds: U. S. Geol. Survey Bull. 257, p. 147, pl. 19, fig. 4, 1905.

[80] Knowlton, F. H., Flora of the Montana formation: U. S. Geol. Survey Bull. 163, p. 55, pl. 13, fig. 7, 1900.

[81] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 101, p. 307, pl. 79, fig. 2, 1917 [1918].

[82] Heer, Oswald, Flora fossilis arctica, vol. 5, pt. 2, p. 44, pl. 13, fig. 7, 1878.

tiary flora," fig. 7); No. 363 (fig. 8)], although there are several unfigured examples recorded under the same number. No additional specimens appear to have been obtained from the type locality.

In the paleontologic collection of Princeton University, kindly placed at my disposal by Prof. William Libby, jr., director of the museum, I find a single specimen (No. 2207) from South Table Mountain, Golden, Colo., that must be referred to this species. This specimen, figured on Plate 43, Figure 6, lacks both base and apex, yet the size and nervation are identical with Lesquereux's Plate 43, Figure 8. The camptodrome secondaries with their intermediate secondaries and peculiar branching are clearly the same. This is the only specimen from other than the type locality.

In my bulletin on the flora of the Montana formation (p. 57) I mentioned a single example from a small coal mine on the north fork of Dutton Creek, near the old stage road, Laramie Plains, Wyo., that I doubtfully referred to this species. This leaf has the same size, shape, and thick petiole and approximately the same nervation, though the secondaries are at a little greater angle of divergence and perhaps pass up along the margin for a greater distance. The differences are slight, yet considering the disparity in horizons it is perhaps doubtful if the identity should be insisted upon, and more material will be needed to settle the point.

Among the recently collected specimens from Mount Bross, Middle Park, Colo., I find a single basal portion of a leaf that may well have belonged to this species; it is shown in Plate 43, Figure 4. Several fragments showing only the basal portions and the thick petiole have been found at Sedalia, Colo.

Still more recently a field party under the direction of G. B. Richardson collected in red baked shale near Ramah, Colo., a large number of beautifully preserved leaves that must be referred to this species. There are more than 50 leaves of this species in this collection, 5 of which have been figured. They are very uniform in size, 10 or 12 centimeters long and 2.25 to 3 centimeters wide, with the exceedingly thick petiole about 1.5 centimeters long. The apex is prolonged and truncate or slightly emarginate at the tip. The midrib is very thick and strong in the lower portion of the blade but rapidly diminishes in the apical portion. It is strongly ridged and striated in the middle and lower portions, and this character extends to the thick petiole.

Occurrence: Hanna formation, Carbon, Wyo. (types). Denver formation, South Table Mountain, Golden, Colo., specimen in museum of Princeton University. Middle Park formation, Mount Bross, Middle Park, Grand County, Colo., collected by G. L. Cannon, 1889. Dawson arkose, lower part (in beds equivalent to Arapahoe formation), Sedalia, Colo., 3,000 feet east of the old Douglas coal mine, collected by Arthur Lakes, 1890. Dawson arkose, south of the Ramah oil well, Colorado, in the SE. ¼ sec. 33, T. 9 S., R. 61 W., collected by C. W. Cooke for G. B. Richardson, September, 1910. Fort Union formation, Wind River Basin, Wyo. Midway? formation, Earle, Tex.

Order ROSALES

Family ROSACEAE

Chrysobalanus coloradensis Knowlton, n. sp.

Plate 40, Figures 2, 3; Plate 43, Figures 3, 5, 7–9; Plate 44, Figures 1, 2

Cissus spectabilis Heer. Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 52, 1888.

Leaves thick and coriaceous, oblong-elliptical, abruptly rounded and truncate at the base with a small portion slightly decurrent on the petiole, rounded and apparently obtusely pointed at the apex; margin perfectly entire throughout; petiole about 1 centimeter long, very thick and stout, always striate; nervation pinnate, consisting of a very strong midrib, which is firmly striate below, and about six pairs of very thin alternate, camptodrome secondaries at a low angle; nervilles numerous, approximately at right angles to the secondaries.

This species is represented by about a dozen leaves, all of which are very well preserved except as regards the extreme apex. They are very uniform in size, about 8 or 9 centimeters long and 4 centimeters wide. The petiole is about 1 centimeter long, very thick and provided with a number of fine striae which extend up along the extremely thick midrib. The secondaries are very thin and immersed in the thick substance of the leaf.

There is some doubt about the correctness of this generic reference. These leaves have a degree of resemblance to certain leaves that have been referred to *Ficus*, such as *Ficus puryearensis* Berry[83] from beds of Wilcox age in the Lagrange formation at Puryear, Tenn. On the whole, however, it seems best to refer them to *Chrysobalanus*. This is a small genus of amygdalaceous shrubs or small trees, with simple, leathery leaves and an edible pulpy drupe. Three species are recognized in Florida, of which the best known is *C. icaco* Linné, the so-called gopher or cocoa plum. It occurs in sandy soil in the southern part of the Florida peninsula and also in the West Indies and tropical America. *Chrysobalanus oblongifolius* Michaux is found in dry, sandy pine lands from Georgia to Florida and Mississippi. It is a low shrub

[83] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 205, pl. 30, figs. 4, 5, 1916.

forming wide patches by the spreading of underground stems. The third species is *C. pellocarpus* Meyer, a shrub or small tree of low ground in southern Florida and the West Indies. The genus is also represented in tropical west Africa, where it occurs along the coasts from Senegambia to the Congo Free State, perhaps introduced by the agency of man.

Three fossil species of *Chrysobalanus* have been recorded from this country—*C. pollardanus* Knowlton,[84] from the Esmeralda formation (upper Miocene) of Esmeralda County, Nev.; *C. eocenica* Berry[85] and *C. inaequalis* (Lesquereux) Berry,[86] from the Lagrange formation of Puryear, Tenn.

The present fossil species appears to be most like the living *C. icaco*, from which it differs in its more nearly elliptical shape and more obtuse base. The apex can not be absolutely determined, but it appears to be rather obtuse, though not emarginate. In nervation *C. coloradensis* is suggestive of the living *C. oblongifolius*, but it differs in shape.

Since the above was written I have examined the Golden material in the Museum of Comparative Zoology as identified by Lesquereux, and I find that the specimen recorded as *Cissus spectabilis* Heer[87] is to be referred to *Chrysobalanus coloradensis*. It is a slightly smaller leaf—7 centimeters long and 3.5 centimeters broad—but does not otherwise differ essentially. A comparison of this leaf with the figure cited by Lesquereux in Heer's flora of Sakhalin[88] shows them to be totally unlike.

Occurrence: Dawson arkose, dump of Mosby coal mine, Mosby, El Paso County, Colo., collected by F. H. Knowlton and G. B. Richardson, July, 1910. Denver formation, South Table Mountain, Golden, Colo., collected by Arthur Lakes, specimen in Museum of Comparative Zoology, Cambridge, Mass., No. 1502.

Chrysobalanus? lanceolatus Knowlton, n. sp.

Plate 44, Figure 5

Leaf small, coriaceous, elliptical-lanceolate, slenderly acuminate at the apex, abruptly rounded and slightly unequal-sided at the base; margin perfectly entire; petiole strong, at least 1 centimeter long, finely striate; midrib relatively strong, finely striate; secondaries about eight pairs, alternate, at an angle of about 45°, very thin and immersed in the leaf substance, somewhat curved upward along the margin; finer nervation obsolete.

The example that is here figured as the type of this species is absolutely perfect. It is 6 centimeters long, including the petiole 1 centimeter long, and is about 1.8 centimeters wide. It is narrowly elliptical-lanceolate, with a rounded, slightly unequal-sided base and a slenderly acuminate apex. With the exception of the strong midrib the nervation is rather obscure, being immersed in the evidently thick substance of the leaf. This leaf lies by the side of a stem or something of the kind that was at first supposed to be a rachis, but the leaf is perfectly free and there is no scar or point of attachment to the axis.

This species is found in association with and is undoubtedly congeneric with the preceding species, and indeed it may be only a narrow, slenderly acuminate form of that species. It has the thick substance, immersed secondary nervation, and striate petiole and midrib of *C. coloradensis* but differs in shape, especially in the apex. This species departs so widely from the form of the living leaves that it seemed wise to question the generic reference.

Occurrence: Dawson arkose, dump of Mosby coal mine, Mosby, Colo., collected by F. H. Knowlton and G. B. Richardson, 1910.

Family POMACEAE

Crataegus myricoides Lesquereux

Plate 44, Figures 7–10

Crataegus myricoides Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 56, 1888.

Following is Lesquereux's original description and discussion:

Leaves membranous, small, ovate-lanceolate, more or less deeply dentate, penninerved; lateral nerves simple or forking, oblique and straight to the borders, or curving inside before entering the teeth, teeth alternately larger, or large and bitridentate on the back.

The two leaves representing the species are only 2 or 3 centimeters long, 1.5 centimeters broad, fragmentary. They resemble leaves of *Betula*, but the irregular nervation is that of *Myrica*, the two lower pairs of nerves being longer and entering the teeth, the upper shorter, curved, and effaced near the borders, all at unequal distance, not parallel. They have some resemblance to the leaves of *Crataegus oxycanthoides* Göppert.

This species is based on two types, both of which are here figured. They are small leaves 2.5 to 3 centimeters long and less than 2 centimeters wide and are poorly preserved. The one best preserved is shown in Figure 9. It is elliptical-lanceolate, with a wedge-shaped base and apparently an acuminate apex. The margin is cut into relatively large, sharp teeth, each, as Lesquereux states, bidentate or tridentate on the back. The nervation is pinnate, with a thin midrib and five or six pairs of alternate, craspedodrome secondaries.

[84] Knowlton, F. H., U. S. Geol. Survey Twenty-first Ann. Rept., pt. 2, p. 216, pl. 30, fig. 19, 1900.
[85] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 220, pl. 44, figs. 4, 5, 1916.
[86] Idem, p. 220, pl. 44, figs. 8–10.
[87] Lesquereux, Leo, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 52, 1888.
[88] Heer, Oswald, Miocene Flora des Insel Sachalin, p. 45, pl. 3, fig. 3b, 1878.

The other specimen (fig. 8) lacks the upper half of the blade. It is more obtusely wedge-shaped at the base than the other, and the margin is so broken that the teeth are obscurely preserved. The midrib is thicker, but the secondaries are about the same, though the lower pair show branching. The finer nervation is not retained in either specimen.

The generic reference for these little leaves is perhaps open to question. As Lesquereux stated, they suggest leaves of *Betula*, such as *Betula glandulosa* Michaux and *B. pumila* Linné, but there are points of difference, and it is perhaps as well to leave them at least temporarily as left by Lesquereux.

Occurrence: Denver formation, South Table Mountain, Golden, Colo., collected by Arthur Lakes. Types in Museum of Comparative Zoology, Cambridge, Mass., Nos. 1567, 1568.

Family DRUPACEAE

Prunus denverensis Knowlton, n. sp.

Plate 44, Figures 3, 4, 6, 11

Leaves coriaceous, narrowly ovate-lanceolate, long wedge-shaped at the base, prolonged above into a slenderly acuminate tip; margin almost entire below, then finely and evenly serrate, the teeth being small and sharp; petiole short, rather stout; midrib fairly strong, perfectly straight; secondaries numerous, about 12 or 15 pairs, alternate, at a low angle of emergence, much curved upward, camptodrome, arching near the margin and each joining the one above by a series of bows, sending minute nervilles to the teeth; nervilles numerous, strong, irregular, mainly oblique to the secondaries; finer nervation producing a close network of rather elongated areas.

If I am correct in referring all these leaves to a single species there is a very considerable range in size, but as this appears to be the only noticeable difference they are best considered together for the present. The smallest leaf (fig. 6) is about 4 centimeters long and a little over 1 centimeter wide, and the largest leaf (fig. 11) was probably 10 or 12 centimeters long (upper portion missing) and 3.5 centimeters wide. The very perfect leaf shown in Figure 4 is 5.5 centimeters long and 2 centimeters wide. A still larger one, shown in Figure 3, is 7.5 centimeters long and 2.25 centimeters wide.

This species suggests a number of living American forms, such as *Prunus angustifolia* Marsh and more particularly *P. serotina* Ehrhardt, the common wild black cherry of the eastern United States.

Occurrence: Dawson arkose, oil well near Ramah, Colo., collected by C. W. Cooke for G. B. Richardson, 1910.

Family PAPILIONACEAE

Phaseolites coloradensis Knowlton, n. sp.

Plate 45, Figure 1

Leaflets rather thick, asymmetrically ovate, obtusely pointed at the apex, obtusely wedge-shaped and inequilateral at the base, the margin perfectly entire; petiolule short, very stout; midrib very stout; secondaries five or six pairs, lowest pair stronger, subopposite, arising just above the top of the petiole, at an angle of about 45°, joining the next secondaries by a broad bow, other secondaries alternate and subopposite, at a low angle, camptodrome; nervilles few, strong.

This species is represented by small leaflets; the best one, which is practically perfect, is figured. It is markedly unequal-sided. It is 4 centimeters long and nearly 2.5 centimeters wide. The petiolule is preserved for a length of 5 millimeters. The nervation is distinctive, consisting of the strong midrib and a lower pair of strong secondaries at a different angle from the others, all being camptodrome.

This species appears to be certainly congeneric with *Phaseolites oeningensis* Heer,[89] from the Swiss Miocene, though the European species is much larger, and the lower secondaries are not so conspicuously larger than the upper ones, nor do they differ in angle of origin from the midrib. Heer suggested the resemblance of his species to *Ficus tiliaefolia* but concluded that it is only superficial.

In shape and general appearance *Phaseolites coloradensis* has some resemblance to *Pithecolobium eocenicum* Berry, from beds of Wilcox age in the Lagrange formation at Puryear, Tenn., but it is larger and differs somewhat in nervation. It also agrees very well in size and shape with certain of the leaflets referred to *Sapindus obtusifolius* Lesquereux,[90] from the Green River formation of Green River, Wyo., but differs in the nervation.

Occurrence: Dawson arkose, dump of Mosby coal mine, Mosby, El Paso County, Colo., collected by F. H. Knowlton and G. B. Richardson, July, 1910.

Sophora richardsoni Knowlton, n. sp.

Plate 45, Figure 7

Leaflets small, rather thick, elliptical, rounded below to the short, stout petiolule and in about the same degree above to the abruptly acuminate tip; margin entire; midrib very thick, straight; secondaries about five pairs, thin, at an acute angle, camptodrome; finer nervation obsolete.

[89] Heer, Oswald, Flora tertiaria Helvetiae, vol. 3, p. 103, pl. 133, fig. 6, 1859.

[90] Lesquereux, Leo, The Tertiary flora, p. 266, pl. 49, fig. 10, 1878.

The little leaflet figured is almost regularly elliptical in outline, being 2.5 centimeters long and 1.3 centimeters wide. The petiolule is at least 3 millimeters long.

This species closely resembles a number of described species from the Wilcox group; in fact, it would perhaps be no great violence to identify it with *Sophora paleolobifolia* Berry,[91] which is described by Berry as elliptical and markedly inequilateral, though the figure given does not exhibit this peculiarity. The size and nervation agree very well with the Colorado species.

The leaflet under consideration also closely resembles some of the smaller leaflets of *Sophora wilcoxiana* Berry,[92] and it is also of the same shape and much the same nervation as *Sophora puryearensis* Berry.[93] There are, however, slight differences, and altogether it seems best to consider this a new species, at least until more material can be procured.

Occurrence: Dawson arkose, dump of Mosby coal mine, Mosby, Colo., collected by F. H. Knowlton and G. B. Richardson, 1910.

Sophora puryearensis Berry?

Plate 45, Figure 8

Sophora puryearensis Berry, U. S. Geol. Survey Prof. Paper 91, p. 242, pl. 52, fig. 3, 1916.

The little leaflet here figured appears to belong to *Sophora puryearensis*, as described and figured by Berry.[94] It is smaller than the Wilcox specimen and has only four pairs of secondaries instead of five, but its shape is identical. It is not well preserved, especially in the upper portion, but it does not seem to differ essentially, though I have questioned the full identification.

Occurrence: Dawson arkose, red hill 4 miles south of Ramah, Colo., collected by G. B. Richardson, 1910. Lagrange formation, Puryear, Henry County, Tenn.

Leguminosites? arachioides (Lesquereux) Lesquereux

Leguminosites? arachioides (Lesquereux) Lesquereux, The Tertiary flora, p. 301, pl. 59, figs. 13, 14, 1878; U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1876, p. 519, 1878.

Ward, U. S. Geol. Survey Sixth Ann. Rept., p. 554, pl. 49, fig. 7, 1886; U. S. Geol. Survey Bull. 37, p. 65, pl. 29, fig. 2, 1887.

Penhallow, Report on the Tertiary plants of British Columbia, p. 61, text fig. 14, 1908.

Knowlton, Washington Acad. Sci. Proc., vol. 11, pp. 184, 212, 1909; Jour. Geology, vol. 19, p. 369, 1911; U. S. Geol. Survey Prof. Paper 101, p. 326, 1917 [1918].

Berry, U. S. Geol. Survey Prof. Paper 91, p. 249, pl. 48, fig. 9, 1916.

Carpolithes arachioides Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, p. 403, 1873.

This curious organism was described by Lesquereux as follows:

> Capsules or siliques alternate and sessile on flexuous, thick, woody pedicels; obovate, rounded to a short acumen, mostly enlarged on the lower side, bossed under the point as inclosing a round seed, regularly striated with narrow ridges, generally tending in a curve from the borders to the point, obscurely and transversely wrinkled.
>
> These capsules, or pods, are turned upward in the upper part of the branches, horizontal or pending in the lower part, 2.5 cenimeters long, 1 centimeter broad in the middle, flattened by compression, but generally convex or inflated near the point, or from the presence inside of a large, round seed.

Lesquereux stated that "the relation of these racemes of fructifications is as yet uncertain," but suggested that they appear to belong to the Leguminosae and in some ways suggest the fruits of *Arachis hypogaea*, the well-known peanut.

In the years that have come and gone since Lesquereux wrote *Leguminosites arachioides* has been found to be very widely distributed, and although its exact nature is still a matter of some doubt, it can be described with more assurance. Berry,[95] who has found it at a number of localities in the Wilcox group, has revised the description as follows:

> Pods in compound clusters, arranged alternately in pairs on stout flexuous stems, subsessile, of a ligneous consistency, full and evenly rounded, inflated, about 2.5 centimeters in length and about 1 centimeter wide across the middle, pointed at both ends, mucronate distad, several-seeded, dehiscent. Surface striated; in general there are two series of striae, wrinkles, or corrugations, one set approximately longitudinal and the other transverse. These striations are to a certain extent the result of compression, since a good many of the pods show rounded bases evidently due to deformation.

As to the affinity of *Leguminosites arachioides*, Berry concludes that it "was either a low straggling plant of the sandy beaches, comparable perhaps with the modern forms of *Baptisia* or *Crotalaria*, or else it was a vine like the modern species of *Abrus*." It has not been found in recognized association with foliage, and we must apparently await for future discoveries of this or for a closer interpretation of the fruits.

The type specimens of *Leguminosites arachioides* came from Evanston, Wyo., occurring "in a block of ironstone taken from the mines," and are all preserved in the collections of the United States National Museum (No. 492). Its presence in the Denver Basin and adjacent areas depends on some fragmentary yet characteristic specimens at Golden and near the base of Mount Bross, in Middle Park. They add nothing to our previous knowledge of this curious organism.

[91] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 243, pl. 52, fig. 1, 1916.
[92] Idem, p. 241, pl. 47, fig. 10.
[93] Idem, p. 242, pl. 52, fig. 3.
[94] I regard this as highly improbable.—E. W. B.
[95] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 250, 1916.

Occurrence: Evanston formation (types), Evanston, Wyo. Denver formation, Golden, Colo. Middle Park formation, Middle Park, Colo., at base of Mount Bross. Raton formation, near Berwynd, Colo. Fort Union formation, Clear Creek, near Glendive, Mont. Lance formation, Melville, Mont.; Monarch, Wyo.; and T. 23 N., R. 20 E., S. Dak. Wilcox formation, Hamilton, Sabine County, Tex., and Mansfield, De Soto Parish, La.

Family CAESALPINEACEAE

Cassia vetusta Knowlton, n. sp.

Plate 45, Figure 2

Leaflet small, apparently rather thin, lanceolate, broadest near the middle, whence it narrows to the rather obtusely wedge-shaped base and to the apparently acuminate apex; nervation pinnate, consisting of a relatively strong midrib and about three pairs of secondaries, the lower pair opposite, the others alternate, at an angle of about 60°, all slightly curved upward; finer nervation not retained.

This little leaflet—the only one observed—is about 4.5 centimeters long and 1.5 centimeters wide. It is rather remarkable in that it has only three pairs of secondaries, the lowest pair being opposite and the others strongly alternate.

In size and shape this species is similar to *Cassia emarginata* Berry,[96] from the Wilcox group of Mississippi, but differs in the secondary nervation.

Occurrence: Dawson arkose, Templeton Gap, 4 miles northeast of Colorado Springs, Colo., collected by F. H. Knowlton, July, 1910.

Cercis coloradensis Knowlton, n. sp.

Plate 45, Figure 5

Leaf membranaceous, broadly ovate or nearly circular, truncate at the base, probably obtusely pointed at the apex; margin entire; petiole short, relatively stout; nervation palmately 5-ribbed from the slightly enlarged top of the petiole; a strong basal secondary on each side arises very near the base of the outer pair of ribs, thus producing a false 7-ribbed appearance; midrib much the stronger, especially below, with at least two pairs of alternate, strong secondary branches in the upper part; inner pair of ribs at an angle of about 70°, nearly straight, joining the lowest pair of secondaries on the midrib by a broad loop, each of these ribs with four or five camptodrome secondaries in the upper part; outer pair of ribs at an angle of 40° or 50°, a little curved upward, joining the lowest secondary branch on the inner ribs, each with several secondaries that are approximately at right angles to the midrib, camptodrome and forming a series of loops near the margin; nervilles numerous, strong, mainly broken.

The leaf figured was probably about 8 centimeters long and a little more than 6 centimeters wide. The petiole is preserved for a length of 1.25 centimeters but was probably considerably longer. Another very fragmentary leaf thought to belong to this species was probably 9 or 10 centimeters wide and doubtless as much in length. The nervation is so well shown in the figure that description is not necessary.

Cercis coloradensis was of about the same size as normal leaves of the living *Cercis canadensis* Linné and much resembles it. It differs in the more nearly truncate base, proportionately somewhat narrower blade, fewer secondaries on the midrib, and fewer secondaries on the ribs, but none of these differences are of great importance.

The present species is of about the same size as *Cercis wilcoxiana* Berry,[97] from beds of Wilcox age in the Lagrange formation at Grand Junction, Tenn. It differs, however, in many of the details of nervation, including the number and angle of divergence of the primary ribs, secondary branches on midrib and lateral ribs, and character of the finer nervation.

Occurrence: Dawson arkose, east bank of Jimmy Camp Creek 0.6 mile above Richfield Springs ranch house, 9 miles east of Colorado Springs, Colo., collected by F. H. Knowlton and W. T. Lee, July, 1910.

Order SAPINDALES

Family CELASTRACEAE

Celastrus gaudini Lesquereux

Plate 45, Figures 3, 4, 9

Celastrus gaudini Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 54, 1888.
Parrotia fagifolia Ettingshausen. Lesquereux, op. cit., p. 52.

This species is characterized by Lesquereux as follows:

> Leaves membranous, rugulose on the surface, oval-oblong or broadly oval, crenate or obtusely serrate, abruptly narrowed at base; secondaries alternate, about six pairs, much curved upward in passing to the borders and effaced; tertiary nerves and nervilles obsolete.
>
> These leaves are 5.5 centimeters long, 4.5 to 5 centimeters broad, apparently obtuse, though the upper part is broken in all the specimens. The species is closely related to *Celastrus heerii* Sismonda.[98]

The specimen referred by Lesquereux to *Parrotia fagifolia* Ettingshausen is not to be distinguished from

[96] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 233, pl. 48, fig. 5, 1916.

[97] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 228, pl. 49, fig. 1, 1916.

[98] Sismonda, Eugenio, Matériaux pour servir à la paléontologie du terrain tertiaire du Piémont: Accad. sci. Torino Mem., vol. 22, p. 449, pl. 29, fig. 5, 1865.

this species and has been so referred. It is shown in Figure 9.

Occurrence: Denver formation, South Table Mountain, Golden, Colo., collected by Arthur Lakes. Types in Museum of Comparative Zoology, Cambridge, Mass., Nos. 1527, 1528; specimen identified as *Parrotia fagifolia* Ettingshausen, No. 1512.

Celastrinites artocarpidioides Lesquereux

Celastrinites artocarpidioides Lesquereux, The Tertiary flora, p. 268, pl. 35, fig. 3, 1878.

Artocarpidium olmediaefolium? Unger. Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, pp. 381, 400, 1874; idem for 1876, p. 516, 1878.

The type specimen of this species is No. 407 of the United States National Museum collection. It came from the andesitic material at Golden, Colo., and hence is referred to the Denver formation. So far as known no additional specimens have been obtained at this locality. As Lesquereux pointed out, the specimen is not well preserved, and its intimate characters are made out with difficulty. It is not correctly shown in the figure given in the report on the Tertiary flora, certain folds in the leaf having been mistaken for secondaries. There are six or seven pairs of alternate secondaries, which apparently arch around just inside the margin, and not, as Lesquereux said, "curving at a distance from the borders, and forming a double series of bows by anastomosis of the nervilles."

This species is apparently closely related to *Celastrinites alatus* Knowlton,[99] from the Laramie at Erie, Colo., at least so far as the imperfection of *C. artocarpidioides* permits a comparison. The two species are of about the same size and shape, but *C. artocarpidioides* is without the winged petiole which is so conspicuous a feature in *C. alatus*.

Lesquereux first referred this leaf to *Artocarpidium olmediaefolium?* Unger, which it much resembles, but later decided that its affinity was better expressed by a reference to *Celastrinites*.

Occurrence: Denver formation, Golden, Colo., collected by Arthur Lakes.

Celastrinites populifolius Knowlton, n. sp.

Plate 40, Figure 1; Plate 45, Figure 11

Populus ungeri Lesquereux. Lesquereux, Havard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 46, 1888.

Under the name *Populus ungeri* Lesquereux mentioned and partly described a leaf in the Museum of Comparative Zoology from Golden, Colo. He stated that the "specimen referred to this species, the lower half of a leaf, apparently round, [is] entire on the borders and with the nervation of the species."

As the specimen was seen by Lesquereux it appeared to be a short, round leaf very much like the figure of *Populus ungeri* given in the report on the Tertiary flora, Plate 25, Figure 5, but by removing the matrix it is disclosed as something very different. It is a medium-sized leaf about 7.5 centimeters long and a little over 4 centimeters wide, with the petiole complete, 2.5 centimeters long. It is ovate, abruptly rounded to the slightly decurrent base and apparently narrowed to a moderately pointed apex. The margin is perfectly entire below, but along the sides it is provided with minute, sharp, upward-pointing teeth. The midrib is slender and straight, with about nine pairs of thin, opposite or subopposite secondaries, which arise at an angle of about 40°, much curved upward and disappearing just before reaching the margin. The nervilles are very fine, apparently mainly simple and more or less oblique to the secondaries.

The generic reference for this leaf is somewhat difficult to settle. In the first place it somewhat resembles the lower half of *Populus ungeri*, but it is much more like certain other species of *Populus*—for instance, *Populus mutabilis ovalis* Heer, as figured by Lesquereux[1] from the Evanston formation of Evanston, Wyo. In size, shape, and nervation it is much like certain leaves of *mutabilis ovalis* as figured by Heer[2] from the Swiss Miocene. The presence of small sharp teeth on the margin, however, excludes this leaf from the genus *Populus*.

The reference of this leaf to *Celastrinites* seems justified. It has, for instance, the same shape and nervation as *Celastrinites artocarpidioides* Lesquereux,[3] a Denver species, but differs in the marginal teeth.

Occurrence: Denver formation, South Table Mountain, Golden, Colo., collected by Arthur Lakes. Type in Museum of Comparative Zoology, Cambridge, Mass., No. 1576 (identified by Lesquereux as *Populus ungeri*).

Family ACERACEAE

Negundo decurrens Lesquereux

Plate 45, Figure 10

Negundo decurrens Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 54, 1888.

Described as follows by Lesquereux:

Leaves compound, trifoliolate. Terminal leaflet apparently large, trinerved from above the decurring base; lateral nerves thick, branching on the lower side; lateral leaflets at a distance from the base of the terminal one, undulate and sparingly dentate on the borders, trinervate above the decurring base; secondaries thin with few branches; nervilles indistinct, oblique to the median nerve.

Species related to *Negundo triloba* Newberry,[4] but differing by the prolongation of the base of the lateral leaflets along

[99] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 130, p. 148, pl. 25, figs. 4, 5; pl. 26, fig. 1, 1922.

[1] Lesquereux, Leo, The Tertiary flora, p. 177, pl. 24, fig. 3, 1878.

[2] Heer, Oswald, Flora tertiaria Helvetiae, vol. 2, p. 22, pl. 61, fig. 1, 1856.

[3] Lesquereux, Leo, The Tertiary flora, p. 268, pl. 35, fig. 3, 1878.

[4] Newberry, J. S., U. S. Geol. Survey Mon. 35, p. 115, pl. 31, fig. 5, 1898.

the petiole, not cordate. The nervation is, however, the same, and the borders also are marked by few sharp teeth.

This species is based on the single specimen figured and consists of fragments of two leaflets. All that is retained of the terminal leaflet is a part of the base, this being wedge-shaped or decurrent to the strong rachis. Its whole outline can not be made out, though the presence of strong lateral ribs suggests the possibility of lateral lobes. The lateral leaflets are opposite and are 1.5 centimeters below the decurrent base of the upper one.

Although Lesquereux states that this species is related to *Negundo triloba* Newberry, from the Fort Union formation of North Dakota, the likeness is not very marked. In *N. triloba* the terminal leaflet is smaller than the lower ones and is heart-shaped instead of wedge-shaped at the base. The lateral leaflets in *N. triloba* are truncate or slightly heart-shaped, but in *N. decurrens* they are slightly wedge-shaped at the base.

Occurrence: Denver formation, South Table Mountain, Golden, Colo., collected by Arthur Lakes. Type in Museum of Comparative Zoology, Cambridge, Mass., No. 1523.

Acer sp.

Plate 45, Figure 6

The fragment here figured is the only specimen that can with reasonableness be referred to *Acer*. It is a fragment evidently of a basal lobe with a small portion of the smaller central lobe. The lobes were toothed, though the teeth were small and only moderately pointed. The nervation is clearly that of *Acer*.

There is so little of this leaf present that it is hardly worth comparing with described forms, though so far as can be determined it seems to agree closely with certain of the leaves from the Swiss Miocene referred by Heer[5] to *Acer trilobatum productum;* in fact, it would be difficult to separate them on the material available.

Occurrence: Dawson arkose, lower part (in beds equivalent to Arapahoe formation), 3,000 feet east of the Douglas mine, Sedalia, Colo., collected by Arthur Lakes.

Family SAPINDACEAE

Sapindus caudatus Lesquereux

Sapindus caudatus Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, pp. 380, 397, 1873; idem for 1873, p. 382, 1874; idem for 1876, p. 515, 1878; The Tertiary flora, p. 264, pl. 48, fig. 6, 1878; Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 54, 1888.

The type of this species, now preserved in the United States National Museum (No. 386), was well described and figured by Lesquereux. It appears to be rare, for in addition to the single example on which it is based Lesquereux reported only one in the collection from Golden now belonging to the Museum of Comparative Zoology, and the large recent collections belonging to the United States National Museum include only two or three specimens, but one of them is so complete as to render its determination reasonably certain.

Lesquereux[6] identified a single leaf as this species (U. S. Nat. Mus. No. 2601) from the Wilcox formation of Campbell's quarry, Cross Lake, Caddo Parish, La., but Berry,[7] who has recently restudied this and other similar material, states that it is so fragmentary that it can not be identified even generically.

In a number of particulars *Sapindus caudatus* strongly resembles *Juglans denveriana.* Thus it agrees in the shape of the base and largely in the type of nervation, but it differs in being relatively shorter and broader, in having a long, slender apex, and more particularly in having the margin perfectly entire instead of more or less obscurely toothed. It is possible that a larger series of specimens might show a breaking down, but until this is actually demonstrated it seems best to keep them distinct.

Occurrence: Denver formation, South Table Mountain, Golden, Colo. (type); additional specimens from same locality, collected by Arthur Lakes, 1890.

Sapindus berryanus Knowlton, n. sp.

Plate 46, Figures 1, 2

Leaflets of medium size, thickish, linear-lanceolate, abruptly rounded and slightly unequal-sided at the base, apex destroyed but apparently acuminate; margin perfectly entire; petiolule short, stout; midrib very strong, straight; secondaries numerous, thin, often immersed in the substance of the blade, at a very low angle of emergence, considerably curved upward; finer nervation not retained.

This species is represented in the collections by several examples, two of the best preserved of which are figured. They are 9 or 10 centimeters long and about 2.5 centimeters wide and are slightly unequal-sided at the base. The apex is not preserved in any of the specimens, but to judge from the configuration of the upper portion of the best-preserved specimens it must have been fairly acuminate.

This species is quite distinct from any thus far found in the Dawson arkose. It is suggestive of *Sapindus knowltoni* Berry[8] from the Wilcox group, but that form differs in its smaller size and narrower, more acuminate apex.

[5] Heer, Oswald, Flora tertiaria Helvetiae, vol. 3, p. 47, pl. 114, figs. 2, 7, etc., 1859.

[6] Lesquereux, Leo, U. S. Nat. Mus. Proc., vol. 11, p. 24, 1888.

[7] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 29, 1916.

[8] Idem, p. 274, pl. 63, fig. 6.

Occurrence: Dawson arkose, a quarter of a mile east of the Purdon mine, sec. 27, T. 11 S., R. 61 W., Colo., collected by G. B. Richardson.

Sapindus? obtusifolius Lesquereux?

Plate 46, Figure 3

Sapindus obtusifolius Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, p. 419, 1874; The Tertiary flora, p. 266, pl. 49, figs. 8–10, 1878; The Cretaceous and Tertiary floras, p. 235, pl. 48, figs. 5–7, 1883.

There is some confusion regarding the type locality of this species. In the original description it was stated to have come from the "top of hills, apparently overlying the coal-bearing strata of Rock Springs [Wyoming], seen to the east 5 or 6 miles distant," where it was associated with numerous fragmentary plants that were later described as *Musophyllum complicatum*. When *Sapindus obtusifolius* was taken up in the report on the Tertiary flora the exact locality was given as "8 miles southeast of Green River Station, Wyo., in connection with three beds of coal referable to the Washakie or Carbon group." Still later its presence was noted by Lesquereux[9] in the Badlands of North Dakota in beds now known to be of Fort Union age. In this connection it may be well enough to call attention to the apparent similarity between this species and *Sapindus affinis* Newberry, a species that is very abundant in the Fort Union formation. With the same habit and approximately the same size, the main difference seems to be in the apex of the leaflets, this being obtuse in the present species and long acuminate in *Sapindus affinis*.

The specimen which is here figured is referred with some doubt to *Sapindus obtusifolius*. It is very similar in size and shape to Plate 49, Figure 11, of the report on the Tertiary flora, but differs apparently in having a more pointed apex than is usual in the species; unfortunately both figure and specimen are without the extreme portion of the tip. The nervation is very similar, however.

Occurrence: Denver formation, South Table Mountain, Golden, Colo.

Family ILICACEAE

Ilex? ovata Knowlton, n. sp.

Plate 46, Figure 4

Leaf coriaceous, ovate, abruptly rounded to the base, acuminate at the apex; margin finely serrate, the teeth undulate or sharp-pointed; petiole strong; midrib strong, straight; secondaries four or five pairs, alternate, thin, strongly camptodrome and arching far within the border, each joining the one next above and sending from the outside of the loop a thin tertiary branch or nerville to a marginal tooth; nervilles strong, often percurrent.

This little leaf is all that has been thus far detected in these beds. It is a thick leaf, regularly ovate, with rather small undulate or sharp-pointed teeth. The length is about 5 centimeters and the width 3 centimeters. The nervation is peculiar in that it consists of a rather strong midrib and about five pairs of strong, distinctly alternate secondaries which make broad loops far within the border by joining of a lower with the one next above it.

Occurrence: Denver formation, northwestern base of Green Mountain, Golden, Colo.

Order RHAMNALES

Family RHAMNACEAE

Berchemia multinervis (Al. Braun) Heer

Berchemia parvifolia Lesquereux, Am. Jour. Sci., 2d ser., vol. 45, p. 207, 1868; U. S. Geol. Survey Terr. Ann. Rept. for 1869, p. 96; reprint, 1873, p. 196; idem for 1870, p. 382, 1871; idem for 1871, Suppl., p. 15, 1872; idem for 1873, p. 382, 1874.

Berchemia multinervis (Al. Braun) Heer. Lesquereux, The Tertiary flora, p. 277, pl. 52, figs. 9, 10, 1878; U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1876, p. 517, 1878. Knowlton, Washington Acad. Sci. Proc., vol. 11, p. 213, 1909; U. S. Geol. Survey Prof. Paper 101, p. 333, pl. 101, fig. 5, 1917 [1918].

The status of this species in American strata is not very satisfactory. As indicated by the above synonymy, Lesquereux first called this form *Berchemia parvifolia*, but when he prepared his account of the Tertiary flora he decided that it was not sufficiently distinct from the well-known European species *Berchemia multinervis*. The earlier specimens to which the name *Berchemia parvifolia* was given are said to have come from Raton Pass, N. Mex., but these specimens are not now in the United States National Museum collections. In 1910, however, additional material was procured by W. T. Lee from Raton Pass, hence in the type locality for *Berchemia parvifolia*.

The American form at least seems to be closely related to *Rhamnus goldianus*, from which it differs, according to Lesquereux, in never exhibiting the lower pair of secondaries on the outside. This character Ward[10] did "not regard as of sufficient weight to be treated as generic," and it undoubtedly is a character of slight importance. But, as Lesquereux said, all the leaves of *Rhamnus goldianus*, regardless of size, have the lower secondaries branched, and as none of the leaves of *Berchemia* show this branching it perhaps becomes of generic importance.

[9] Lesquereux, Leo, The Cretaceous and Tertiary floras, p. 235, 48, figs. 5–7, 1883.

[10] Ward, L. F., Types of the Laramie flora: U. S. Geol. Survey Bull. 37, p. 73, 1887.

Much more difficult, it appears to me, is the task of discriminating between *Berchemia multinervis* and the small leaves of *Rhamnus cleburni*, which are not infrequently associated with it. *Rhamnus cleburni* differs from *R. goldianus* in being usually larger and in not having the lower pair of secondaries branched. This is a sufficient criterion in large leaves, but it is almost impossible to separate small leaves of *Rhamnus cleburni* from *Berchemia multinervis;* in fact, they can be distinguished only by the shape, *Berchemia multinervis* being nearly elliptical and *Rhamnus cleburni* more pointed.

The recent collections from the Denver Basin include this species from the south face of South Table Mountain, Golden, and from the vicinity of the Douglas coal mine, west of Sedalia. As they do not add anything to our knowledge of this species it has not been thought necessary to figure them.

Occurrence: Denver formation, south face of South Table Mountain, Golden, Colo., collected by Arthur Lakes, 1890. Dawson arkose, lower part (in beds equivalent to Arapahoe formation), 3,000 feet east of the Douglas coal mine, Sedalia, Colo., collected by Arthur Lakes, 1890. Raton formation, Raton Pass, Raton Mountains, N. Mex., and near Yankee, N. Mex., collected by W. T. Lee. Fort Union formation, mouth of Yellowstone River, Mont.

Rhamnus? praealaternoides Knowlton, n. sp.

Plate 46, Figures 7, 8

Rhamnus alaternoides Heer. Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, p. 405, 1874; idem for 1876, p. 517, 1878; The Tertiary flora, p. 278, pl. 52, figs. 11, 11a, 1878.

Leaf small, about 14 millimeters long and 6 millimeters wide, subcoriaceous, elliptical, obtusely pointed, narowed from near the middle to the wedge-shaped base; margin obscurely dentate, apparently only above the middle; midrib strong for the size of the leaf; secondaries about five pairs, alternate, at somewhat irregular distances, emerging at an angle of about 45°, considerably curved upward, camptodrome, with thin branches passing to the obscure teeth; finer nervation not retained.

This species, it must be confessed, has not a very firm or satisfactory standing. It is based entirely on the single leaf (U. S. Nat. Mus. 432) identified by Lesquereux with *Rhamnus alaternoides* Heer,[11] from the Swiss Miocene. Heer has figured three specimens, one of which has entire margins and the others are obscurely few-toothed. The leaf from Golden resembles the European leaves closely, but it is more nearly elliptical and has the secondaries at a slightly more acute angle. It lacks a good deal of the actual margin, and hence it is difficult to compare closely with the Swiss leaves. Considering the geographic and stratigraphic difference between these American and European leaves it seems very doubtful if there can be identity between them; hence the American leaf has been given a new name, which, however, preserves its supposed resemblance to Heer's species. The generic reference has also been questioned, for it is impossible to be certain of the affinity of only a single rather poorly preserved leaf, especially as the finer nervation is not observable.

Occurrence: Denver formation, South Table Mountain, Golden, Colo., collected by Leo Lesquereux, about 1875.

Rhamnus goldianus Lesquereux

Rhamnus goldianus Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, p. 381, 1873; idem for 1873, p. 405, 1874; idem for 1876, p. 517, 1878; The Tertiary flora, p. 281, pl. 53, figs. 4–8, 1878.

Berchemia multinervis Al Braun. Ward, U. S. Geol. Survey Sixth Ann. Rept., p. 554, pl. 51, fig. 13, 1886; U. S. Geol. Survey Bull. 37, p. 73, pl. 33, fig. 2, 1887.

Leaves thick, subcoriaceous, smooth, entire, broadly oblong or oval, obtusely pointed or acuminate at the apex, subcordate or rounded at the base; petiole short; secondaries numerous, 12 to 16 pairs, close, parallel, slightly curved, forming a series of simple bows near the margin; lowest pair of secondaries branching downward in anastomosing with the short, marginal veins; nervilles very numerous, both simple and forked, usually more or less oblique to the secondaries.

This species is closely allied to *Rhamnus cleburni* Lesquereux, from which it differs in its generally smaller size, rounded or heart-shaped base, and downward arching of the tertiary branches of the lowest pair of secondaries. The question of size, however, is not one of great importance, for the recent collections contain specimens clearly referable to this species which are larger than the figured types of *R. cleburni.* They are, however, generally smaller. The rounded base and branched lowest secondaries become the important characters, and in considering specimens without the base it is a question to which form they should be referred.

The type specimens of *Rhamnus goldianus* are all preserved in the United States National Museum (Nos. 441 to 445) and are all in the typical andesitic material of the Denver formation at Golden, Colo. Accompanying them and having the same number is a small example on a hard reddish sandstone that seems to have come from a different locality and to belong to a different species, possibly *Berchemia multinervis.* In the report on the Tertiary flora (p. 281) Lesquereux reported this species from Black

[11] Heer, Oswald, Flora tertiaria Helvetiae, vol. 3, p. 78, pl. 124, figs. 21–23, 1859.

Buttes, Wyo., "where it is rare," but the National Museum does not possess and so far as the catalogue goes has never possessed a specimen from this locality. It is not contained in the large collections procured by Ward at Black Buttes in 1881, nor was it found by me on a visit made in 1896. Lesquereux said also: "One specimen, representing the large form, is from Carbon, Wyo." As no specimens can be found from this locality, either among the original or the later collections, it seems more than likely that this remark was intended to apply to *Rhamnus cleburni*, which precedes it on the page and which has larger leaves than Lesquereux ever assigned to *R. goldianus*.

The National Museum collection contains another fragmentary specimen (No. 2375), from the rhyolite beds at Silver Cliff, Colo., identified by Lesquereux [12] as this species, but it represents only the upper half of a medium-sized leaf, and as shown above this is not enough to establish positively the identity of this species.

In working up the flora of the Laramie formation I found a single fragmentary specimen probably of this species in beds of this age at Marshall, Colo. It seems to be identical with some of the smaller leaves referred to *Rhamnus goldianus*, but as it lacks the base and much of the margin its identification has been questioned.

Specimens from the Raton formation of the Raton Mesa region of Colorado are referred with but little hesitation to *Rhamnus goldianus*.[13]

The specimens figured by Ward [14] under the name *Berchemia multinervis* Al. Braun may be briefly considered. Of these, one, the original of Figure 13, came from Golden, Colo., and is undoubtedly referable to *Rhamnus goldianus*. It is a small leaf, but it has the tertiary branches on the lowest pair of secondaries. The other specimen (fig. 12) is from the Fort Union formation in the Bull Mountains, Mont., where it was collected by A. C. Peale. This is a small leaf lacking the basal portion and may be correctly placed; in any event it may be permitted to remain in this species for the present.

Occurrence: Denver formation (types), Golden, Colo., South Table Mountain, collected by Arthur Lakes and others; ?Silver Cliff, Colo., collected by Whitman Cross. Raton formation, Wootton and near Aguilar, Colo., collected by W. T. Lee, 1909. Laramie(?) formation, Marshall, Colo., wooded bluff just north of station and highest point in the section, collected by F. H. Knowlton, 1908.

[12] Lesquereux, Leo, U. S. Nat. Mus. Proc., vol. 10, p. 44, 1887.

[13] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 101, p. 332, pl. 101, fig. 4; pl. 112, fig. 5, 1917 [1918].

[14] Ward, L. F., U. S. Geol. Survey Sixth Ann. Rept., p. 554, pl. 51, figs. 12, 13, 1886; U. S. Geol. Survey Bull. 37, p. 73, pl. 33, figs. 1, 2, 1887.

[*Rhamnus goldianus latior* Lesquereux was described briefly in 1873 (U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, p. 381, 1873) but was not afterward referred to by its author. It came from Golden, Colo., but it can not be placed without a knowledge of its matrix.]

Rhamnus cleburni Lesquereux

Plate 40, Figure 6; Plate 46, Figures 10, 11

Rhamnus cleburni Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, pp. 381, 400, 1873; idem for 1873, p. 382, 1874; idem for 1876, p. 517, 1878; The Tertiary flora, p. 280, pl. 53, figs. 1–3, 1878; Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 55, 1888; U. S. Nat Mus. Proc., vol. 10, p. 44, 1887; vol. 11, pp. 20, 24, 1888.
Knowlton, U. S. Geol. Survey Bull. 204, p. 80, 1902; U. S. Geol. Survey Prof. Paper 101, p. 332, pl. 113, fig. 3, 1917 [1918].
Berry, U. S. Geol. Survey Prof. Paper 91, p. 283, 1916.
Cornus studeri Heer. Lesquereux, The Tertiary flora, p. 244, pl. 42, figs. 4, 5, 1878; Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 52, 1888.
Rhamnites knowltoni Berry, U. S. Geol. Survey Prof. Paper 131, p. 16, 1922 [part].

The figured types of this species are preserved in the United States National Museum (Nos. 356a, 439, 440). There are also a large number of other specimens that have been collected in recent years. This species is undoubtedly most closely related to *Rhamnus goldianus*, from which it differs in being usually larger, more nearly elliptical, with a tapering point, and narrowed to a comparatively long, slender petiole. The most important difference and one that appears to be constant is the absence of branches on the lower side of the basal pair of secondaries. This is really the crucial test of the species, for there are leaves of *Rhamnus goldianus* as large as small leaves of *R. cleburni*. It appears plain that the base of the leaf must be present in order that these species may be separated with certainty, and the identifications of one or the other of them made without knowing this character are at least open to question.

It is also to be noted that very small leaves of *R. cleburni* are difficult if not impossible to distinguish from large leaves of *Berchemia multinervis*, as pointed out under the latter species.

The question of the generic reference of these two species (*R. cleburni* and *R. goldianus*) is still open. According to Lesquereux European paleobotanists—presumably Saporta and Heer—to whom he had submitted either specimens or drawings inclined to the opinion that they showed more affinity with the Euphorbiaceae or Moraceae, especially with the genus *Ficus* and its allies. Take, for example, certain leaves of *Ficus irregularis* as figured by Lesquereux.[15] They have the same general shape, much the same character of secondary nervation, and particularly the numerous,

[15] Lesquereux, Leo, The Tertiary flora, p. 196, pl. 34, figs. 4, 5, 7, 1878.

close nervilles. It would seem that all these leaves are congeneric—that is, if those above mentioned have been correctly referred to *Ficus* those under consideration should also be so placed—but so long as it is well understood that they occupy this somewhat anomalous position there can be little objection.

Aside from the original locality there are a number of other localities from which *Rhamnus cleburni* has been reported. Thus a single specimen is present in the United States National Museum (No. 2373) from the upper Kanab Valley, Utah, as identified by Lesquereux.[16] This leaf is much more slender than the typical form and it lacks the base. It has the numerous close secondaries of *R. cleburni*, and to judge from the general shape is more likely to be this species than *R. goldianus*, but, as above stated, it can not be positively identified without the base.

I have also reported [17] the doubtful presence of *R. cleburni* in the lower part of the Clarno formation of Cherry Creek, Oreg.; but, as the specimen is only the upper portion of the blade, it is impossible to make the identification positive.

Among the specimens recently obtained from Middle Park, Colo., I find a number of leaves that seem to belong to this species, but in the absence of the basal portion the assignment can not be positively made.

Rhamnus cleburni was identified by Lesquereux [18] from the Wilcox formation of Louisiana, and its presence is confirmed by the later work of Berry,[19] though he considers it to be rather rare.

Among the collections from the Dawson arkose along Jimmy Camp Creek there are a number of fairly well preserved leaves that undoubtedly belong to *Rhamnus cleburni*.

After careful consideration I have reached the conclusion that the specimens from Golden, Colo., that were referred by Lesquereux [20] to *Cornus studeri?* Heer should be referred to *Rhamnus cleburni*. Both of the specimens figured by Lesquereux as the American types of *Cornus studeri* are preserved in the United States National Museum (Nos. 355, 356). They are both somewhat fragmentary, yet are sufficiently well preserved to show their general character. Both came from the andesitic beds at Golden and are like a number of more or less fragmentary specimens obtained from the same beds in recent years. In his account of the Tertiary flora (p. 244) Lesquereux gives Evanston, Wyo., as the principal locality for *Cornus studeri*, and this locality appears to have been the one at which the species was first detected in American strata,[21] but I have not been able to find any specimens from this locality in the United States National Museum in either the old or the recent collections.

As the status of *Cornus studeri* Heer as an American plant has recently been brought in question by Berry,[22] it may be of value to set forth the facts as at present understood. *Cornus studeri* was described by Heer [23] from the so-called Swiss Miocene, where apparently it is a not uncommon form. It has since been found at a number of other European localities.

The supposed presence of *Cornus studeri* in North America was first made known by Lesquereux [24] in 1871, when he reported it from Evanston, Wyo. This was based on a single large leaf "of which the base was destroyed, but whose form and peculiar nervation are in accordance with the characters of this species." It was said to be similar to Figure 18 of Heer's plate above cited. This specimen is not now known to be in existence, nor has it been duplicated in subsequent collections at this locality.

The next mention of this species by Lesquereux, except incidental mention in lists, was in 1878 in the report on the Tertiary flora. He gave figures of two specimens, both of which are preserved in the United States National Museum (Nos. 355, 356), and both are on the andesitic material characteristic of the Denver formation at Golden, Colo. They are rather fragmentary, the larger one especially, which could hardly have been less than 16 centimeters in length and 8 centimeters in width when growing. This leaf is very much larger than any figured by Heer, but Lesquereux mentions leaves from Golden that are only 6.5 centimeters long. The Swiss specimens range from about 5.5 centimeters to 12 centimeters in length and from 2.25 to nearly 5 centimeters in width. Lesquereux mentions the presence at Golden of numerous fragments of this species, and in his report on a collection studied for the Harvard College Museum of Comparative Zoology, in 1888, he records two additional specimens.

Ward [25] identified as *Cornus studeri* a very perfect leaf from the Mesaverde formation at Point of Rocks, Wyo., and in 1900 I admitted this species in the Montana flora and figured another leaf from Point of Rocks.[26] A priori it seems improbable that this Euro-

[16] Lesquereux, Leo, U. S. Nat. Mus. Proc., vol. 10, p. 44, 1887.
[17] Knowlton, F. H., U. S. Geol. Survey Bull. 204, p. 80, 1902.
[18] Lesquereux, Leo, U. S. Nat. Mus. Proc., vol. 11, p. 24, 1888.
[19] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 283, 1916.
[20] Lesquereux, Leo, The Tertiary flora, p. 244, pl. 42, figs. 4, 5, 1878.
[21] Cf. U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1871, p. 293, 1872.
[22] Berry, E. W., U. S. Geol. Survey Prof. Paper 131, p. 16, 1922.
[23] Heer, Oswald, Flora tertiaria Helvetiae, vol. 3, p. 27, pl. 105, figs. 18–21, 1859.
[24] Lesquereux, Leo, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1871, Suppl., p. 9, 1872.
[25] Ward, L. F., U. S. Geol. Survey Sixth Ann. Rept, p. 553, pl. 48, fig. 1, 1886; U. S. Geol. Survey Bull. 37, p. 55, pl. 26, fig. 1, 1887.
[26] Knowlton, F. H., U. S. Geol. Survey Bull. 163, p. 68, pl. 15, fig. 3, 1900.

pean Miocene species should, in America, extend downward into the Montana group, but it is not easy to separate them. The leaf figured by Ward has a much thicker petiole and midrib than the specimens from the Denver beds at Golden, and the specimen figured by me is certainly different. It is relatively larger and narrower and has a different type of finer nervation. The Point of Rocks leaves identified as *Cornus studeri* are not accepted as valid at present, pending a fuller study of further material.

As Lesquereux pointed out, and as further emphasized by the question mark placed by him after the species, there has always been doubt as to the correctness of identifying *Cornus studeri* in American rocks. They are in general much larger leaves than the European specimens and differ in having the nerves branch near the border. According to Schenk,[27] there is also some doubt as to the generic reference of certain of the leaves usually placed in *Cornus*, especially *C. studeri*. The American leaves strongly suggest leaves that have been placed in *Ficus*. Thus they may be compared with certain leaves of *Ficus denveriana* Cockerell, *F. irregularis* Lesquereux, *F. uncata* Lesquereux, and *F. artocarpoides* Lesquereux. All things considered, it seems best to refer the two leaves from Golden figured by Lesquereux [28] as *Cornus studeri* Heer? to *Rhamnus cleburni*, as already stated. The smaller of these leaves (Lesquereux's fig. 4) is clearly indistinguishable from *Rhamnus cleburni*, but the larger specimen (fig. 5) is much larger than any previously noted, being about 16 centimeters long and 8 centimeters wide.

In 1917 I referred the upper portion of a large leaf from the Raton formation to *Cornus studeri* Heer? as then currently accepted, some of which it closely resembles.[29] However, it is not identical with *Rhamnus cleburni*, and if retained in *Cornus*, which it apparently should be, it should receive a new name.

The status of the American leaves referred to *Cornus studeri* has recently been reviewed by Berry,[30] who concluded that none can be considered conspecific with the European leaves, and he then proceeds to give them a new name—*Rhamnites knowltoni*. According to the synonymy cited, this proposed new species is made to include the original leaves from the Denver formation at Golden, Colo., the several leaves from the Mesaverde formation at Point of Rocks, Wyo.—which, as I have pointed out above, should probably be separated as a new species—and the leaf from the Raton formation of southern Colorado. This Raton specimen is probably a *Cornus* and should also have a new name. Thus we have left for consideration only the specimens first identified as *Cornus studeri* by Hollick [31] and Berry [32] from the Wilcox formation of Louisiana. These southern specimens are in general very much larger than the northern ones, sometimes reaching a length of 19 centimeters and a width of 9.5 centimeters, according to Berry. He may be right in removing these leaves from *Cornus*, but to judge from the figures given they are certainly not conspecific with the leaves from Golden now referred to *Rhamnus cleburni*. Berry's description of *Rhamnites knowltoni* reads as follows:

> Leaves large, broadly ovate, many of them slightly inequilateral, the tip somewhat narrowed and acuminate and the base rounded or very broadly pointed. Margins entire, in some specimens faintly undulate. Texture subcoriaceous. Midrib stout and prominent. Secondaries stout, six to nine pairs, diverge from the midrib at irregular intervals at angles of about 45°, camptodrome. Tertiaries [nervilles] thin, closely spaced, percurrent, typically rhamnaceous.

These southern leaves are thus seen to differ from those of *Rhamnus cleburni* by their generally larger size, broadly ovate shape, rounded, obtuse base, fewer secondaries, and apparently slightly different nervilles. For the present, therefore, it would seem best to restrict the application of *Rhamnites knowltoni* to the leaves from the Wilcox deposits.

Occurrence: Denver formation (types), Golden, Colo. Dawson arkose, east bank of Jimmy Camp Creek 1 mile above Richfield Springs ranch house, 9 miles east of Colorado Springs, Colo., collected by F. H. Knowlton, July, 1910.

Rhamnus crenatulus Knowlton and Cockerell

Rhamnus crenatulus Knowlton and Cockerell, U. S. Geol. Survey Bull. 696, p. 545, 1919.

Rhamnus crenatus Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 55, 1888. [Homonym, Siebold and Zuccarini, 1843.]

Following is Lesquereux's original description and discussion of this species:

> Leaf large, ovate-lanceolate, acuminate, rounded or subcordate at the base (broken), minutely crenate; lower lateral nerves more open, the upper more oblique, all much curved in passing toward the borders, and inclining to the midrib; the two highest pairs acrodrome; nervilles numerous, close, parallel.
>
> This fine leaf is 12 centimeters long (base and apex broken), 6 centimeters broad a little above the base. It has the same form, size, and nervation as *Rhamnus grosse-serratus* Heer (Flora von Bornstädt, p. 20, pl. 4, fig. 10), differing by the borders being crenate and the nervilles less distinct.

This species should be in the Museum of Comparative Zoology, but I was not able to find it, and it must stand as left by Lesquereux.

[27] Schenk, August, Die fossilen Pflanzenreste, p. 236, 1888.

[28] Lesquereux, Leo, The Tertiary flora, p. 244, pl. 42, figs. 4, 5, 1878.

[29] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 101, p. 342, pl. 109, fig. 2, 1917 [1918].

[30] Berry, E. W., U. S. Geol. Survey Prof. Paper 131, p. 16, pl. 12, fig. 7, 1923.

[31] Hollick, Arthur, Louisiana Geol. Survey Rept. for 1899, Special Rept. 5, p. 286, pl. 45, fig. 2, 1899.

[32] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 331, pl. 68, fig. 3, 1916.

Occurrence: Denver formation, Golden, Colo., collected by Arthur Lakes. Type in Museum of Comparative Zoology, Cambridge, Mass.

Rhamnus cannoni Knowlton, n. sp.

Plate 46, Figure 5

Leaf of very firm texture, oblanceolate, narrowly wedge-shaped from a point apparently above the middle (apex destroyed); margin perfectly entire; midrib relatively strong, straight; secondaries numerous, probably a dozen or more pairs, strong, alternate, emerging at an acute angle, passing upward for relatively long distances, camptodrome or just reaching the border; nervilles numerous, strong, approximately at right angles to the secondaries, often forked or broken.

Unfortunately the only example found is the one here figured, and this lacks considerable of the upper part. It is narrowly oblanceolate with a long, narrowed base and entire margin. The length was probably about 6 centimeters and the width about 2.25 centimeters in the broadest part, which is apparently somewhat above the middle.

As this is an imperfect leaf it perhaps should not be described as new, yet it seems to be fairly well characterized and, moreover, does not agree entirely with other described forms. It approaches in size and shape *Rhamnus obovatus* Lesquereux,[38] but it differs in having fewer secondaries and these at a much more acute angle. It may possibly be a very small, unusually narrow leaf of *Rhamnus cleburnii*, but I do not recall having seen one so small.

Occurrence: Middle Park formation, Kinney Creek near Hot Sulphur Springs, Middle Park, Grand County, Colo., collected by George L. Cannon, of Denver, for whom it is named.

Rhamnus salicifolius Lesquereux?

Plate 46, Figure 12

Rhamnus salicifolius Lesquereux, Am. Jour. Sci., 2d ser. vol. 45, p. 206, 1868; U. S. Geol. Survey Terr. Ann. Rept. for 1869, p. 196, 1869; idem for 1872, p. 400, 1873; U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, p. 382, 1874; idem for 1876, p. 517, 1878; The Tertiary flora, p. 282, pl. 53, figs. 9, 10, 1878.

Knowlton, U. S. Geol. Survey Bull. 163, p. 70, 1900; U. S. Geol. Survey Prof. Paper 101, p. 271, 1917 [1918]; U. S. Geol. Survey Prof. Paper 130, p. 154, pl. 15, fig. 4; pl. 19, fig. 2b, 1922.

The early history of this species has been given at length in Professional Paper 130 and need not be repeated here except in the merest outline. The type specimen came from the Laramie at Marshall, Colo. This specimen is the original of Figure 9 of Plate 53 of the report on the Tertiary flora and is No. 446 of the United States National Museum collection, though it is now lost or misplaced. The other figured type (Lesquereux's pl. 53, fig. 10) is said to have come from Black Buttes, Wyo., but its exact status is not known. It has never been in the National Museum, where theoretically it should be, and this species has not been again collected at Black Buttes, and consequently its standing is problematical. A study of the two figures as given by Lesquereux discloses a number of minor differences that might be sufficient to separate them. Thus the leaf of Figure 10, said to be from Black Buttes, is much narrower, is more acutely pointed at the apex, and has fewer secondaries at a more acute angle than that shown in Figure 9.

A specimen of *Rhamnus salicifolius* was reported by Lesquereux from the roof of a coal mine on Sand Creek, east of Denver. This is No. 935 of the National Museum collection. It is much larger than the largest of the figured specimens, being 11 or 12 centimeters long and between 4 and 5 centimeters wide, whereas the type is only 9.5 centimeters long and 2 centimeters wide. This should probably be separated as a different species.

In the recent revision of the Laramie flora a number of specimens of *Rhamnus salicifolius* have been found in the Laramie formation of the Denver Basin, notably at Cowan station, near Denver, and in a cut on the Denver & Salt Lake Railroad near Lyden Gulch. This species has also been identified, though perhaps not always correctly, at a number of earlier horizons, as the Vermejo formation near Rockvale and 2 miles west of Trinidad, Colo., and the Montana group (Mesaverde formation) near Harper station, on the Laramie Plains, and near the Van Dyke coal, Rock Springs, Wyo.

In the collection from Templeton Gap, near Colorado Springs, occurs the specimen here figured, which appears to belong to *Rhamnus salicifolius*. It is rather fragmentary, and the identification is not positive. So far as can be made out it appears to agree in size with the larger of the type specimens (Lesquereux's pl. 53, fig. 9), but the nervation is more like that of the smaller type figured by Lesquereux.

Occurrence: Dawson arkose, Templeton Gap, 4 miles northeast of Colorado Springs, Colo., collected by F. H. Knowlton, 1910. Laramie formation (type), Marshall, Colo.; Cowan station, 10 miles south of Denver; cut on Denver & Salt Lake Railroad near Lyden Gulch, Colo. Vermejo formation, Canon City field and near Trinidad, Colo. Montana group (Mesaverde formation), Harper station, Wyo., and near the Van Dyke coal, east of Rock Springs, Wyo.

[38] Lesquereux, Leo, The Tertiary flora, p. 281, pl. 54, fig. 1, 1878.

Paliurus coloradensis Lesquereux

Paliurus coloradensis Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 55, 1888.

Leaf small, obovate, obtuse, denticulate above, triple-nerved from above the base, with a single pair of opposite secondary veins above the middle of the leaf, parallel to the basilar ones, acrodrome and branching outside.

The top of the leaf is somewhat obliterated; its nervation is much like that of *Paliurus ovoideus* (Göppert) Heer.[34] Its size is intermediate between that of Figures 58 and 59, but it greatly differs by its obovate form and the position of the intermediate pair of secondary nerves, as thick as the primaries and parallel to them.

Occurrence: Denver formation, South Table Mountain, Golden, Colo., collected by Arthur Lakes. Type in Museum of Comparative Zoology, Cambridge, Mass.

Zizyphus fibrillosus (Lesquereux) Lesquereux

Plate 46, Figures 6, 9

Zizyphus fibrillosus (Lesquereux) Lesquereux, The Tertiary flora, p. 276, pl. 52, figs. 1–5 [not fig. 6, which=*Zizyphus daphnogenoides*], 1878; Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 55, 1888.

Knowlton, U. S. Geol. Survey Prof. Paper 101, p. 335, pl. 102, fig. 1, 1917 [1918].

Ceanothus fibrillosus Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, p. 381, 1873; idem for 1873, p. 404, 1874.

Zizyphus distortus Lesquereux, The Tertiary flora, p. 275, pl. 51, fig. 7 [not figs. 8, 9], 1878.

Types: U. S. National Museum, Nos. 425–429.

The figured type specimens of this fine species, together with a number of others collected at the same time, are preserved in the National Museum. None of these specimens are perfectly preserved, but as they represent different parts of the blade a fairly good idea of the appearance can be gained.

This species was first reported by Lesquereux as being rather rare, but subsequent collections have shown it to be one of the most abundant and characteristic plants of the Denver formation. The collection studied by Lesquereux for the Museum of Comparative Zoology contained seven specimens, and the collections made more recently for the United States Geological Survey contain about 50 more or less perfect leaves.

In the light of all the material now available Lesquereux's description may be supplemented to read as follows: Leaves rather thick, oval or broad ovate-elliptical, entire, obtusely pointed at the apex, abruptly rounded and truncate or somewhat heart-shaped at the base; petiole thick, at least 1 or 2 centimeters long; essentially 3-ribbed from the inflated top of the petiole, central or midrib straight, ending in the tip, unbranched or rarely with a single secondary in the upper part, lateral ribs at an acute angle, slightly arching outward, then in, and ending in or near the tip of the blade; lateral ribs with numerous outside branches, some of which arise so near the base as to produce a 5-ribbed or even 7-ribbed appearance; secondary branches often with tertiary branches on the outside; all nervation camptodrome; nervilles very numerous, strong, close, parallel, and mainly unbroken, approximately at right angles to the midrib.

Lesquereux gave the range in size as from 2 to 7 centimeters both ways, but the recent material shows some variation in this respect. The leaves ordinarily range from 5 to 8 centimeters in width and from 7 to 13 centimeters in length, but recently I have found an exceptionally small leaf that is only 4.5 centimeters long and about 2.25 centimeters wide. This leaf, shown in Plate 46, Figure 6, may represent a distinct species, but as it does not appear to differ essentially except in size it is retained under Lesquereux's name.

As there appears to be no essential difference between one of the figured types of Lesquereux's *Zizyphus distortus*[35] and the present species, it has been transferred as is indicated in the synonymy. The two other type specimens of *Z. distortus* probably belong here also, but as set forth under that species there are reasons for retaining them as left by Lesquereux.

Zizyphus fibrillosus was found in one of the collections from the Raton formation in southern Colorado. The specimen figured[36] is an exceptionally well-preserved leaf, at least as regards the basal portion and the petiole, and is seen to belong to the broader 7-ribbed type of this species.

The statement made by Lesquereux in his report on the Tertiary flora (p. 276) that *Zizyphus fibrillosus* has been found at Black Buttes, Wyo., appears to be in error. No specimen is known to be extant which shows such distribution.

A small collection made on Sand Creek near Magnolia, just northeast of Denver, contains three specimens of this very characteristic species.

Occurrence: Denver formation (types), Golden, Colo., collected by F. V. Hayden, Leo Lesquereux, and others; a number of fine specimens in the collection returned to the United States National Museum by J. S. Newberry and a larger number in the collections made about 1890 by Arthur Lakes; Sand Creek near Magnolia, northeast of Denver, Colo., collected by Francis M. Collins, 1909. Dawson arkose, half a mile west of Ramah, Colo., collected by W. T. Lee, 1915. Raton formation, Apishapa Canyon, 3 miles northeast of Abeton, Colo.

[34] Heer, Oswald, Flora tertiaria Helvetiae, vol. 3, p. 76, pl. 121, figs. 58, 59; pl. 122, fig. 3, 1859.

[35] Lesquereux, Leo, The Tertiary flora, pl. 51, fig. 7 [not figs. 8, 9], 1878.

[36] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 101, p. 335, pl. 102, fig. 1, 1917 [1918].

Zizyphus daphnogenoides Knowlton

Plate 48, Figures 5, 6

Zizyphus daphnogenoides Knowlton, U. S. Geol. Survey Prof. Paper 134, p. 91, 1924.

Daphnogene anglica? Heer. Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, p. 401, 1874; idem for 1876, p. 510, 1878; The Tertiary flora, p. 222, pl. 37, fig. 9, 1878.

Zizyphus fibrillosus (Lesquereux) Lesquereux, The Tertiary flora, pl. 52, fig. 6 [not figs. 1–5], 1878.

Leaves of firm texture, ovate-lanceolate, abruptly rounded or very obtusely wedge-shaped at the base, long and narrowly acuminate at the apex; margin entire, perhaps slightly undulate; petiole very thick, the principal ribs descending into it for some distance below the margin of the blade; nervation peculiar, strong, 3-ribbed, the ribs arising well down in the petiole, the middle one slightly strongest, straight, ending in the extreme tip; lateral ribs at a very acute angle, arching outward but slightly, then inward and running nearly or quite to the tip; midrib without secondary branches, lateral ribs with five or six secondary branches on the outside, the lowest nearly basal, all at relatively acute angles, arching and passing high upward, camptodrome; lower secondary with a few short, camptodrome tertiary branches on the outside; nervilles numerous, strong, parallel, unbroken, mainly at right angles to the midrib.

Types: United States National Museum Nos. 317 (identified as *Daphnogene anglica*), 430 (identified as *Zizyphus fibrillosus*), 51066 (with manuscript identification as *Zizyphus raincourtii* var.).

The species is represented by some half a dozen more or less perfect examples from the Denver formation at Golden, which together afford a pretty complete knowledge of its size and form. There is considerable range in size, the smallest being the specimen described and figured by Lesquereux as *Daphnogene anglica?* Heer ("Tertiary flora," pl. 37, fig. 9), which is 6 centimeters long and only 1.6 centimeters wide, and the largest being fully 12 centimeters in length and about 6 centimeters in width. The petiole is preserved for about 1.5 centimeters and is evidently not complete. The outline also differs somewhat, ranging from narrowly ovate-lanceolate to broadly ovate-lanceolate. The base is in no specimen heart-shaped. The apex is long and narrowly acuminate. The primary nervation is strongly marked and is peculiar in that the three ribs arise well down in the petiole and far below the lower margin of the blade. It is really only 3-ribbed, but the lowest pair of secondaries sometimes arise so low down as to make it appear 5-ribbed.

The solitary leaf identified by Lesquereux as *Daphnogene anglica?* Heer is present in the United States National Museum collection (No. 317) and has long been a puzzle. Its identification with this European species rested on extremely insecure grounds, as *D. anglica* was never figured, Lesquereux making the identification on Heer's short description alone. It has remained unique in American strata until the present time; but although much smaller and narrower than the typical form appears to be, it is so absolutely similar in everything except size that I have no hesitation in placing them together.

The question of relationship has to be further considered. Lesquereux was evidently in doubt as to the propriety of referring it to *Daphnogene* and stated, "It is therefore probable that, as Saporta supposes, this leaf may represent a *Zizyphus* or a *Ceanothus*," and such seems to me to be the case. The little narrow original specimen has seemingly a relationship to *Zizyphus vulgaris* Linné, the common living form, though this differs in having serrate margins and in lacking the strong branching on the outside of the lateral ribs. But in the light of the additional material now referred to this form it appears beyond question to be most closely related to *Zizyphus fibrillosus* Lesquereux; in fact, the line separating them is very uncertain. Unfortunately most of the leaves of *Z. fibrillosus* are so fragmentary that it is difficult to determine the shape of the base; it appears, however, that this is always more or less deeply heart-shaped, whereas in the form under discussion the base is truncate or obtusely wedge-shaped. The apex is also uncertain in many of the examples referred to *Z. fibrillosus*, but in none does it appear so long or narrowly acuminate as in the specimens under consideration. The nervation is certainly very much of the same type in both, and it may be that subsequent events will show that *Z. daphnogenoides* is not a well-founded species, though in the light of present understanding it seems a far call from the narrow leaf figured by Lesquereux in the report on the Tertiary flora (pl. 37, fig. 9) to the large, extremely broad leaves of typical *Z. fibrillosus*.

This is also to be compared with *Zizyphus distortus* Lesquereux, which is really almost too close to warrant separation, and if the type and only examples of *Z. distortus* were better preserved or reinforced by additional material it is possible that all three would be thrown together.

I have also referred to *Zizyphus daphnogenoides*, one of the six specimens figured by Lesquereux in his account of the Tertiary flora as *Zizyphus fibrillosus*—the one shown in his Plate 52, Figure 6. This specimen (No. 430, U. S. Nat. Mus.) represents the nearly complete apical portion of a long, narrow leaf that was probably about 7 centimeters long and not much if any over 3 centimeters wide. It must have been narrowed or very obtusely wedge-shaped at the

base and is certainly quite unlike the broad truncate or heart-shaped leaves normal for *Z. fibrillosus*.

Among the specimens from the Denver formation acquired by the United States National Museum from the Lacoe collection is one labeled by Lesquereux as an undescribed variety of *Zizyphus raincourtii* (Saporta) Saporta. This specimen (No. 51066, U. S. Nat. Mus.) is a rather fragmentary basal portion of a small leaf that appears indistinguishable from certain of the leaves now placed in *Z. daphnogenoides*. Saporta's species,[37] which is from the Eocene of Sezanne, is of about the same size as the leaf under consideration but differs in a number of marked particulars. Thus it is 3-ribbed from the top of the petiole, but the lateral ribs do not ascend much above the middle of the blade, and the middle rib has numerous secondary branches in the upper part. The margin of the leaf is denticulate instead of entire. The Lacoe specimen is undoubtedly referable to *Zizyphus daphnogenoides*.

The Lacoe collection also contains another specimen that must be referred to *Zizyphus daphnogenoides*. This specimen (No. 51063) was labeled by Lesquereux "*Smilax* sp.," but it is indistinguishable from the ordinary leaves of *Z. daphnogenoides*, such as that figured by Lesquereux in the report on the Tertiary flora (pl. 52, fig. 6) as *Zizyphus fibrillosus*.

After the above account of the Denver leaves was written *Zizyphus daphnogenoides* was found in the Animas formation, near Pagosa Junction, Colo. This identification was based on a very perfect leaf that lacks only the extreme tip. It is narrowly ovate-lanceolate, about 6 centimeters long and 2 centimeters wide, and has the complete petiole, 2 centimeters long. This leaf is identical in all particulars with the Denver leaf identified by Lesquereux as *Daphnogene anglica?* Heer, and there can be no doubt as to their being the same.

As the Animas report (Professional Paper 134) was to be published first the description of this species as well as most of the discussion was transcribed for that report.

Occurrence: Denver formation, Golden, Colo. The leaf figured by Lesquereux as *Daphnogene anglica?* Heer was collected in the seventies by Capt. Ed. Berthoud; the specimen removed from *Zizyphus fibrillosus* was collected about 1872 by Leo Lesquereux; the additional examples were collected by Arthur Lakes on the south face of South Table Mountain, 100 feet below the lava cap. Animas formation, Pagosa quadrangle, half a mile west of Pagosa Junction, Colo., collected by J. B. Reeside, jr., 1921 (lot 7496).

[37] Saporta, Gaston de, Prodrome d'une flore fossile des travertins anciens de Sézanne: Soc. géol. France Mém., 2d ser., vol. 7, p. 414, text fig. 22, pl. 35 (14), figs. 8–10, 1868.

Zizyphus beckwithii Lesquereux

Plate 47, Figure 3

Zizyphus beckwithii Lesquereux, The Cretaceous and Tertiary floras, p. 125, pl. 19, fig. 5, 1883.

Type: United States National Museum, No. 1557.

This species, so far as now known, rests on the single example originally described and figured. It was characterized by Lesquereux as follows:

> Leaf membranaceous, oval or obovate, rounded at the top, narrowed and decurrent to the petiole, palmately trinerved from the base; medial nerve narrow, with a single branch above the middle, the lateral curving up at a distance from the borders, nearly acrodrome, much branched outside; nervilles close, distinct, at right angles to the midrib.

The length is about 4.5 centimeters and the width 3 centimeters. It has a thick petiole a little more than 1 centimeter long.

The basal portion of this leaf is not distinguishable from certain leaves of *Zizyphus daphnogenoides*, as already described in this work. The apical portion, however, is very different. Instead of being prolonged into a slender, acuminate tip it is abruptly rounded and obtuse above. The nervation is of precisely the same type as that in *Zizyphus daphnogenoides*, even to the single secondary branch on the upper portion of the midrib. It may be that the leaf of *Zizyphus beckwithii* is abnormal as regards the configuration of the upper portion, though there is no direct evidence of this condition. As it stands it is perfectly distinct from either *Zizyphus daphnogenoides* or *Z. fibrillosus*, to both of which it is undoubtedly related, and it must be left to the future to determine whether it is normal and a good species or abnormal and referable to one or the other of the obviously related forms.

Occurrence: Denver formation, Golden, Colo., collected by H. C. Beckwith, in whose honor it was named.

Zizyphus distortus Lesquereux

Plate 47, Figure 2; Plate 52, Figure 1

Zizyphus distortus Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, pp. 382, 404, 1874; idem for 1876, p. 576, 1878; The Tertiary flora, p. 275, pl. 51, figs. 8, 9 [not fig. 7, which=*Zizyphus fibrillosus*], 1878.

Leaves of small or medium size, membranaceous, elliptical or oblong, rounded below to an obtusely wedge-shaped or truncate base, apparently obtuse above; margin entire; petiole about 1 centimeter long, stout; primary nervation palmately 3-ribbed (or falsely 5-ribbed) from the top of the petiole, the midrib slightly the stronger, with several pairs of secondary branches in the upper part; outer ribs nearly as strong as the midrib, at an angle of 60° or 70°, not

much curved, lost in the upper third of the blade, each with several secondary branches on the outside, the lowest ones arising so near the top of the petiole as to give the appearance of being true ribs—hence the 5-ribbed effect—these secondaries apparently all camptodrome; nervilles numerous, strong, mainly unbroken, and at right angles to the midrib.

Two of the types of *Zizyphus distortus*—the originals of Lesquereux's Figures 8 and 9—are preserved in the United States National Museum (Nos. 434, 435). The original of Figure 7 is not and, so far as the records show, has never been in the Museum collection. To judge from the figure alone it appears indistinguishable from leaves of *Zizyphus fibrillosus* Lesquereux, and it has therefore been transferred to that species.

It thus appears that *Zizyphus distortus* was founded on two broken specimens which up to the present time appear to be all that have been found. They are in effect 5-ribbed, though the lower or outer pair of ribs are thinner than the others and do not branch. In the collection from the Dawson arkose along Jimmy Camp Creek I find two examples, both of which are here figured, that seem to belong to this species. They appear to be a little larger than the types and add considerably to our knowledge of the species. The best-preserved example (pl. 52, fig. 1) must have been 10 centimeters or more in length and nearly 8 centimeters in width. It has the complete petiole, which was about 1 centimeter long. The other example (pl. 47, fig. 2) was only 8 or 9 centimeters in length and 6 or 7 centimeters in width. The nervation is well brought out in the figures and need not be further described.

Zizyphus distortus belongs to the group typified by *Z. fibrillosus* but differs by its wedge-shaped instead of more or less heart-shaped base, by the lateral ribs little or not at all curved upward.

Occurrence: Denver formation (types), South Table Mountain, Golden, Colo. Dawson arkose, east bank of Jimmy Camp Creek 0.6 mile above Richfield Springs ranch house, 9 miles east of Colorado Springs, Colo., collected by F. H. Knowlton and W. T. Lee, July, 1910.

Zizyphus lesquereuxii Knowlton

Zizyphus lesquereuxii Knowlton, U. S. Geol. Survey Bull. 152, p. 246, 1898.

Zizyphus hyperboreus? Heer. Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, p. 389, 1873; idem for 1873, p. 387, 1874; idem for 1876, p. 516, 1878; The Tertiary flora, p. 276, pl. 51, fig. 15, 1878.

The single example upon which Lesquereux based his original identification with Heer's *Zizyphus hyperboreus*[38] is preserved in the United States National Museum (No. 424), but it appears to differ from that species in being twice or more times the size and in being clearly 5-nerved instead of 3-nerved. The outer nerves in *Z. lesquereuxii* ascend in an even curve nearly to the tip of the leaf, branching on the outside. In *Z. hyperboreus* the outer pair of nerves, if they may be so called, ascend in a series of bows, or rather the principal pair of nerves branch on the outside and form by a series of simple bows somewhat the appearance of a nerve. The finer nervation has entirely disappeared from *Z. lesquereuxii*, and consequently it can not be compared in this particular with *Z. hyperboreus*.

Occurrence: Denver formation, Golden, Colo. Hanna formation, Carbon, Wyo.

Zizyphus hesperius Knowlton, n. sp.

Plate 49, Figure 2

Zizyphus hyperboreus Heer. Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 55, 1888.

Leaf of rather coarse texture, ovate or ovate-elliptical, abruptly rounded at the base, slenderly acuminate at the apex; margin obscurely preserved but apparently remotely undulate-toothed; nervation strong, 3-ribbed from the base of the blade, the midrib with two pairs of strong secondaries in the upper part, lateral ribs as strong as the midrib, arising at an angle of about 50°, much curved inward, reaching the margin just below where the lowest pair of secondaries approach the margin, each with numerous thin branches on the outside which join and make a series of loops just inside the margin; nervilles strong, at right angles to the midrib.

The specimen figured is the only one that is referred with certainty to this species. It is 8.5 centimeters long and about 5 centimeters broad at a point about one-third the length of the blade above the base. The coarse, heavy nervation is well brought out in the figure.

The type specimen of this species was identified by Lesquereux as *Zizyphus hyperboreus* Heer on the ground of its similarity to a leaf from the Hanna formation of Carbon, Wyo., so identified by him[39] (since renamed *Zizyphus lesquereuxii* Knowlton). A comparison of the two shows that although agreeing in size and shape the leaf from Carbon is distinctly 5-ribbed, with the inner pair of ribs ascending nearly or quite to the tip of the blade, with several outside branches, while the outer pair of ribs reach more than two-thirds the length of the blade and also have out-

[38] Heer, Oswald, Flora fossilis arctica, vol. 1, p. 123, pl. 49, fig. 2, 1868; vol. 2, p. 482, pl. 50, fig. 20, 1869.

[39] Lesquereux, Leo, The Tertiary flora, p. 276, pl. 51, fig. 15, 1878.

side branches. The margin also differs, and the whole nervation is very light, and altogether it is apparent that the two can not be conspecific.

A comparison of this Golden specimen with Heer's figures of his *Zizyphus hyperboreus*[40] shows a number of essential differences, such as the inner pair of ribs ascending to the tip of the blade. It is also a smaller, narrower leaf.

Occurrence: Denver formation, South Table Mountain, Golden, Colo., collected by Arthur Lakes. Type in Museum of Comparative Zoology, Cambridge, Mass., No. 1534.

Family VITACEAE

Cissus grosse-dentata Knowlton

Plate 48, Figure 2; Plate 51, Figure 10

Cissus grosse-dentata Knowlton, U. S. Geol. Survey Prof. Paper 101, p. 340, pl. 104, fig. 1, 1917 [1918].

With slight modification the original description is as follows:

Leaf of large size and firm texture, broadly ovate, rather abruptly rounded below to a slightly decurrent basal portion, acuminate above; margin entire at base, then strongly few toothed, the teeth large, obtusely acute, separated by shallow sinuses; midrib strong below, becoming thin above; secondaries five or six pairs, at an angle of 45° or 50°, the lowest pair much the stronger, arising well above the decurrent portion of the blade, each with four or five tertiary branches on the outside which are curved upward and pass to the marginal teeth; other secondaries alternate or nearly opposite, terminating in the large teeth; nervilles numerous, rather delicate, irregular.

The present specimen, although not nearly so perfect as the type specimen, appears to agree with it in all essential particulars. The type specimen was about 14 centimeters in length, but the present specimen could hardly have been more than 10 or 11 centimeters; it has the petiole preserved for more than 2.5 centimeters. The width of the blade is a little over 7 centimeters.

As pointed out in the original discussion of this species it seems to be most closely related to *Cissus parrottiaefolia* Lesquereux, from which it differs in its greater length, much more pointed apex, and decurrent basal portion and in having its lowest pair of secondaries arising well above the base instead of at or near the top of the petiole.

Occurrence: Dawson arkose, Rice's clay pit, 1 mile southwest of Calhan, Colo., collected by F. H. Knowlton, 1910. Raton formation, Morley, Colo.

Cissus hesperia Knowlton, n. sp.

Plate 47, Figure 1

Leaf of medium size, subcoriaceous, ovate, very obtusely wedge-shaped or nearly truncate at the base, rather obtusely pointed at the apex; margin entire at the base, thence strongly undulate; petiole short, relatively stout; midrib very strong below, much thinner above; secondaries about eight pairs, alternate, at irregular distances, emerging at an angle of about 45°, not much curved upward, craspedodrome; nervilles numerous, mainly unbroken, at right angles to the secondaries.

The example figured is the only one observed. It it about 7.5 centimeters long and a little over 5 centimeters wide. The petiole, which is complete, is 1.3 centimeters long.

This species is referred to the genus *Cissus* on the ground of its resemblance to *Cissus parrottiaefolia* Lesquereux,[41] supposed to be from the Green River formation of Wyoming. It agrees with this species in size and shape and to a less extent in the undulate margin. The nervation in *C. parrottiaefolia* differs from that of *C. coloradensis* in that the lowest pair of secondaries has several tertiary branches on the outside.

Occurrence: Dawson arkose, Rice's clay pit, 1 mile southwest of Calhan, Colo., collected by F. H. Knowlton, 1910.

Cissus coloradensis Knowlton and Cockerell

Plate 47, Figure 6; Plate 50, Figure 2

Cissus coloradensis Knowlton and Cockerell, U. S. Geol. Survey Bull. 696, p. 176, 1919.

Cissus laevigata Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, p. 380, 1873; idem for 1876, p. 512, 1878; The Tertiary flora, p. 238, pl. 40, figs. 12, 13, 1878. [Homonym, Blume, 1825–26.]

Leaves membranaceous, broadly oval, narrowing in a broad curve to the short petiole; 3-ribbed from the base or slightly above it, the lateral ribs running nearly straight to about the middle of the leaf, branching on the outside; secondaries alternate or subopposite, parallel; nervilles prominent, percurrent, approximately at right angles to the midrib; areolation quadrangular.

This species, according to Lesquereux, was founded on two specimens, both of which lacked the upper portion. Only one of these type specimens is now to be found in the collections of the United States National Museum (No. 347). This is the original of Figure 13 of Lesquereux's plate. Both specimens are said to have come from the same place together with a number of smaller fragments, but none appear to have been since obtained from the type locality.

The two specimens here figured were found near Sedalia, Colo., and agree in every essential particular with the figures of the original specimens. Like the originals they both lack the upper portions of the

[40] Heer, Oswald, Flora fossilis arctica, vol. 2, pt. 4, p. 482, pl. 50, fig. 20, 1869.

[41] Lesquereux, Leo, The Tertiary flora, p. 239, pl. 42, fig. 1, 1878.

leaf, although one (pl. 47, fig. 6) has fully two-thirds of the lamina preserved. Lesquereux thought it probable that the type specimens were obscurely trilobate at the apex, but there is no indication in the most perfect leaf that this would be the case. Another specimen obtained near Sedalia represents the middle part of a leaf but a little higher up than that shown in Plate 47, Figure 6, and there is every indication that it would be rounded at the apex very much like the base.

Occurrence: Dawson arkose, lower part (in beds equivalent to Arapahoe formation), 3,000 feet east of the Douglas coal mine, near Sedalia, Colo., collected by Arthur Lakes, 1890. Denver formation, Golden, Colo. Raton formation, Abeton, Colo.

Cissus? cannoni Knowlton, n. sp.

Plate 47, Figure 5

Leaf evidently coriaceous, roughly deltoid or deltoid-ovate, truncate at the base, obtuse at the apex; margin irregularly cut into a number of obtuse, often toothed lobes; midrib very strong; secondaries about four pairs, the lower pair as strong as the midrib, much arched upward, passing to lobes in about the middle of the blade, each with several tertiary branches on the outside, these or their branches passing to lobes or marginal teeth; upper secondaries simple, ending in lobes or teeth; nervilles few, strong.

The single leaf figured is all that was observed of this species. It is broadly ovate, with an abruptly rounded truncate base and an obtuse apex. The margin is provided with about three relatively strong, obtuse lobes on each side, in addition to which the basal portion and some of the lobes are provided with a few obtuse teeth. The strongly marked nervation is well shown in the figure. The length of this little leaf is about 3.75 centimeters and the width about 2.5 centimeters; its petiole is not preserved.

This leaf appears to be most closely related to a small leaf referred by Lesquereux to *Cissus tricuspidata* Heer,[42] the only one of the specimens figured under this name that can not be found in the collections of the United States National Museum. The locality whence this came is unknown. Our leaf is of approximately the same size but is broadly truncate instead of obtusely wedge-shaped at the base; the secondaries are fewer and the lower pair much curved upward. The marginal lobes and teeth are similar in both, though rather sharper in Lesquereux's specimen. The general arrangement of the secondaries is also suggestive of the arrangement in the leaf referred by Lesquereux[43] to *Vitis olriki*, but the size, outline, and margin are quite different. It may be that a larger series of specimens would show a further transition between the one in hand and *Cissus tricuspidata*, but for the present it seems necessary to keep them apart.

I have named this supposed new species in honor of Mr. George L. Cannon, the collector of much of the material from Middle Park.

Occurrence: Middle Park formation, high terrace ridge between forks of Kinney Creek, in "breccia spoon," east of Hot Sulphur Springs, Middle Park, Grand County, Colo., collected by Whitman Cross, October, 1891.

Cissus corylifolia Lesquereux

Plate 47, Figure 4; Plate 48, Figure 1; Plate 49, Figure 1

Cissus corylifolia Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 52, 1888.

Lesquereux describes this species as follows:

> Leaves thickish, ovate, blunt at apex, simply or doubly short dentate, strongly pinnately nerved; lateral nerves at an acute angle of divergence, close, parallel, scarcely curved in passing to the borders, the lowest much branched on the under side, the upper ones branching near their ends, craspedodrome; nervilles at right angles to the nerves, simple or branched in the middle, deeply impressed.
>
> These finely preserved leaves vary in length from 6 to 9.5 centimeters and from 4 to 7.5 centimeters in width, being broadest a little below the middle. They have a degree of likeness to *Parrotia pristina* Ettingshausen.[44]

The three type specimens on which this species was based are all nearly perfect and all have been figured. The two smaller leaves (pl. 47, fig. 4; pl. 49, fig. 1) are undoubtedly conspecific, but the assignment of the larger one (pl. 48, fig. 1) is less certain. It is very much larger and has the secondaries at a somewhat sharper angle, the upper ones being alternate instead of opposite and the lower pair with compound branching on the lower side. The margin is entire below and seemingly remotely dentate above, though most of the upper margin is missing. This specimen suggests certain of the leaves that have been referred to *Quercus viburnifolia* Lesquereux, but the marginal characters can not be compared.

The two smaller specimens are very close to *Cissus coloradensis*, described above, differing apparently in the margin being somewhat doubly toothed and in the secondaries being at a more acute angle.

Occurrence: Denver formation, South Table Mountain, Golden, Colo., collected by Arthur Lakes. Types in Museum of Comparative Zoology, Cambridge, Mass., Nos. 1501, 1503, 1504.

[42] Lesquereux, Leo, The Tertiary flora, p. 240, pl. 41, fig. 6, 1878.

[43] Idem, pl. 41, fig. 8.

[44] Ettingshausen, Constantin von, Flora von Bilin, pt. 2, pl. 39, fig. 23, 1868.

Cissus lesquereuxii Knowlton

Plate 48, Figures 3 and 4

Cissus tricuspidata (Heer) Schimper, Paléontologie végétale, vol. 3, p. 44, 1874.

Cissus tricuspidata (Heer) Schimper. Lesquereux, The Tertiary flora, p. 240, pl. 41, figs. 4–7, 1878; Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 51, 1888. [Homonym, Siebold and Zuccarini, 1846.]

Cissus lesquereuxii Knowlton, U. S. Geol. Survey Bull. 696, p. 177, 1919.

There are several specimens in a collection obtained near Calhan, Colo., that appear to be identical with certain leaves from Black Buttes, Wyo., which were identified by Lesquereux with Heer's *Cissus tricuspidata.* Although all of them are fragmentary, they show the basal portion fairly well. The best-preserved specimen is shown in Figure 4. It is a small leaf not quite 4 centimeters wide and has the complete petiole preserved, 1.5 centimeters long and seemingly strong for the size of the blade. The margin of the base for a distance of 1 centimeter from the insertion of the petiole is entire, but thence it is sharply serrate. The primary nervation consists of five ribs, which arise near the top of the petiole. The basal pair are much the lighter and have a few tertiary branches on the outside which pass to the teeth. The finer nervation is not retained.

The validity of referring either these Calhan leaves or those from Black Buttes to Heer's species may well be questioned; in fact, Lesquereux pointed out a number of marked differences in his discussion of the Black Buttes specimens. The point that it is desired to establish now is the apparent identity between the Calhan and Black Buttes leaves, but their reference to the European Miocene species may well be deferred until the thorough revision of the Black Buttes flora is undertaken.

Since the above statement was written I have had opportunity to study the three specimens from Golden referred by Lesquereux[45] to this species. They are of about the same size as the leaves from Calhan and like them do not have the extreme basal portion serrated. However, two of the type specimens as figured by Lesquereux[46] show the same tendency, so it evidently is not a significant character. One of the Golden specimens is represented by Figure 3.

Occurrence: Dawson arkose, Rice's clay pit, 1 mile southwest of Calhan, Colo., collected by F. H. Knowlton, 1910. Denver formation. The examples from South Table Mountain, Golden, Colo., identified by Lesquereux, are in the Museum of Comparative Zoology, Cambridge, Mass., Nos. 1493, 1493a.

[45] Lesquereux, Leo, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 51, 1888.

[46] Lesquereux, Leo, The Tertiary flora, pl. 41, figs. 4, 6, 1878.

Cissus obovata Knowlton, n. sp.

Plate 49, Figure 5

Cissus parrottiaefolia Lesquereux. Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 52, 1888.

Leaf coriaceous, the nervation deeply impressed, obovate or elliptical-obovate, broadest near the middle, whence it tapers in an almost straight line to the base and is rounded to the subacute apex; margin entire to a point well above the middle, thence undulate-dentate, the teeth remote, rather obtuse; nervation 5-ribbed from the top of the petiole, the midrib straight, with two or three alternate secondary branches in the extreme upper part, next pair of ribs as strong as the midrib, at an acute angle, slightly incurved, reaching the upper margin, with four or five branches on the outside, some of which are again branched, outer primary ribs at an angle of about 60°, nearly straight, each with several secondary branches; branches of the outer primaries camptodrome, all other ribs and their branches craspedodrome; nervilles very strong, usually unbroken. The length of this leaf is 6.5 centimeters, and the width a little over 5 centimeters.

This species is based on the single specimen figured. It was identified by Lesquereux as *Cissus parrottiaefolia* Lesquereux, but a comparison with the figures of this species in his account of the Tertiary flora (pl. 40, figs. 15–17) shows distinct differences. Thus, the original specimens supposed to be from Green River, Wyo., are all distinctly ovate, with a very obtusely wedge-shaped or even slightly heart-shaped base and large undulate-toothed margin. The present species is obovate, with a wedge-shaped base and a margin which is entire below and slightly undulate-toothed above, the teeth acute rather than obtuse and rounded. The nervation in *Cissus parrottiaefolia* is essentially 3-ribbed, with the lateral ribs at an angle of about 50°, little curved inward and not reaching the upper portion of the blade; none of the secondary branches are forked. The whole nervation in *C. parrottiaefolia* is lighter than in *Cissus obovata.*

Occurrence: Denver formation, South Table Mountain, Golden, Colo., collected by Arthur Lakes. Type (under the name *Cissus parrottiaefolia*) in the Museum of Comparative Zoology, Cambridge, Mass., No. 1495.

Cissus lobato-crenata Lesquereux

Plate 49, Figures 3, 4

Cissus lobato-crenata Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, p. 396, 1873; idem for 1873, pp. 382, 385, 408, 1874; idem for 1876, p. 512, 1878; The Tertiary flora, p. 240, pl. 41, figs. 1–3, 1878; U. S. Nat. Mus. Proc., vol. 11, p. 38, 1888; Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 52, 1888.

The three figured types of this species are preserved in the United States National Museum (Nos. 349, 354a,

354b) and are before me. They are not particularly well preserved but appear to have been as accurately described and figured as their condition warrants. The species was first described from Black Buttes, Wyo., the original specimen being apparently that shown in Plate 41, Figure 1, of the report on the Tertiary flora. It was later detected on Mount Bross, Middle Park, Colo., and the specimens found there are shown in Figures 2 and 3 of the same plate and are preserved on the same piece of matrix. The Black Buttes specimen is the most perfect, having the upper portion and most of the margin preserved. It is obscurely crenate-lobed; the lobes correspond to the number of prominent ribs and secondaries, and the spaces between the lobes are crenate. The examples from Mount Bross do not seem to be lobed but are simply crenate, though the margin is not well preserved. The size and general character of the nervation is practically the same in all the type specimens, and it is probable that they should be considered identical, but more material is needed to settle the point. Among the numerous specimens obtained by Ward at Black Buttes I do not note any that belong to *Cissus lobato-crenata*, unless possibly what he has called *Hedera bruneri*[47] should be so referred. This specimen is strongly 3-ribbed from the base and has a long, strong petiole, but the upper portion of the blade is lacking and hence can not be satisfactorily compared with Lesquereux's species. The nervation of *H. bruneri* is similar to that of the form under consideration except that the lateral ribs curve slightly upward.

In the recent collections from Middle Park I find several rather poorly preserved leaves that are undoubtedly similar to the types that came from this locality.

A single fairly well preserved leaf from Sedalia, Colo., shown in Figure 4, has been referred to this species. It is of about the same size as the smaller of Lesquereux's types, and although it has not quite so broad a base it has the marginal cutting and nervation of this form. It has what the other specimens unfortunately lack, namely, the petiole or a portion of it; this is relatively strong.

Another specimen from Colorado has also been illustrated (fig. 3) for the purpose of showing the complete petiole. This is 4.5 centimeters long and is relatively strong. The blade of this leaf is fragmentary, but so far as preserved it is not to be distinguished from one of the type leaves figured by Lesquereux.

Occurrence: Black Buttes coal group (type), Black Buttes, Wyo. Dawson arkose, lower part (in beds equivalent to Arapahoe formation), 3,000 feet east of Douglas coal mine, near Sedalia, Colo., collected by Arthur Lakes, 1890. Middle Park formation, Mount Bross, Middle Park, Grand County, Colo. (type), also débris on slope of Mount Bross, opposite Hot Sulphur Springs, collected by G. L. Cannon, 1889. Dawson arkose, Red Hill, 4 miles south of Ramah, Colo., collected by G. B. Richardson, 1910.

[47] Ward, L. F., U. S. Geol. Survey Bull. 34, p. 58, pl. 26, fig. 6, 1887.

Vitis olriki Heer

Plate 49, Figure 6; Plate 50, Figure 4

Vitis olriki Heer, Flora fossilis arctica, vol. 1, p. 120, pl. 48, fig. 1, 1868.

Lesquereux, U. S. Geol. Survey Terr. Ann. Rept. for 1871, Suppl., p. 12, 1872; U. S. Geol. and Geog. Survey Terr Ann. Rept. for 1873, p. 385, 1874; idem for 1876, p. 512, 1878; The Tertiary flora, p. 241, pl. 41, fig. 8, 1878.

Knowlton, U. S. Geol. Survey Prof. Paper 101, p. 338, 1917 [1918].

The presence of this species in American strata was first based on a single example described and figured by Lesquereux from Evanston, Wyo., in beds lying "above the coal" and regarded by me as being Tertiary, or in the approximate position of the Denver beds. Lesquereux also stated that this species had been found in the Raton Mountains of Colorado, but no specimen from this region was contained in the older collections of the United States National Museum. In recent years, however, specimens representing this species were found in the Raton formation of the Raton region of New Mexico, though they were not very well preserved and were not figured, as they could add nothing to our knowledge of this form.

In the collections obtained near Ramah there is the single example here figured (pl. 50, fig. 4), which is certainly the same as the leaf figured by Lesquereux in the volume on the Tertiary flora. Although it is fragmentary it admirably exhibits the basal portion, which is deeply heart-shaped with the two lobes close together if not overlapping. The margin of the lower part is undulate rather than strongly toothed. The nervation is very strong and is precisely like that in the Evanston leaf figured by Lesquereux.

A specimen found near Calhan, Colo., has also been figured (pl. 49, fig. 6), and although it is somewhat narrower than the figure given by Lesquereux it does not differ essentially.

Occurrence: Dawson arkose, Red Hill, 4 miles south of Ramah, Colo., about 100 feet above a coal bed, which is equivalent to the Purdon coal or near it, collected by G. B. Richardson, 1910. Raton formation, mesa north of Raton, N. Mex., at top of formation, collected by W. T. Lee. Evanston formation, Evanston, Wyo.

Order **MALVALES**

Family TILIACEAE

Grewiopsis tenuifolia Lesquereux

Plate 50, Figure 3

Grewiopsis tenuifolia Lesquereux, The Tertiary flora, p. 258, pl. 40, fig. 14, 1878; U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1876, p. 514, 1878; Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 54, 1888.

The type specimen of this species is fortunately preserved in the United States National Museum (No. 348). It is recorded in the Museum catalogue and also in the published accounts as having come from Black Buttes, Wyo., but the matrix shows beyond question that it came from the andesitic beds of the Denver formation at Golden, Colo. There is also another specimen identified as this species in the Museum collection under the same number, and one specimen was reported by Lesquereux among the plants from Golden, Colo., examined for the Museum of Comparative Zoology of Harvard College.

The type specimen is fragmentary, consisting of only one side of the leaf, the base and apex being absent. It is possible that Lesquereux had other specimens that are not now preserved, for he characterized the species as follows:

> Leaves membranaceous, rounded or cordate, taper-pointed, subpalmately nerved; borders irregularly dentate; lateral nerves mostly craspedodrome or entering the teeth by strong nervilles.

There is a single specimen that undoubtedly belongs to this species from Mosby, Colo., and, although it lacks much of one side and the extreme apex, it shows the base and margin very perfectly. By drawing the characterization from the type specimen and the Mosby specimen, it is possible to give the following description:

Leaf of medium size, membranaceous, broadly ovate, abruptly truncate at the base, with a small cordate portion just above the petiole, and rather acutely pointed at the apex; margin entire on the truncate basal portion and thence remotely and somewhat irregularly few toothed, the teeth low, sharp, or almost spiny; petiole about 1.3 centimeters in length, apparently short for the size of the leaf; nervation consisting of a rather slender, straight midrib and three or possibly four pairs of craspedodrome secondaries, the lowest pair arising some distance above the top of the petiole, each with three or four tertiary branches on the outside which end in marginal teeth; other secondaries, especially the lower pair, with two or three tertiary branches passing to the teeth; nervilles thin, mostly unbroken, approximately at right angles to the secondaries or their branches.

The type specimen is about 9 centimeters long and 6 centimeters wide, and the Mosby specimen is probably between 10 and 12 centimeters long and is 8 centimeters wide. The petiole in the Mosby specimen is a little over 1 centimeter long.

Occurrence: Denver formation (type), Golden, Colo. (erroneously recorded as coming from Black Buttes, Wyo.). Dawson arkose, dump of Mosby coal mine, Mosby, Colo., collected by F. H. Knowlton and G. B. Richardson, 1910. Black Buttes coal group, Black Buttes, Wyo.

Family STERCULIACEAE

Sterculia? heterodonta Knowlton, n. sp.

Plate 50, Figure 5; Plate 51, Figures 4, 8

Leaves of medium size, firm in texture, ovate or squamose, truncate or slightly decurrent at the base; margin with four or five large, deltoid, rather obtuse teeth or lobes on each side, separated by shallow sinuses; nervation pinnate, consisting of a relatively very strong midrib and usually three pairs of opposite or subopposite secondaries, the lowest pair arising at the top of the petiole in the decurrent portion of the blade and simulating ribs; secondaries at an angle of 45° to 50°, the lowest pair with two or three branches on the lower side which end in the large teeth; middle pair of secondaries parallel to the lower pair, craspedodrome; upper secondaries thin, camptodrome, curving up along the border; short branches from the secondaries pass up to and around the sinuses; finer nervation not retained.

This species is represented by nearly a dozen examples, several of which are exceptionally well preserved. They are 7 or 8 centimeters long and 5.5 or 6 centimeters wide. The petiole was not observed. The lobes are approximately 1 centimeter long and separated by rather shallow sinuses. The lobes are all rather obtuse and rounded.

There are a number of described species to which the present form has more or less resemblance. Among these may be mentioned *Platanus rhomboidea* Lesquereux,[48] from the Denver formation at Golden, Colo., which is of about the size of the leaves under consideration but differs in being distinctly wedge-shaped at the base and having more numerous as well as smaller and sharper teeth. They can hardly be even congeneric.

There is a remote, perhaps only superficial resemblance between *Sterculia? heterodonta* and what Ward[49] called *Credneria? daturiaefolia*, from the Fort Union formation of Montana. This also has more numerous teeth, which are of irregular sizes and are

[48] Lesquereux, Leo, The Tertiary flora, p. 186, pl. 26, figs. 6, 7. 1878.
[49] Ward, L. F., U. S. Geol. Survey Sixth Ann. Rept., p. 556, pl. 58, figs. 1–5, 1886.

very sharply pointed. The nervation is also quite different.

Occurrence: Dawson arkose, east bank of Jimmy Camp Creek 1 mile above Richfield Springs ranch house, 9 miles east of Colorado Springs, Colo., collected by F. H. Knowlton, July, 1910.

Sterculia saportanea Knowlton

Plate 53, Figure 6

Sterculia saportanea Knowlton, U. S. Geol. Survey Bull. 152, p. 224, 1898.

Sterculia modesta Saporta,[50] Prodrome d'une flore fossile des travertins anciens de Sézanne: Soc. géol. France Mém., 3d ser., vol. 8, p. 401, pl. 12, fig. 2, 1868.

Lesquereux, The Cretaceous and Tertiary floras, p. 125, pl. 20, fig. 5, 1883.

Following is Lesquereux's original description:

Leaves thick, rounded in the lower part, trilobate at apex; median lobe longer, separated from the lateral [lobes] by broad sinuses; nervation trifid from the base; lateral nerves camptodrome.

This finely preserved leaf is about 8 centimeters long from the base to the apex of the middle lobe and 6 centimeters broad between the tips of the lateral lobes. It is enlarged in the middle, a little contracted below the lateral lobes, and deltoid to the apex. The primary nerves are strong; the lateral nerves are entwined by distinct nervilles, and the areolation is in loose, irregularly quadrate meshes.

This fine species is obviously closely related to *Sterculia libbeyi*, next described, under which the points of difference are more fully set forth. The type specimen is the property of Princeton University, but unfortunately it could not be found at the time of my visit to that institution. It is recorded by Lesquereux as having come from Golden, Colo., and there is no reason to doubt the statement, but without seeing the matrix I can not be certain of the horizon from which it came. Inasmuch as it is so closely allied with *Sterculia libbeyi*, which came from the andesite beds at Golden, it is assumed that *Sterculia saportanea* also came from these beds, but obviously this assumption requires confirmation. If this species had been subsequently found its horizon would be settled more definitely, but so far as known the type specimen remains unique.

Occurrence: Denver formation(?), Golden, Colo. Type in museum of Princeton University.

Sterculia libbeyi Knowlton, n. sp.

Plate 53, Figure 2

Leaf large, broadly ovate, regularly rounded at the base, palmately 3-lobed, the lateral lobes short, sharp pointed, the central lobe much the larger, long acuminate; nervation tripalmate, the two lateral ribs rather slender, slightly curving and entering the points of the lateral lobes, the midrib of about the same size, straight, entering the apex of the terminal lobe; lateral ribs with about seven secondaries on the outside only, these camptodrome, each joining the one next above by a broad loop some distance inside the margin; outside these larger loops is a single series of smaller loops just within the margin, producing more or less of a line; midrib with about eight or nine pairs of alternate, slender camptodrome secondaries having the same series of smaller outside loops as the lateral ones; nervilles prominent, mostly at right angles to the secondaries, a few percurrent, but mostly broken in the middle; ultimate nervation thin, quadrangular, filling the space between the nervilles with a fine quadrangular areolation.

This specimen figured, unfortunately the only one found, is a large, beautifully preserved leaf so far as nervation goes, although lacking the greater portion of one side. It is about 16 centimeters long and 10 centimeters wide in the broadest portion, which is in the lower part of the blade. The base appears to have been rounded, probably truncate without being heart-shaped. It is broadly ovate, with the small, sharp-pointed lateral lobes some distance above the middle portion. The central portion of the leaf, or terminal lobe, as it may be called, is very long and slender in comparison with the lateral lobes. The leaf is palmately 3-ribbed, the lateral ribs entering the lateral lobes and the middle one the apex. The secondaries are all camptodrome, forming broad, even loops with a smaller series of loops outside. The nervilles are all well preserved and seem to be mainly at right angles to the secondaries or to the lateral ribs and lower pair of secondaries in the central lobe. The finer nervation is also well preserved and produces a fairly regular quadrangular areolation between the nervilles.

This species is undoubtedly closely related to *Sterculia saportanea* Knowlton as figured by Lesquereux[51] (under the preoccupied name *S. modesta* Saporta). The fine leaf that was the original of Lesquereux's figure is the property of Princeton University, as indeed is the present species, but it can not now be found, and without seeing it I am unable to determine whether it came from Laramie or Denver strata at Golden. *Sterculia libbeyi* differs from *S. saportanea* in being twice as long and nearly twice as broad, with the central or terminal lobe twice as long. The nervation is of the same character in both.

Sterculia libbeyi recalls slightly the larger leaves described by Newberry from Cook Inlet, Alaska, as

[50] As *Sterculia modesta* of Saporta, 1868, is preoccupied by *S. modesta* Heer, 1853–1855, it was changed to *S. saportanea*, in honor of M. le Comte Gaston de Saporta, who did so much to make known the paleobotanic riches of his own country.

[51] Lesquereux, Leo, The Cretaceous and Tertiary floras, pl. 20, fig. 5, 1883.

Ficus? alaskana,[52] but this species really differs in many particulars, such as being heart-shaped at the base, with five prominent ribs palmately arranged, as well as in nervation.

The type specimen of *Sterculia libbeyi* is No. 2339 of the collection of Princeton University, where it is now preserved. This with a small amount of other material was kindly placed at my disposal by the curator of the museum, Prof. William Libbey, jr., in whose honor I take pleasure in naming it.

Occurrence: Denver formation, Golden, Colo. Type in Princeton University.

Pterospermites grandidentata Lesquereux

Plate 50, Figure 6; Plate 51, Figure 3

Pterospermites grandidentata Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 53, 1888.

This species was described and discussed by Lesquereux as follows:

Leaves large, sometimes very large, somewhat like leaves of *Platanus*, palmately sub-5-nerved; the outer lateral nerves generally thin and shorter, much divided outside; lower secondary nerves opposite, at a distance from the base; borders deeply dentate, the teeth acute, turned upward, entered by the primary nerves and their branches, while toward the apex the secondaries curve in festoons along the borders, joined to the teeth by small anastomosing branches; nervilles strong, at right angles to the nerves.

This definition is about the same as that given by Saporta[53] of *Pterospermites inaequifolius*. One of the leaves from Golden is well preserved and merely differs from those described by Saporta in having the lateral nerves somewhat incurved, not quite straight. The two other specimens represent merely the base of two leaves with five primary nerves around the point of attachment of the petiole and two smaller ones declining downward to the cordate base, as in the leaves of *Ficus* (*Dombeyopsis*) *grandifolia* Unger.

The two best-preserved specimens are here figured. Of these the most perfect, shown in Plate 51, Figure 3, is broadly ovate-acuminate, 11.5 centimeters long and about 8 centimeters broad. The base is very slightly heart-shaped, almost truncate, and entire. Above the basal portion the margin is provided with large, sharp-pointed teeth. The nervation is very strong, being in effect 7-nerved instead of 5-nerved as stated by Lesquereux. There is a strong, straight midrib with three or four secondary branches above the middle of the blade. The next pair of ribs is nearly as strong as the midrib. They arise at an angle of about 70° and curve upward, reaching within one-fourth the length of the blade from the apex. They are provided with five or six outside branches that enter the teeth. The next pair of ribs are at the same angle as the branches above them but arise at the top of the petiole. There is a thin pair of ribs below that supply the basal lobes of the blade. These, as well as the ribs next above, have a number of outside branches. The nervilles are very strong, usually broken.

This species, as Lesquereux has pointed out, is undoubtedly similar to *Pterospermites inaequifolius* Saporta, from the travertines of Sezanne. It has the large ribs at a less acute angle and little curved upward, and the margin is much less strongly toothed; the nervilles are the same in both.

Occurrence: Denver formation, South Table Mountain, Golden, Colo., collected by Arthur Lakes. Types in Museum of Comparative Zoology, Cambridge, Mass., Nos. 1517, 1519.

Order UMBELLALES

Family CORNACEAE

Cornus impressa Lesquereux

Plate 51, Figures 1, 2

Cornus impressa Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, p. 408, 1874; The Tertiary flora, p. 243, pl. 42, fig. 3, 1878.

Cornus emmonsii Ward, U. S. Geol. Survey Sixth Ann. Rept., p. 553, pl. 48, fig. 2 [not fig. 3], 1885; U. S. Geol. Survey Bull. 37, p. 55, pl. 26, fig. 2 [not fig. 3], 1887.

The type specimen of *Cornus impressa*, from Mount Bross, Middle Park, Colo., is No. 354 of the United States National Museum collection. It was characterized as follows:

Leaves thick, coriaceous, entire, deeply impressed into the stone, regularly elliptical, rounded to a very short, scarcely marked acumen, rounded also to the base; secondary nerves at an acute angle (about 40°) of divergence, slightly curving in ascending to the borders, regularly camptodrome, simple or rarely branched once near the point, and anastomosing in festoons along the borders, with strong nervilles at right angles to the midrib, mostly simple and continuous.

The type is about 7 centimeters long and nearly 4.5 centimeters wide.

Cornus impressa was compared by Lesquereux to *Cornus orbifera* Heer,[54] from the Swiss Miocene, though he points out a number of minor differences. It does not appear to have been a very abundant species, though it has been found rather widely distributed. One or two broken examples have been found in the andesitic beds at Golden, Colo., and a single well-preserved specimen came from the Denver beds in a ravine opposite St. Luke's Hospital in North Denver.[55] This specimen was one of the types of Ward's *Cornus emmonsii*, and although it differs slightly from the type of *C. impressa* seems best referred to that species. The *Cornus emmonsii* of Ward rests on two specimens,

[52] U. S. Nat. Mus. Proc., vol. 5, p. 512, 1882 [1883].

[53] Saporta, Gaston de, Prodrome d'une flore fossile des travertins anciens de Sézanne, vol. 7, p. 402, pl. 35 (12), figs. 3–5, 1868.

[54] Heer, Oswald, Flora tertiaria Helvetiae, vol. 3, p. 27, pl. 105, figs. 15–17, 1859.

[55] Wrongly stated by Ward to be from Golden, Colo.

the one above mentioned from North Denver and the other from the Mesaverde formation at Point of Rocks, Wyo. In 1900 [56] I referred both these specimens to *C. impressa* on the basis of the figures given by Ward, as the specimens were not then available. Since then I have studied the specimens and found that the Point of Rocks example has been entirely misinterpreted and incorrectly drawn. The margin throughout and the distal terminations of the secondaries are exceedingly obscure. Several of the secondaries seem to enter the margin, and in one place it is possible to demonstrate with considerable certainty that they are camptodrome and arch just within the margin; hence it is probable that all of them do this. The apex is entirely wrong in the figure. For these reasons the name *Cornus emmonsii* has been restored to the Point of Rocks specimen, and the other from North Denver is referred to *C. impressa.*

The example here figured from Mosby, Colo., is lacking in considerable degree, but so far as can be made out it agrees well enough with *C. impressa.*

Occurrence: Middle Park formation (type), Mount Bross, Middle Park, Colo. Denver formation, ravine opposite St. Luke's Hospital, North Denver, Colo., and South Table Mountain, Golden, Colo. Dawson arkose, dump of Mosby coal mine, Mosby, Colo., collected by F. H. Knowlton and G. B. Richardson, 1910; Rice's clay pit, 1 mile southwest of Calhan, Colo., collected by F. H. Knowlton, 1910.

Cornus lakesii Knowlton, n. sp.

Plate 50, Figure 1

Leaf coriaceous, ovate-lanceolate, entire, broadest just below the middle, tapering upward into a long, slender acuminate apex and downward to a wedge-shaped base; nervation pinnate, midrib strong, secondaries four pairs, alternate, emerging at an acute angle, curving along the margin high above their insertion; nervilles numerous, fine, broken, approximately at right angles to the midrib.

This fine leaf, which is the only one obtained, has a length of 6 centimeters and a width of about 2.5 centimeters in the broadest part, just below the middle. The upper portion is slightly oblique—that is, turned to one side—after the manner of several living species. The petiole, unfortunately, is not preserved.

This species seems to have several near relatives among living species. It may be compared with *C. paniculata* L'Héritier, a shrub common on river banks in the eastern United States, and more particularly with small leaves of *C. sericea* Linné, which grows in wet places from Canada and Dakota to Florida.

[56] Knowlton, F. H., Flora of the Montana formation: U. S. Geol. Survey Bull. 163, p. 68, 1900.

Among fossil species the present form approaches in shape *Cornus newberryi* Hollick,[57] from the Fort Union beds of the lower Yellowstone in Montana. *Cornus newberryi* differs notably, however, in having 8 or 10 or more pairs of subopposite secondaries. The finer nervation is not shown.

I have ventured to name this species in honor of the Rev. Arthur Lakes, who collected not only this leaf but a very large proportion of the material from these beds.

Occurrence: Denver formation, quarry on northern base of Green Mountain, Golden, Colo.

Cornus denverensis Knowlton, n. sp.

Plate 13, Figure 1

Leaf regularly oval, abruptly acuminate at the apex, evidently regularly narrowed to the base, perfectly entire; midrib strong, straight; secondaries five pairs, opposite or subopposite at an acute angle, the lower ones slightly arching in, the upper ones much arched but not joining the midrib; nervilles numerous, percurrent, at right angles to the secondaries.

This small leaf, which unfortunately lacks the base and the greater portion of one side, is the only one found. It is perhaps doubtful whether or not a new species should be founded on such scanty material, but there appears to be nothing identical with it in the collections. It is a small leaf, only about 4.5 centimeters long and 2.5 centimeters wide, but it shows clearly the characters of *Cornus.* Among living species it resembles some of the small narrow leaves of *Cornus alternifolia* Linné, also small leaves of *C. mas* Linné, from southern Europe. Among American species it is quite like *Cornus pubescens* var. *californica* and small leaves of *C. sericea* Linné. Among fossil species its closest relative appears to be *Cornus newberryi* Hollick [58] [*C. acuminata* Newberry], from the Fort Union formation of the lower Yellowstone in Montana, but *C. denverensis* differs in its smaller size and much less acuminate apex. It is also somewhat like *Cornus rhamnifolia* O. Weber, as figured by Lesquereux,[59] from a locality near Point of Rocks, Wyo.

Occurrence: Denver formation, Golden, Colo. Type specimen the property of Princeton University, No. 2339 of the Princeton Museum. On same stone with *Sterculia libbeyi.*

Cornus holmesii Lesquereux

Cornus holmesii Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, p. 402, 1874.

Following is Lesquereux's description of this form:

The upper part of an ovate-lanceolate entire leaf, with the secondary veins thin, very distant, alternate, much curved

[57] Newberry, J. S., U. S. Geol. Survey Mon. 35, p. 124, pl. 28, figs. 2–4, 1898.

[58] Idem, p. 124, pl. 37, figs. 2–4.

[59] Lesquereux, Leo, The Tertiary flora, p. 244, pl, 42, fig. 6, 1878.

in passing up in an acute angle from the middle nerve [midrib] toward the borders. The point of the leaf is broken. Though the specimen is fragmentary, it evidently represents a *Cornus* specifically distinct from other fossil species by the great distance of the secondary veins. By this character only is it distantly related to *Cornus buchi* Heer.

This species was not figured nor afterward referred to by Lesquereux and was probably merged with some other form without any synonymic record being made. The specimen on which it was based is not now known to be in existence. The locality is given as follows: "Bituminous shale, Coal Creek, Colo.; W. H. Holmes." This is supposed to be the Coal Creek or Sand Creek about 15 miles east of Denver and is presumed to be in the Denver formation. It is mentioned in this place merely to keep the record clear.

Nyssa lanceolata Lesquereux

Plate 52, Figure 2

Nyssa lanceolata Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, p. 407, 1873; idem for 1873, p. 385, 1874; idem for 1876, p. 513, 1878; The Tertiary flora, p. 245, pl. 35, fig. 5 [not fig. 6], 1878.
Knowlton, U. S. Geol. Survey Bull. 105, p. 56, 1899; U. S. Geol. Survey Prof. Paper 101, p. 343, pl. 108, fig. 1; pl. 113, fig. 2, 1917 [1918].

This species was founded on material from "Spring Canyon, Mont." [Meadow Creek, 12 miles southeast of Bozeman, Gallatin County], in beds presumed to belong to the Livingston formation. It appears to have been founded on fragments of leaves which are not now preserved in any known collection, and, moreover, it does not seem to have been collected there subsequently.

The two additional references to the Hayden reports quoted in the above synonymy are only lists which refer to the type locality, so that the remarks in the account of the Tertiary flora constitute the only additional utterance by Lesquereux concerning this species. Two figures were given at this time, one of a leaf and the other of a number of fruits which Lesquereux said he referred "hypothetically" to this species. The original of the leaf figured is No. 303 in the United States National Museum collection and is preserved on the andesitic matrix characteristic of the Denver formation at Golden, Colo. Although this is not the actual type of the species, it is the first and only leaf figured by Lesquereux and hence it becomes to all intents and purposes the figured type. It is the basis for the identification of the species elsewhere.

As it is obviously impossible to connect the seeds with the leaf just mentioned, it has seemed best to give them a new name. They may now be called *Nyssa denveriana.*

The leaf figured by Lesquereux as *Nyssa lanceolata* is very similar to certain of the leaflets he figured[60] as *Juglans rugosa*, but it differs by its much lighter nervation—that is, it is less rugose. Another species figured by Lesquereux,[61] *Sapindus caudatus*, is much more difficult to distinguish from *Nyssa lanceolata. Sapindus caudatus*, as its name implies, has a long, narrowly caudate apex and when complete is very easily identified. The leaf figured as *Nyssa lanceolata* lacks the apical portion, but it is difficult to note any difference between the portion present and the similar portion of the figure of *Sapindus caudatus.*

I have figured two leaves from the Raton formation of the Raton Mesa region under the name *Nyssa lanceolata.*[62] One of these (pl. 113, fig. 2) agrees well with the type figure in size, shape, and general character of the nervation but differs from it in the slightly more acute divergence of the lower secondaries. The other specimen is slightly more wedge-shaped at the base but does not differ markedly from the first.

The collection from Mosby, Colo., contains the single example here figured, which is certainly indistinguishable from Plate 113, Figure 2, of the Raton report above cited.

Occurrence: Denver formation (figured type), South Table Mountain, Golden, Colo., collected by Leo Lesquereux about 1873. Raton formation, canyon west of Mayne, Colo., and Purgatoire Canyon at mouth of Riley Canyon, Colo., collected by W. T. Lee. Dawson arkose, dump of Mosby coal mine, Mosby, Colo., collected by F. H. Knowlton and G. B. Richardson in 1910. Livingston(?) formation, Spring Canyon, Mont. [Meadow Creek, 12 miles southeast of Bozeman, Gallatin County].

Nyssa denveriana Knowlton, n. sp.

Nyssa lanceolata Lesquereux. Lesquereux, The Tertiary flora, p. 245, pl. 35, fig. 6 [not fig. 5], 1878.

Following is Lesquereux's description of the seeds of this species as given under the name *Nyssa lanceolata:*

Fruit comparatively large, precisely ovate, round on one side, obtusely pointed on the other, deeply, distantly costate, and striate.

In discussing the fruits he continued:

The fruits, which I refer hypothetically to the same species [*Nyssa lanceolata*] for the reason that both kinds of organs were found at the same place, * * * are 15 millimeters long and 8 millimeters broad below the middle, marked by regular small costae, with the intervening space flat, and narrowly lined. For its size the fruit is comparable to some of the fossil seeds described by European authors, especially to *N.*

[60] Lesquereux, Leo, The Tertiary flora, p. 286, pl. 55, 1878.
[61] Idem, p. 264, pl. 48, fig. 6.
[62] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 101, p. 343, pl. 108, fig. 1; pl. 113, fig. 2, 1917 [1918].

maxima Weber, *N. arctica* Heer, *N. ornithobroma* Unger, etc. The position of the two fruits upon the same specimen seems to indicate them as originally in a cluster.

The specimen from which the figure of the fruits was made is preserved in the United States National Museum (No. 506). It is recorded in the Museum catalogue as having come from Black Buttes, Wyo., but the matrix proves conclusively that it came from the andesitic beds of the Denver formation, presumably from Golden, Colo., as this is the locality given by Lesquereux. The fruits are now very obscure, having evidently been much abraded since the figure was made. None have since been noted in beds of the Denver formation.

The National Museum, however, contains a series of fine specimens (No. 3579) of this species collected by T. W. Stanton from the coal bed at Parker's mine, 3 miles from White Oaks, N. Mex. They agree in every particular with Lesquereux's figures, although, as already stated, the type specimen is very obscure. The age of the coal-bearing rocks at White Oaks is still undetermined.[63] Additional specimens from the White Oaks locality were obtained by C. H. Wegemann, of the United States Geological Survey, in 1912. They are now preserved in the National Museum.

Occurrence: Denver formation, Golden, Colo., collected by Leo Lesquereux, about 1873. Tertiary(?), Parker's coal mine, 3 miles from White Oaks, N. Mex., collected by T. W. Stanton in 1889 and by C. H. Wegemann in 1912.

Nyssa? obovata Knowlton, n. sp.

Plate 54, Figure 1

Leaf of firm texture, obovate, broadest above the middle, whence it is broadly wedge-shaped to the base and rather abruptly acute at the apex; margin entire for lower two-thirds, coarsely few-toothed above; midrib strong, straight; secondaries eight or nine pairs, alternate, at an angle of about 45°, very slightly curved upward, camptodrome, becoming craspedodrome above and passing to the teeth; nervilles obscure, much broken, and forming large irregular areas; finer nervation not preserved.

The example figured is nearly perfect. It is strongly obovate with an obtusely wedge-shaped base and obtusely acute apex. The margin above bears a few rather large, coarse teeth. The length of the leaf is about 9 centimeters and the width a little more than 5 centimeters.

It is with some hesitation that this leaf is referred to the genus *Nyssa*, yet it is strongly suggestive of certain others that have been so considered. Among the living American species it has much the shape of *N. biflora* Walter, and in the matter of toothing it is nearest to *N. aquatica* Linné. Among fossil forms it appears to approach most closely *Nyssa? cuneata* Newberry[64] from the Upper Cretaceous of Orcas Island, Washington.

Occurrence: Denver formation, Golden, Colo., south face of South Table Mountain, 100 feet below the lava cap, collected by Arthur Lakes, 1890.

[63] See Wegemann, C. H., U. S. Geol. Survey Bull. 541, p. 428, 1914.

Order EBENALES

Family EBENACEAE

Diospyros brachysepala Al. Braun

Plate 51, Figures 5, 6, 7, 9; Plate 52, Figure 3

Diospyros brachysepala Al. Braun, Die tertiär Flora von Oeningen: Neues Jahrb., 1845, p. 170.

Lesquereux, U. S. Geol. Survey Terr. Ann. Rept. for 1872, p. 394, 1873; idem for 1873, p. 401, 1874; idem for 1874, p. 306, 1876; idem for 1876, p. 511, 1878; U. S. Geol. and Geog. Survey Terr. Bull., vol. 1, p. 367, 1875; The Tertiary flora, p. 232, pl. 40, figs. 7–10, pl. 63, fig. 6, 1878; The Cretaceous and Tertiary floras, p. 174, pl. 34, figs. 1, 2, 1883; U. S. Nat. Mus. Proc., vol. 10, p. 41, 1887.

Proof that all the leaves in Europe and America that have been referred to *Diospyros brachysepala* really belong to this species, if obtainable, would show not only that it is an exceedingly polymorphous species but that it has an extraordinarily wide geographic and geologic range. As a matter of fact, it will probably ultimately be shown that perhaps as many as half a dozen species have been confused under this name, but until larger series of specimens can be brought together it is best to make only such segregation as can be pretty well established.

The type locality of *Diospyros brachsepala* is the Miocene of Oeningen, in Baden.[65] The plate devoted by Heer[66] to this species shows a considerable range in size and shape. His diagnosis reads as follows:

Foliis petiolatis, ellipticis, utrinque attenuatis, membranaceis vel subcoriaceis, integerrimis, nervis secundariis alternantibus, remotiusculis, subangulo acuto egredientibus, curvatis, ramosis.

Most of the leaves figured by Heer are elliptical in shape and about equally narrowed to the base and apex. Several are distinctly lanceolate, with a rather long, sharp-pointed apex and a wedge-shaped base. A single leaf is distinctly obovate. The nervation is very much the same regardless of shape—that is, it

[64] Newberry, J. S., U. S. Geol. Survey Mon. 35, p. 125, pl. 17, figs. 4, 5, 1898.

[65] The locality of Oeningen, long and widely known for its deposits of wonderfully preserved plants, insects, fish, etc., is usually given as being in Switzerland. Recently T. D. A. Cockerell, of the University of Colorado, visited the region and determined that the celebrated fossil beds are located near the town of Wangen, which is on the north bank of the Rhine in the German Province of Baden. See Scientific Monthly, vol. 1, pp. 287–291, 1915.

[66] Heer, Oswald, Flora tertiaria Helvetiae, vol. 3, p. 11, pl. 102, figs. 1–14, 1859.

consists of a fairly thick midrib and 8 to 12 pairs of thin, usually alternate, camptodrome secondaries, usually at a low angle of origin. The leaves range from 4 to 9 centimeters in length and 1.5 to 3.5 centimeters in width.

As already indicated, this species has been widely identified in European rocks which range in age practically throughout the Tertiary.

Diospyros brachysepala was first noted in American rocks by Lesquereux,[67] who identified it at Black Buttes, Wyo. The following year Lesquereux[68] reported this species from Sand Creek, Colo., in beds then supposed to be Miocene but now known to belong to the Denver formation. He apparently had only a single leaf, which he described as follows:

> Leaves broadly oval or slightly obovate, narrowed in a curve to the base, entire, rather membranaceous, but not thick; secondary nerves alternate, curving to and along the borders, mostly simple or with few branches, deflected downward in reaching the middle nerve.

Lesquereux especially compared this leaf with Figure 6 of Heer's plate for size and shape and Figure 2 for nervation.

In 1874 Lesquereux identified *Diospyros brachysepala* at Point of Rocks, Wyo., comparing the leaves from this locality with Figure 2 of Heer's plate, which is a long, narrow, sharp-pointed leaf. The remarks concerning these Point of Rocks leaves were republished without change in 1876.[69]

In 1878 Lesquereux[70] figured for the first time the various specimens he had referred to *Diospyros brachysepala.* They were said to have come from Golden, Colo., and Black Buttes and Point of Rocks, Wyo. Of the five figures given, only three appear to be represented by specimens in the United States National Museum collections. These are Figures 7 (No. 339), 8 (No. 338), and 10 (No. 337) of his Plate 40. Figure 7 is said to have come from Black Buttes, Figure 8 from Point of Rocks, and Figure 10 from Golden. None of these leaves are very well preserved; the best one is that of Figure 7, which in size and shape is very similar to Figure 8 of Heer's plate,[71] but the secondaries are at a slightly more acute angle. The specimen shown in Lesquereux's Figure 8, from Point of Rocks, is only the tip of a very small leaf that may or may not be referable to *Diospyros brachysepala.* The Point of Rocks material is mentioned again below. Figure 10 of Lesquereux's plate shows a very fragmentary specimen, lacking both base and apex and much of one side. Its reference to this species can hardly be considered firmly established. In 1883 Lesquereux[72] admitted *Diospyros brachysepala* as present in the Miocene Florissant lake beds of Colorado. He figured two fine leaves that are now preserved in the museum of Princeton University. They are elliptical-obovate, and, as Lesquereux said, are "more positively identified with the European species" than those figured in the report on the Tertiary flora.

In passing it may be noted that the leaf described by Cockerell[73] under the name *Diospyros princetonia* does not seem to me to be distinguishable from the leaves from Florissant figured by Lesquereux as *Diospyros brachysepala*, though Cockerell says: "Both apex and base are more pointed than in normal *D. brachysepala.*"

Two leaves from the Fort Union formation of the lower Yellowstone in Montana were referred by Ward[74] to *Diospyros brachysepala.* They both have a distinctly decurrent base and I suspect should be referred to *Sapindus alatus* Ward [*S. glendivensis* Knowlton],[75] though otherwise they agree pretty closely with Heer's figures of *D. brachysepala.*

In 1900 I reviewed the flora of the Montana group[76] and referred a single leaf to *Diospyros brachysepala.* It is a narrowly lanceolate, long acuminate leaf very unlike most of the leaves usually referred to this species, though not greatly unlike the narrow sharp-pointed leaves so referred by Heer. On again studying this specimen I am convinced that I was in error in referring it to *Diospyros brachysepala;* in fact, even its reference to *Diospyros* is considered questionable.

The presence of *Diospyros brachysepala* in the Wilcox group of the Southern States has been reported by Berry.[77] Of the three leaves figured by him two (figs. 3 and 6) appear to be referred to this species with a considerable degree of certainty, but the other one (fig. 4) seems to me to belong with *Diospyros wilcoxiana* Berry, as figured on the same plate. Although it is slightly smaller than one of the figures of *D. wilcoxiana* (fig. 1) it has the same markedly decurrent base and the same nervation.

To recapitulate concerning the presence of *Diospyros brachysepala* Al. Braun in American rocks: The speci-

[67] Lesquereux, Leo, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1872, p. 394, 1873.

[68] Idem for 1873, p. 401, 1874.

[69] Lesquereux, Leo, On some new species of fossil plants from the Lignitic formations: U. S. Geol. and Geog. Survey Terr. Bull., vol. 1, No. 5, 2d ser., p. 367, 1876.

[70] Lesquereux, Leo, The Tertiary flora, p. 232, pl. 40, figs. 7–10; pl. 63, fig. 6, 1878.

[71] Heer, Oswald, Flora tertiaria Helvetiae, vol. 3, p. 11, pl. 102, 1859.

[72] Lesquereux, Leo, The Cretaceous and Tertiary floras, p. 174, pl. 34, figs. 1, 2, 1883.

[73] Cockerell, T. D. A., Am. Mus. Nat. Hist. Bull., vol. 24, p. 105, pl. 10, fig. 36, 1908.

[74] Ward, L. F., U. S. Geol. Survey Sixth Ann. Rept., p. 556, pl. 60, figs. 4, 5, 1886; U. S. Geol. Survey Bull. 37, p. 104, pl. 49, figs. 1, 2, 1887.

[75] Ward, L. F., op. cit. (Sixth Ann. Rept.), pl. 50, figs. 9, 10.

[76] Knowlton, F. H., U. S. Geol. Survey Bull. 163, p. 74, pl. 18, fig. 3, 1900.

[77] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 333, pl. 101, figs. 3, 4; pl. 107, fig. 6, 1916.

mens identified by Lesquereux from Black Buttes, Wyo., and Golden, Colo., should probably be accepted, but the fragment from Point of Rocks, Wyo., is too small and doubtful to be of convincing value. The two leaves from the Miocene at Florissant, Colo., identified by Lesquereux are apparently correct generically but are open to question specifically. The leaves from the Fort Union formation of the lower Yellowstone in Montana, as determined by Ward, should probably be referred to *Sapindus alatus* Ward (*S. glendivensis* Knowlton). The single leaf identified by me in the Mesaverde formation at Point of Rocks, Wyo., is not *Diospyros brachysepala* and should be given a new name. Of the three leaves from the Wilcox group figured by Berry, two may be accepted as *Diospyros brachysepala* and the other referred to *D. wilcoxiana* Berry.

We may now consider the leaves that the present study has brought to light in the Denver Basin and adjacent areas. Several leaves have been found in the Denver formation at Golden that may be referred to *Diospyros brachysepala* as currently accepted. One of these is shown in Plate 51, Figure 6. It is ovate-elliptical, about 5.5 centimeters long and nearly 3 centimeters wide. The midrib is fairly strong, but the secondaries are thin and at a low angle.

The leaf shown in Plate 51, Figure 5, is from the Dawson arkose near Mosby, Colo. It is practically perfect, including the petiole, which is 1 centimeter long. It is elliptical, with a sharp-pointed apex. Its length is 6 centimeters and its width 2.5 centimeters.

Leaves that are referred to *Diospyros brachysepala* have also been found in the lower part of the Dawson arkose near Sedalia, Colo.; they have not been figured.

Occurrence: Denver formation, South Table Mountain, Golden, Colo., collected by Arthur Lakes. Dawson arkose, dump of Mosby coal mine, Mosby, Colo., collected by F. H. Knowlton and G. B. Richardson, 1910; also in lower part of Dawson arkose near Douglas coal mine, Sedalia, Colo., in beds equivalent to Arapahoe formation, collected by Arthur Lakes, 1890.

Family STYRACACEAE

Styrax? laramiensis Lesquereux

Plate 52, Figure 7

Styrax laramiense Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 51, 1888.

Leaf subcoriaceous, smooth on the surface, elliptical, apparently about equally rounded to both base and apex (apex absent), abruptly slightly decurrent at base; petiole evidently strong; margin perfectly entire; nervation pinnate but 3-ribbed in effect, midrib very strong, straight, with four or five pairs of secondaries, the lowest pair nearly as strong as the midrib, arising some distance above the base of the blade, at an angle of about 45°, slightly curved upward, camptodrome, each with four or five tertiary branches on the outside, all camptodrome and joining along the border, upper secondaries alternate, camptodrome; nervilles numerous, thin, mainly broken.

This species was based on a single specimen by Lesquereux—the one here figured. It is a small oval or elliptical leaf that must have been about 5.5 centimeters long and 3.5 centimeters wide. Lesquereux apparently did not note that it is slightly decurrent on the stout petiole or that the lowest pair of secondaries are nearly as strong as the midrib and arise above the base of the blade, thus producing a pseudopalmate aspect.

There is some question as to the proper generic reference of this leaf. Lesquereux states that it is related to the European *Styrax officinalis* Linné, but it does not greatly resemble the American species, especially as they usually have more or less toothed or lobed leaves and this is perfectly entire. In some respects it strongly resembles certain of the leaves referred to *Ficus planicostata* Lesquereux,[78] but this never has the blade decurrent, only rarely are the lowest pair of secondaries inserted above the top of the petiole, and the nervilles are not of the same character as in *Styrax? laramiensis*.

There is also some resemblance between this leaf and certain leaves referred to *Oreodaphne*, as, for instance, small leaves of *O. obtusifolia* Berry,[79] from the Wilcox deposits of Mississippi and Louisiana. This species is often slightly decurrent at the base, and the lowest secondaries always arise well above the base of the blade, but they never branch on the outside like the "ribs" in *Styrax? laramiensis*.

Occurrence: Denver formation, South Table Mountain, Golden, Colo., collected by Arthur Lakes. Type in Museum of Comparative Zoology, Cambridge, Mass., No. 1488.

Order OLEALES

Family OLEACEAE

Fraxinus eocenica Lesquereux

Plate 52, Figures 4–6

Fraxinus eocenica Lesquereux, The Tertiary flora, p. 229, 1878; The Cretaceous and Tertiary floras, p. 123, pl. 20, figs. 1–3 [figures here reproduced], 1883.

The type specimens of this fine species are the property of Princeton University and are preserved in the Princeton Museum of Natural History. It appears

[78] Lesquereux, Leo, The Tertiary flora, p. 201, pl. 31, figs. 1–8, 10–12, 1878.

[79] Berry, E. W., U. S. Geol. Survey Prof. Paper 91, p. 301, pl. 83, fig. 3, 1916.

to be a rare species, for so far as I can learn no others have been found. It was not reported by Lesquereux in the large collection from Golden in the Museum of Comparative Zoology of Harvard University, nor does it appear to be present in the still larger collections in the United States National Museum.

This species was described and discussed by Lesquereux as follows:

Leaves of large size, subcoriaceous, distantly obtusely dentate or merely undulate on the borders, broadly lanceolate, rounded in narrowing to the inequilateral base; nervation subcamptodrome.

The largest of these leaflets is about 15 centimeters long and 5 centimeters broad below the middle, where it is the widest; the other leaflets are somewhat smaller but exactly of the same form. The secondary nerves, on an open angle of divergence, nearly parallel and equidistant, generally curve in passing toward the borders, where they form, close to them, a series of simple bows, from which emerge the nervilles which enter the blunt distant teeth. * * * The nervilles are distinct, irregular in direction, much divided; the areolation, as far as it is discernible, is in irregular polygonal meshes. The base of the leaf is cuneate on one side, descending lower and rounded on the other, or rounded on both sides, which then are nearly equal; the upper part is gradually tapered upward and then contracted to a slightly obtuse acumen, as in the leaves of *Fraxinus pubescens* Lamarck and *F. americana* Linné, to which this fossil species is related.

In some respects *Fraxinus eocenica* suggests certain leaflets of *Juglans denveriana* as described above, especially in the shape of the base, but it differs in being relatively shorter and broader and more particularly in the margin, which is undulate or strongly toothed in *F. eocenica* and entire or obscurely serrate in *J. denveriana.* Also, the secondaries in *F. eocenica* emerge at a lower angle and are somewhat less curved upward than in *J. denveriana.*

Occurrence: Denver formation, Golden, Colo., collected by Arthur Lakes, about 1875.

Fraxinus sp.

Plate 58, Figure 7

Fraxinus denticulata Heer. Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 51, 1888.

In the collection of Denver plants identified by Lesquereux for the Museum of Comparative Zoology he listed with question a single specimen under the name *Fraxinus denticulata* Heer. He wrote of it as follows:

A fragment only, the upper part of a small oblong-oval leaf, with the borders slightly denticulate, the lateral nerves mostly craspedodrome, entering the teeth. * * * The identity is not positively ascertained.

This is a mere fragment of the upper portion of a leaf that must have been about 5 centimeters long and 2.5 centimeters in width. So far as can be made out it resembles *Fraxinus denticulata* Heer,[80] from the Miocene of Greenland, but it is so fragmentary that the identification can not be made positive. The specimen has been figured here in the hope that it will be sufficient to call attention to the presence of a type of foliage not otherwise represented.

Occurrence: Denver formation, South Table Mountain, Golden, Colo., collected by Arthur Lakes. Type in Museum of Comparative Zoology, Cambridge, Mass, No. 1487.

Order TUBIFLORAE

Family BIGNONIACEAE

Dombeyopsis obtusa Lesquereux

Dombeyopsis obtusa Lesquereux, U. S. Geol. Survey Terr. Ann. Rept. for 1872, p. 375, 1873; idem for 1873, p. 382, 1874; idem for 1876, p. 514, 1878; The Tertiary flora, p. 255, pl. 47, figs. 4, 5, 1878.

Knowlton, U. S. Geol. Survey Prof. Paper 130, p. 162, pl. 13, fig. 4; pl. 20, fig. 11; pl. 27, figs. 1–4, 1922.

This species was named and described from specimens obtained about 1871 from a locality known as Gehrung's coal mine, about 15 miles southeast of Colorado Springs, Colo., in the Laramie formation. These specimens can not now be found. They are not in the United States National Museum, unless there has been an error in recording them, nor has the species been noted in material recently obtained at or near the original locality.

The two specimens figured as types of this species are preserved in the United States National Museum (Nos. 380, 381), and, if correctly labeled, both came from the true Laramie at Golden, Colo. In any event they are preserved on the hard, white sandstone matrix characteristic of the Laramie, whether they came from Golden or not. The further occurrence of this species in the true Laramie is set forth at some length in my report on the Laramie flora[81] and need not be repeated here.

Dombeyopsis obtusa is one of the few species known to cross the line between the Laramie and Denver or Dawson arkose. A very fine leaf of this species was found in the andesitic beds of the Denver formation at Golden. It was preserved on the same piece of matrix as the type of *Ficus occidentalis* Lesquereux (see p. 68), which is No. 281 of the National Museum collection, but as the specimen was somewhat irregular an attendant who attempted to reduce its size entirely removed this leaf of *Dombeyopsis obtusa.* This is much to be regretted, for it proved to be one of the most perfectly preserved examples known. It was nearly circular in outline, being about 9.5 centimeters long and 10 centimeters wide.

Among the collections made by Lakes at the old Douglas coal mine, near Sedalia, Colo., there are three

[80] Heer, Oswald, Flora fossilis arctica, vol. 1, p. 118, pl. 16, fig. 4, 1868.

[81] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 130, p. 162, 1922.

or four somewhat fragmentary specimens that appear to belong with *Dombeyopsis obtusa*. They represent only basal portions of the leaves, but so far as I can see they are not to be distinguished from this species.

Occurrence: Laramie formation (type), Gehrung's coal mine, southeast of Colorado Springs, Colo.; figured types, Golden, Colo.; also found at Coal Creek, Marshall, Hoyt's coal mine, 1 mile south of Golden, and Crow Creek, 25 miles northeast of Greeley, Colo. Denver formation, South Table Mountain, Golden, Colo. Dawson arkose, Pulpit Rock, near Colorado Springs, Colo.; also lower part of Dawson arkose (in beds equivalent to Arapahoe formation), 3,000 feet east of Douglas coal mine, Sedalia, Colo.

Dombeyopsis magnifica Knowlton, n. sp.

Plate 54, Figure 4; Plate 55, Figure 4; Plate 57, Figure 1; Plate 58, Figure 8

Dombeyopsis grandifolia Unger? Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, pp. 382, 404, 1874; idem for 1876, p. 514, 1878; The Tertiary flora, p. 255, pl. 47, fig. 6, 1878.

Leaves large and thick, roughly deltoid, from truncate and slightly heart-shaped to deeply heart-shaped at the base, where the margin is entire, other portions of the margin cut into four or five very large, deltoid, rather obtuse lobes on a side, the apical lobe similar; the lowest lobe is turned downward, the others outward or upward; petiole exceedingly large and strong, split at the base of the blade into seven or nine strong radiating ribs, all except lowest ones ending in lobes; midrib slightly the strongest, with three or four pairs of secondaries, one or two of which end in marginal lobes; next pair of secondaries at an angle of about 45°, craspedodrome, with one or more branches entering lobes; next pair slightly smaller, a little above a right angle in insertion; in 7-ribbed leaves the lower ribs to enter the lowest lobe have several camptodrome secondaries on the lower side, the first one arising with the large ribs and thus producing the 7-ribbed appearance; in 9-ribbed leaves the lowest pair of ribs fall below a right angle, and here the first secondaries arise with the ribs, thus producing this 9-ribbed effect; nervilles numerous, strong, not often broken, approximately at right angles to the ribs or their secondaries.

This splendid species is represented by half a dozen or more examples, two of them being exceptionally perfect. One of these, shown in Plate 57, Figure 1, is about 10 centimeters long and was not far from 16 centimeters wide. It has four lobes on a side, 1 to 3 centimeters long and separated by broad, shallow sinuses. The petiole is not preserved in this specimen. The other nearly perfect example is shown in Plate 58, Figure 8. It is about 11 centimeters long and 14 centimeters wide and has the petiole preserved for a length of nearly 8 centimeters. It also has four prominent lobes on each side, but they are longer and more sharply pointed, especially the terminal lobe.

The other specimens have the base well preserved, but otherwise they all lack most if not all of the margin. They are much larger than those first mentioned, one shown in Plate 54, Figure 4, for instance, being at least 16 centimeters long and when perfect probably not far from 20 centimeters wide. This specimen has the petiole preserved for a length of about 3.5 centimeters, and in the one shown in Plate 57, Figure 1, the petiole is preserved for over 5 centimeters. This specimen was clearly more than 20 centimeters wide, but its length can only be conjectured. It is safe to say that these leaves were from 15 to nearly or quite 25 centimeters wide and from 10 to 16 or 18 centimeters long.

This species is undoubtedly congeneric with *Dombeyopsis trivialis* Lesquereux,[82] from the Laramie formation at Golden, Colo. The Laramie species differs in being more nearly square in general outline, much smaller, and only 5-ribbed. It is only 7 centimeters long and less than 8 centimeters wide and has only one or two large lobes on each side of the blade. It is also more deeply heart-shaped at the base than *D. magnifica*.

In 1873 Lesquereux referred with question a single fragmentary leaf from the andesitic beds of South Table Mountain, Golden, Colo., to the European species *Dombeyopsis grandifolia* Unger. This was figured and further described by Lesquereux in 1878,[83] but no additional examples appear to have been found at Golden. This specimen—No. 382 of the United States National Museum collection—is a mere fragment from the base of what was apparently a large leaf. It shows a portion of a very thick petiole, somewhat expanded at the apex, where it gives rise to six strong, nearly equal, radiating ribs. The base of the blade appears to be heart-shaped, but this point is obscure. It seems probable that there were at least seven ribs when this leaf was perfect, for six is an unusual number. On comparison this Golden fragment is practically indistinguishable from some of the leaves here described as *Dombeyopsis magnifica*, especially the one shown in Plate 57, Figure 1. It has the same thick petiole, strong, radiating ribs, and coarse nervilles. The size, as nearly as I can judge, must have been about the same in both. *Dombeyopsis grandifolia* Unger is a handsome species from the Miocene of

[82] Lesquereux, Leo, The Tertiary flora, p. 255, pl. 47, fig. 3, 1878.
[83] Idem, p. 255, pl. 47, fig. 6.

Styria and Bohemia. Unger [84] devoted two plates to this species, but, as Schimper long ago pointed out, all but one of Unger's figures probably represent the polymorphous *Ficus tiliaefolia*. The exception is Figure 1, Plate 27, which is the one most like what I have here called *D. magnifica*. It is so fragmentary that no part of the margin except the base is to be seen. The size of the blade, number and disposition of the ribs, nervilles, and petiole are like those features in *D. magnifica*, but it is impossible to compare the configuration of the margin in the two forms.

Occurrence: Dawson arkose, a quarter of a mile east of the Purdon mine, sec. 27, T. 11 S, R. 61 W., Colo., collected by G. B. Richardson.

Dombeyopsis? sedaliensis Knowlton, n. sp.

Plate 56, Figure 5; Plate 59, Figure 1

Leaves large, apparently rather thin and membranaceous, nearly circular or possibly very broadly ovate, markedly heart-shaped at the base (apex unknown); margin entire; petiole very strong and long; 5-ribbed from the extreme base of the blade, the ribs of about equal strength; midrib with two or three pairs of strong, alternate secondaries in the middle and upper portions of the blade; next pair of ribs arising at an angle of about 45°, considerably curving upward, each with three or four secondary branches on the lower or outer side; lowest pair of ribs arising nearly at right angles to the midrib, soon curving slightly or sometimes considerably upward, each with several camptodrome secondary branches on the lower side which supply the rounded basal lobes of the blade; nervilles numerous, mainly unbroken, mainly at right angles to the ribs or to the secondary branches.

This species is represented apparently by several specimens, but unfortunately they are so fragmentary that they are made out with difficulty. It is a large-leaved species, being some 10 or 12 centimeters in width and probably a little longer. The petiole is very strong, being fully 3 millimeters thick in some specimens where it merges into the blade. The length of the petiole is at least 6 or 7 centimeters.

It is with some hesitation that these leaves are referred to the genus *Dombeyopsis*, but they are found in intimate association with other species of this genus which they closely resemble and are therefore tentatively referred to it. At first it was supposed that they belonged to *Dombeyopsis obtusa*, with which they are associated, but they differ in having five instead of three ribs; otherwise the differences are not great.

Occurrence: Dawson arkose, lower part (in beds equivalent to Arapahoe formation), 3,000 feet east of the Douglas coal mine, Sedalia, Colo.

[84] Unger, Franz, Fossile Flora von Sotzka: K. Akad. Wiss. Wien Denkschr., vol. 2, p. 175 (45), pls. 47 (26), 48 (27), 1850.

Order RUBIALES

Family CAPRIFOLIACEAE

Viburnum richardsoni Knowlton, n. sp.

Plate 52, Figure 8; Plate 53, Figures 1, 3, 4, 5; Plate 54, Figures 2, 3

Crataegus betulaefolia Lesquereux, Harvard Coll. Mus. Comp. Zoology Bull., vol. 16, p. 56, 1888 [part].

Leaves evidently very firm, broadly ovate to nearly circular, generally more or less obtusely wedge-shaped at the base, rounded and rather obtuse at the apex; margin regularly and finely toothed throughout except at the very base, the teeth deltoid in shape; petiole long, relatively strong; nervation strong, deeply impressed, consisting of a markedly zigzag midrib and four to six pairs of strong, alternate, straight secondaries arising at an angle of 60° or 70°, the lowest pair arising at the very base of the blade, each with five or six strong branches on the lower side, some of which are forked, all entering the marginal teeth; upper secondaries close, parallel, with one or two branches which enter the teeth; nervilles numerous, strong, at right angles to the secondaries or their branches.

This species is the dominant form at Palmer's ranch and is represented by more than 25 more or less perfect specimens. As shown by the examples selected for illustration there is considerable range in size and a minor range in shape. The smallest specimen (pl. 52, fig. 8) is 4 centimeters long and a little less than 3 centimeters wide. The longest specimen is 8.5 centimeters long and was probably not less than 6 or 7 centimeters wide; this particular specimen has the petiole preserved for a length of 2 centimeters. A still larger specimen not figured is fully 10 centimeters long. The range in the shape of the base is also well shown in the five examples figured. Thus the specimen shown in Plate 52, Figure 8, is markedly wedge-shaped, that shown in Plate 53, Figure 3, is much less wedge-shaped, and that shown in Plate 54, Figure 3, is so much rounded that the whole leaf is nearly circular. This last-mentioned specimen is the most perfectly preserved of the lot. It is 5 centimeters long (exclusive of the petiole, which is 2 centimeters long) and about 4.5 centimeters wide. The rather obtuse apex is brought out in four of the examples figured.

As may be seen from the excellent figures this species is extremely well marked. It is clearly distinct from any species heretofore described from the Denver formation, though some of the forms approach some of the named forms rather closely. Thus Plate 53, Figure 3, suggests what has been identified by Lesquereux [85] as *Viburnum dichotomum*, from Black Buttes, Wyo. This differs in having fewer, smaller marginal teeth and fewer, more irregular secondaries.

[85] Lesquereux, Leo, The Tertiary flora, p. 225, pl. 38, fig. 6, 1878.

The perfect specimen seen in Plate 54, Figure 3, is very similar to an undescribed species from the Livingston formation of Montana, at least in general appearance. The Livingston species, however, has a more truncate base, minute marginal teeth, and slightly different nervation.

Since the above was written I have studied the types of *Crataegus betulaefolia* Lesquereux in the Museum of Comparative Zoology, and I have found that one of these is undoubtedly identical with *Viburnum richardsoni*. This specimen is practically complete, even to the major part of the petiole. It is shown in Plate 53, Figure 4. It is 4 centimeters long and 3 centimeters wide and agrees very well with the figure of *Viburnum richardsoni* given on Plate 52, Figure 8.

Occurrence: Dawson arkose, Palmer's ranch, Templeton Gap, 4 miles northeast of Colorado Springs, Colo., about 40 feet above base of section, collected by F. H. Knowlton, July, 1910; also lower part of Dawson arkose (in beds equivalent to Arapahoe formation), 3,000 feet east of Douglas coal mine, Sedalia, Colo. Denver formation, South Table Mountain, Golden, Colo., collected by Arthur Lakes; specimen in Museum of Comparative Zoology, Cambridge, Mass. (No. 1576), one of the types of *Crataegus betulaefolia* Lesquereux.

Viburnum contortum Lesquereux?

Plate 55, Figure 1

Viburnum contortum Lesquereux, U. S. Geol. Survey Terr. Ann. Rept. for 1872, p. 396, 1873.

Knowlton, U. S. Geol. Survey Prof. Paper 101, p. 346, pl. 108, fig. 3, 1917 [1918].

Viburnum marginatum Lesquereux, The Tertiary flora, p. 223, pl. 38, fig. 2 [not fig. 3], 1878.

In my report on the flora of the Raton formation [86] I gave the following account of the present disposition of this species:

Viburnum contortum was described originally from Black Buttes, Wyo., where it was found in association with such well-known forms as *Ficus planicostata* and *Ficus latifolia*. At the time it was founded Lesquereux stated that it might perhaps be considered as merely a variety of *Viburnum marginatum* [*Platanus marginata*], and in "The Tertiary flora" he so considered it and merged the name of *V. contortum* with *marginatum* and placed the two specimens figured (the types of *contortum*) under that name. This disposition by Lesquereux has been accepted until the present time, though all who have compared the figures given under *Viburnum marginatum* could hardly have failed to note the marked difference between them, particularly in shape, the one being broadly obovate with a truncate or rounded apex and the other with an acuminate apex. If leaves of the *contortum* type were only found in direct association with the *marginatum* type, it might perhaps be permissible to allow them to remain together, but where leaves that are obviously of the type of *contortum* are found at widely distant points where they are not associated with the *marginatum* type, it seems best to regard them as specifically distinct.

A specimen that is almost exactly similar to Lesquereux's Figure 2 was found in the Raton formation and is figured in the report above quoted. The only noticeable difference is the possession of fewer, slightly larger teeth.

The leaf figured here under the name *V. contortum* is rather fragmentary, lacking all of the apical portion. The base including the petiole is fairly complete, and the nervation is strongly preserved. The preservation of the margin is only sufficient to show two or three of the lower sharp teeth. Although this leaf so far as it is preserved agrees perfectly with Lesquereux's figure, as well as with the Raton specimen, so much of the upper portion is wanting that it seems best to question the identification.

Occurrence: Dawson arkose, Rice's clay bank, 1 mile southwest of Calhan, Colo., collected by F. H. Knowlton, July, 1910. Raton formation, Rockland mine, Cucharas Canyon, Colo. Black Buttes coal group, Black Buttes, Wyo.

Viburnum? heterodontum Knowlton, n. sp.

Plate 55, Figure 2

Leaf firm or coriaceous, approximately circular, truncate or very slightly heart-shaped at the base but equally rounded in other portions; margin conspicuously but rather finely serrate, the teeth of two sizes, a series of slightly larger ones which are entered by the principal branches of the nervation and a smaller, more irregular series of intermediate teeth; nervation strong, palmately 5-ribbed from the base of the blade, the central or midrib perfectly straight and bearing in the upper part one or two pairs of alternate, forked, craspedodrome secondaries; lowest pair of ribs at an angle of about 40°, passing with a slight upward curve to a marginal tooth, and bearing on the outside only six or seven strong secondary branches, which are mostly simple and enter the marginal teeth; other pair of ribs dividing about equally the space between the midrib and lower pair of ribs, very strong, much curved upward, each with three or four very strong secondary branches on the outside, each of which forks and passes to the larger marginal teeth; nervilles numerous, strong, mainly percurrent and at right angles to the primary branches of the nervation, between which they pass.

The single example here figured is apparently all of the species thus far brought to light, and even this is not quite perfect, as it lacks the major portion of one side. This leaf appears to have been of very firm texture, nearly circular, with the margin bearing numerous rather small teeth of two distinct series—a

[86] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 101, p. 346, 1917 [1918].

southern Colorado, with which it appears to agree in shape, but it has apparently a camptodrome instead of a somewhat craspedodrome secondary nervation. In general appearance and the finer nervation it is quite similar to the Raton species.

Occurrence: Dawson arkose, lower part (in beds equivalent to Arapahoe formation), 3,000 feet east of the Douglas coal mine, Sedalia, Colo., collected by Arthur Lakes.

Phyllites denverensis Knowlton, n. sp.

Plate 59, Figure 5

The material preserved on a red baked shale from the vicinity of Ramah, Colo., contains a number of fragments of a large palmately ribbed leaf that can not be made out with distinctness. The best preserved of these specimens is shown in the figure. As nearly as can be discerned it was an ovate leaf with a broad, shallow heart-shaped base and sharply serrate margin. The most conspicuous feature is the extremely large petiole, which is about 8 centimeters long and nearly 2 millimeters thick. The petiole splits at the lower border of the blade into three strong branches, of which the midrib is the strongest. The midrib has a single pair of alternate secondaries on the preserved portion. The lateral ribs arise at an angle of about 45° and have several strong, somewhat irregular secondary branches on the outside, the lower pair with tertiary branches on the lower side. The finer nervation consists of numerous strong, irregular nervilles. The width of this leaf was at least 10 centimeters. It has about 5 centimeters of the length preserved, but there is no means of knowing its total length.

So little of this leaf is present that its probable affinity is difficult to determine. In some respects it suggests the genus *Tilia*, but it could hardly be referred to this genus, and it must await adequate material for its allocation. The obvious size, long, thick petiole, three ribs, and serrate margin will probably permit its recognition if it should be subsequently found.

Occurrence: Denver formation, red, baked shale near Ramah oil well, in the SE. ¼ sec. 33, T. 9 S., R. 61 W., Colo., collected by C. W. Cooke for G. B. Richardson, 1910.

Phyllites sp.

Plate 56, Figure 3

The little leaf here figured is the only one of its kind noted in the collections. It is so fragmentary that ordinarily a description would hardly be worth while, but the portion preserved is so well marked that it may be included. It was apparently ovate, probably about 3 centimeters long and 2 centimeters wide, slightly heart-shaped at the base, and with entire margins. The petiole is short—about 7 millimeters—and comparatively very stout. The midrib is extremely thick, and the lowest pair of secondaries are of the nature of ribs. They arise at the very top of the petiole and have three or four camptodrome tertiary branches on the outside and an equal number on the upper side, which join the next secondary above. The number of secondaries is not known, though there were at least three pairs, all opposite and at an angle of 45° or 50°. The finer nervation is not retained.

Occurrence: Dawson arkose, dump of Mosby coal mine, Mosby, Colo., collected by F. H. Knowlton and G. B. Richardson, 1910.

Phyllites calhanensis Knowlton, n. sp.

Plate 56, Figure 1

The collection obtained near Calhan, Colo., includes among many other leaves a specimen with its counterpart that is here figured. It is evidently a leaflet, being unequal-sided and slightly arcuate. It is lanceolate, about equally narrowed to both base and apex, and entire margined. The length is 4 centimeters and the width 1.75 centimeters. The petiolule is hardly more than 3 millimeters long. The nervation, with the exception of the midrib, is very obscure. The midrib is strong, and there appear to be several pairs of light, much curved secondaries. The secondaries are obscured by the thick substance of the leaflet.

In the absence of adequate information concerning the nervation it is impossible to place the leaflet satisfactorily. It is not unlike some species of *Sapindus*, such as *Sapindus affinis* Newberry,[89] from the Fort Union formation, but it is too obscure for certainty. It also resembles certain leguminous leaves and leaflets, but again the obscurity of the nervation precludes positive identification. Under the circumstances it seems best placed under *Phyllites*.

Occurrence: Dawson arkose, Rice's clay bank, 1 mile southwest of Calhan, Colo., collected by F. H. Knowlton, July, 1910.

Phyllites pellucidus Knowlton, n. sp.

Plate 39, Figure 2; Plate 56, Figure 4

In the material collected near Calhan, Colo., there are a number of very fragmentary leaves that seem to merit description. Two of the largest and best preserved of the fragments have been figured. These leaves were thin in texture. The outline is difficult to make out beyond the fact that the apex was prolonged into a rather narrow acuminate point. The margin is toothed and the teeth are low, sharp-pointed, and separated by very shallow sinuses. The width

[89] Newberry, J. S., The later extinct floras of North America: U. S. Geol. Survey Mon. 35, p. 116, pl. 30, fig. 1; pl. 40, fig. 2, 1898.

was at least 9 centimeters and the length could hardly have been less than 12 or 15 centimeters. The nervation consists of an apparently straight midrib and numerous pairs of opposite or subopposite secondaries at an angle of about 45°; the secondaries are craspedodrome. The nervilles are relatively strong and are both percurrent and broken.

It is difficult with fragments of the size available to suggest affinities for these leaves.

Occurrence: Dawson arkose, Rice's clay bank, 1 mile southwest of Calhan, Colo., collected by F. H. Knowlton, 1910.

Carpites oviformis Lesquereux

Carpites oviformis Lesquereux, The Tertiary flora, p. 302, pl. 30, fig. 6a, 1878.

The type specimen of this species is in the United States National Museum (No. 266) and is preserved on the same piece of matrix with a small leaf of *Ficus auriculata*. It has suffered to a considerable extent in the years that have intervened since it was described, and at present is so worn that little can be made out concerning it. It was described by Lesquereux as follows:

> Fruit exactly ovoid, 10 millimeters long, 6 millimeters broad in the middle. This small nut is apparently a hard drupe, as it is not flattened by compresson. Its surface is neither striate nor lineate but somewhat rough.

I have not found this species in the large collections made by Lakes and others, but in the material acquired by the National Museum with the collections donated by R. D. Lacoe there is a single specimen (No. 51027) that was referred to *Carpites oviformis* by Lesquereux, who identified and labeled these collections. It is a smooth, ovoid fruit about 12 millimeters long and 8 millimeters broad and appears to be slightly narrowed at one end. Lesquereux compared this fruit to that of *Prunus scottii* Heer, from Greenland, but it is unwise to attempt a definite allocation or interpretation of possible affinity.

Occurrence: Denver formation, Golden, Colo., collected by Leo Lesquereux, about 1875. Additional specimen from Lacoe collection.

Carpites quadrivalvis Knowlton, n. sp.

Plate 56, Figure 2

Fruit small, narrowly conical, ligneous, apparently 4-valved, the sutures deeply furrowed, the backs of the valves rough, with strong transverse lines or ridges.

This little fruit appears to be a 4-valved capsule, as it shows one valve complete and portions of two others, one on each side of the perfect one, which probably means that there is a similar one on the concealed side. It is narrowly conical in shape, about 11 millimeters long, obtuse or truncate at the base and acute at the apex. The perfect valve is about 2 millimeters wide in the middle. The back of this valve and the sides of the lateral valves are thick and raised above the suture and are crossed by deeply impressed fine lines which are often broken.

The affinity of this fruit has not been recognized.

Occurrence: Dawson arkose, Palmer's road, Templeton Gap, 4 miles northeast of Colorado Springs, Colo., sandy bed 6 feet thick, about 90 or 100 feet above base of section, collected by F. H. Knowlton, July, 1910.

Carpites templetoni Knowlton, n. sp.

Plate 58, Figure 6

In one of the small collections from the Dawson arkose at Templeton Gap, above Colorado Springs, I find two small fruits that do not appear to be described. The best-preserved specimen—the one here figured—is circular, about 6 millimeters in diameter, and compressed to a thickness of about 1 millimeter. The unfigured specimen is only about 5 millimeters in diameter but does not otherwise differ. The figured specimen has a number of rather strong ridges, but their direction and character are uncertain. The surface otherwise is apparently roughened or possibly striate, but this is also uncertain. The point of attachment is not shown, hence it is impossible to orient the specimen with any certainty of this being its correct position.

These little fruits have somewhat the appearance of certain thin-fleshed "berries" of certain palms, but obviously this is hardly more than conjecture.

Occurrence: Dawson arkose, Palmer's road, Templeton Gap, 4 miles northeast of Colorado Springs, Colo., sandy bed 6 feet thick, about 90 or 100 feet above base of section, collected by F. H. Knowlton, July, 1910.

Carpites rostellatus Lesquereux

Carpites rostellatus Lesquereux, The Tertiary flora, p. 303, pl. 60, figs. 11, 12, 1878.

The figured types of this species are preserved in the United States National Museum (No. 503). They are recorded by Lesquereux as coming from Golden, Colo., a reference that is sustained by the Museum record as well as by the matrix in which they are preserved. In the same box and under the same number is another unfigured specimen, preserved in a very hard, nearly black matrix unlike anything known from Golden. It is close to but possibly not identical with the other specimens of *Carpites rostellatus*. It is probably from older rocks, possibly from the Laramie of Coal Creek, Boulder County, Colo., but this is not known positively.

At first it was thought that *Carpites rostellatus* should be referred to *Ginkgo? truncata*, and it is still

possible that this should be done, but they are much more distinctly and prominently ribbed than any so referred. Nothing exactly like this species has been noted in the recent collections.

Occurrence: Denver formation, Golden, Colo., original collections probably made by Leo Lesquereux about 1875.

Carpites costatus Lesquereux

Carpites costatus Lesquereux, The Tertiary flora, p. 303, pl. 60, fig. 5, 1878; U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1876, p. 520, 1878.

The type of this species is No. 497 of the United States National Museum collection and appears to be the only example obtained. It represents the base of a fruit with the scar of attachment. Its affinity has not been made out.

Occurrence: Denver formation, South Table Mountain, Golden, Colo.

Carpites coffeaeformis Lesquereux

Carpites coffeaeformis Lesquereux, The Tertiary flora, p. 303, pl. 60, figs. 6, 7; U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1876, p. 520, 1878.

The types of this species are Nos. 495 and 502 of the United States National Museum collection. They represent the only examples thus far discovered and have been as well described and figured by Lesquereux as the specimens warrant. Their affinity has not been made out.

Occurrence: Denver formation, Golden, Colo.

Carpites minutulus Lesquereux

Carpites minutulus Lesquereux, The Tertiary flora, p. 305, pl. 60, fig. 25, 1878; U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1876, p. 520, 1878.

This specimen, which represents, so far as known, the only one ever obtained, is not to be found in the collection of the United States National Museum, where it should be. There is no record of its having been sent here, and it is undoubtedly lost. It was described by Lesquereux as follows:

> Seeds very small, 3 millimeters long, only half as broad, inflated and rounded at one end, gradually narrowed to a short acumen, smooth. * * * It is mixed with fragments of stems and branches which appear to belong to some conifer.

Occurrence: Denver formation, South Table Mountain, Golden, Colo.

Carpites myricarum Lesquereux

Carpites myricarum Lesquereux, The Tertiary flora, p. 303, pl. 60, figs. 8–11, 1878.

This species was recorded by Lesquereux as having come from Black Buttes, Wyo., but at least one of the type specimens (the original of Lesquereux's pl. 60, fig. 9, equivalent to No. 499, U. S. Nat. Mus.) certainly came from the andesitic beds at Golden, Colo. Only one additional type specimen (the original of pl. 60, fig. 10) has ever been the property of the United States National Museum, so far as the records show. This probably came from Black Buttes, as recorded by Lesquereux.

Carpites myricarum is obviously close to *Carpites laurineus* Lesquereux, which is now referred to *Ginkgo? truncata*. Lesquereux interpreted *Carpites myricarum* as being seeds, which he says resemble large seeds of *Myrica*, but *Carpites laurineus* was thought to be a berry. Be this as it may, it is thought best to keep *C. myricarum* as a distinct species, at least until additional examples can be procured.

Occurrence: Denver formation, Golden, Colo., Black Buttes coal group, Black Buttes, Wyo.

Carpites coryloides Knowlton, n. sp.

Plate 58, Figures 3–5

One of the collections from the Dawson arkose on Jimmy Camp Creek, east of Colorado Springs, contains several specimens of a fruit that seems worthy of description. It was evidently a hard nut inclosed in a thick fibrous covering or "husk," somewhat after the manner of the common hazelnut and its inclosing covering. The nut itself is ovoid, about 22 millimeters long and 12 or 14 millimeters broad. It is somewhat angled, though doubtless it has been more or less distorted and compressed by fossilization. The outer covering was about 30 millimeters long.

The most instructive specimen with its counterpart is that shown in Figures 3 and 4. In Figure 3 the outer covering is shown. It is emarginate at the base, as if it fitted around an axis of some kind. The depression in which the nut rested is well shown. The counterpart shown in Figure 4 shows the nut lying in the opposite half of the outer covering. The nut is considerably flattened. In Figure 5 the nut has not been so much distorted, though the outer covering is not well preserved.

Occurrence: Dawson arkose, east bank of Jimmy Camp Creek opposite Richfield Springs ranch house, 9 miles east of Colorado Springs, Colo., collected by A. C. Peale, September 18, 1908.

Eriocaulon? porosum Lesquereux

Eriocaulon? porosum Lesquereux, U. S. Geol. and Geog. Survey Terr. Ann. Rept. for 1873, p. 396, 1874; The Tertiary flora, p. 106, pl. 16, figs. 2, 2a, 1878.

Lesquereux's original description reads as follows:

> 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 petiole; median

nerve broad, concave; lateral veins two, nearly parallel, with apparent ramifications toward the borders, forming round polygonal small areolae.

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 compared, except the leaves of some large rosulate *Eriocaulon*. The specimen is cut through by rootlets as thick as the leaves are broad.

Thus far the type specimen, which is before me as I write (U. S. Nat. Mus. No. 137), is the only one that has been found. The type specimen is preserved on a piece of soft, fine-grained clay and has been fairly well described and figured by Lesquereux. It is preserved on and partly wrapped around the end of the piece of matrix, and the "leaves," therefore, do not all lie in the same plane. Apparently, however, as Lesquereux supposed, they were disposed in a circle, possibly around a stem. The nervation in these "leaves" is uncertain. There is clearly a strong central nerve or midrib and apparently about two thinner ribs on each side, but the remainder is obscure and uncertain. The "leaf" was evidently a very thick and leathery one, and the surface has been more or less wrinkled, in addition to which there are numerous obvious joint checks, so that any actual nervation, if present, is difficult to make out. It seems probable, however, that some of the meshing or areolation must belong to the nervation.

In subsequent years a number of organisms were found, mainly in older rocks, that were at first thought to be at least congeneric with the *Eriocaulon? porosum* of Lesquereux. They were mostly isolated "leaves" or segments, though occasionally several were found that showed these segments pretty closely associated. It was not, however, until some very perfect examples were found in the Vermejo formation in the Canon City field of Colorado that the distinctness from Lesquereux's species became clear. These were described under the name *Palaeoaster inquirenda* Knowlton,[90] with the frank admission that their affinity was unrecognized. They consist of 8 to 12, usually about 9 narrow, erect "leaves" or members 3.5 to about 4.5 centimeters long and 6 to 10 millimeters wide in the middle. They are slightly narrowed to the sessile base, where they are in contact, though evidently perfectly free from each other. Above they are narrowed to a very slender acuminate point, usually somewhat incurved. The segments are thick and leathery, if not indeed woody, and are traversed dorsally by a deep median furrow. These specimens, preserved in rather coarse sandstone, show very little trace of structure other than the median rib.

[90] Knowlton, F. H., U. S. Geol. Survey Prof. Paper 101, p. 278, pl. 69, figs. 5, 6, 1917 [1918].

It seems probable that these organisms were terminal, for there is some evidence of the presence of a scar or point of attachment at the base, but no axis on which they might have stood has ever been noted. They are certainly not leaves whorled around a stem, for, had they been, some trace of the stem should have been detected in some of the numerous specimens. It appears much more likely that they were capsular in nature, for, if the now spreading segments were brought together, they would apparently make a tightly closed "capsule." The incurved tips of the segments lend support to this view, though no evidence of seeds or other interior structure has been observed.

Among the several lots of specimens from the Raton Mesa region there is one found near Walsenburg that consists of a number of detached leaves or segments. Only three or four leaves are preserved on any piece of matrix, but these seem to arise from a central point, as in the other examples referred to *Palaeoaster inquirenda* and as in the type of *Eriocaulon? porosum*. The leaves in these Walsenburg specimens are rather longer and narrower than common, and they appear, if anything, to have been thicker, as shown by the layer of carbonaceous matter remaining in favored places. The midrib is very deeply impressed—channeled, in fact—and at right angles to it there are minute parallel lines connecting with the margin. These specimens approach most closely *Eriocaulon? porosum*, and it is possible that they should be united. However, the specimens involved are so few in number and their nature so obscure that it seems best to hold them apart until more conclusive data are forthcoming. It is, of course, practically certain that Lesquereux's species has no connection whatever with the genus *Eriocaulon*, but, on the other hand, it is not at all clear that there is any closer affinity.

The specimen from Black Buttes, Wyo., that was referred by Lesquereux [91] to *Eucalyptus haeringiana?* Ettingshausen is probably also congeneric with *Eriocaulon? porosum* and possibly also with the leaves above mentioned from Walsenburg. In any event it is fairly clear that this specimen has nothing to do with *Eucalyptus*.

Occurrence: Denver formation, Sand Creek about 12 miles east of Denver, Colo., supposed to have been collected by W. H. Holmes.

Genus BERRYA Knowlton, n. gen.

Generic characters the same as the specific characters.

[91] Lesquereux, Leo, The Tertiary flora, p. 296, pl. 59, fig. 10, 1878.

Berrya racemosa (Knowlton) Knowlton, n. comb.

Plate 41, Figures 4, 5

Nyssa? racemosa Knowlton, U. S. Geol. Survey Bull. 152, p. 153, 1898.

Sabalites fructifer Lesquereux [part], The Tertiary flora, p. 114, pl. 11, figs. 3 (fruits at base of figure), 3a (fruit enlarged), 1878.

Fruits in a compound raceme with a very thick, strong rachis; individual fruits 10 to 16 millimeters long, 4 to 6 millimeters in diameter, erect, short-pediceled, oblong, acute at both ends or sometimes slightly obtuse at apex, provided with probably about 12 to 15 faint longitudinal striae or ribs and very numerous, delicate transverse striae.

The type locality for this striking fossil is in the Denver beds at Golden, Colo. It is represented by two large, nearly perfect compound racemes, by a number of parts of racemes, and by a very considerable number of detached fruits. The larger and more perfect specimen was at least 8 centimeters long, with the rachis fully 2 millimeters thick. It is branched near the base into two nearly equal portions, along which the fruits are dispersed alternately, each branch bearing six or seven fruits.

The other of the more perfect specimens found had at least three branches—a lateral one, the base with five fruits; one on the opposite side and a little higher up with three fruits; and the basal portion of another branch still higher. Each fruit has a short, thick pedicel, from which it appears to have been detached at maturity by an abscission at the base of the fruit. Each fruit shows a number of longitudinal lines or ribs, the exact number of which can not be positively determined, though there appear to be about 12 or 15.

The transverse striae are very fine and delicate and may possibly have been produced by the wrinkling of a fleshy exocarp. These fruits appear to have been drupes with probably a thin, fleshy exocarp which in drying may have caused some of the corrugations observed, though it seems unlikely that this could have produced all of the very regular fine lines.

These fruits were first detected by Lesquereux, who found them in close association with a small pinnate palm leaf on a small piece of matrix. On account of this association Lesquereux concluded that they represented the fruit of this palm. The original specimen upon which this determination rests is preserved in the United States National Museum under the name *Sabalites fructifer*. It needs but a glance at this specimen, or indeed at the well-executed figure of it, to show that there is no organic connection between them, nor is such union implied by Lesquereux. On this point he said: "The fruits are probably referable to the same species, as they are not only seen at the base of the leaf but more numerous still embedded in the stone." The specimen consists of the upper part of a raceme with three fruits.

It was with much hesitation that these fruits were at one time referred to the genus *Nyssa*. It had not then been found possible to locate a living genus to which they could be referred with reasonable certainty, and they were placed tentatively in *Nyssa* mainly on account of slight resemblance to certain fossil fruits that have been described under this generic name.

The fossil species to which the fruits from Golden show the most resemblance is perhaps *Nyssa arctica* Heer,[92] from the Eocene of Cape Lyle, Spitzbergen. It differs in being much larger (17 to 21 millimeters long and 8 to 10 millimeters wide) and in having more numerous and more prominent longitudinal ribs. The transverse striae are of about the same character in both. There is no evidence that *Nyssa arctica* had the fruits arranged in a raceme, although several are figured as having two fruits sessile on the top of a short peduncle, as in the modern *Nyssa*.

Some of the more elongated fruits of *Nyssidium ekmani* Heer,[93] from Cape Staratschin, Spitzbergen, are also similar to the Golden fruits, but differ mainly in being smaller and apparently without transverse striae.

A number of other fruits from Cape Staratschin are described by Heer under the name *Nyssidium*, and although they all resemble in a general way the individual fruits of *Berrya*, their manner of growth is not at all similar.

Since this species was first made known it has been found at a number of localities in beds of approximately the same age. Thus it occurs in the Dawson arkose near Ramah, Colo., in the Raton formation near Raton, N. Mex., in the Animas formation on the northern rim of the San Juan Basin, Colo., and in the Black Buttes coal group at Black Buttes, Wyo.

I take pleasure in dedicating this genus to Prof. Edward Wilber Berry, professor of geology and paleontology in the Johns Hopkins University, Baltimore, Md.

Occurrence: Denver formation (type), Golden, Colo., probably collected by Lesquereux, about 1872; additional material, including the two figured specimens, collected by Arthur Lakes on the south face of South Table Mountain, 100 feet below the lava cap. Dawson arkose, Coal Gulch, about 2 miles northwest of Ramah, Colo., collected by W. T. Lee, 1914. Black Buttes coal group, Black Buttes, Wyo., collected by F. H. Knowlton and A. C. Peale in 1909. Raton for-

[92] Heer, Oswald, Flora fossilis arctica, vol. 4, p. 80, pl. 19, figs. 1–10, 1877.

[93] Idem, vol. 2, p. 62, pl. 15, figs. 1–7, 1870.

mation, Yankee mine, near Raton, N. Mex., collected by W. T. Lee. Animas formation, Ignacio quadrangle, Colo., pebbles near top of beds, collected by J. H. Gardner, 1909.

Decorticated roots?

Plate 58, Figures 1, 2

The collections from the Dawson arkose along Jimmy Camp Creek contain a large number of fragmentary specimens that appear to be decorticated roots or rootstocks, but their exact affinity has not been recognized. The largest portion of the main axis that is preserved is about 1 centimeter in diameter. It is slightly and irregularly ridged and also is finely striate. It gives off the "roots" at alternate intervals, these emerging at an angle of about 45° and of unknown length but at least 10 centimeters. The "roots" or rootstocks are more strongly ribbed or striate than the main axis and show a regular series of scars whence apparently finer roots have emerged. These scars, if this is what they are, are strong, fairly regularly disposed, and probably though not certainly spiral.

I have at present no knowledge as to the probable affinity of this plant.

Occurrence: Dawson arkose, east bank of Jimmy Camp Creek 0.6 mile above Richfield Springs ranch house, 9 miles east of Colorado Springs, Colo., collected by F. H. Knowlton and W. T. Lee, July, 1910.

PLATES

NOTE.—The museum numbers are given in parentheses—U. S. N. M., United States National Museum; M. C. Z., Harvard College Museum of Comparative Zoology, Cambridge, Mass.; Pr., Princeton University Museum, Princeton, N. J

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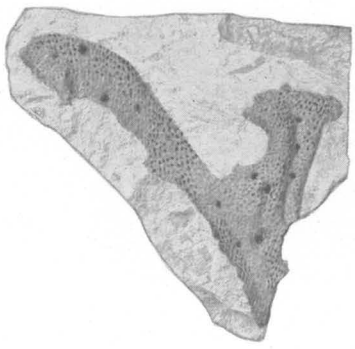

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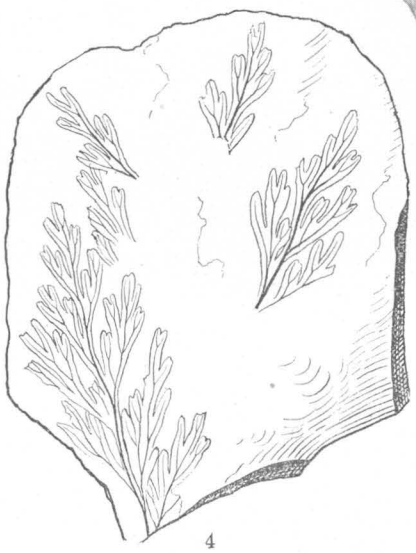

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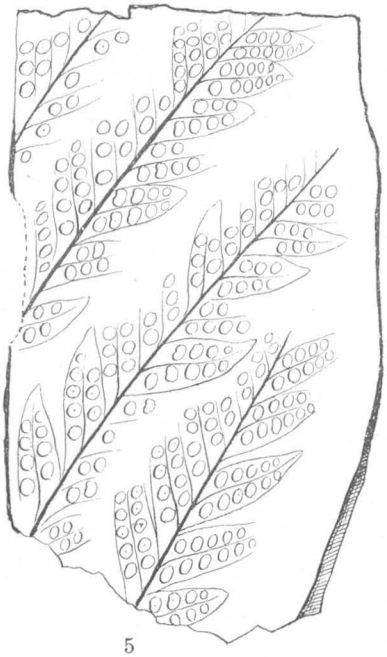

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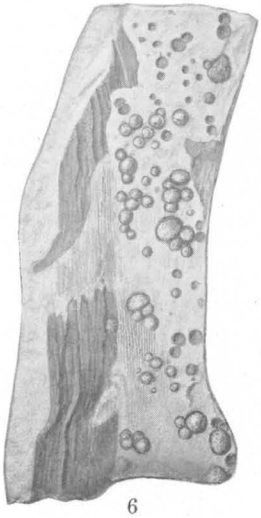

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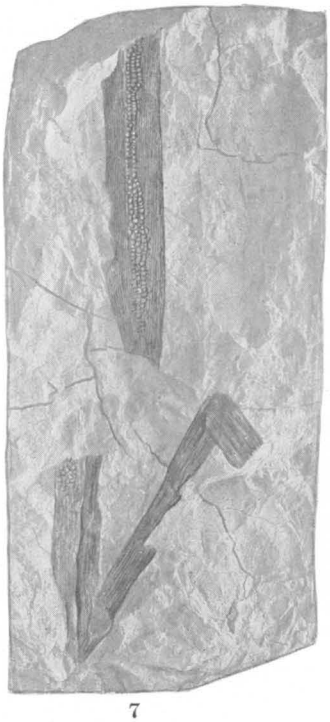
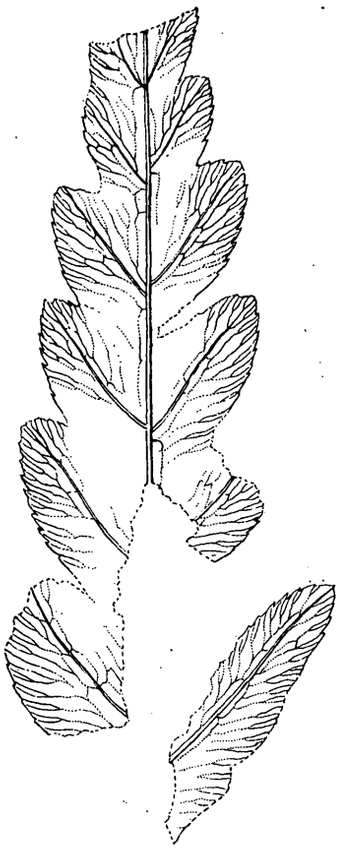


7

DENVER FLORA

1, 2. *Dryopteris lakesii* (Lesquereux) Knowlton, n. comb. (2, U.S.N.M. 37750), Denver formation.
3. *Marchantites? coloradensis* Knowlton, n. sp. (U.S.N.M. 37791), Dawson arkose.
4. *Hymenophyllum confusum Lesquereux* (U.S.N.M. 37782), Denver formation.
5. *Dryopteris integra* Knowlton, n. sp., Middle Park formation.
6. *Sclerotites? hesperius* Knowlton, n. sp., Dawson arkose.
7. *Sclerotites? cypericola* Knowlton, n. sp. (U.S.N.M. 37834), Dawson arkose.



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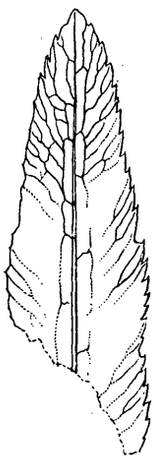

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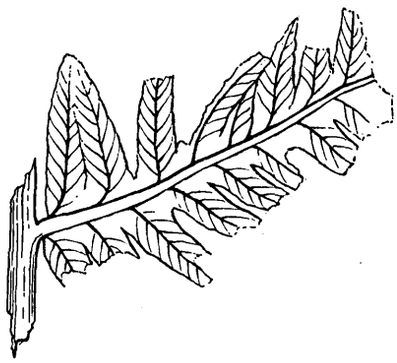

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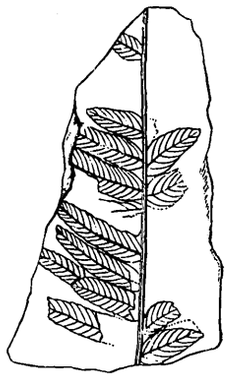

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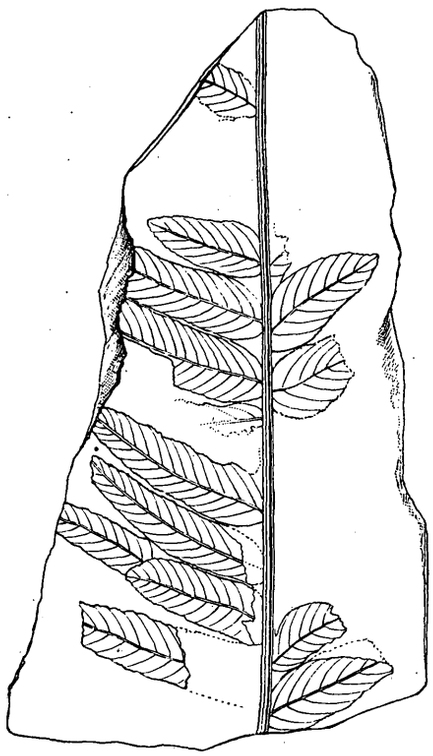

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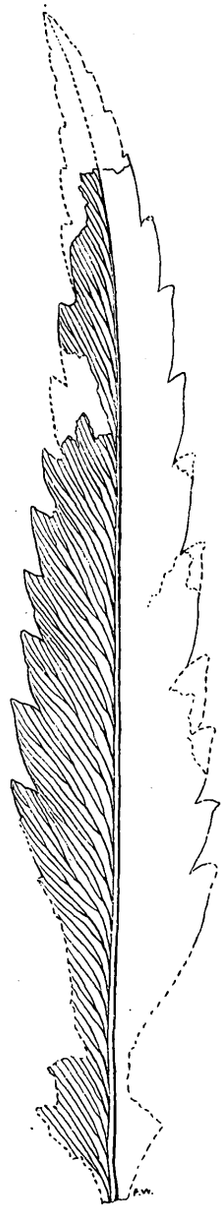

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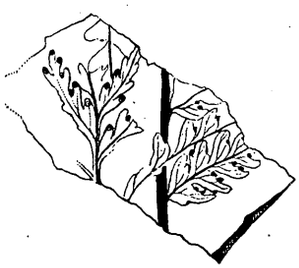

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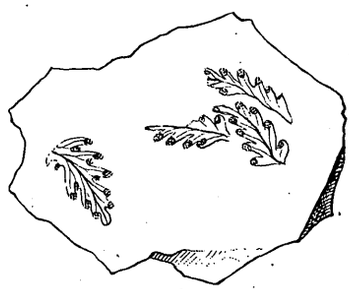

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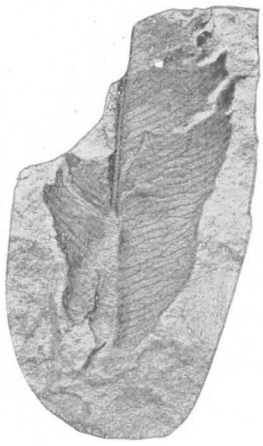
DENVER FLORA

1, 2. *Woodwardia latiloba serrata* Knowlton, n. var. (1, U.S.N.M. 37846), Middle Park formation. (1 × 2; 2 × 4.)

3–5. *Dryopteris richardsoniana* Knowlton, n. sp. (U.S.N.M. 37751), Dawson arkose.

6. *Diplazium crossii* (Knowlton) Knowlton, × 2 (U.S.N.M. 37752), Denver formation.

7–9. *Dennstaedtia crossiana* Knowlton, n. sp., Dawson arkose, lower part (in beds = Arapahoe formation). (8, single pinnule × 2.)



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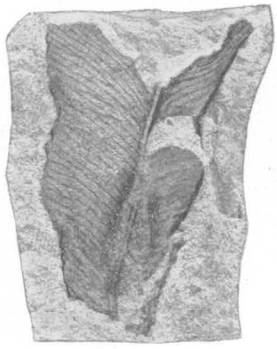

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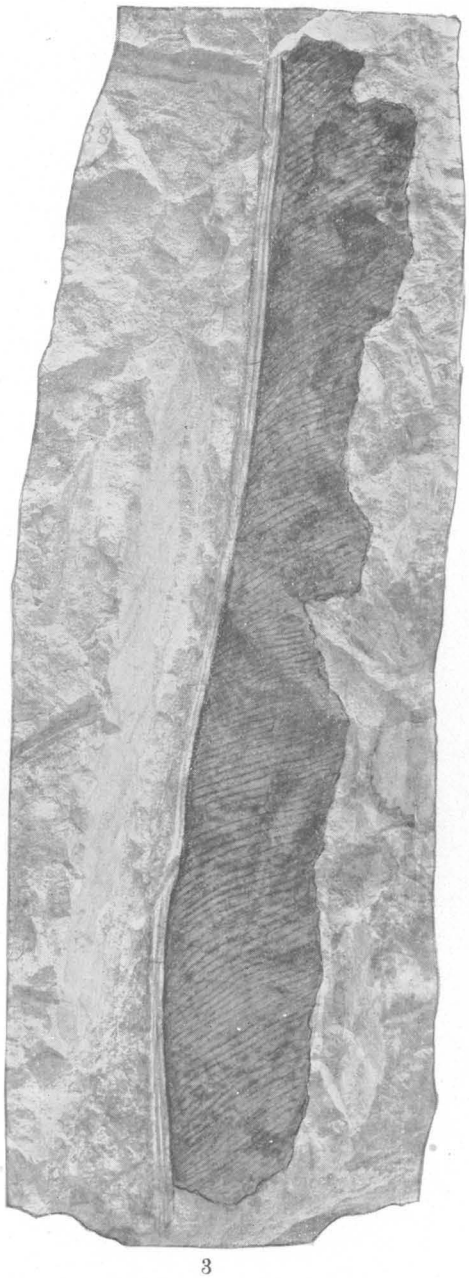

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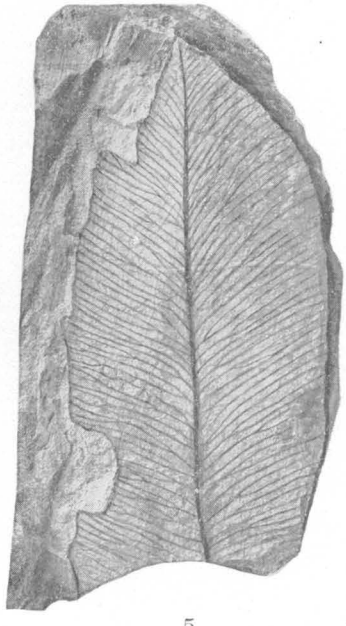

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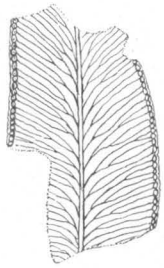

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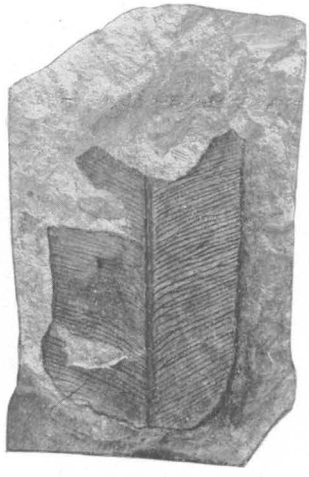

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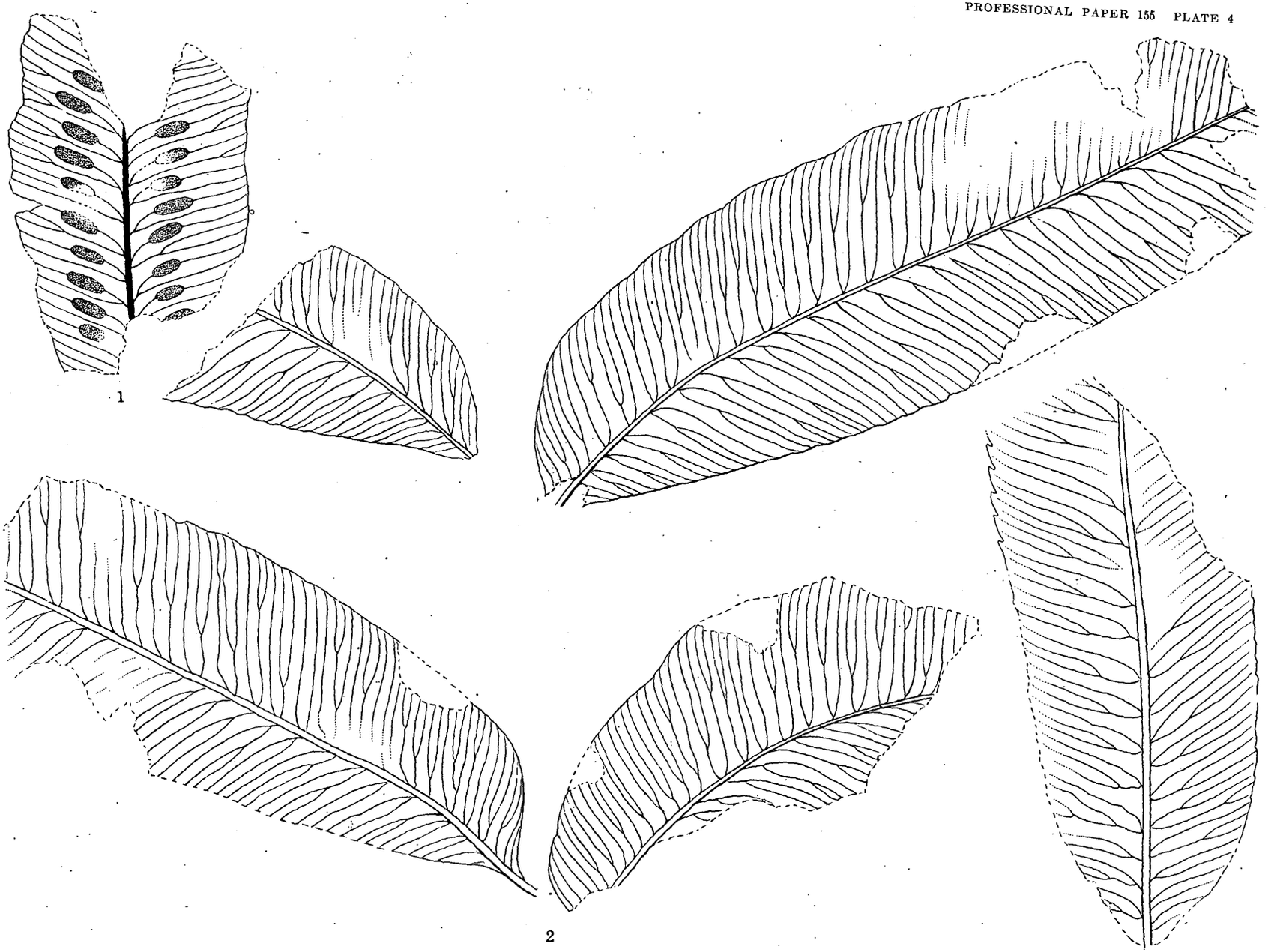
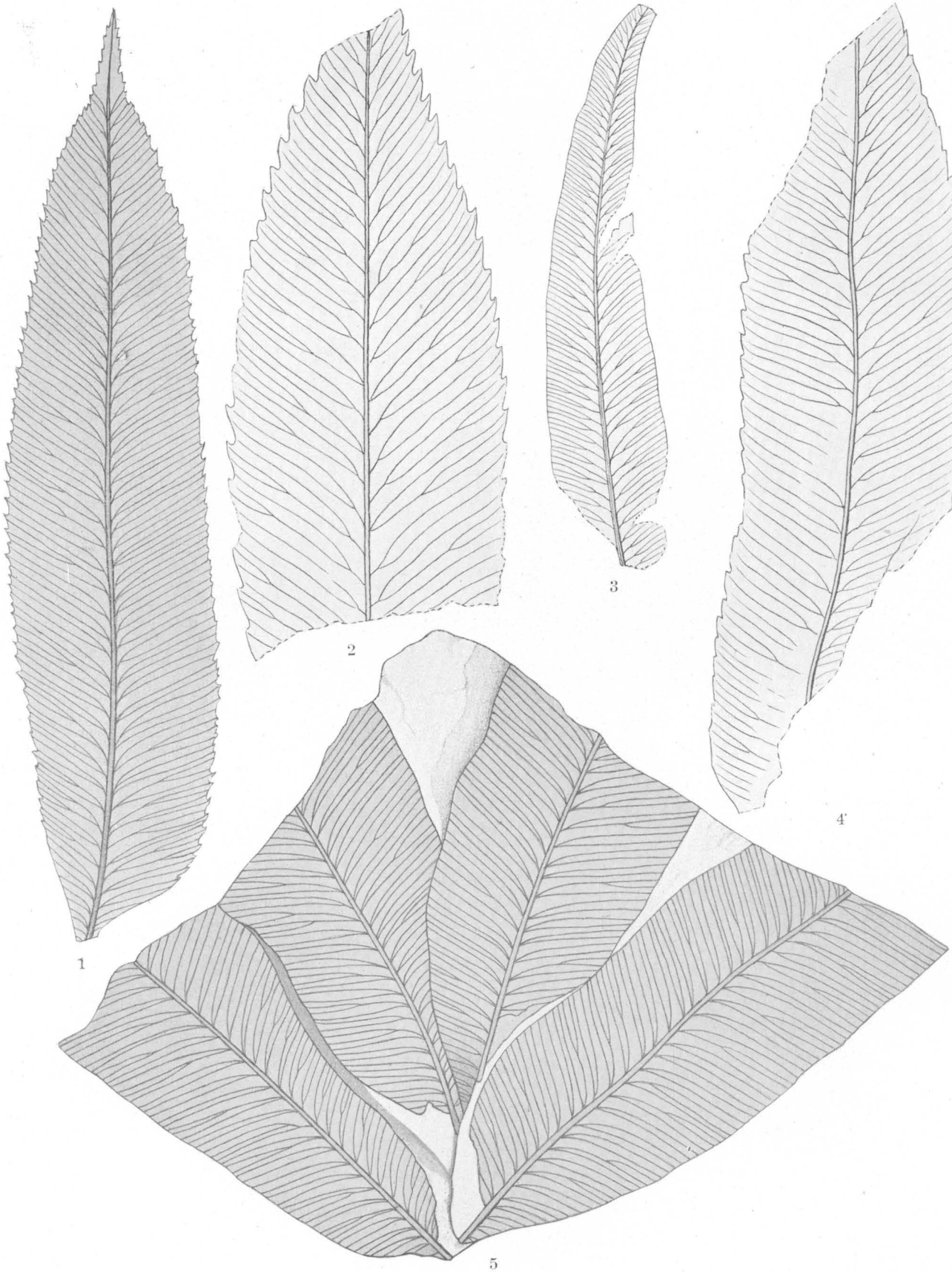
DENVER FLORA

1, 2. *Saccoloma* sp. Knowlton (U.S.N.M. 37831), Dawson arkose.
3–8. *Saccoloma gardneri* (Lesquereux) Knowlton (3, 5, 8, U.S.N.M. 37832; 4, M.C.Z. 853), Dawson arkose. (7, fruiting specimen.)



DENVER FLORA

Allantodiopsis erosa (Lesquereux) Knowlton and Maxon (U.S.N.M. 37712-37714). (1, fruiting specimen. All × 2.)

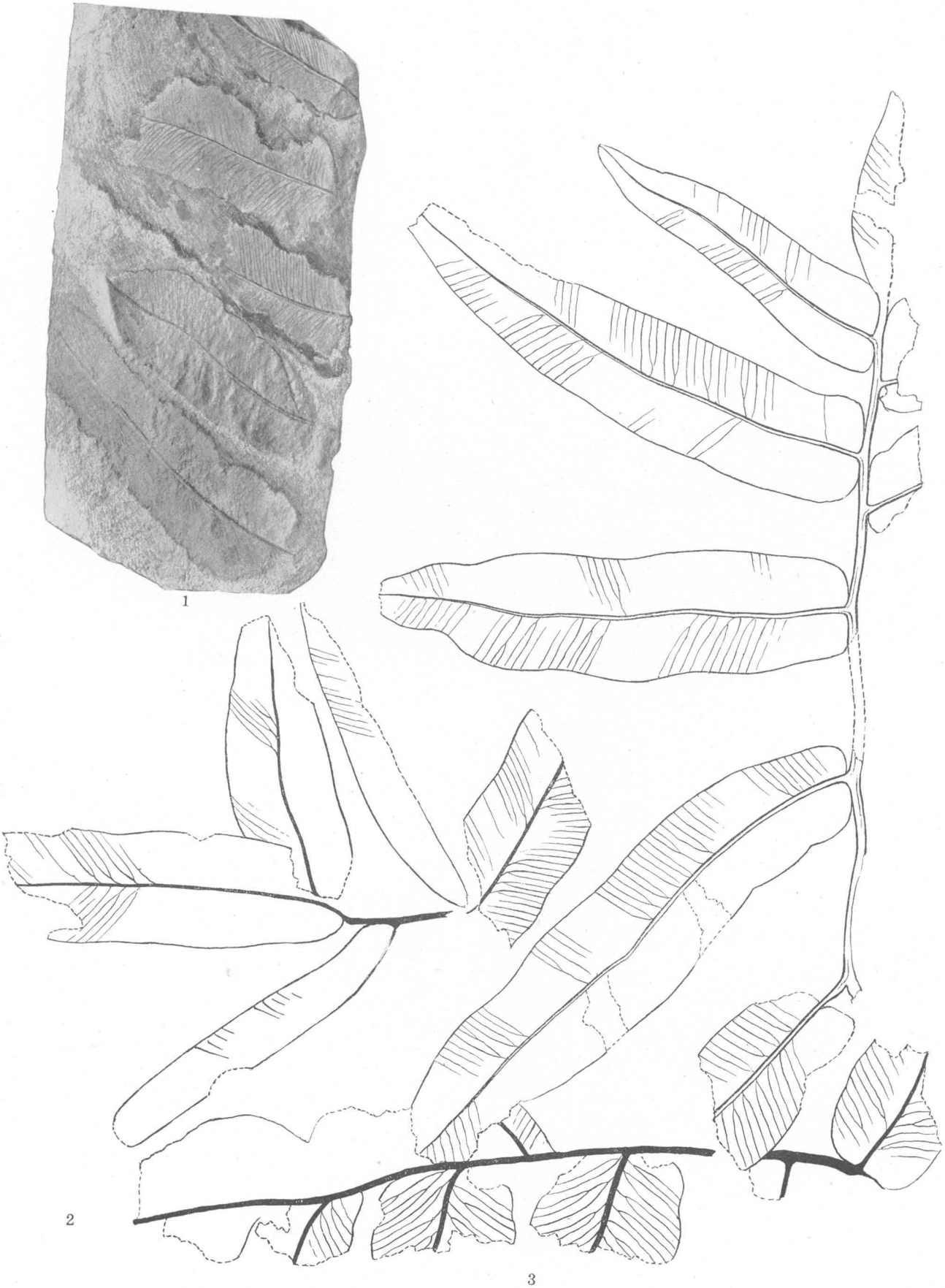


DENVER FLORA

Allantodiopsis erosa (Lesquereux) Knowlton and Maxon (1, U.S.N.M. 3618; 5, U.S.N.M. 37715). (1 and 5 after Lesquereux.)

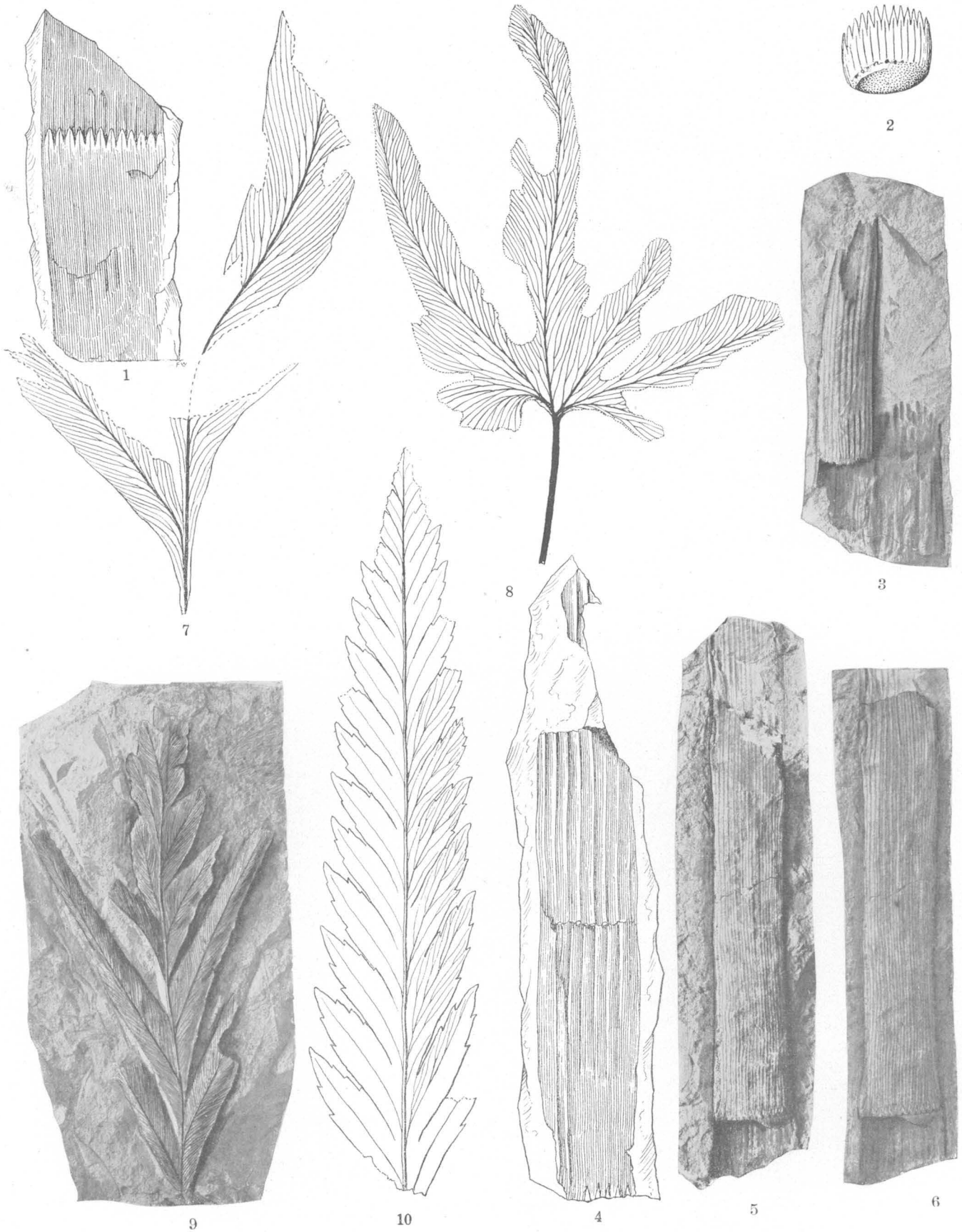
DENVER FLORA

Geonomites tenuirachis Lesquereux (U.S.N.M. 37777), Dawson arkose.



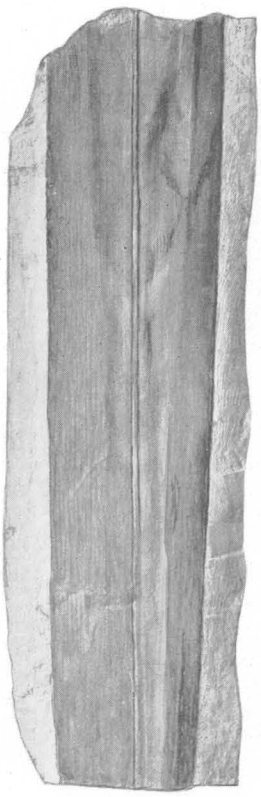
DENVER FLORA

Salpichlaena anceps (Lesquereux) Knowlton (1, M.C.Z. 852), Denver formation.



DENVER FLORA

1–6. *Equisetum coloradense* Knowlton, n. sp. (U.S.N.M. 37753). 1, 2, 4 × 2, Middle Park formation; 3, 5, 6 natural size, Dawson arkose.
7. *Anemia* sp. Knowlton, Middle Park formation.
8. *Lygodium coloradense* Knowlton, n. sp., Dawson arkose.
9. *Anemia mosbyensis* Knowlton, n. sp. (U.S.N.M. 37719), Dawson arkose.
10. *Anemia lanceolata* Knowlton, n. sp., Middle Park formation.



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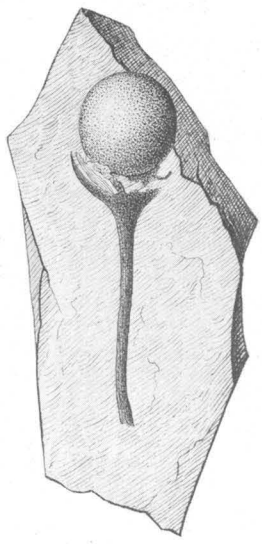

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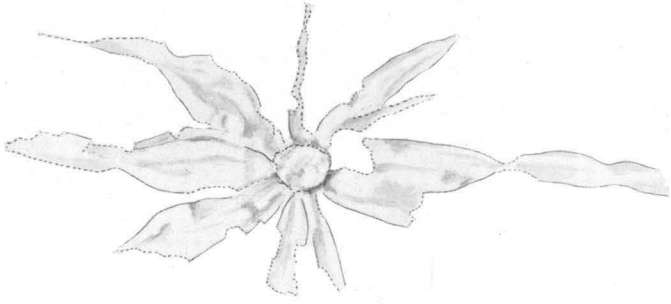

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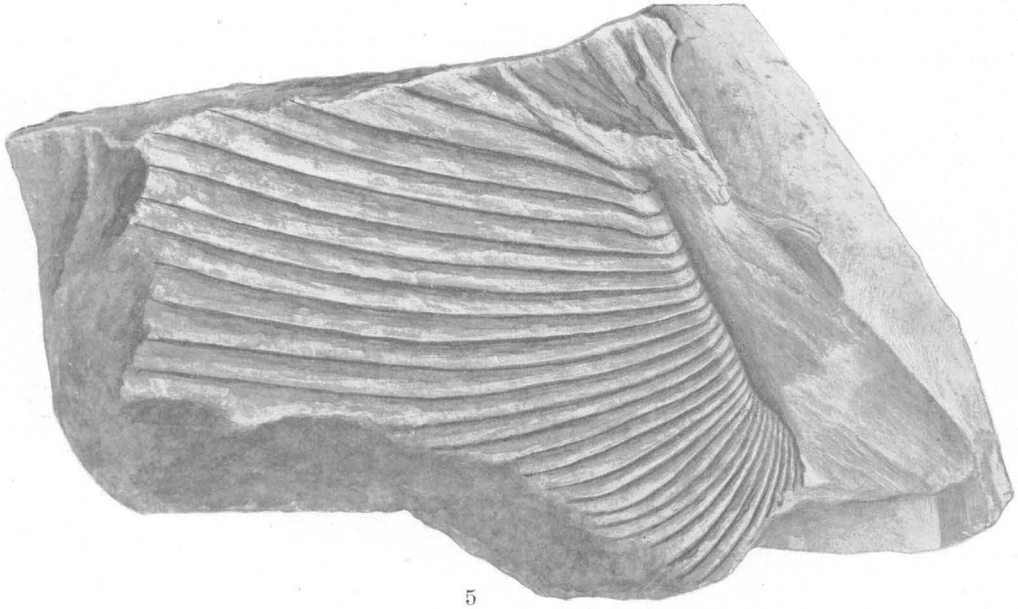

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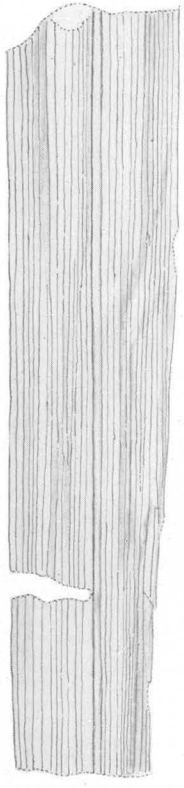
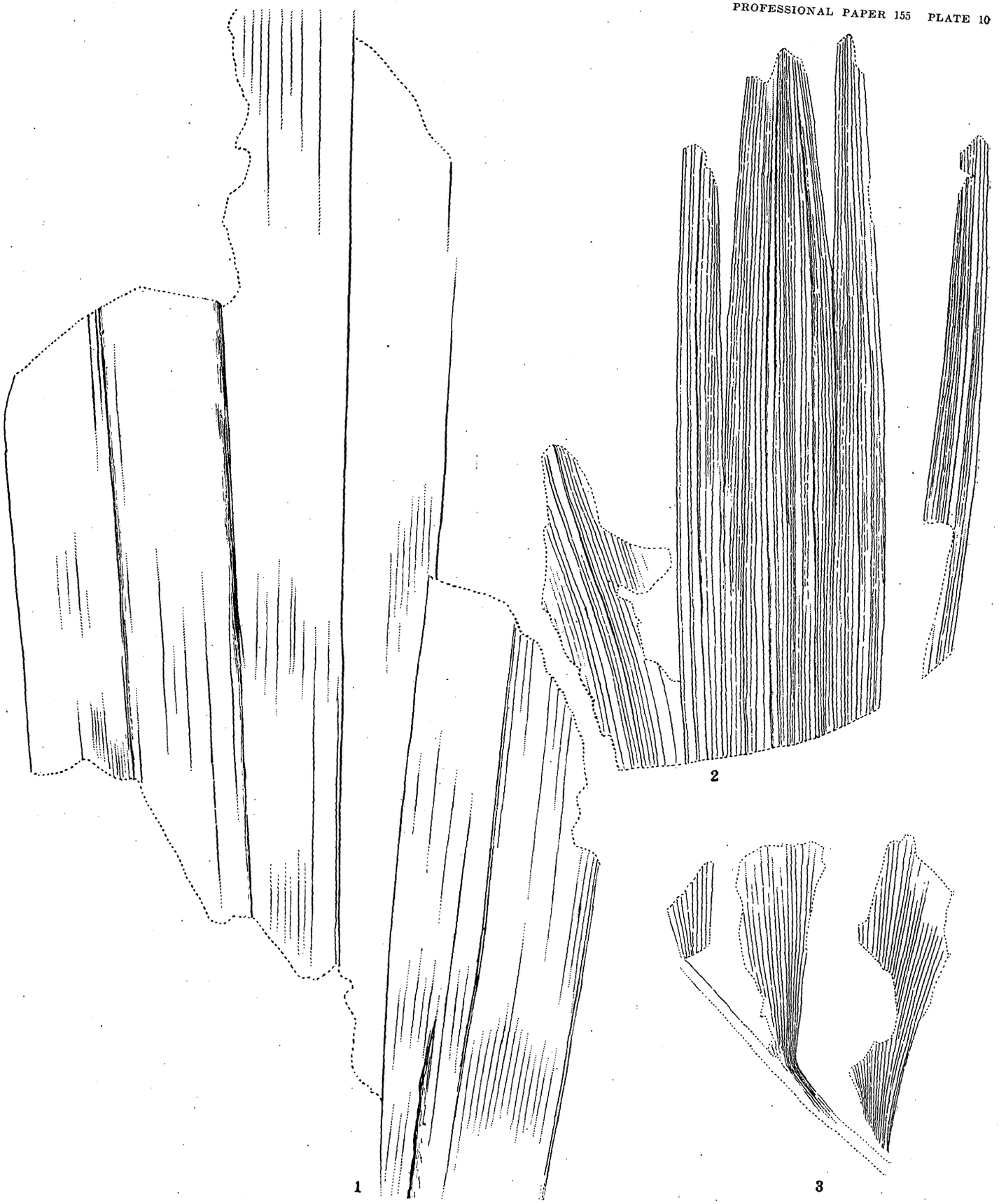


6

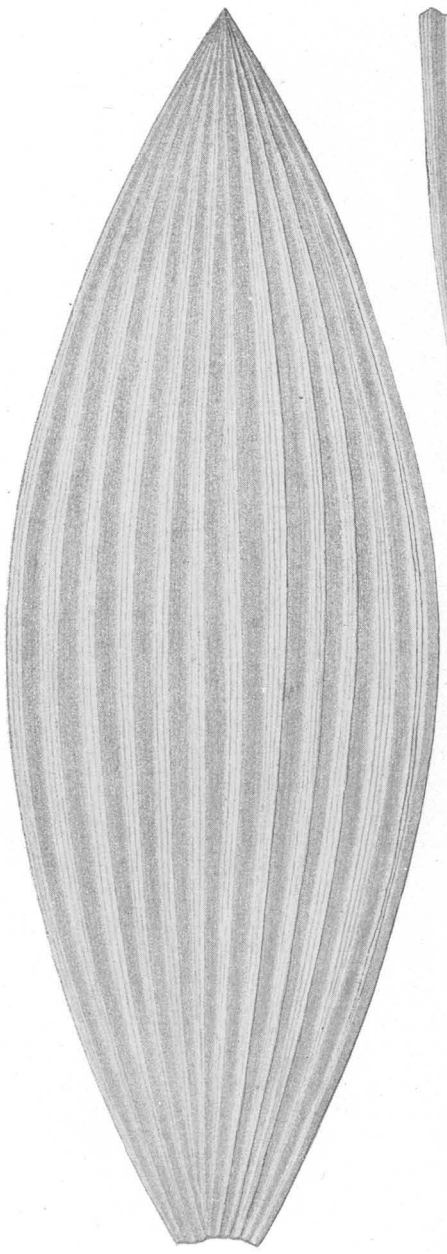
DENVER FLORA

1, 2, 6. *Geonomites tenuirachis* Lesquereux (1, U.S.N.M. 37778; 2, U.S.N.M. 37777), Dawson arkose.
3. *Ginkgo? truncata* (Lesquereux) Knowlton, n. comb., × 2 (U.S.N.M. 37780), Denver formation.
4. *Equisetum* sp. Knowlton (U.S.N.M. 37754), Denver formation.
5. *Sabalites grayanus* (Lesquereux) Lesquereux (U.S.N.M. 37830), Denver formation.



DENVER FLORA

1. *Geonomites?* sp. Knowlton (U.S.N.M. 37779), Denver formation.
2. *Geonomites goldianus* (Lesquereux) Lesquereux (U.S.N.M. 2059), Denver formation.
3. *Chamaedorea? coloradensis* Knowlton, n. sp. (U.S.N.M. 37727), Middle Park formation.



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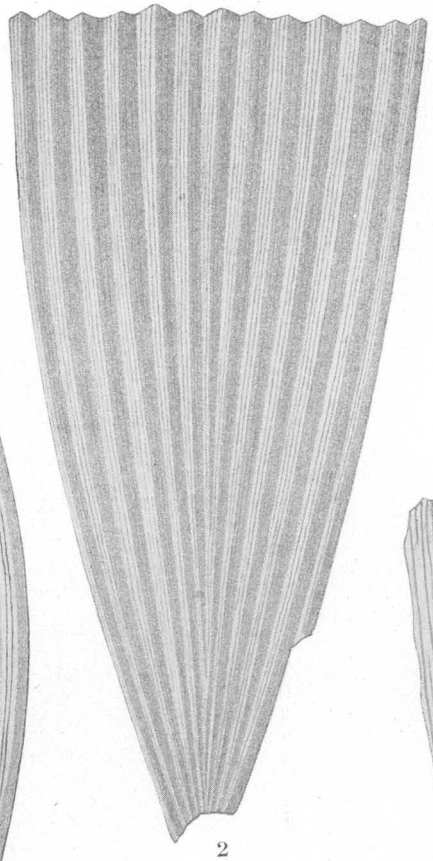

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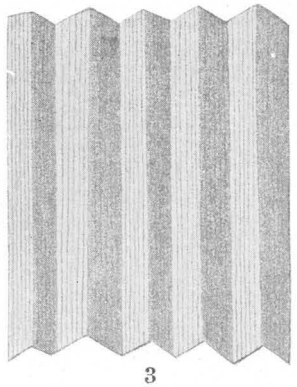

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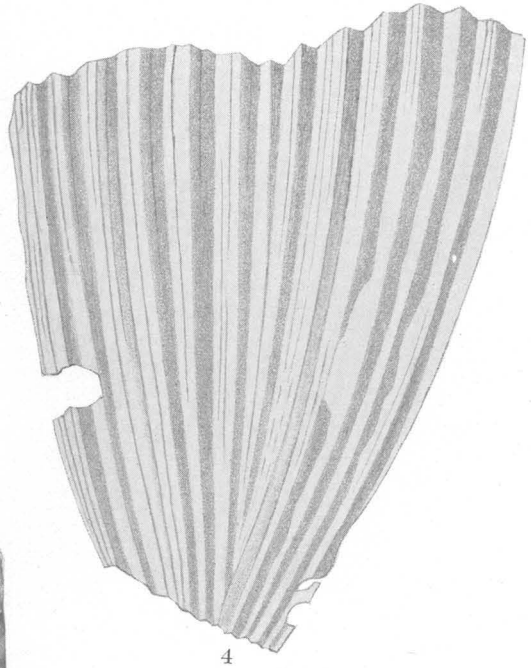

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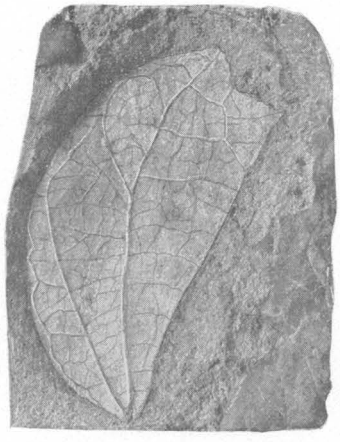

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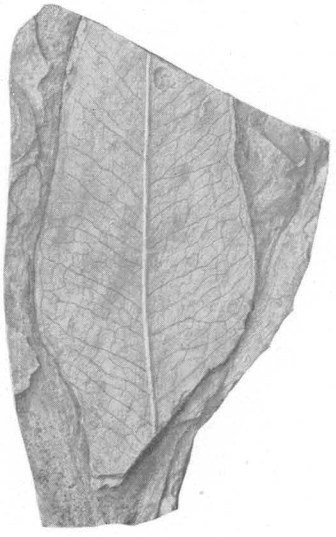


7

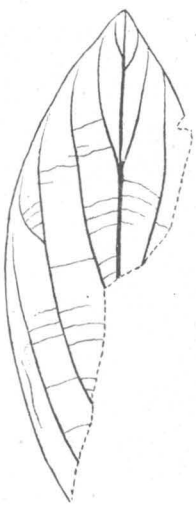
DENVER FLORA

1-4. *Paloreodoxites plicatus* (Lesquereux) Knowlton, n. comb., Denver formation.
5. *Palmocarpon? lineatum* Lesquereux (M.C.Z. 1616), Denver formation.
6. *Piper heeri* Lesquereux (M.C.Z. 1037), Denver formation.
7. *Myrica* sp. Knowlton (U.S.N.M. 37792), Dawson arkose.

1 2

DENVER FLORA

Juglans denveriana Knowlton, n. sp. (U.S.N.M. 2062, 2063), Denver formation.



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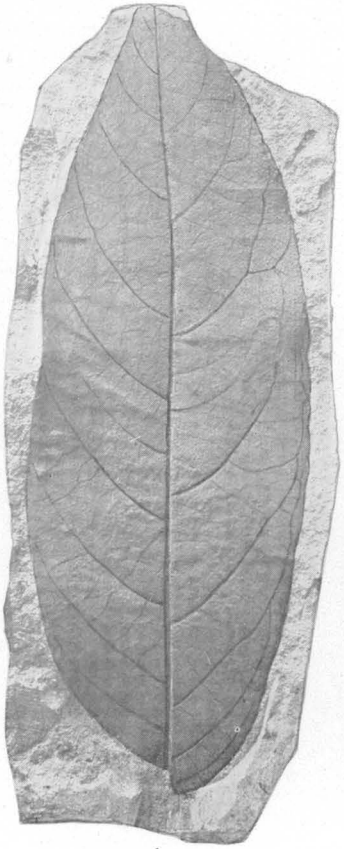

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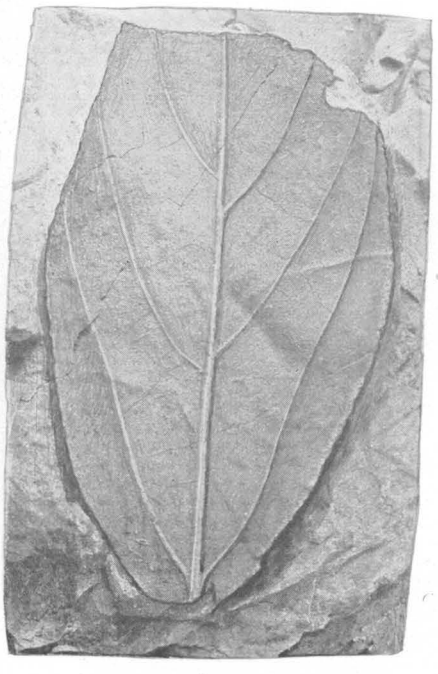
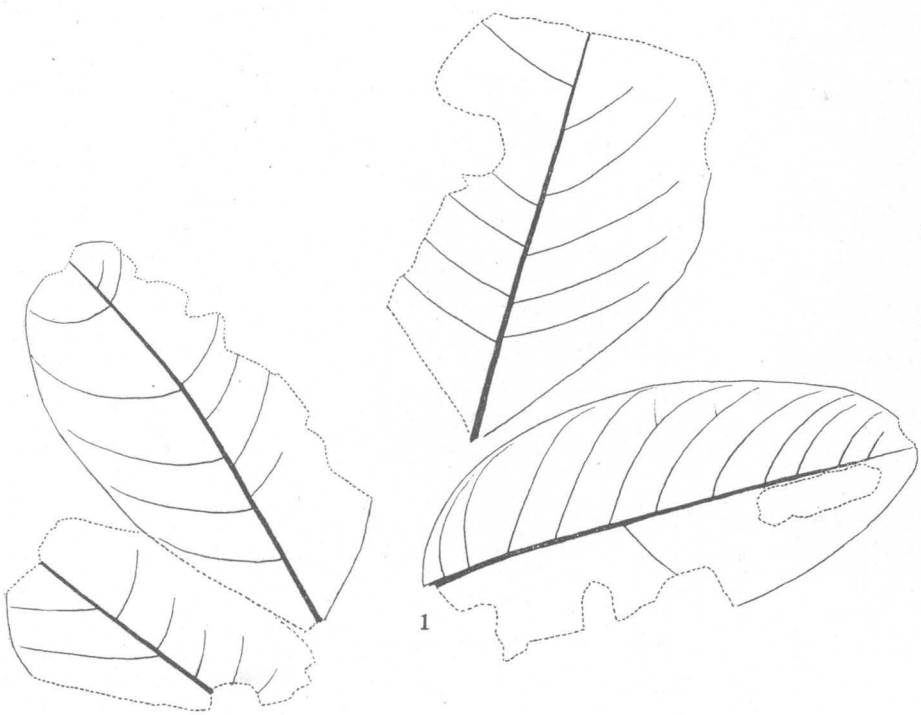


5

DENVER FLORA

1. *Cornus denverensis* Knowlton, n. sp., × 2 (Pr. 2339), Denver formation.
2–4. *Juglans denveriana* Knowlton, n. sp. (U.S.N.M. 2061, 37785, 3626), Denver formation.
5. *Juglans thermalis* Lesquereux (U.S.N.M. 37787), Middle Park formation.



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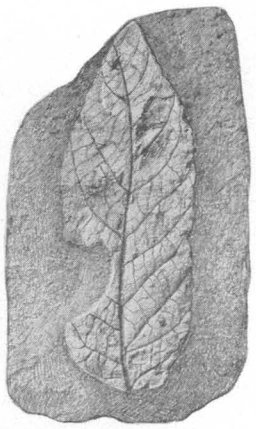

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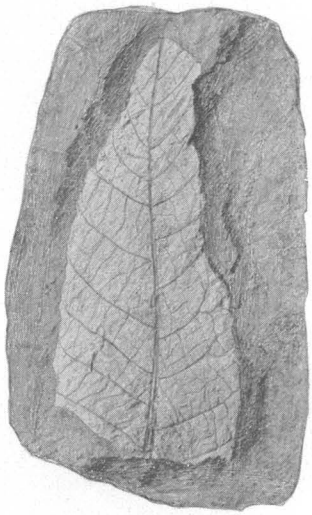

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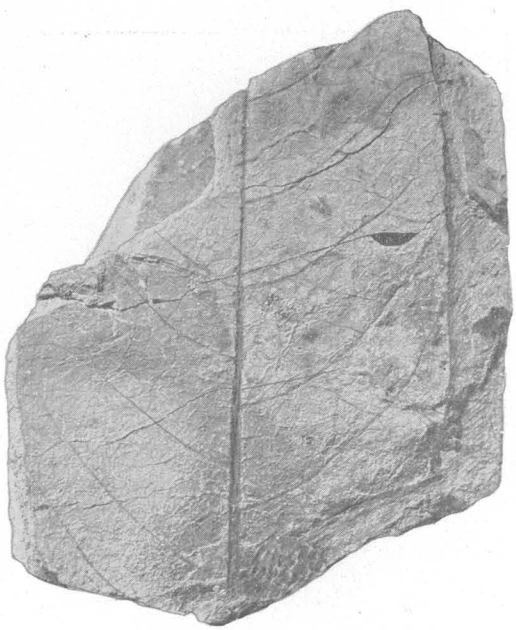
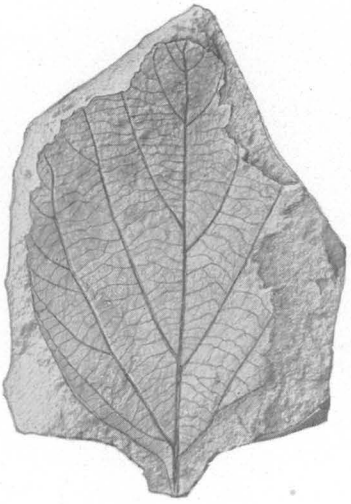


5

DENVER FLORA

1. *Juglans rugosa* Lesquereux (U.S.N.M. 37786), Denver formation.
2–4. *Pterocarya? retusa* Lesquereux (M.C.Z. 1558, 1559, 1561), Denver formation.
5. *Juglans* sp. Knowlton (U.S.N.M. 37784), Dawson arkose.

1



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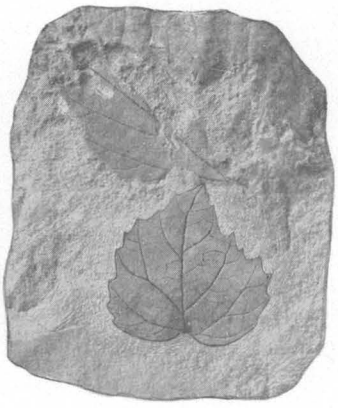

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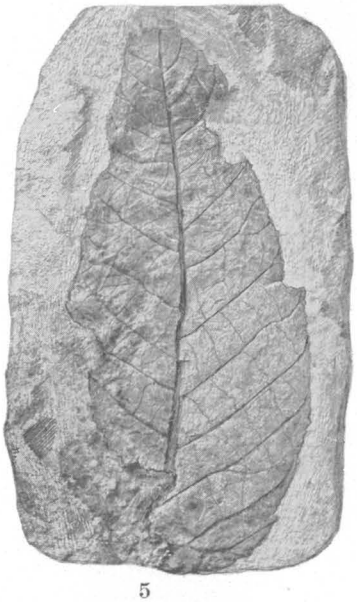

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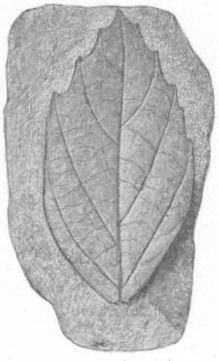

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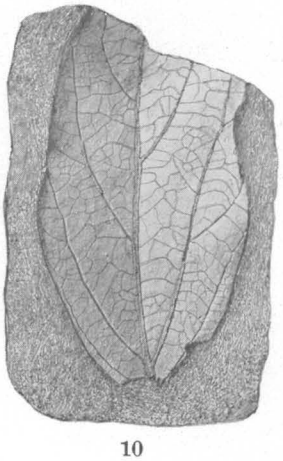

10

DENVER FLORA

1. *Juglans* sp. Knowlton (U.S.N.M. 37784), Dawson arkose. (Photograph made before specimen was broken as shown on pl. 14, fig. 5.)
2. *Alnus carpinifolia* Lesquereux (M.C.Z. 1056), Denver formation.
3, 4. *Betula schimperi* Lesquereux (M.C.Z. 1035, 1036), Denver formation.
5. *Pterocarya? retusa* Lesquereux (M.C.Z. 914), Denver formation.
6. *Alnus auraria* Knowlton and Cockerell (M.C.Z. 1057), Denver formation.
7–10. *Betula fallax* Lesquereux (M.C.Z. 1034, 1045, 1058, 1620), Denver formation.

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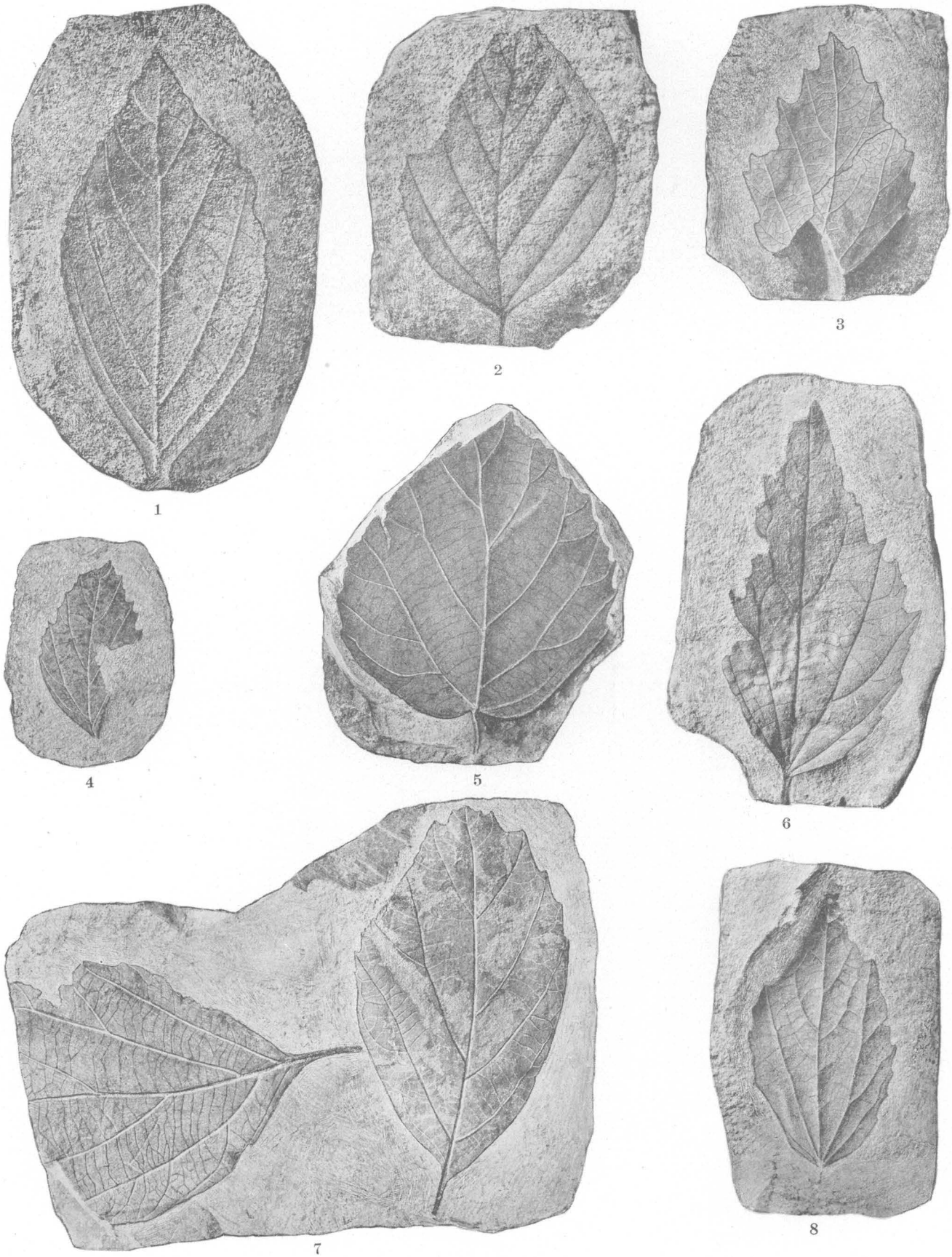
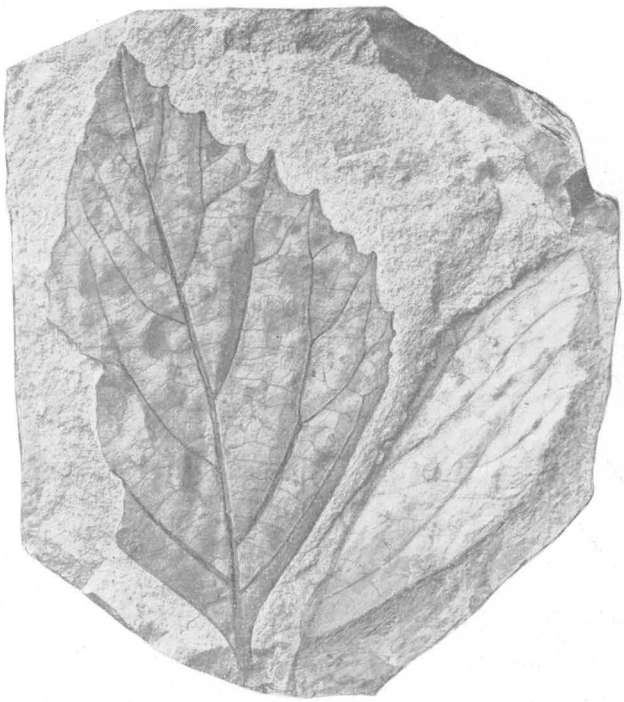


DENVER FLORA

1, 2. *Betula fallax* Lesquereux (M.C.Z. 1043, 1044), Denver formation.
3–8. *Quercus viburnifolia* Lesquereux (3, 4, 6–8, M.C.Z. 1572, 1578, 1585, 1631; 5, U.S.N.M. 37825), Denver formation.



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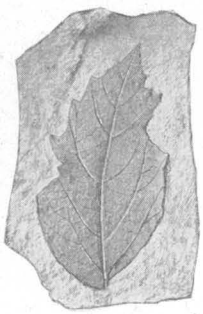

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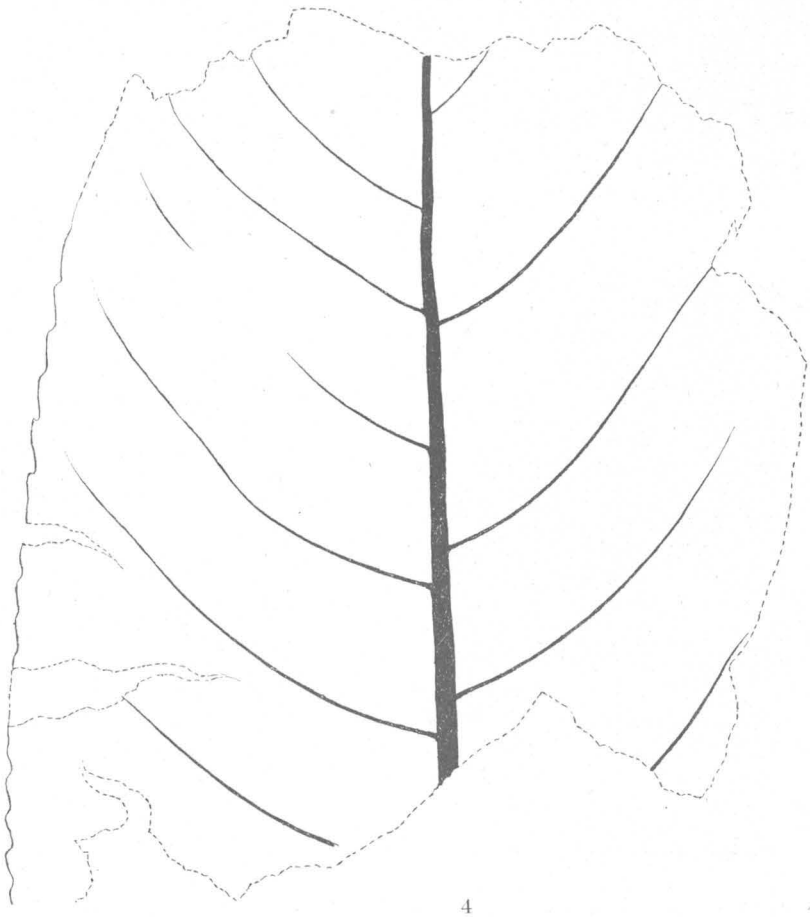

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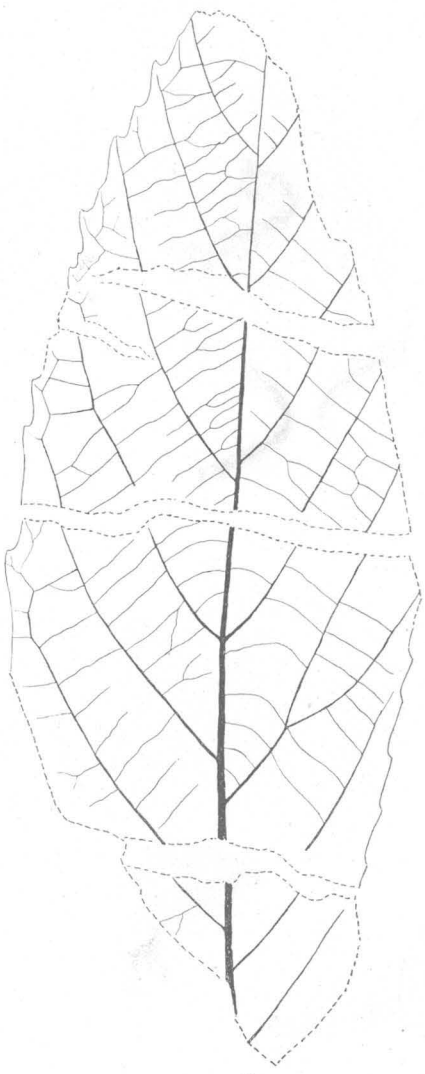
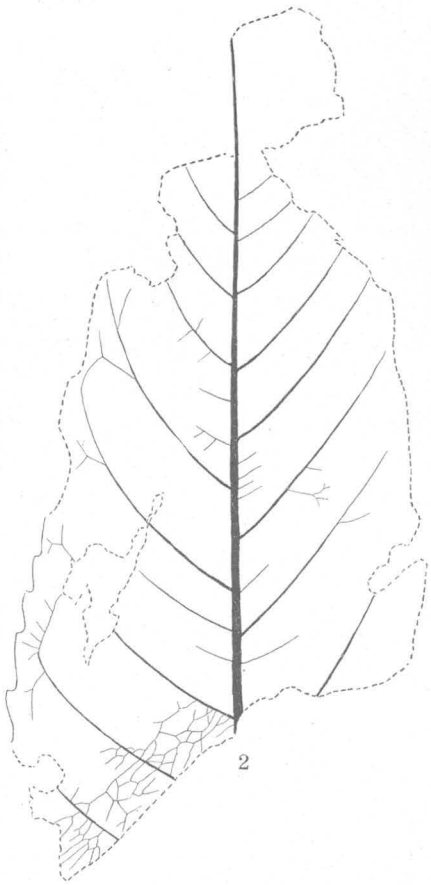


5

DENVER FLORA

1. *Quercus viburnifolia* Lesquereux (U.S.N.M. 37824), Denver formation.
2. *Quercus purdonensis* Knowlton, n. sp. (U.S.N.M. 37822), Dawson arkose.
3. *Quercus whitei* Lesquereux (M.C.Z. 1056), Denver formation.
4. *Quercus? sedaliensis* Knowlton, n. sp., × 1½ (U.S.N.M. 37823), Dawson arkose, lower part (in beds = Arapahoe formation).
5. *Quercus whitmani* Knowlton, n. sp. (U.S.N.M. 37826), Middle Park formation.

1



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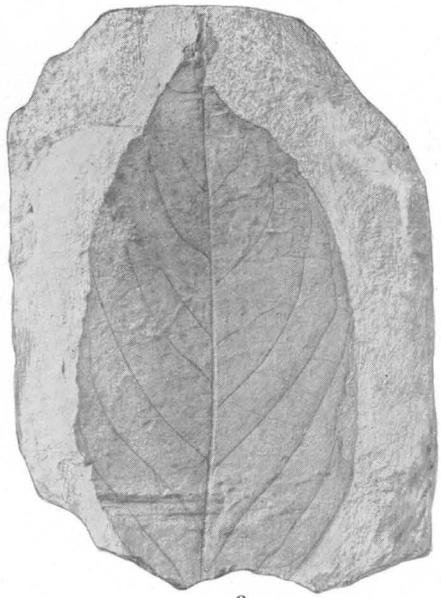

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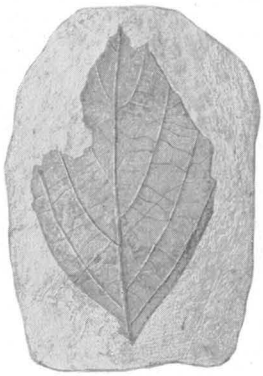

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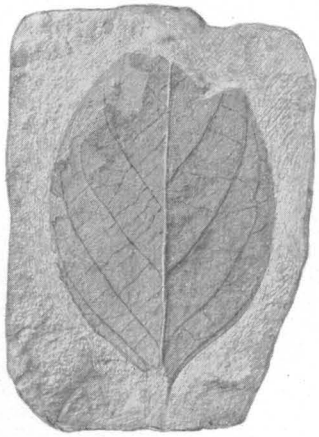

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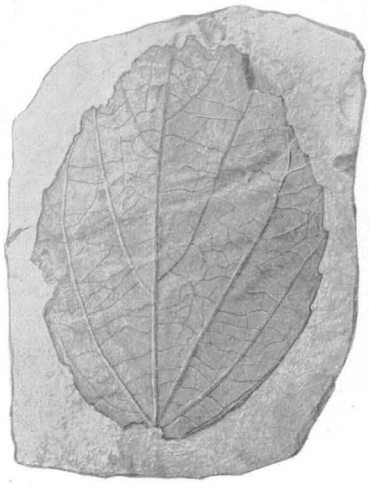

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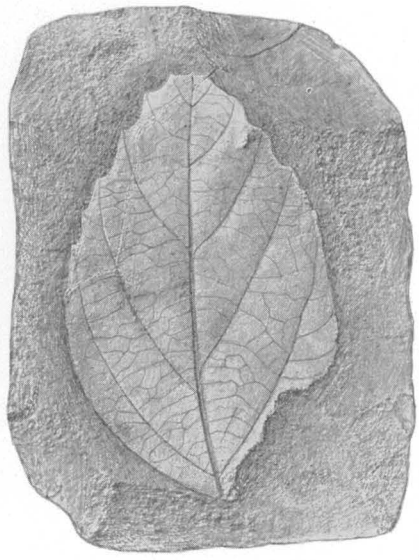
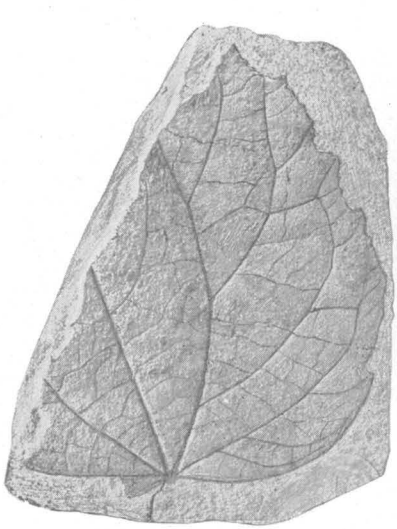


7

DENVER FLORA

1. *Quercus whitei* Lesquereux (M.C.Z. 1073), Denver formation.
2, 3. *Quercus leonis* Knowlton, n. sp. (2, U.S.N.M. 37838; 3, M.C.Z. 1625), Denver formation.
4–7. *Quercus celastrifolia* Lesquereux (M.C.Z. 1071, 1075, 1076, 1626), Denver formation.
8. *Populus zeilleri* (Lesquereux) Knowlton, n. comb. (M.C.Z. 1672), Denver formation.



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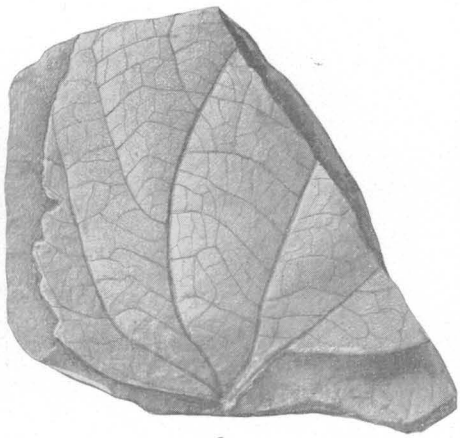

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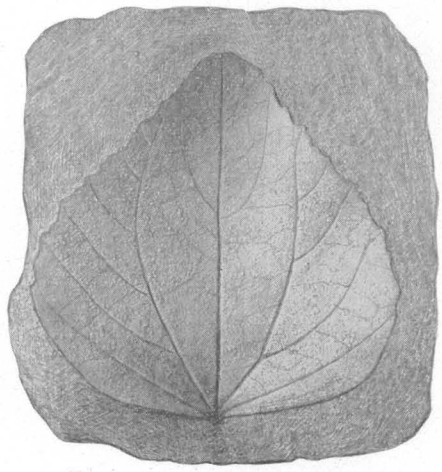
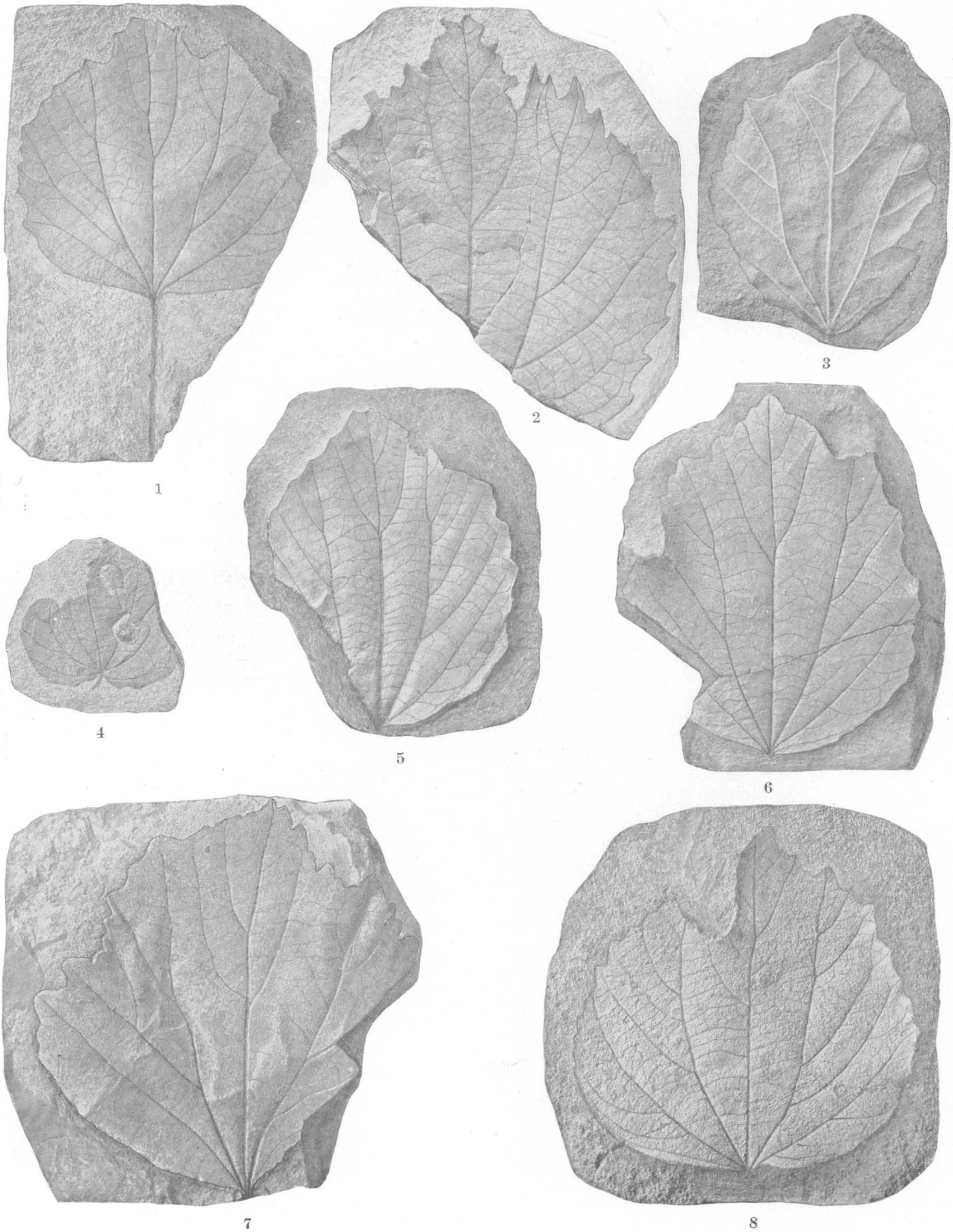


7

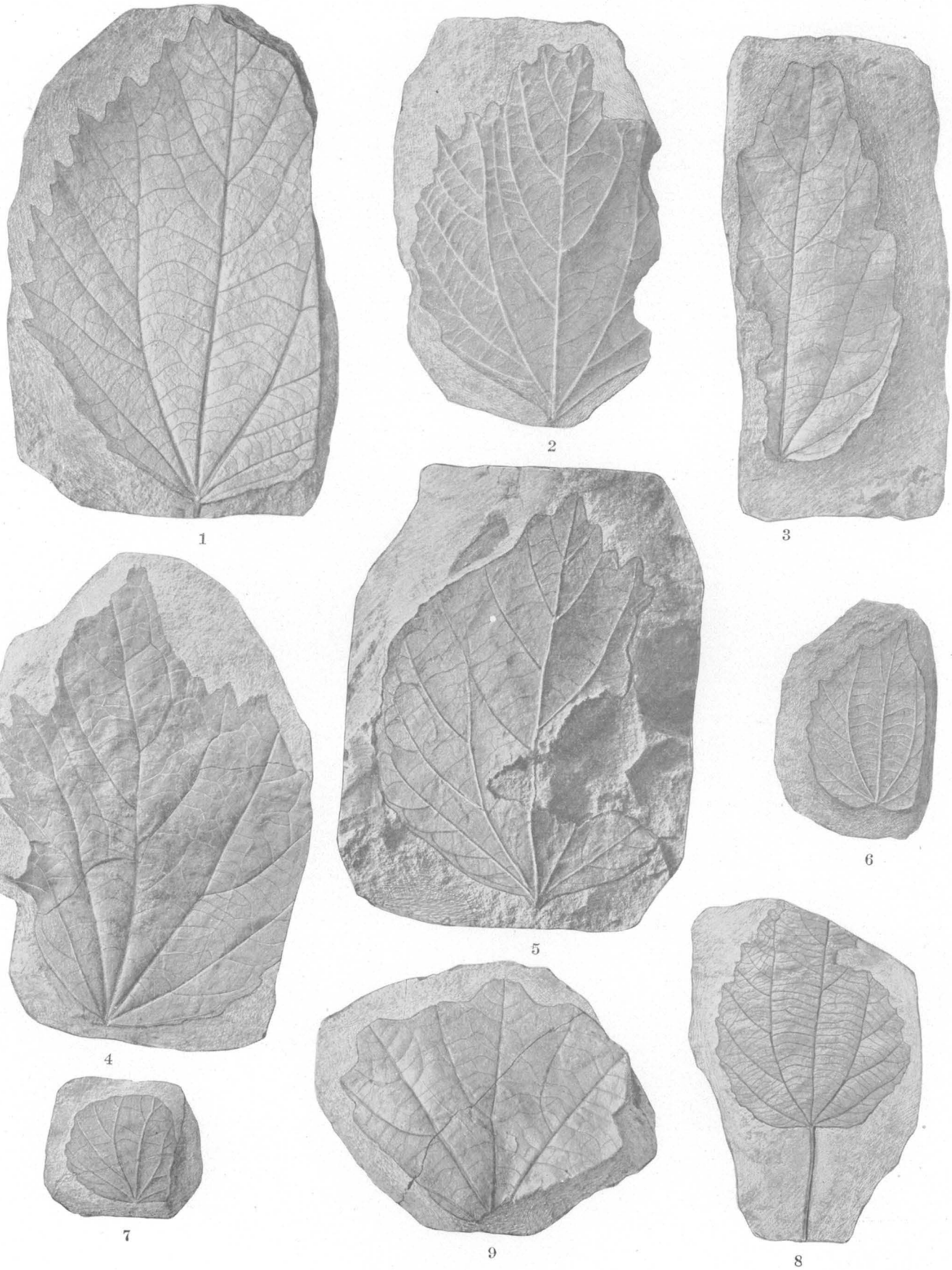
DENVER FLORA

1–3. *Populus zeilleri* (Lesquereux) Knowlton, n. comb. (M.C.Z. 1671, 1674, 1675), Denver formation.
4–7. *Populus nebrascensis* var. *grandidentata* Lesquereux (4–6, M.C.Z. 1123, 1219, 1226; 7, U.S.N.M. 37817), Denver formation.



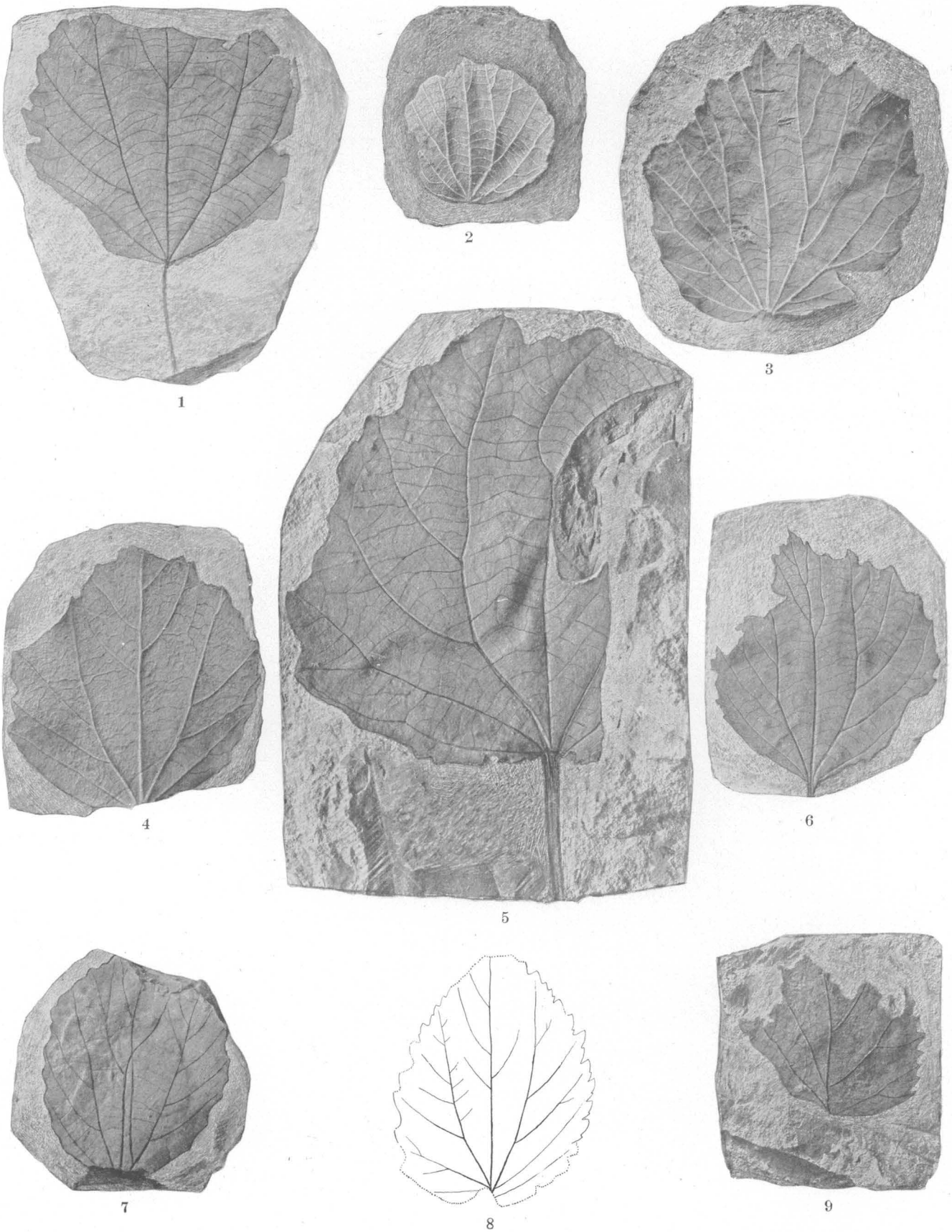
DENVER FLORA

1, 3, 4, 5, 8. *Populus nebrascensis* var. *rotundata* Lesquereux (3–5, M.C.Z. 1441, 1498, 1505), Denver formation.
2, 6, 7. *Populus nebrascensis* var. *grandidentata* Lesquereux (2, 6, M.C.Z. 1499, 1683; 7, U.S.N.M. 37817), Denver formation.



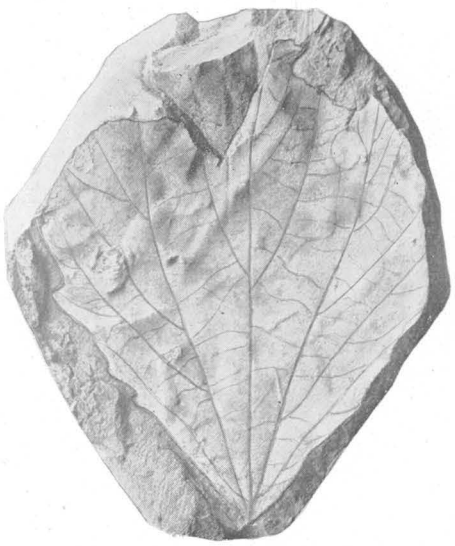
DENVER FLORA

1, 2. *Populus nebrascensis* var. *acutidentata* Lesquereux (M.C.Z. 1202, 1210), Denver formation.
3–5. *Populus nebrascensis* var. *longifolia* Lesquereux (M.C.Z. 1239, 1244, 1245), Denver formation.
6–8. *Populus jacksoni* Knowlton, n. sp. (M.C.Z. 1077, 1083, 1084), Denver formation.
9. *Populus?* sp. Knowlton (M.C.Z. 1286), Denver formation.



DENVER FLORA

1–4, 6. *Populus tenuinervata* Lesquereux (M.C.Z. 1252, 1256, 1266, 1274, 1513), Denver formation.
5. *Populus lacoeana* Knowlton, n. sp. (U.S.N.M. 37816), Denver formation.
7. *Populus jacksoni* Knowlton, n. sp. (M.C.Z. 1085), Denver formation.
8. *Populus zaddachi* Heer? (U.S.N.M. 37820), Middle Park formation.
9. *Populus subrotunda* Lesquereux (U.S.N.M. 37819), Denver formation.



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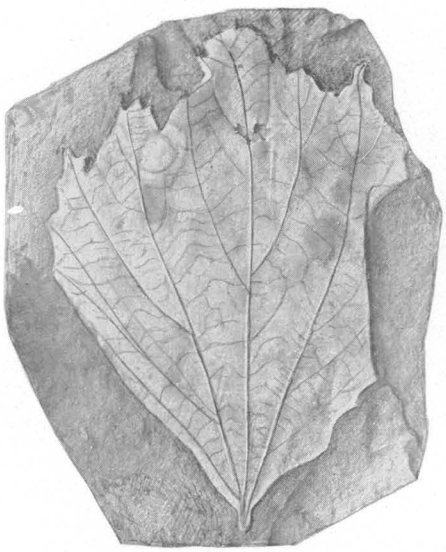

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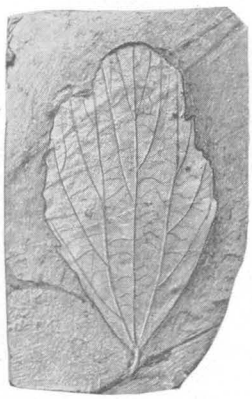

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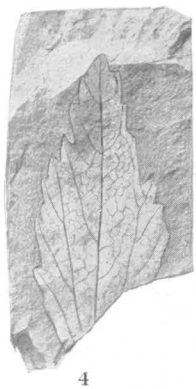

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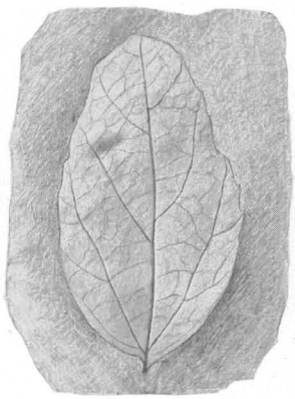

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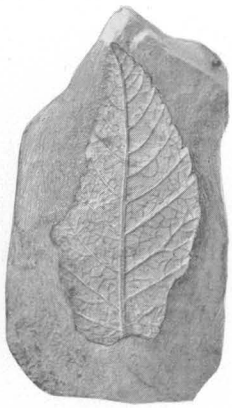

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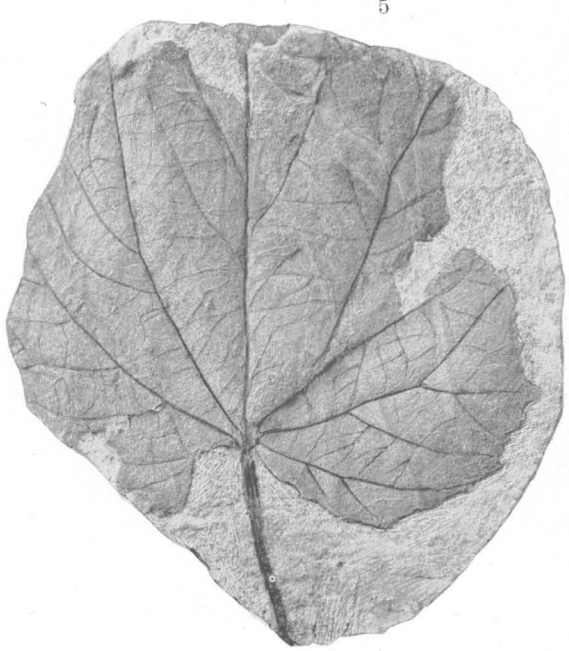

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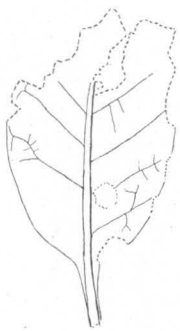

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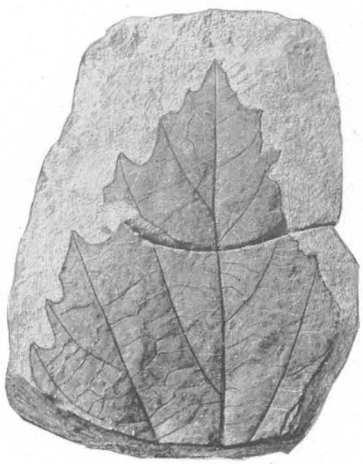
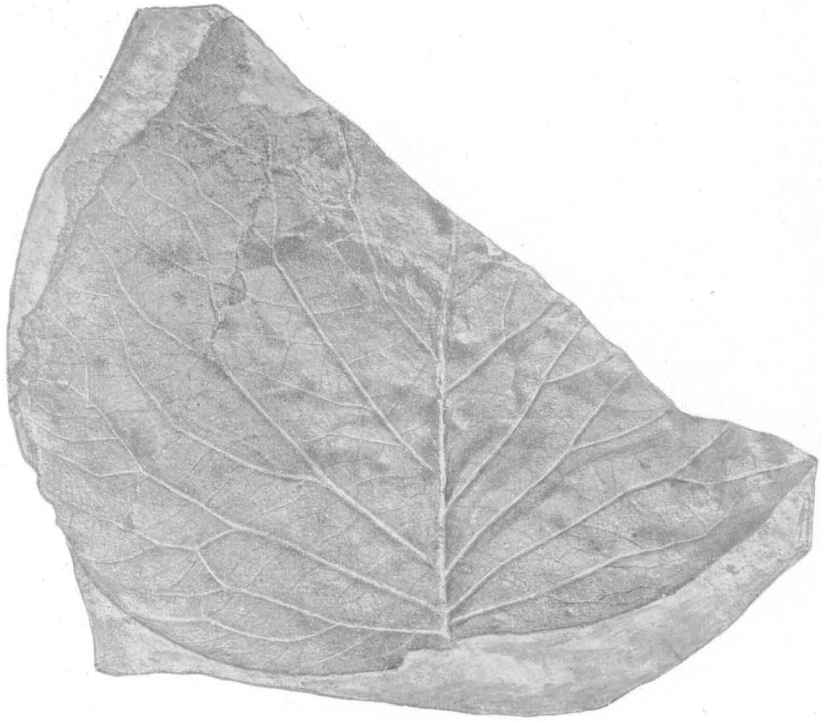


10

DENVER FLORA

1–4. *Populus knowltoni* Berry, n. sp. (U.S.N.M. 37815), Dawson arkose.
5. *Populus denverensis* Knowlton, n. sp. (U.S.N.M. 37814), Denver formation.
6, 8. *Populus richardsoni* Heer? (U.S.N.M. 37818), Middle Park formation.
7. *Ulmus antecedens* Lesquereux (M.C.Z. 1692), Denver formation.
9. *Ficus? alata* Knowlton, n. sp. (U.S.N.M. 37760), Dawson arkose, lower part (in beds = Arapahoe formation).
10. *Ulmus? quercifolia* Unger? (M.C.Z. 1628), Denver formation.



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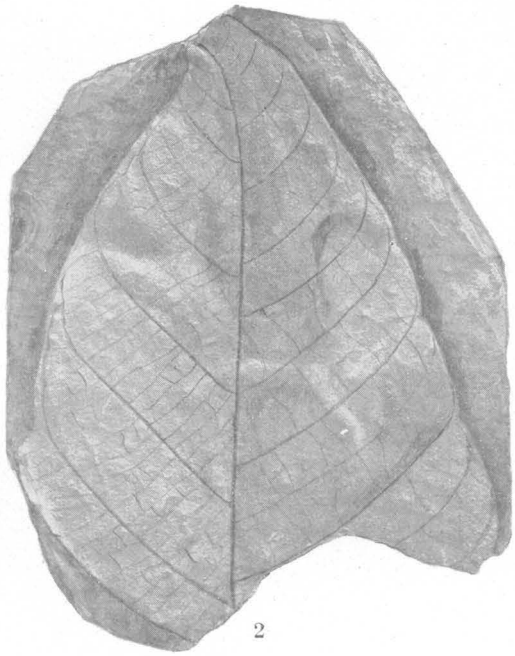

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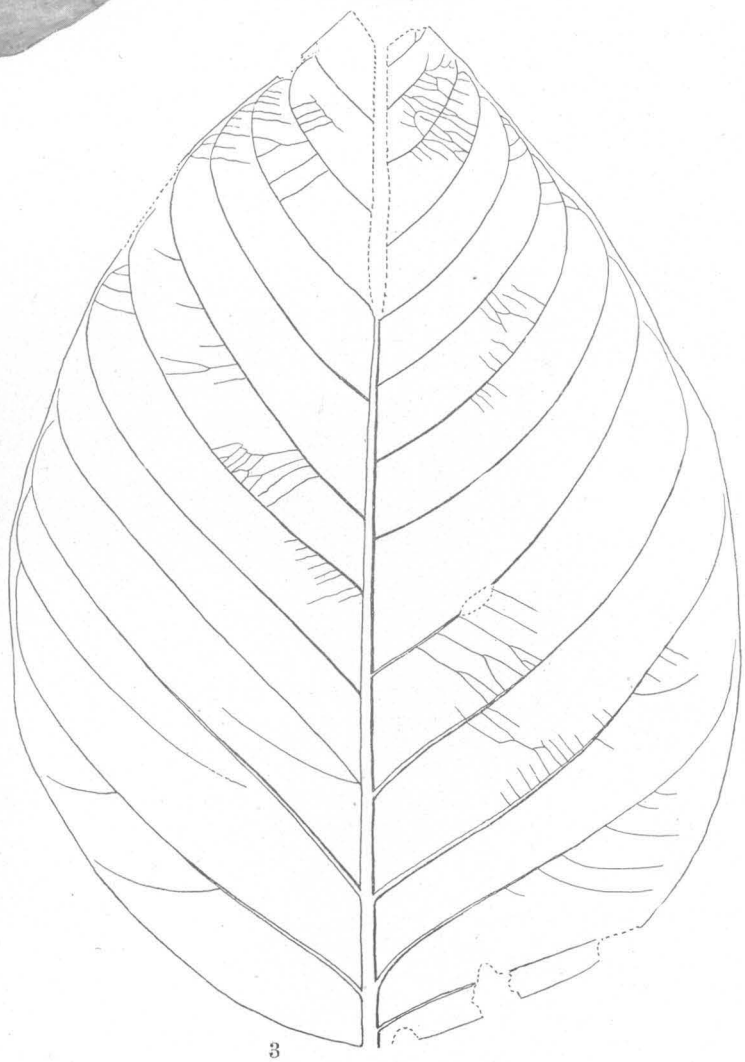

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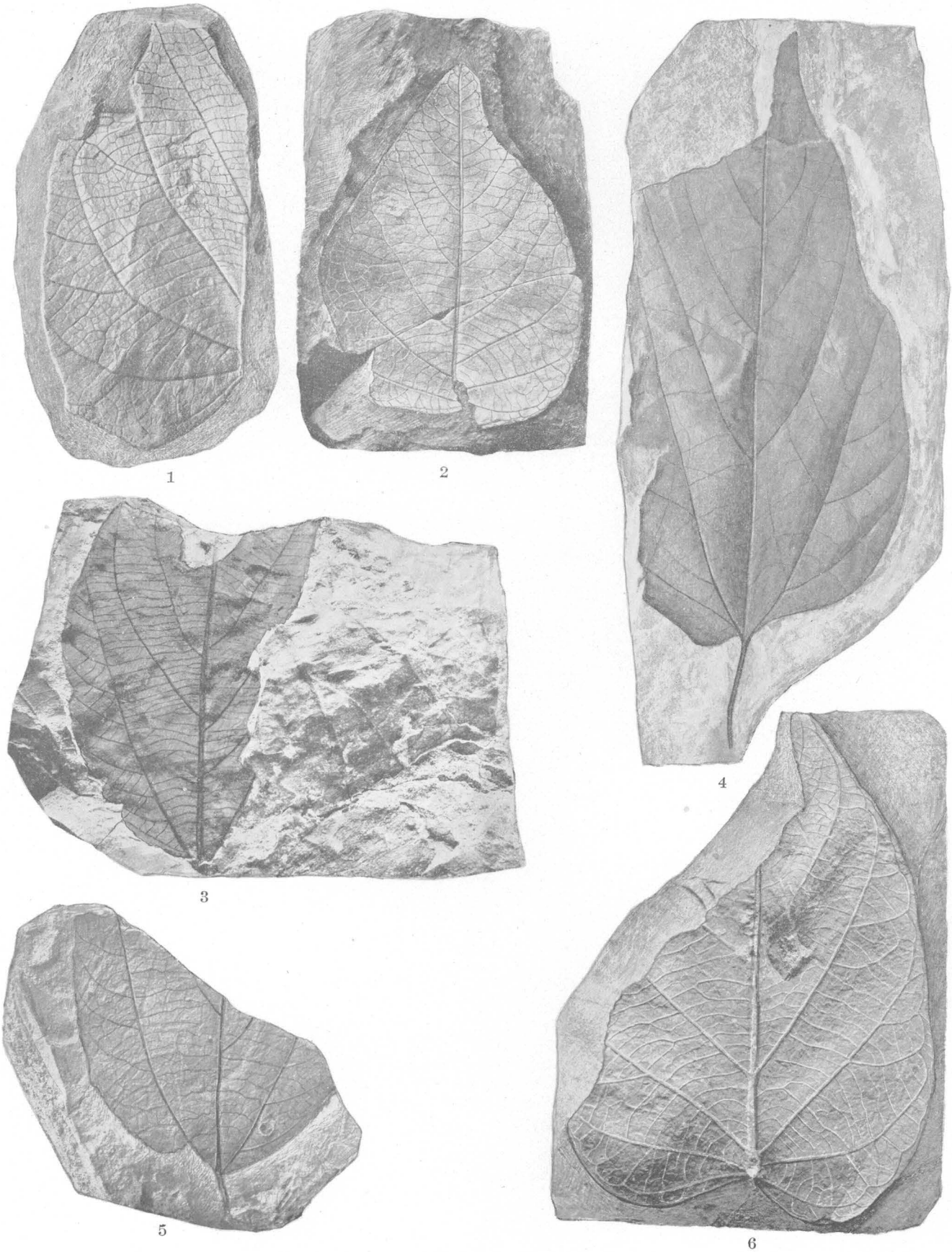
4

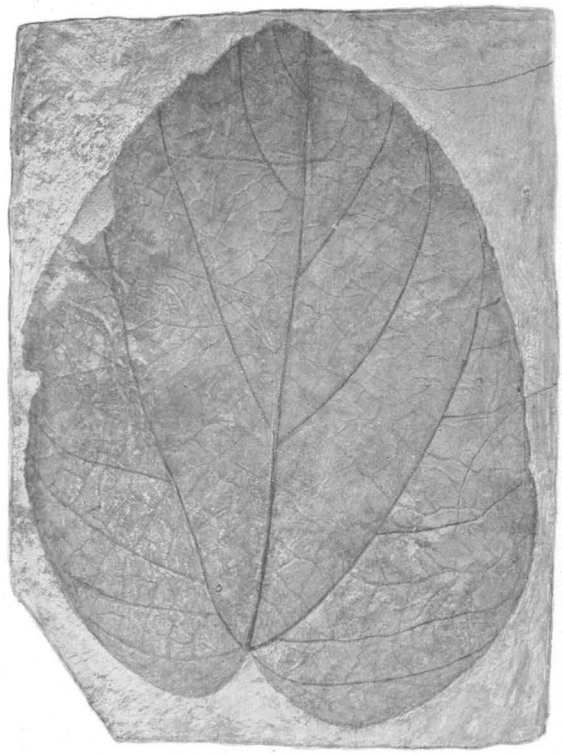
DENVER FLORA

1–3. *Ficus denveriana* Cockerell (1, 2, U.S.N.M. 37762; 3, U.S.N.M. 3621) Denver formation.
4. *Ficus aguilar* Knowlton (U.S.N.M. 37759), Dawson arkose.



DENVER FLORA

1, 2, 6. *Ficus berthoudi* Lesquereux (M.C.Z. 1089a, b, 1440, 1442), Denver formation.
3–5. *Ficus pseudopopulus* Lesquereux (4, U.S.N.M. 37772; 5, U.S.N.M. 37773), Dawson arkose.



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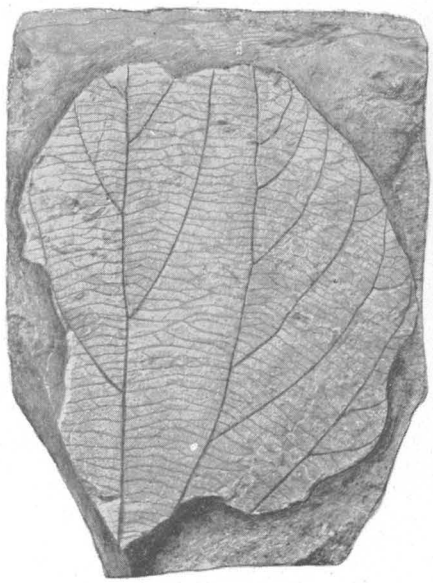

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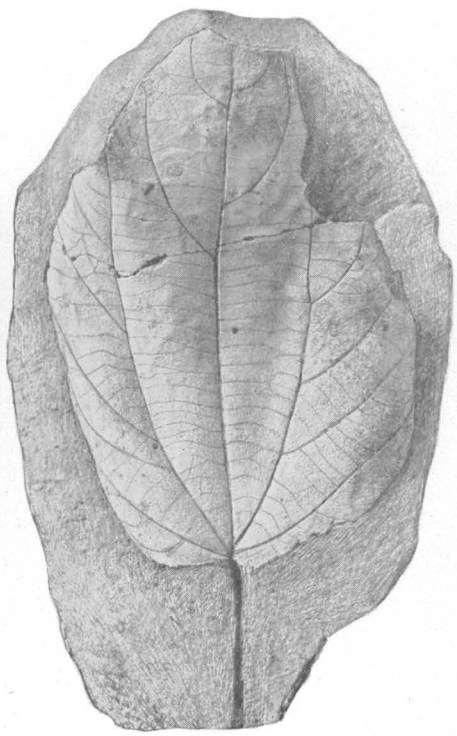

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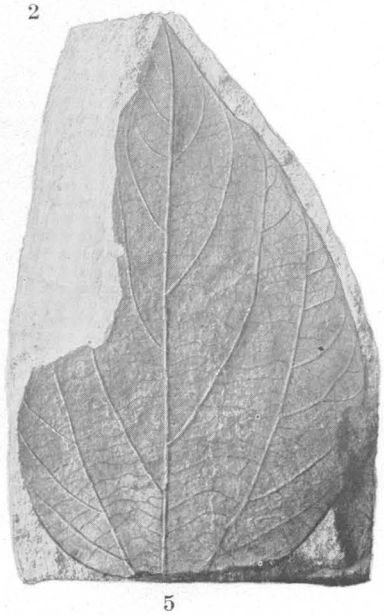
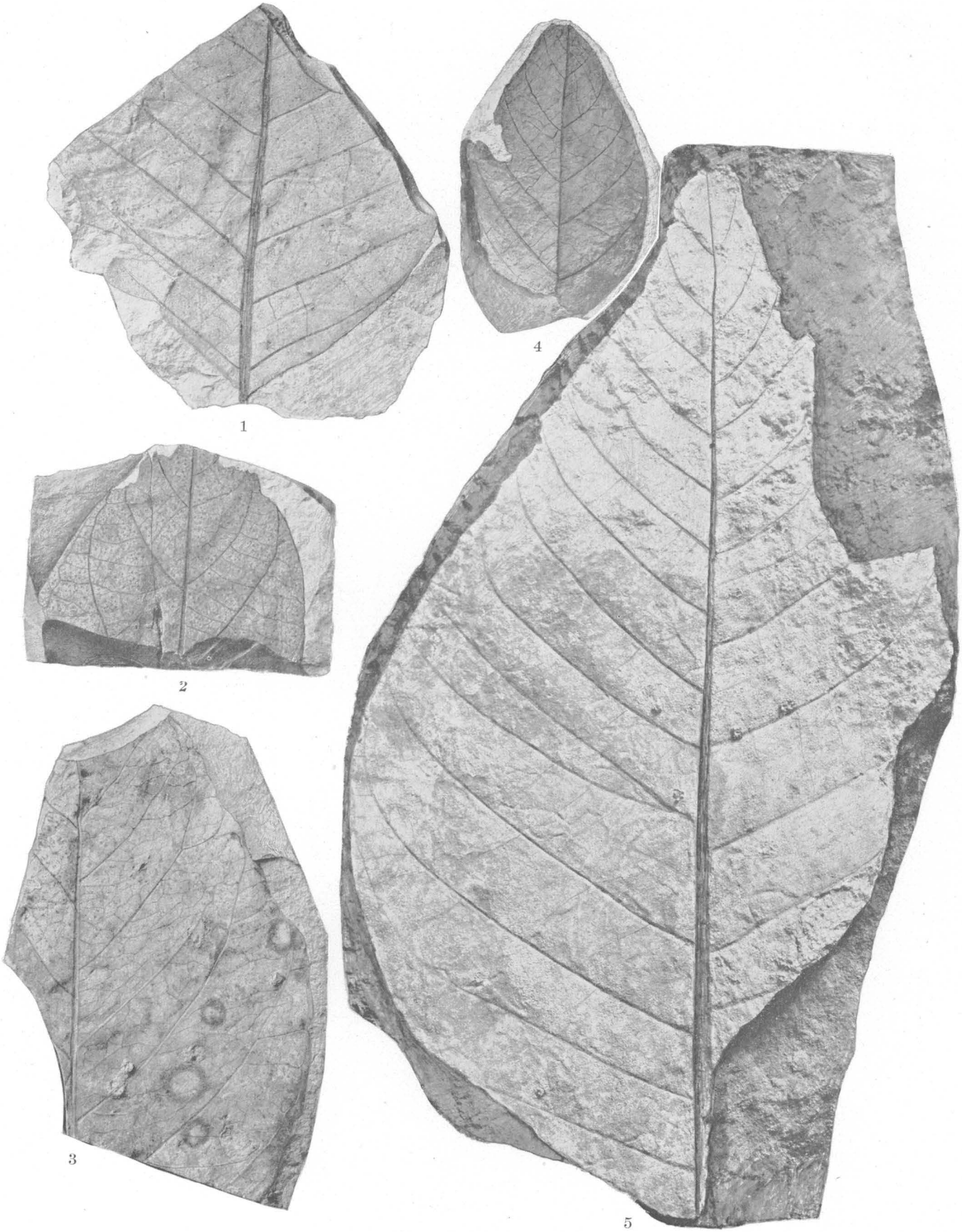


5

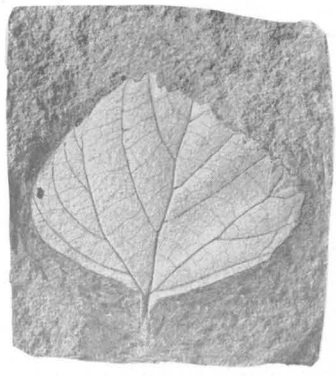
DENVER FLORA

1. *Ficus dawsonensis* Knowlton, n. sp. (U.S.N.M. 37761), Dawson arkose.
2–4. *Ficus pseudopopulus* Lesquereux (2, 3, U.S.N.M. 37770, 37771; 4, M.C.Z. 1677), Dawson arkose.
5. *Ficus occidentalis* (Lesquereux) Lesquereux (U.S.N.M. 37768), Denver formation.



DENVER FLORA

1-3. *Ficus* sp. Knowlton (U.S.N.M. 37758), Dawson arkose.
4. *Ficus occidentalis* (Lesquereux) Lesquereux, Denver formation.
5. *Ficus ramahensis* Knowlton, n. sp. (U.S.N.M. 37776), Dawson arkose.



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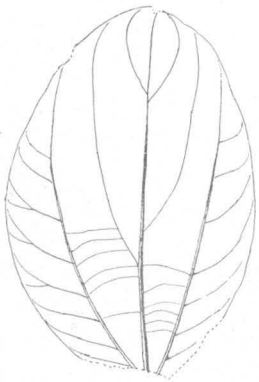

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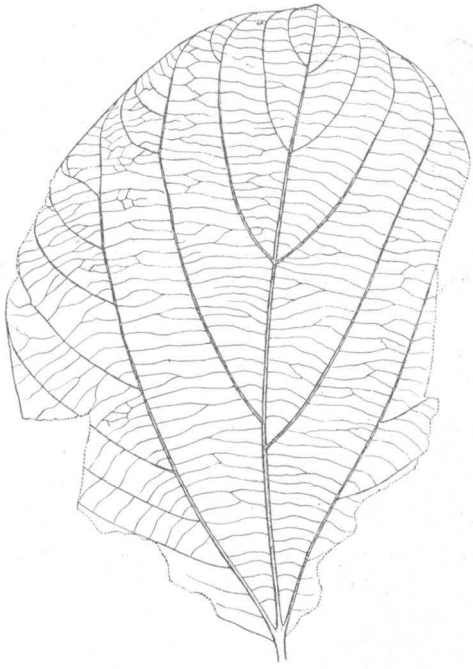

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2

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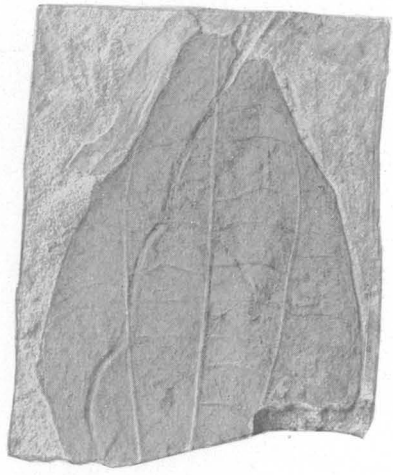

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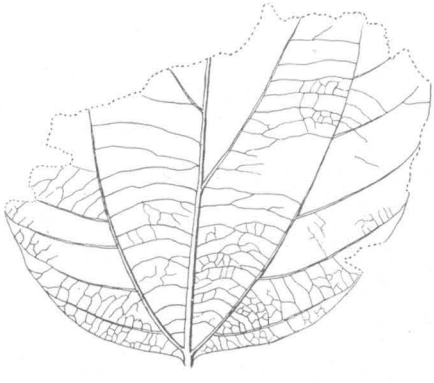


7

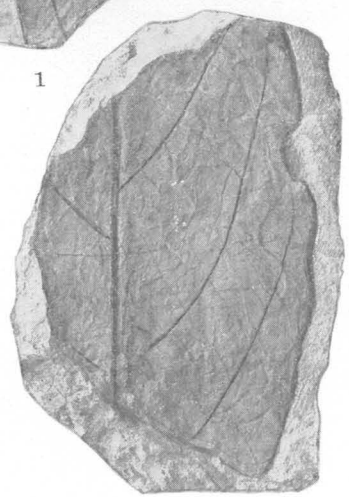
8

10

DENVER FLORA

1. *Ficus? lakesii* Knowlton, n. sp. (U.S.N.M. 37763), Denver formation.
2. *Ficus planicostata* var. *problematica* Knowlton, n. var. (U.S.N.M. 37767), Denver formation.
3, 4, 6, 7. *Ficus neoplanicostata* Knowlton (3, U.S.N.M. 37764; 4, U.S.N.M. 3633; 6, U.S.N.M 37765), Denver formation.
5. *Ficus planicostata* var. *goldiana* Lesquereux (U.S.N.M. 37769), Denver formation.
8–10. *Ficus praetrinervis* Knowlton, n. sp. (U.S.N.M. 37774), Dawson arkose.

1



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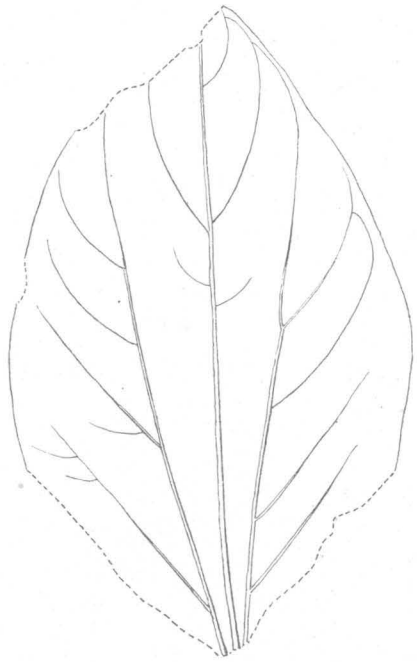

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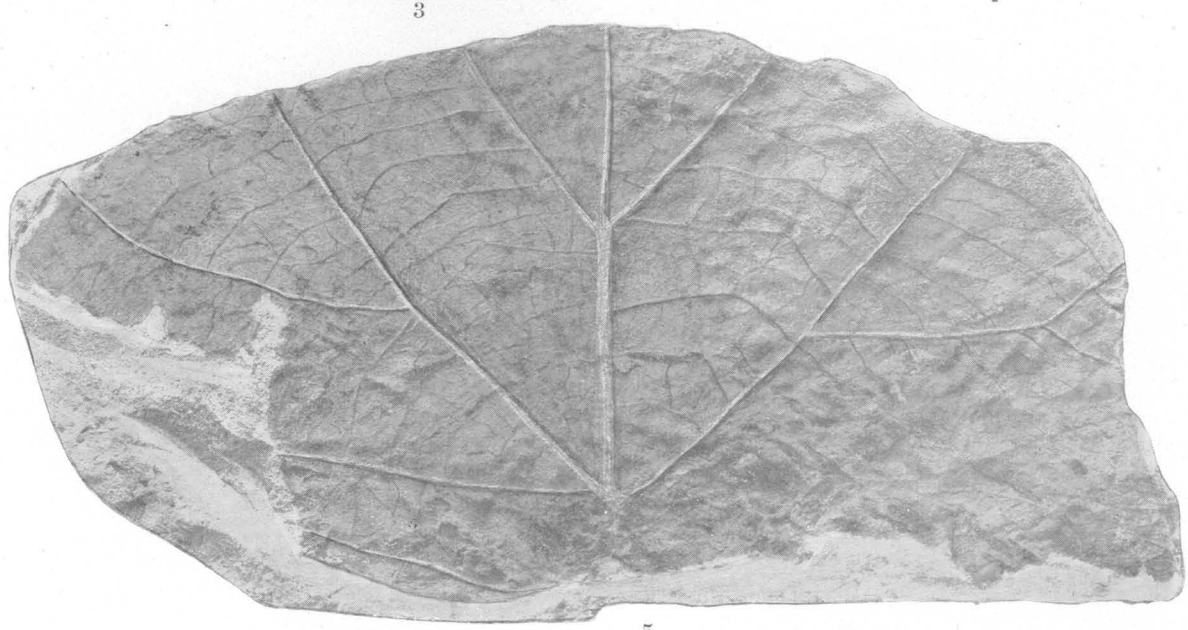
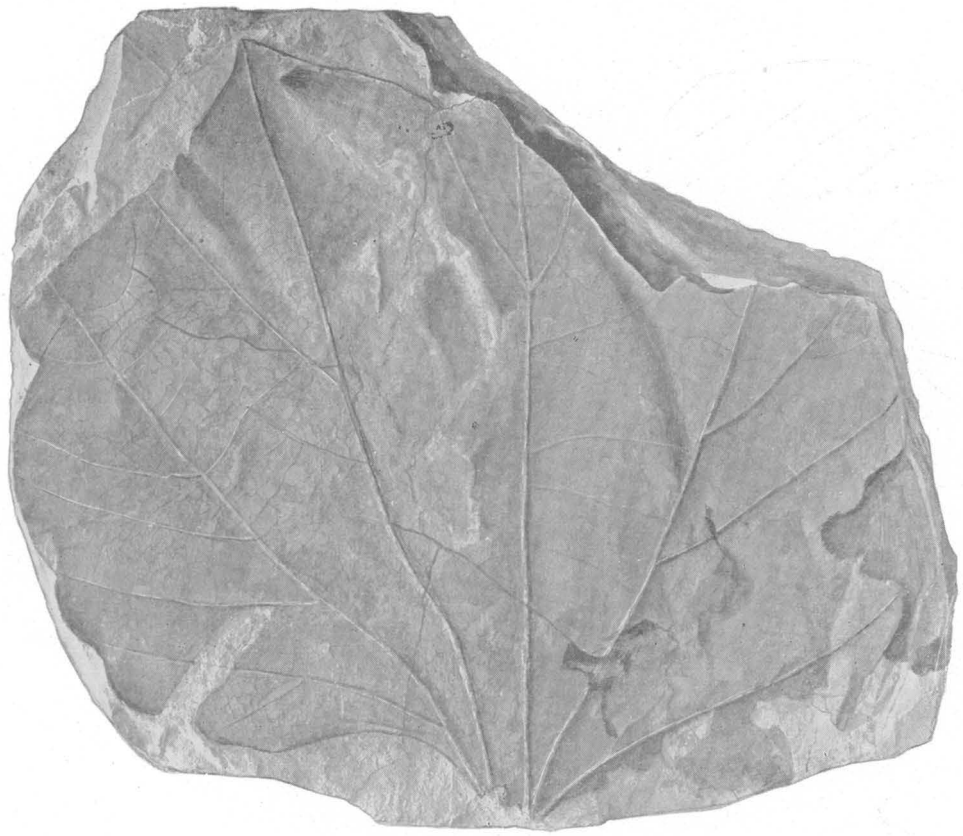


5

DENVER FLORA

1, 2. *Ficus puryearensis* Berry? (U.S.N.M. 37775), Dawson arkose.
3, 4. *Ficus neoplanicostata* Knowlton (U.S.N.M. 37766), Denver formation.
5. *Ficus* sp. Knowlton (U.S.N.M. 37756), Dawson arkose.

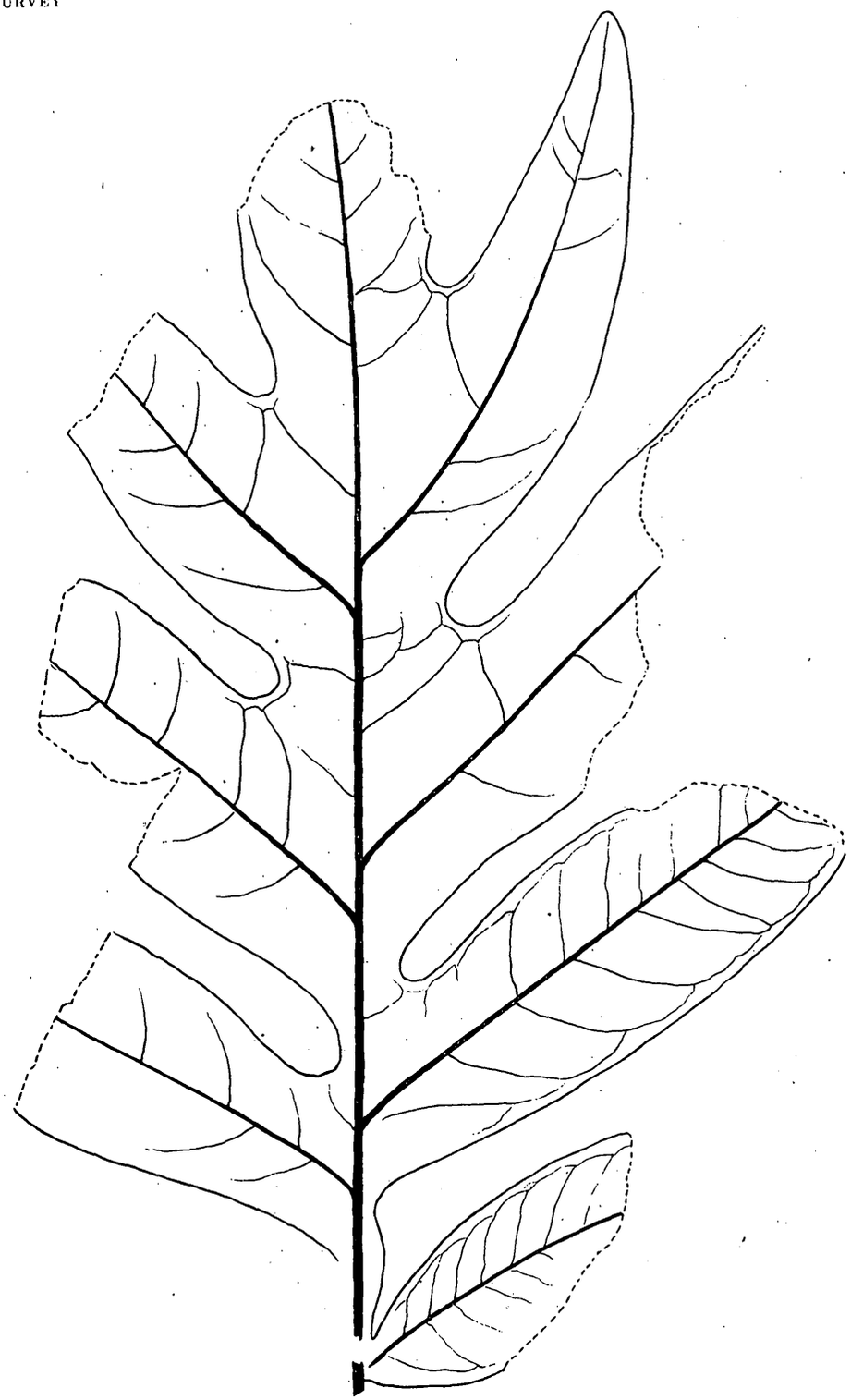


1

2

DENVER FLORA

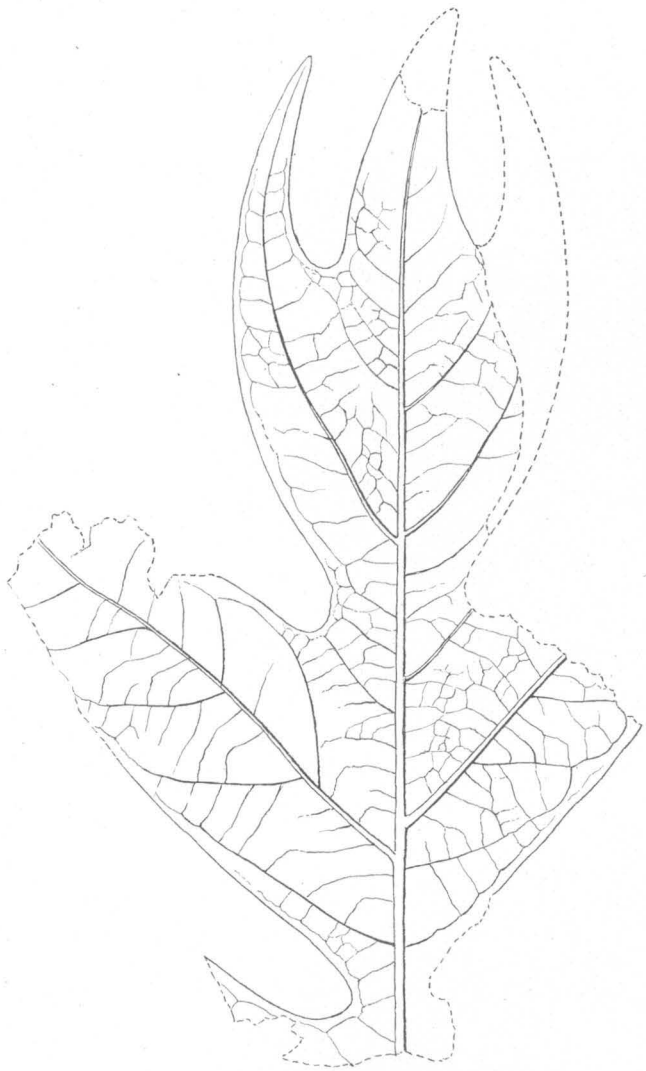
1. *Ficus* sp. Knowlton (U.S.N.M. 37757), Dawson arkose.
2. *Artocarpus pungens* (Lesquereux) Hollick. (After Lesquereux.)



DENVER FLORA

Artocarpus pungens (Lesquereux) Hollick (U.S.N.M. 2069), Denver formation.

85492—30——12



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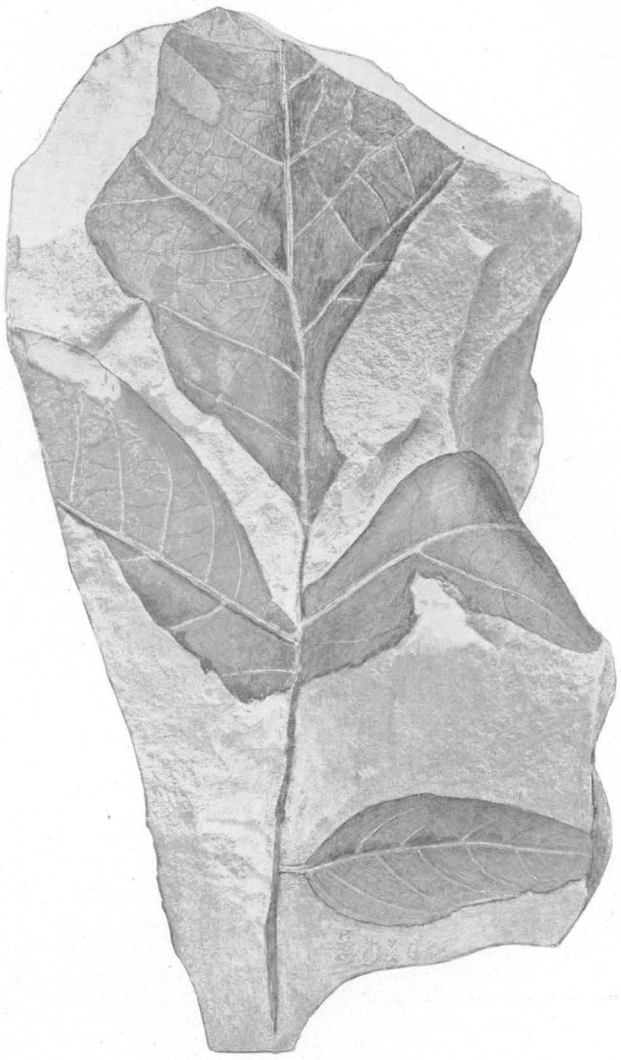

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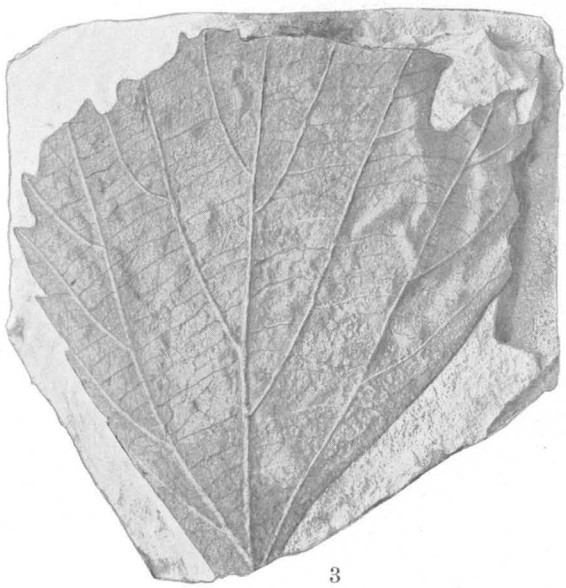

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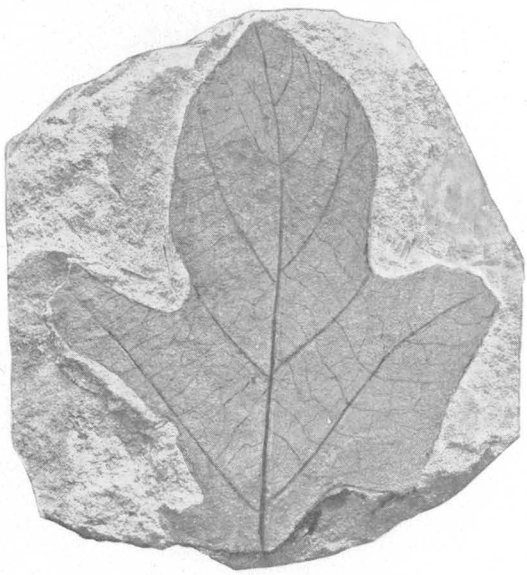


4

DENVER FLORA

1. *Artocarpus pungens* (Lesquereux) Hollick, refigured type (Pr.). (After Lesquereux.)
2. *Artocarpus pungens* (Lesquereux) Hollick (U.S.N.M. 2067), Denver formation.
3. *Platanus rhomboidea* Lesquereux (U.S.N.M. 37812), Dawson arkose.
4. *Artocarpus similis* Knowlton (U.S.N.M. 37711), Dawson arkose.

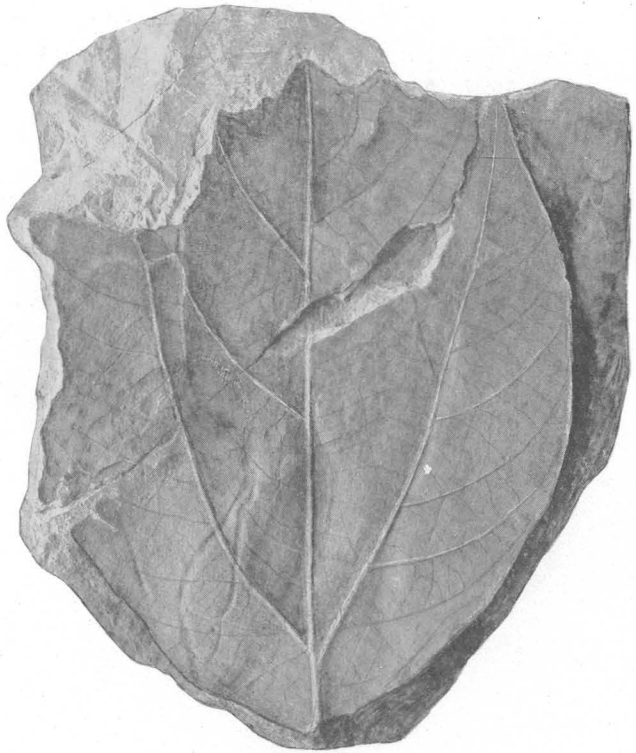
1

2

DENVER FLORA

1. *Platanus aceroides* var. *latifolia* Knowlton (U.S.N.M. 37805), Denver formation.
2. *Platanus guillelmae* Göppert (U.S.N.M. 37807), Denver formation.

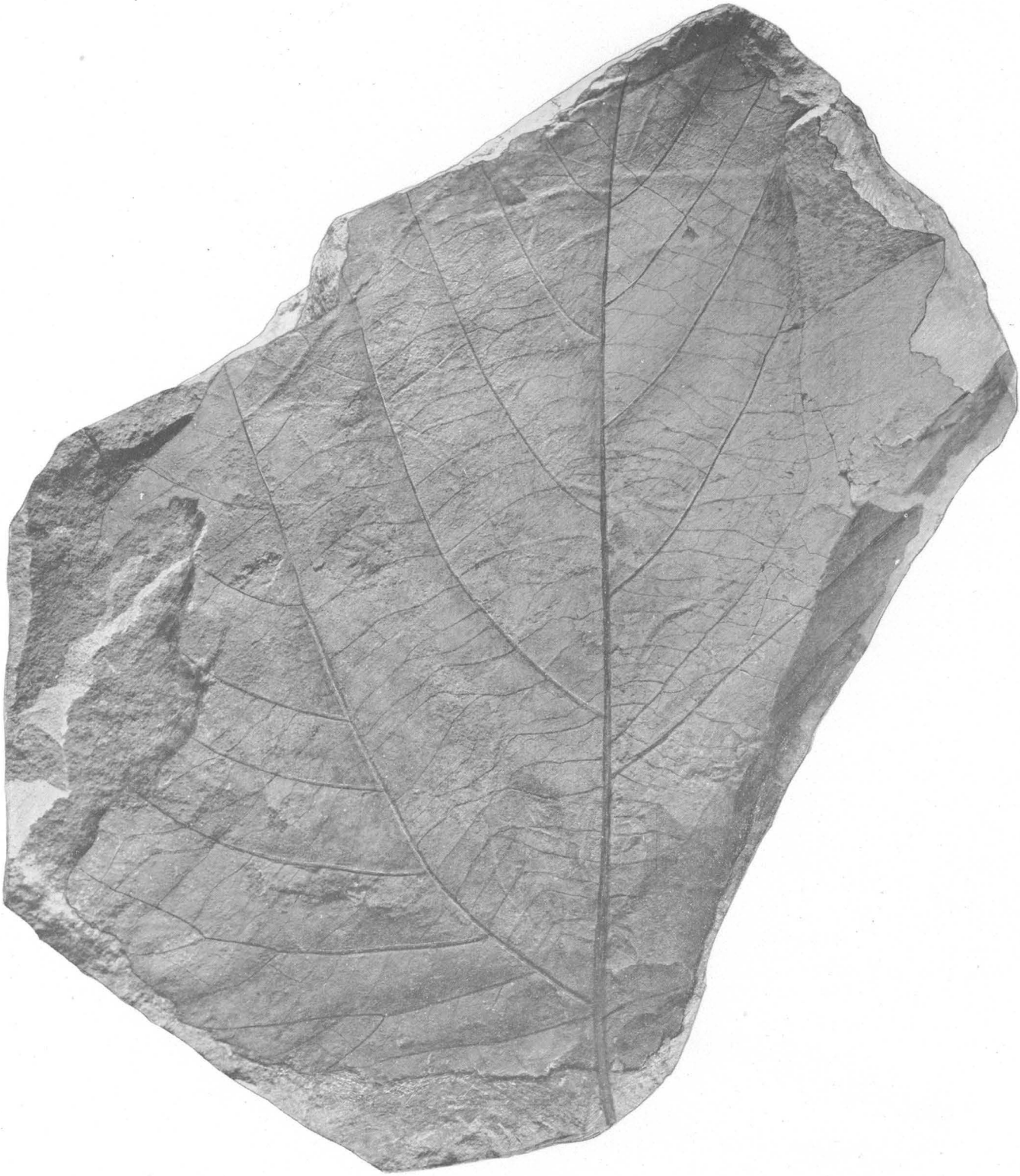
1



2

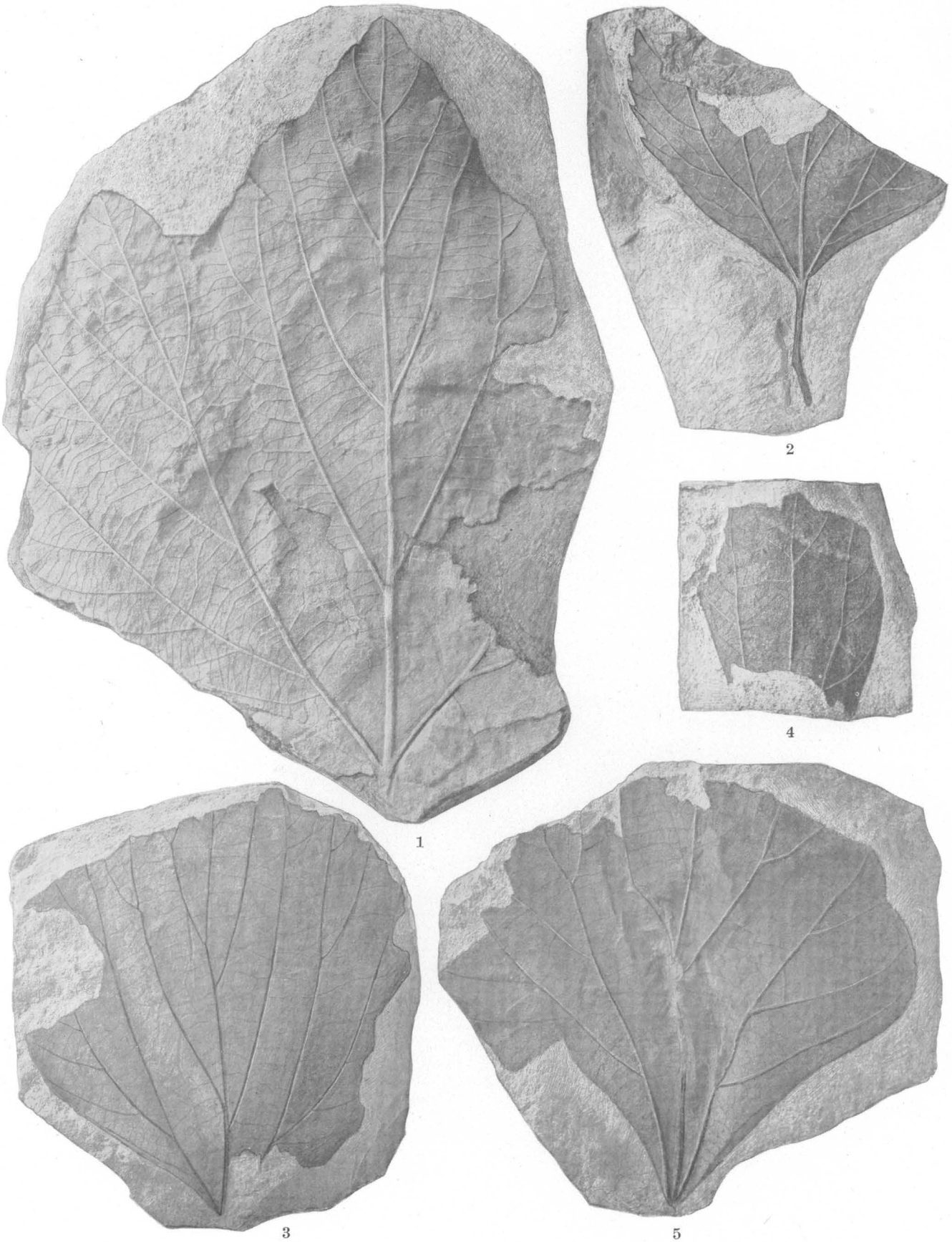
DENVER FLORA

1. *Platanus guillelmae* Göppert (U.S.N.M. 3622), Denver formation.
2. *Platanus raynoldsii* var. *integrifolia* Lesquereux (U.S.N.M. 37811) Denver formation.



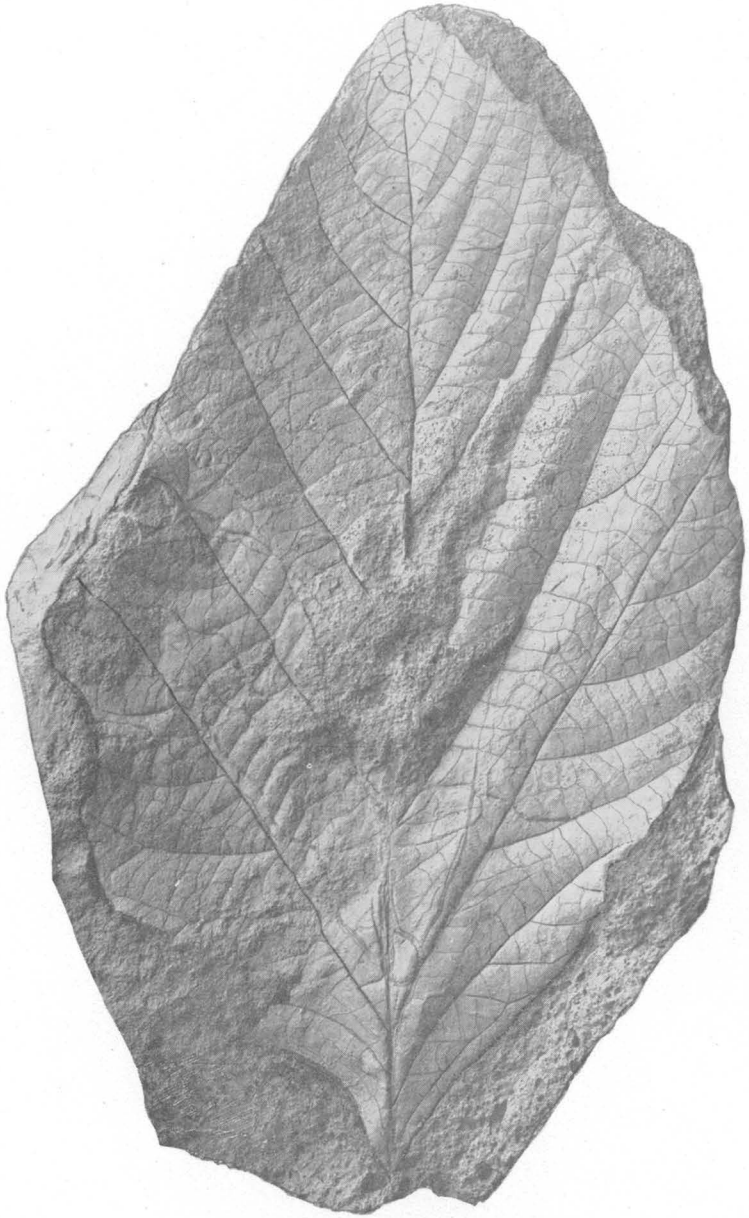
DENVER FLORA

Platanus raynoldsii Newberry (U.S.N.M. 37810), Denver formation.



DENVER FLORA

1. *Platanus haydenii* Newberry (M.C.Z. 1371), Denver formation.
2, 3. *Platanus marginata* (Lesquereux) Heer (U.S.N.M. 37808), Dawson arkose.
4. *Cinnamomum?* sp. Knowlton (U.S.N.M. 37732), Dawson arkose.
5. *Platanus platanoides* (Lesquereux) Knowlton (U.S.N.M. 37809), Dawson arkose.



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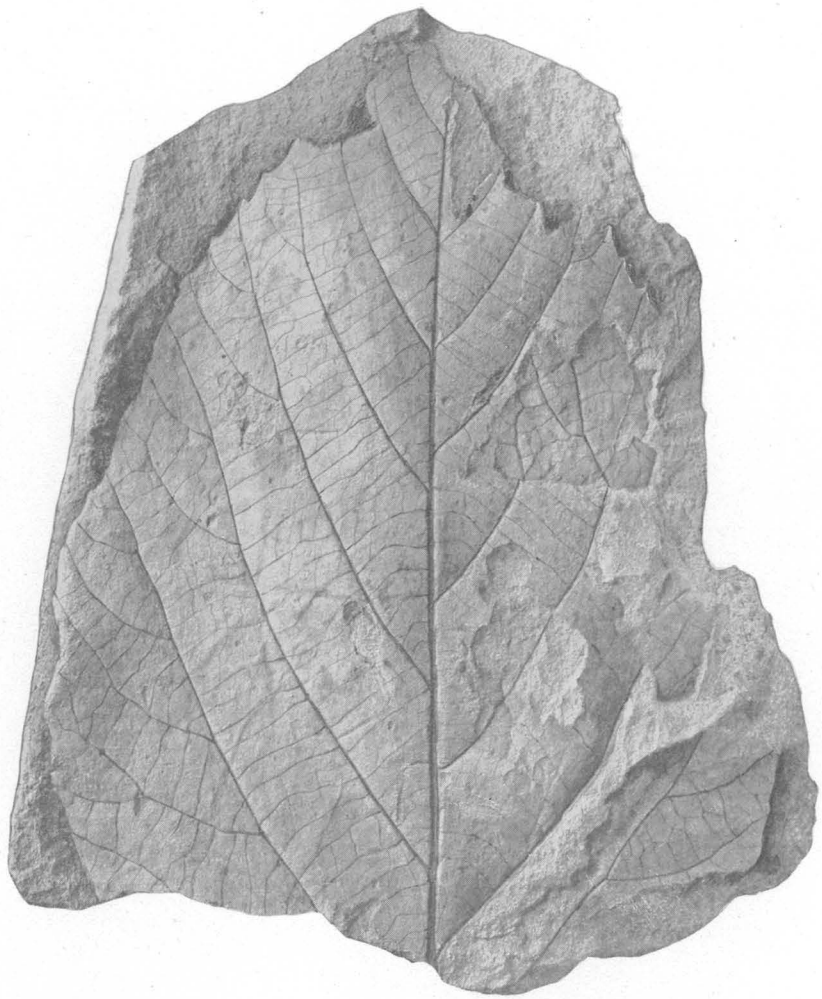
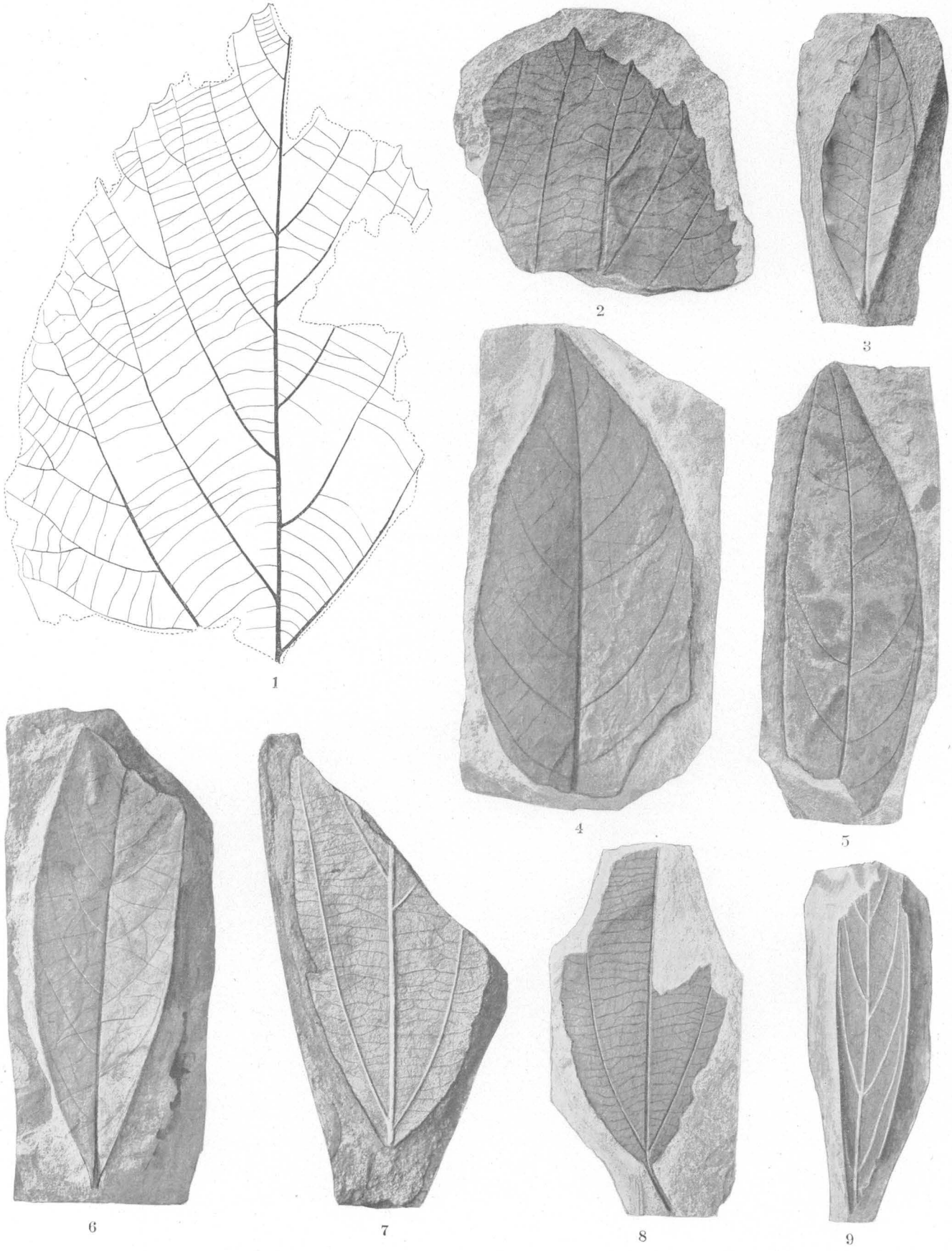


2

DENVER FLORA

Platanus coloradensis Knowlton, n. sp. (U.S.N.M. 37806), Middle Park formation.



DENVER FLORA

1. *Platanus coloradensis* Knowlton, n. sp. (Drawing of specimen shown on pl. 37, fig. 2.)
2. *Platanus* sp.? Knowlton (U.S.N.M. 37813), Dawson arkose.
3, 5, 6. *Laurus primigenia* Unger (3, M.C.Z. 1466; 5, 6, U.S.N.M. 37789), Dawson arkose.
4. *Laurus socialis* Lesquereux (U.S.N.M. 37790), Dawson arkose.
7, 8. *Cinnamomum sezannense* Watelet? (U.S.N.M. 37735), Dawson arkose.
9. *Laurus lanceolata* Knowlton, n. sp. (U.S.N.M. 37788), Dawson arkose.

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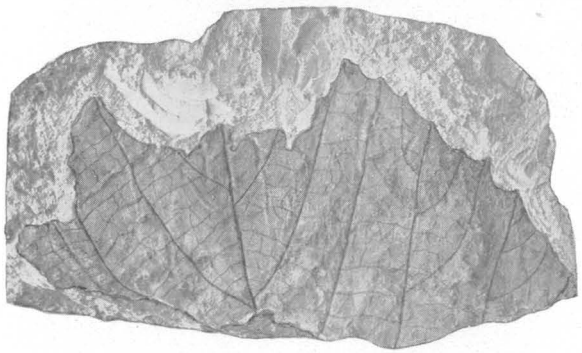
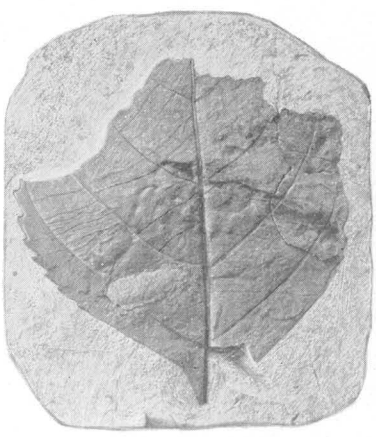


2

3

DENVER FLORA

1. *Cinnamomum* sp. Knowlton (U.S.N.M. 37733), Denver formation.
2. *Phyllites pellucidus* Knowlton, n. sp. (U.S.N.M. 37801), Dawson arkose.
3. *Paleonelumbo macroloba* Knowlton, n. sp. (U.S.N.M. 37796), Dawson arkose.



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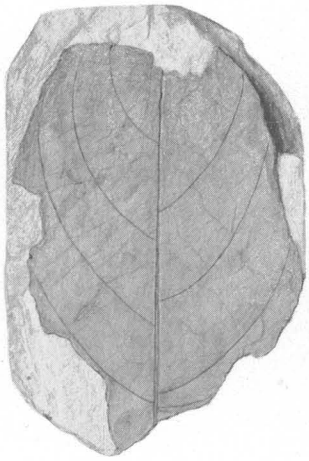

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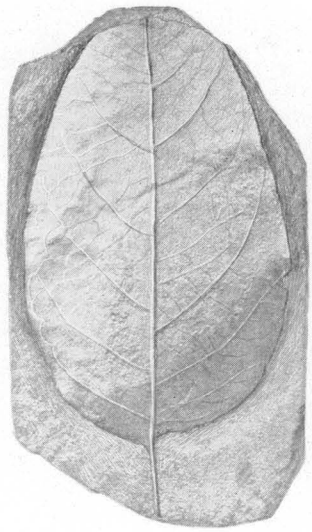

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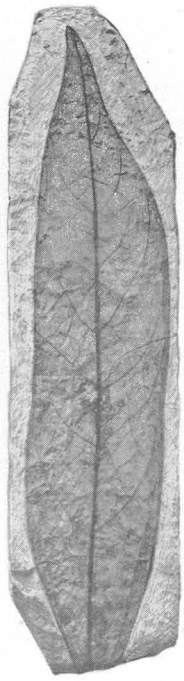

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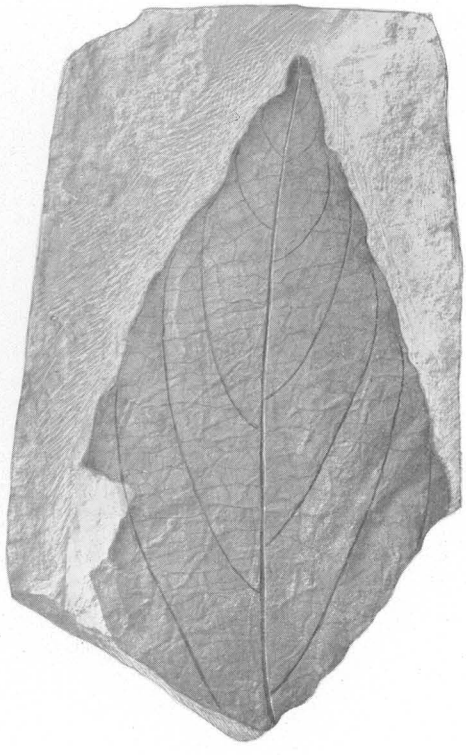
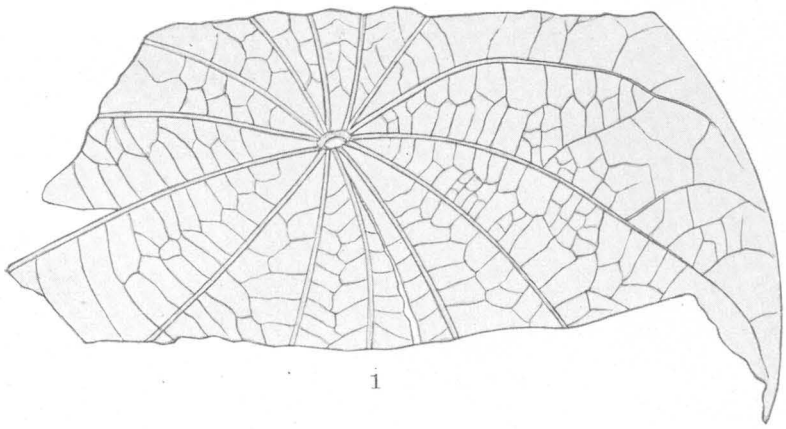


6

DENVER FLORA

1. *Celastrinites populifolius* Knowlton, n. sp. (M.C.Z. 1422), Denver formation.
2, 3. *Chrysobalanus coloradensis* Knowlton, n. sp. (U.S.N.M. 37729, 37730).
4. *Asimina eocenica* Lesquereux (U.S.N.M. 37718), Denver formation.
5. *Ficus martini* Knowlton, n. sp., Denver formation.
6. *Rhamnus cleburni* Lesquereux (U.S.N.M. 37828), showing character of larger leaves from the Denver formation formerly referred to *Cornus studeri* Heer.



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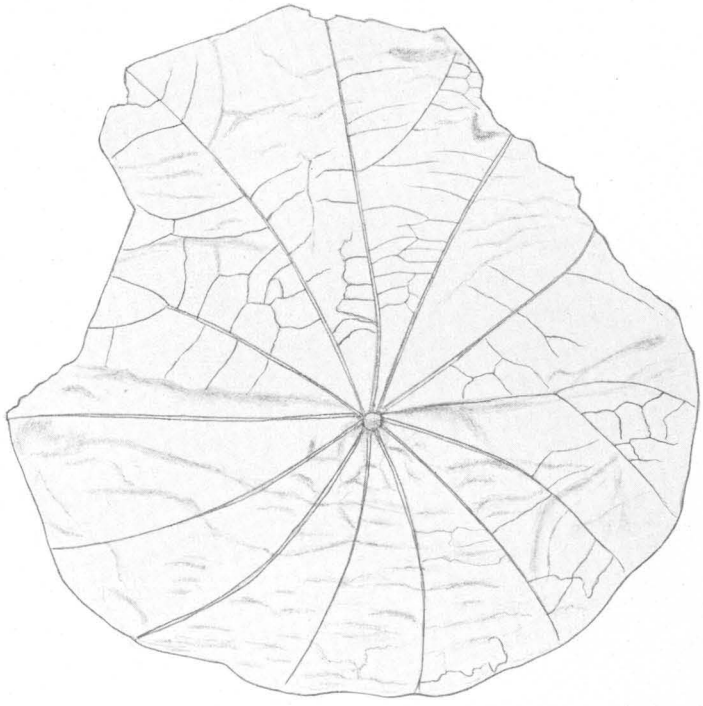

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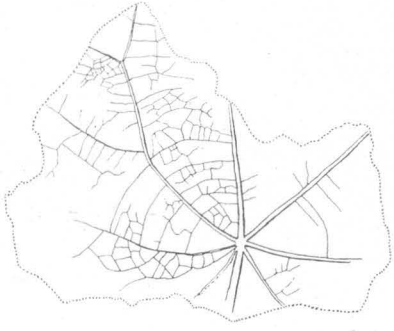

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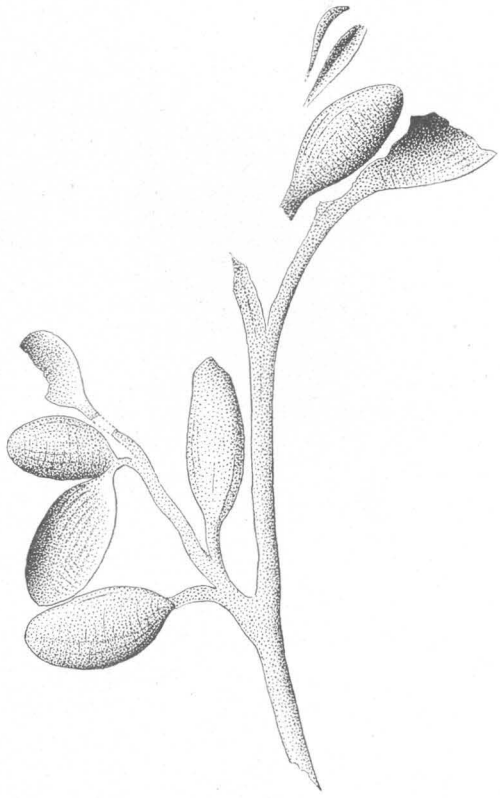

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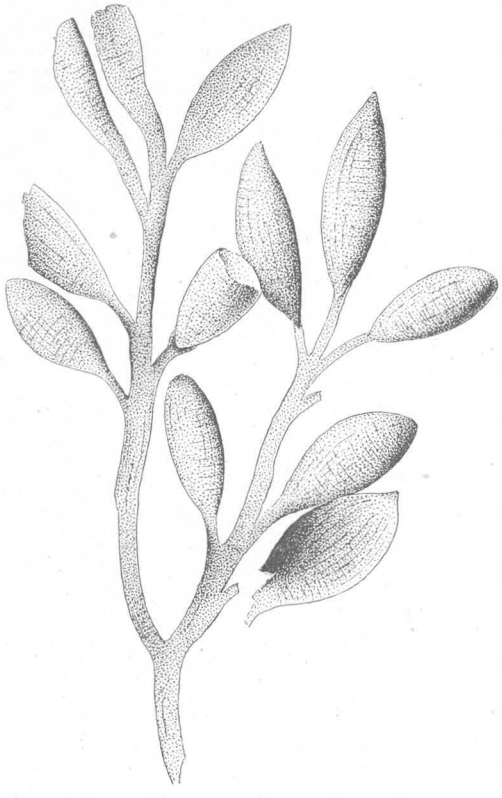
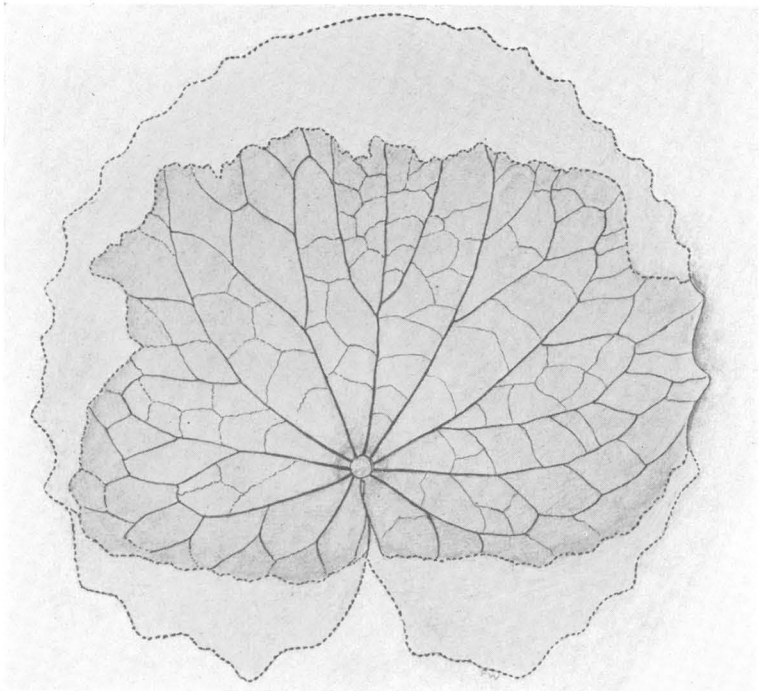


5

DENVER FLORA

1. *Nelumbo lakesiana* Lesquereux. (After Lesquereux.)
2. *Nelumbo tenuifolia* (Lesquereux) Knowlton. (After Lesquereux.)
3. *Nelumbo crossii* Knowlton, n. sp. (U.S.N.M. 37793), Dawson arkose, lower part (in beds=Arapahoe formation).
4, 5. *Berrya racemosa* (Knowlton) Knowlton, n. comb. (5, U.S.N.M. 37720), Dawson arkose.



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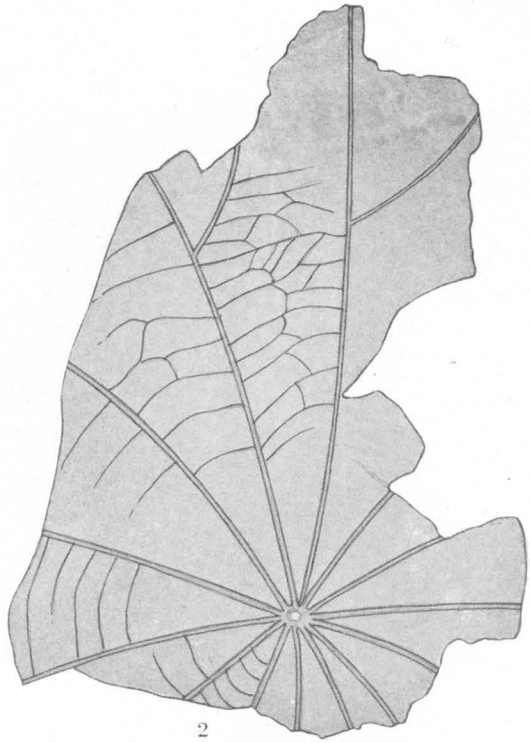

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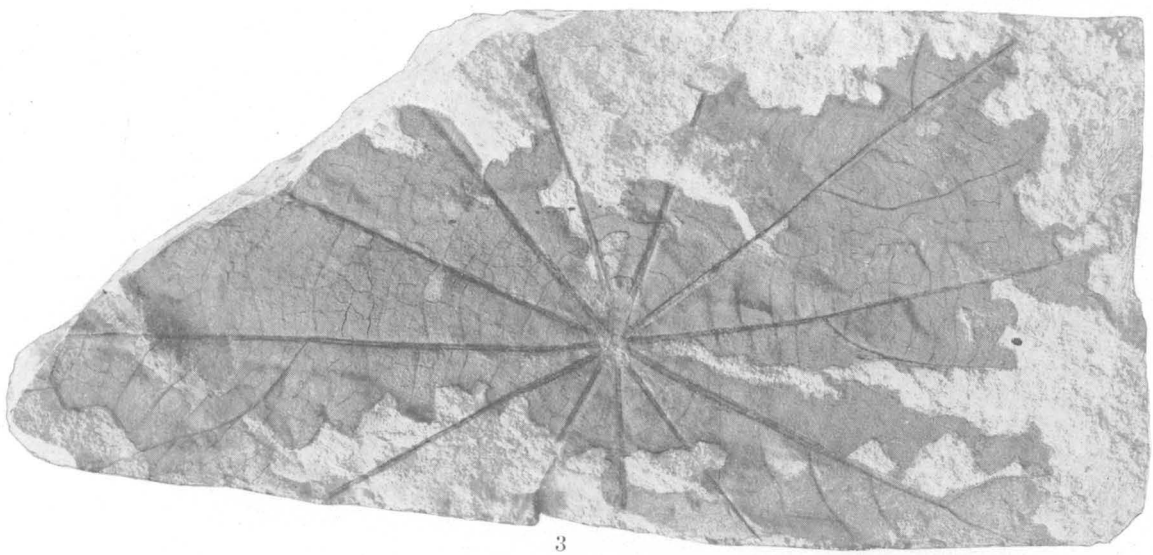

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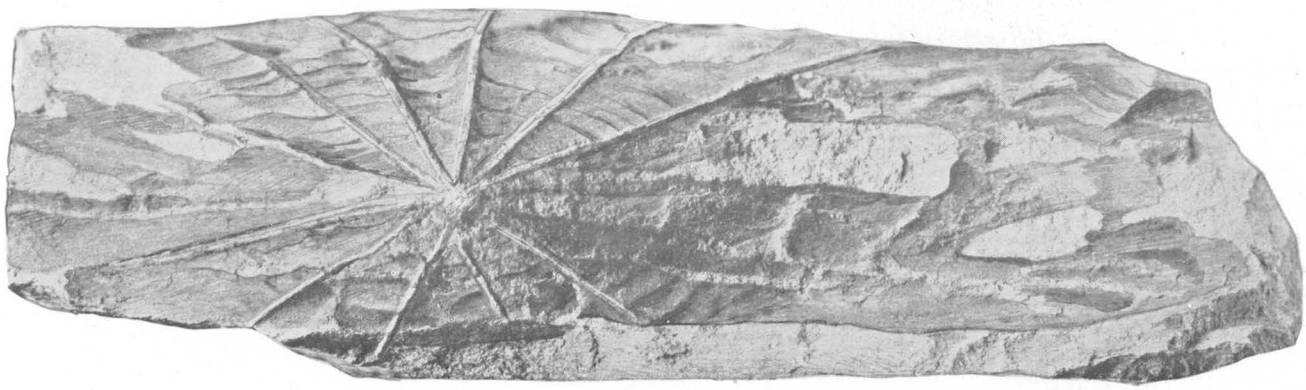
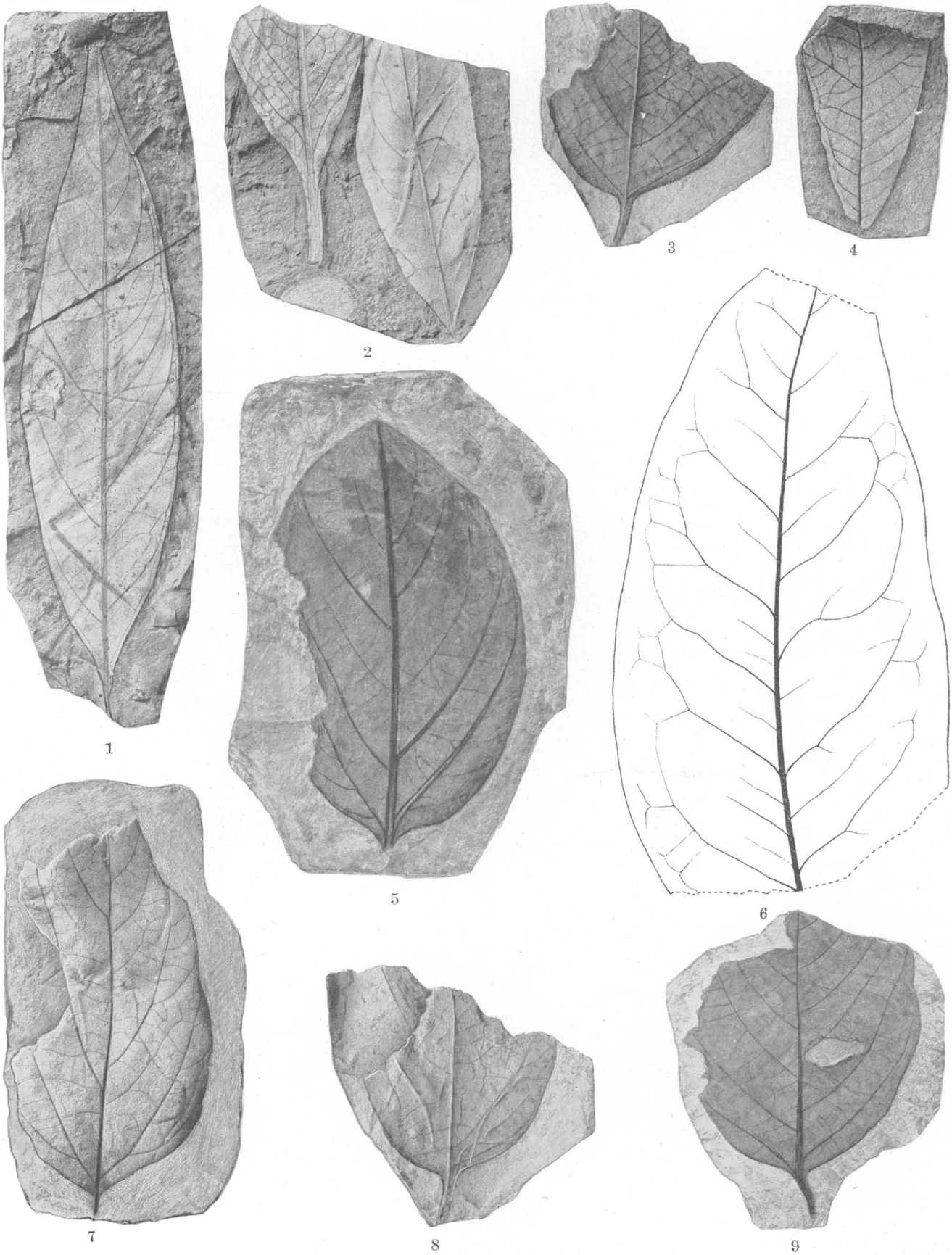


4

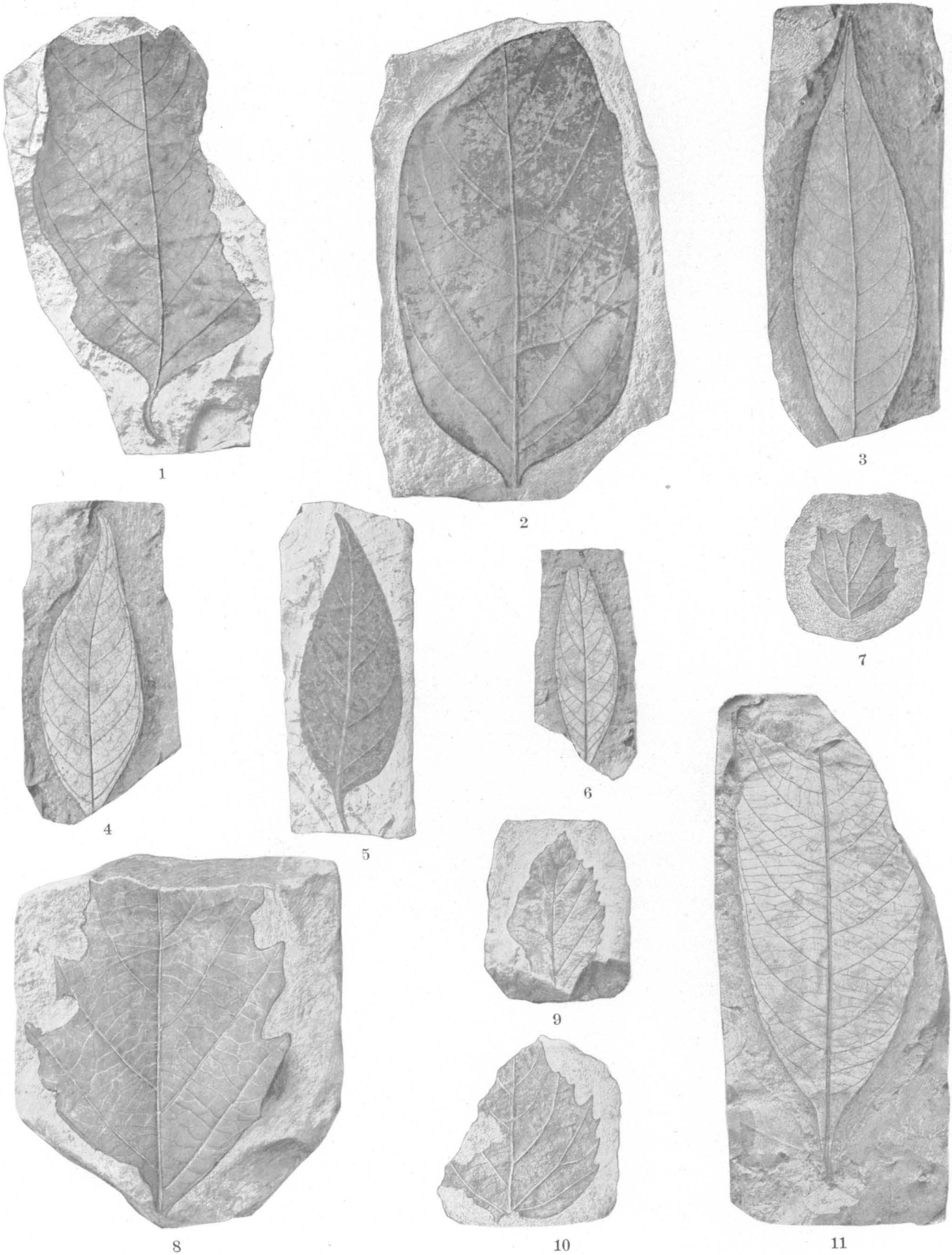
DENVER FLORA

1. *Castalia pulchella* Knowlton, n. sp. (restoration), Dawson arkose.
2. *Nelumbo lakesiana* Lesquereux. (After Lesquereux.)
3, 4. *Paleonelumbo macroloba* Knowlton, n. sp. (U.S.N.M. 37796), Dawson arkose.



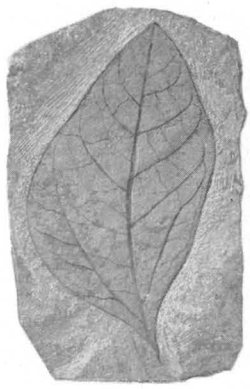
DENVER FLORA

1, 2, 4, 6. *Asimina eocenica* Lesquereux (1, 2, U.S.N.M. 37804; 4, U.S.N.M. 37717; 6, Pr. 2207). 4, Middle Park formation; 1, 2, 6, Dawson arkose; 6, × 2.
3, 5, 7–9. *Chrysobalanus coloradensis* Knowlton, n. sp. (3, 5, 8, 9, U.S.N.M. 37728; 7, M.C.Z. 1502).



DENVER FLORA

1, 2. *Chrysobalanus coloradensis* Knowlton, n. sp. (U.S.N.M. 37728).
3, 4, 6, 11. *Prunus denverensis* Knowlton, n. sp. (U.S.N.M. 37821), Dawson arkose.
5. *Chrysobalanus? lanceolatus* Knowlton, n. sp. (U.S.N.M. 37731), Dawson arkose.
7–10. *Crataegus myricoides* Lesquereux (8–10, M.C.Z. 1072, 1566, 1567), Denver formation.



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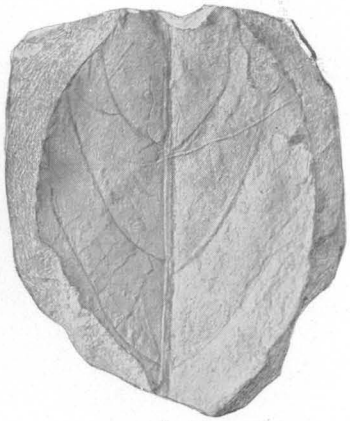

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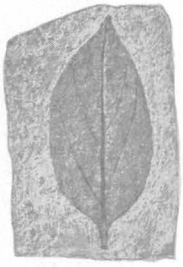

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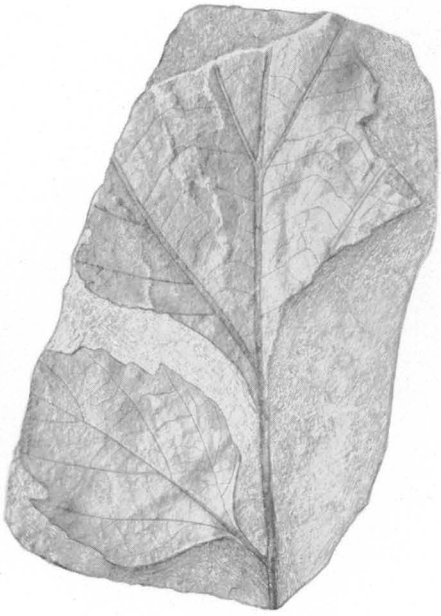

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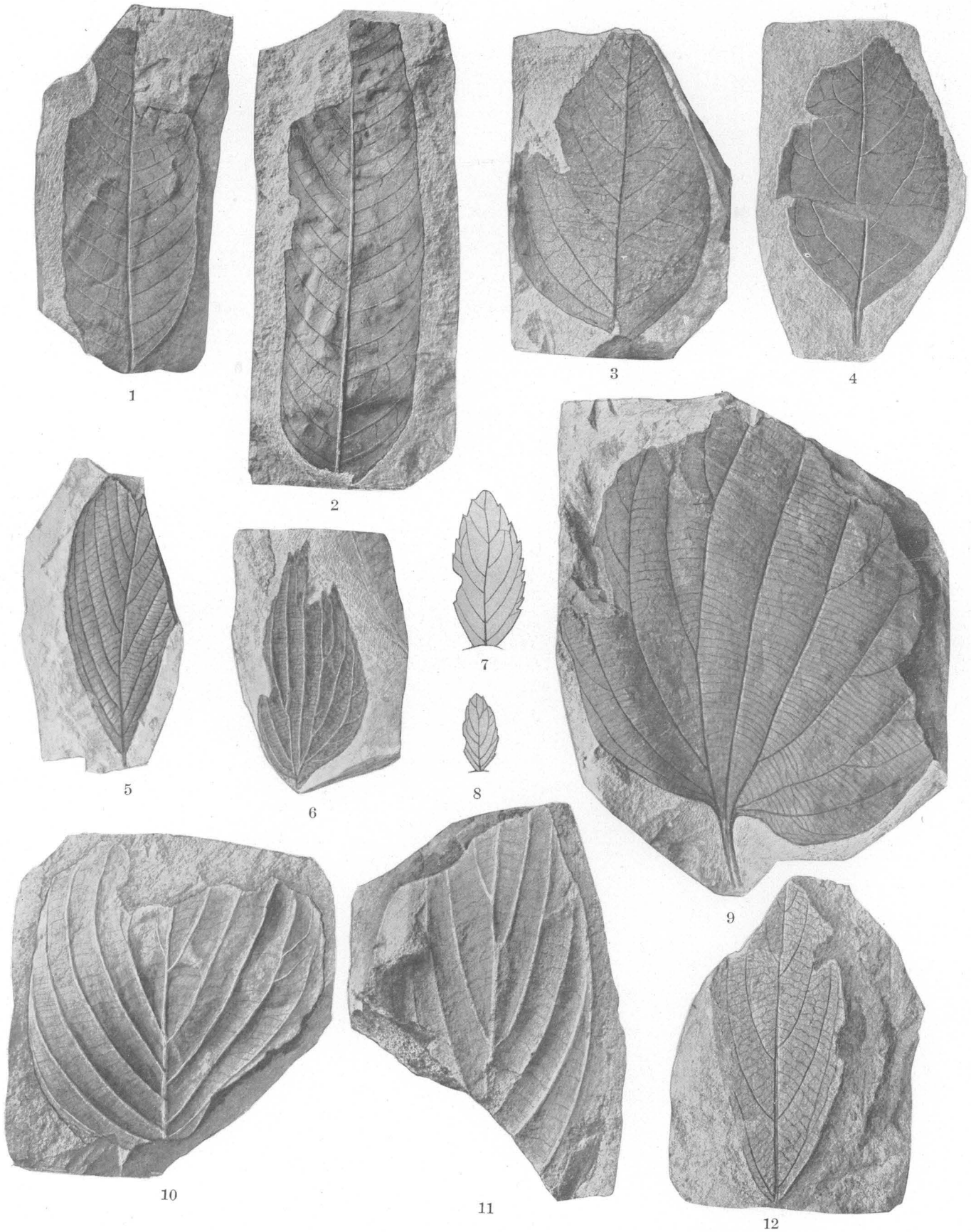
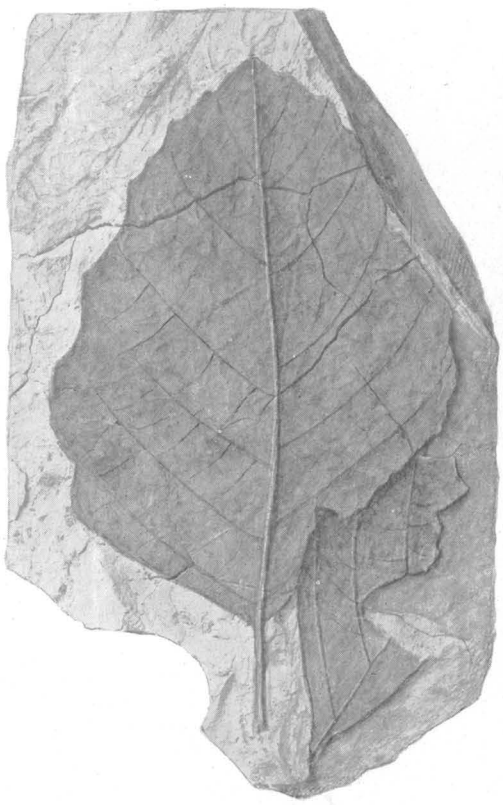
DENVER FLORA

1. *Phaseolites coloradensis* Knowlton, n. sp. (U.S.N.M. 37798), Dawson arkose.
2. *Cassia vetusta* Knowlton, n. sp. (U.S.N.M. 37724), Dawson arkose.
3, 4, 9. *Celastrus gaudini* Lesquereux (3, 9, M.C.Z. 1528, 1512), Denver formation.
5. *Cercis coloradensis* Knowlton, n. sp. (U.S.N.M. 37726), Dawson arkose.
6. *Acer* sp. Knowlton (U.S.N.M. 37716), Dawson arkose, lower part (in beds = Arapahoe formation).
7. *Sophora richardsoni* Knowlton, n. sp. (U.S.N.M. 37836), Dawson arkose.
8. *Sophora puryearensis* Berry? (U.S.N.M. 37835), Dawson arkose.
10. *Negundo decurrens* Lesquereux (M.C.Z. 1523), Denver formation.
11. *Celastrinites populifolius* Knowlton, n. sp. (M.C.Z. 1576), Denver formation.



DENVER FLORA

1, 2. *Sapindus berryanus* Knowlton, n. sp. (U.S.N.M. 37833), Dawson arkose.
3. *Sapindus? obtusifolius* Lesquereux, Denver formation.
4. *Ilex? ovata* Knowlton, n. sp. (U.S.N.M. 37783), Denver formation.
5. *Rhamnus cannoni* Knowlton, n. sp. (U.S.N.M. 37827), Middle Park formation.
6, 9. *Zizyphus fibrillosus* (Lesquereux) Lesquereux (U.S.N.M. 37849), Denver formation.
7, 8. *Rhamnus? praealaternoides* Knowlton, n. sp. (U.S.N.M. 432), Denver formation. (After Lesquereux.)
10, 11. *Rhamnus cleburni* Lesquereux (U.S.N.M. 37828), Dawson arkose.
12. *Rhamnus salicifolius* Lesquereux? (U.S.N.M. 37829), Dawson arkose.



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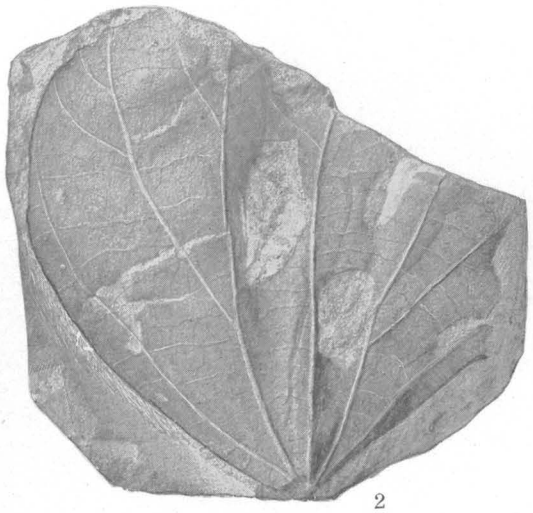

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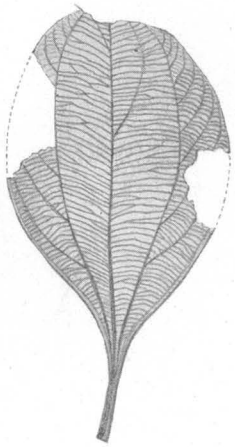

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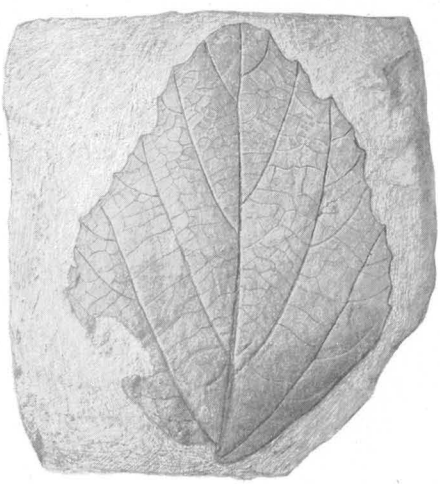

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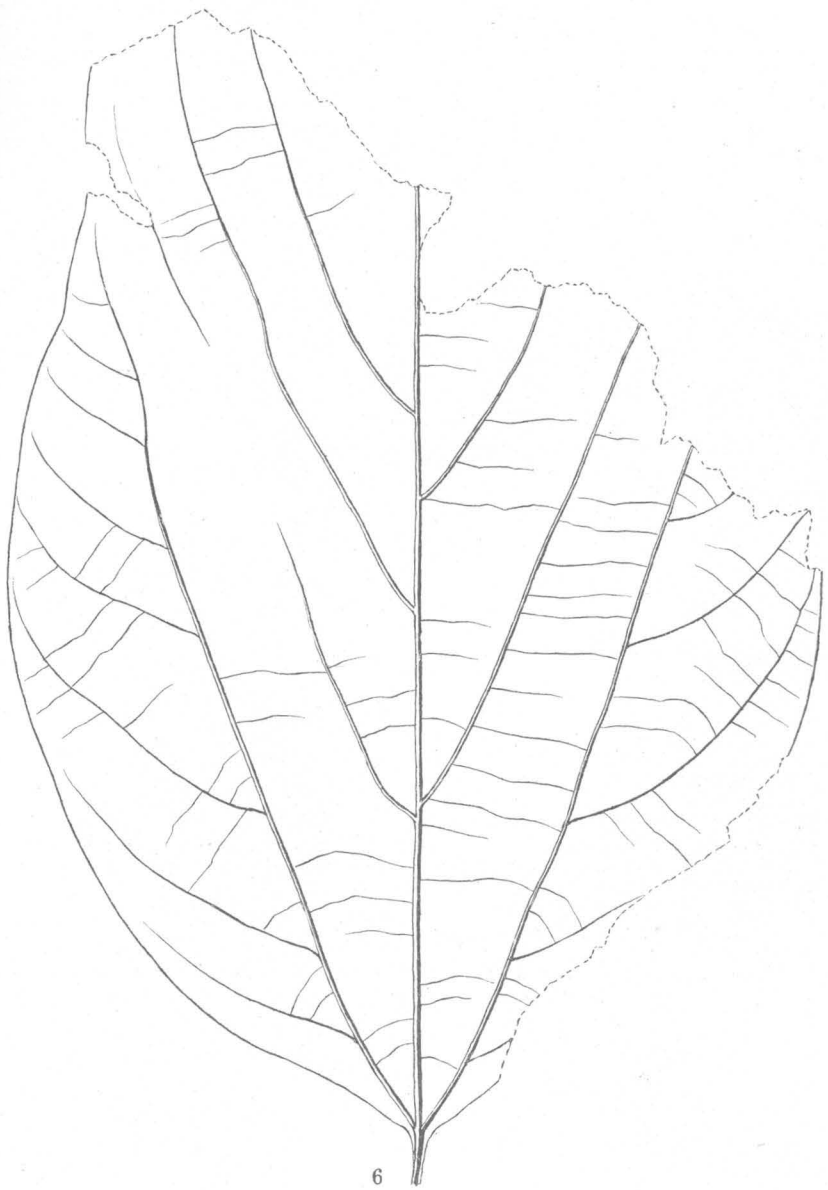

6

DENVER FLORA

1. *Cissus hesperia* Knowlton, n. sp. (U.S.N.M. 37740), Dawson arkose.
2. *Zizyphus distortus* Lesquereux (U S.N.M. 37848), Dawson arkose.
3. *Zizyphus beckwithii* Lesquereux, Denver formation. (After Lesquereux.)
4. *Cissus corylifolia* Lesquereux (M.C.Z. 1501), Denver formation.
5. *Cissus? cannoni* Knowlton, n. sp. (U.S.N.M. 37737), Middle Park formation.
6. *Cissus coloradensis* Knowlton and Cockerell, × 2 (U.S.N.M. 37736), Dawson arkose, lower part (in beds=Arapahoe formation).

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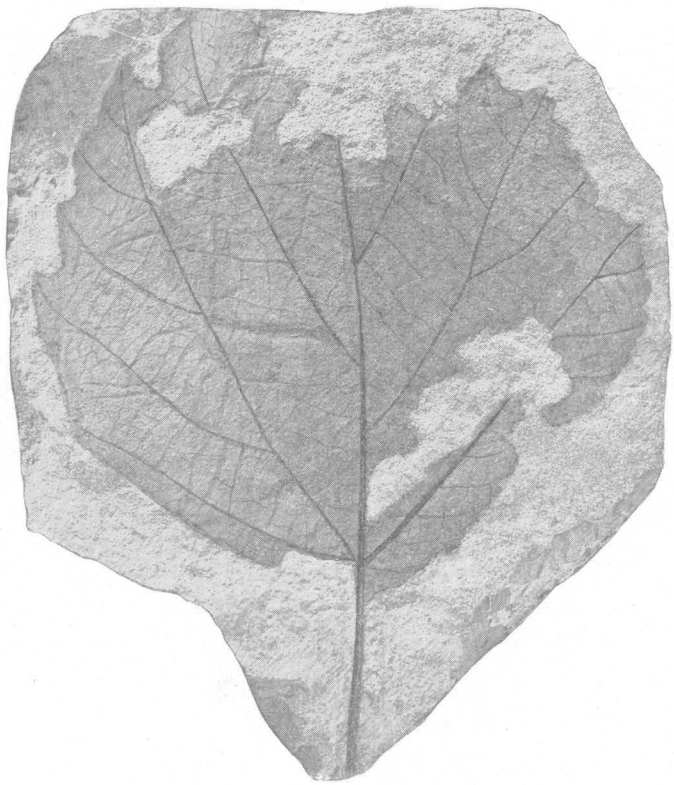

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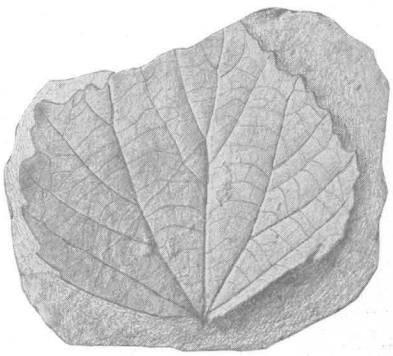

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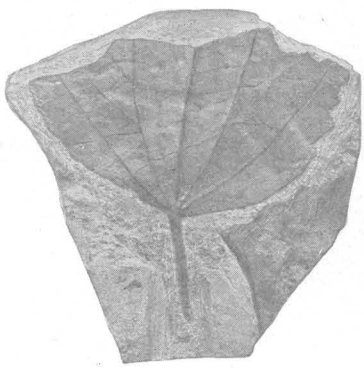

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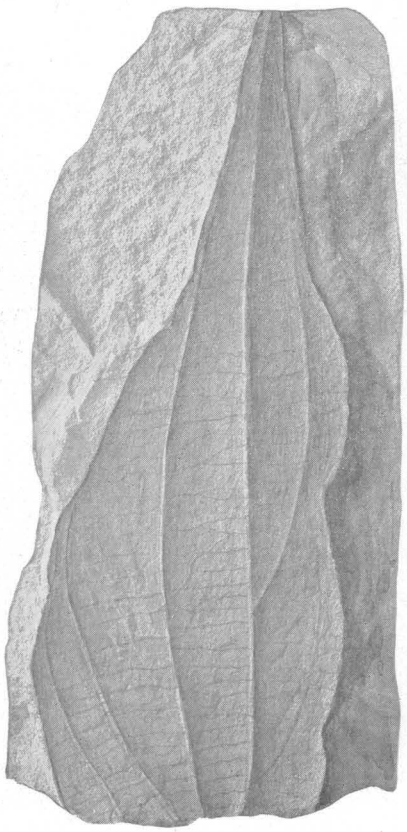

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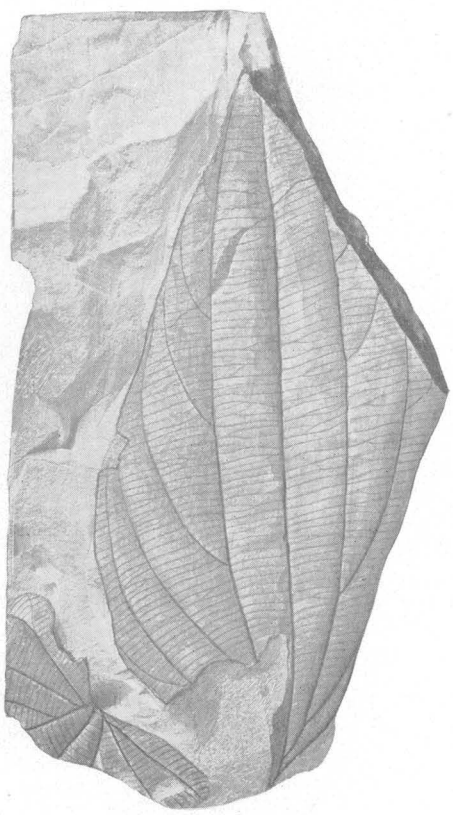
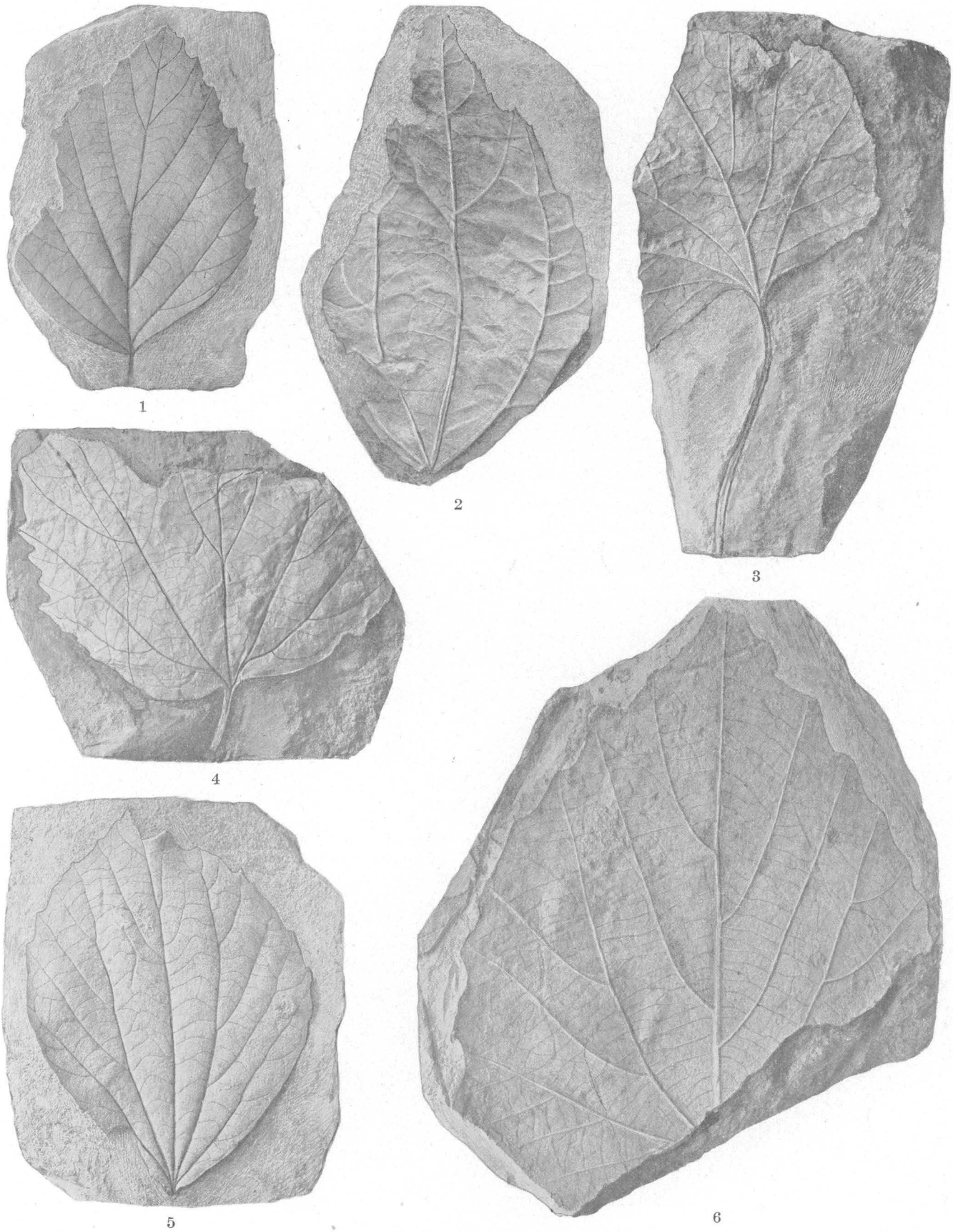


6

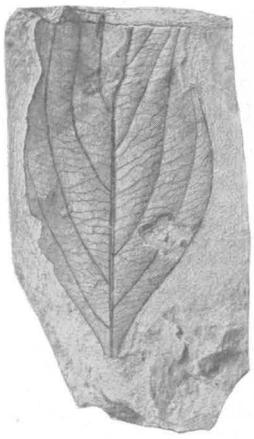
DENVER FLORA

1. *Cissus corylifolia* Lesquereux (M.C.Z. 1503), Denver formation.
2. *Cissus grosse-dentata* Knowlton (U.S.N.M. 37738), Dawson arkose.
3, 4. *Cissus lesquereuxii* Knowlton (3, M.C.Z. 1493; 4, U.S.N.M. 37741), Denver formation.
5, 6. *Zizyphus daphnogenoides* Knowlton (U.S.N.M. 37847), Denver formation.



DENVER FLORA

1. *Cissus corylifolia* Lesquereux (M.C.Z. 1504), Denver formation.
2. *Zizyphus hesperius* Knowlton, n. sp. (M.C.Z. 1534), Denver formation.
3, 4. *Cissus lobato-crenata* Lesquereux (U.S.N.M. 37742, 37743), Dawson arkose, lower part (in beds=Arapahoe formation)
5. *Cissus obovata* Knowlton, n. sp., Denver formation.
6. *Vitis olriki* Heer (U.S.N.M. 37844), Dawson arkose.



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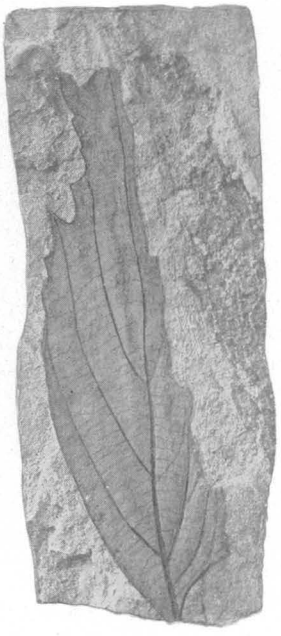

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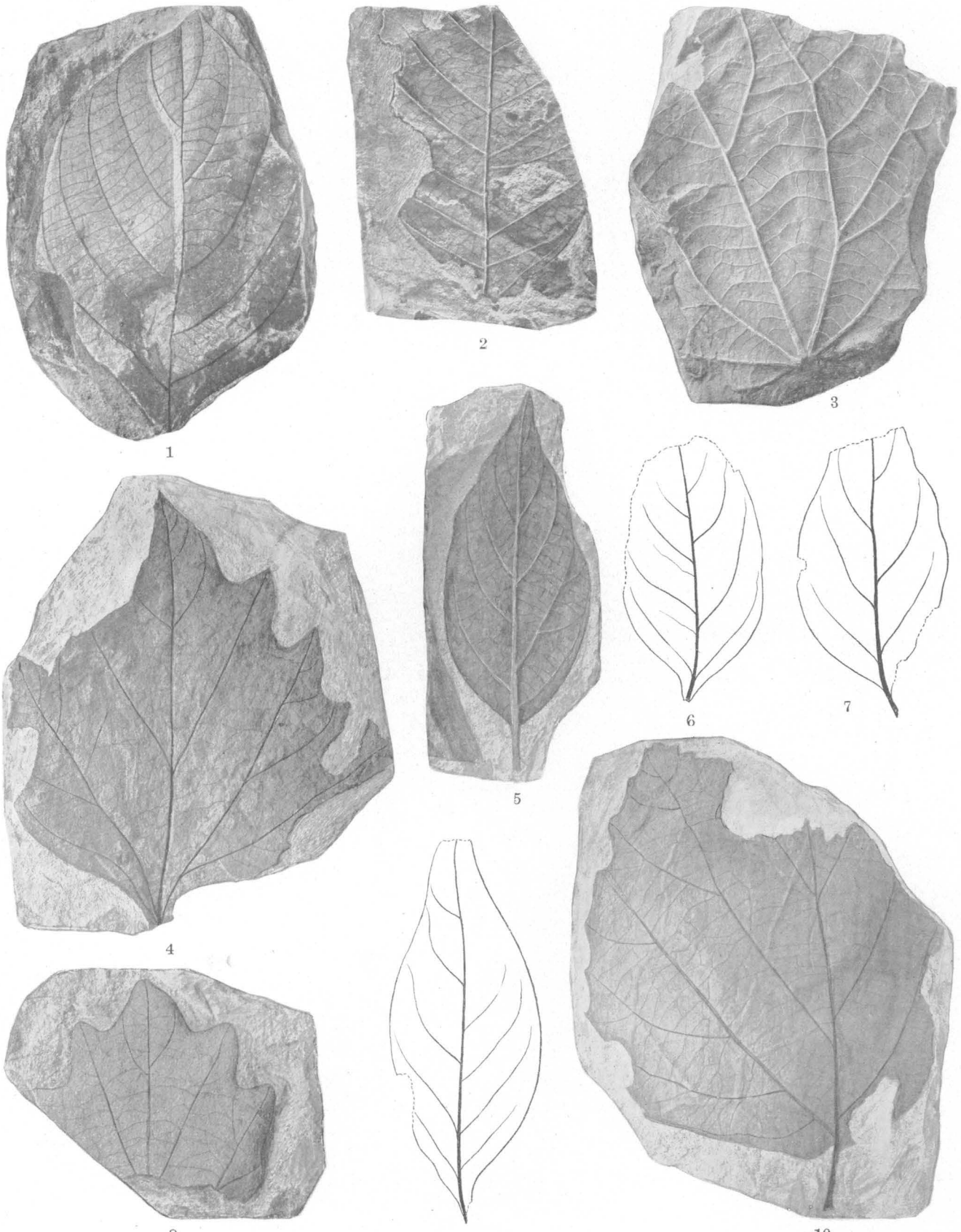
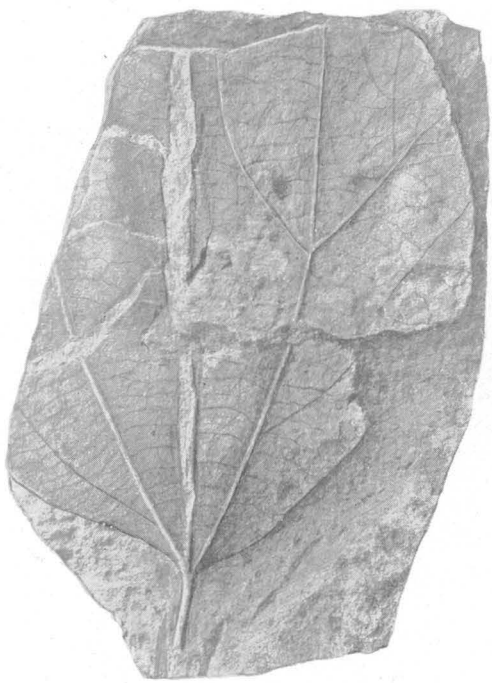
DENVER FLORA

1. *Cornus lakesii* Knowlton, n. sp. (U.S.N.M. 37746), Denver formation.
2. *Cissus coloradensis* Knowlton and Cockerell, × 2 (U.S.N.M. 37736), Dawson arkose, lower part (in beds=Arapahoe formation).
3. *Grewiopsis tenuifolia* Lesquereux (U.S.N.M. 37781), Dawson arkose.
4. *Vitis olriki* Heer (U.S.N.M. 37845), Dawson arkose.
5. *Sterculia? heterodonta* Knowlton, n. sp. (U.S.N.M. 37837), Dawson arkose.
6. *Pterospermites grandidentata* Lesquereux (M.C.Z. 1519), Denver formation.



DENVER FLORA

1, 2. *Cornus impressa* Lesquereux (U.S.N.M. 37744, 37745), Dawson arkose.
3. *Pterospermites grandidentata* Lesquereux (M.C.Z. 1517), Denver formation.
4, 8. *Sterculia? heterodonta* Knowlton, n. sp. (U.S.N.M. 37837), Dawson arkose.
5, 6, 7, 9. *Diospyros brachysepala* Al. Braun (5, U.S.N.M. 37748; 6, 7, 9, U.S.N.M. 37749), 5, Dawson arkose; 6, 7, 9, × 1½, Denver formation.
10. *Cissus grosse-dentata* Knowlton (U.S.N.M. 37739), Dawson arkose.



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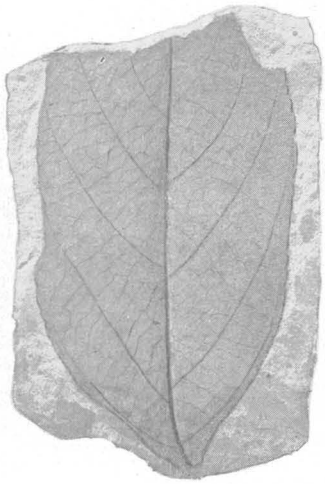

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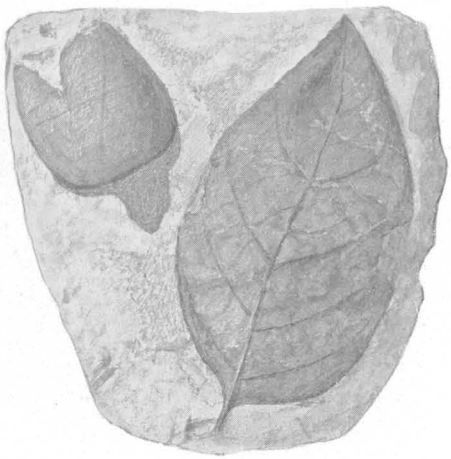

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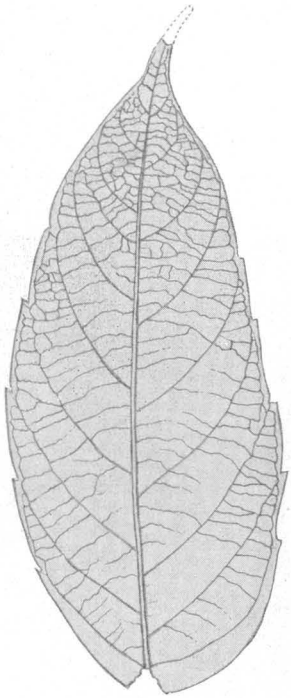

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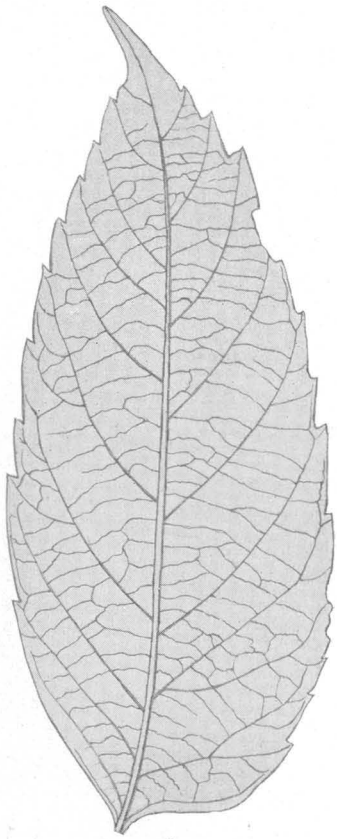

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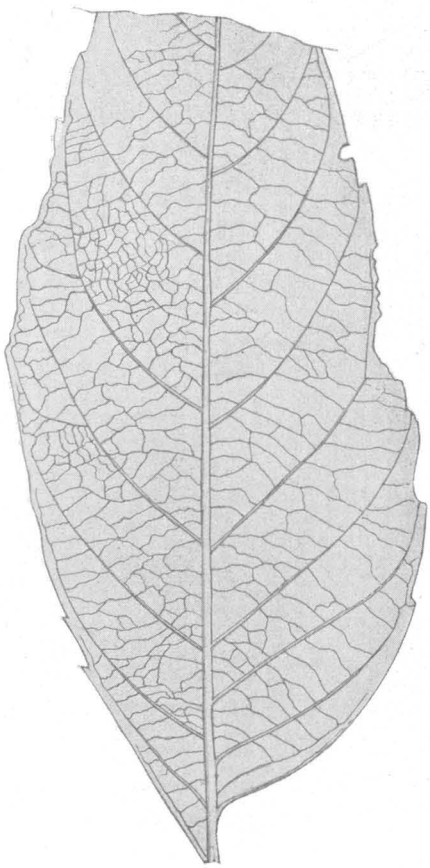

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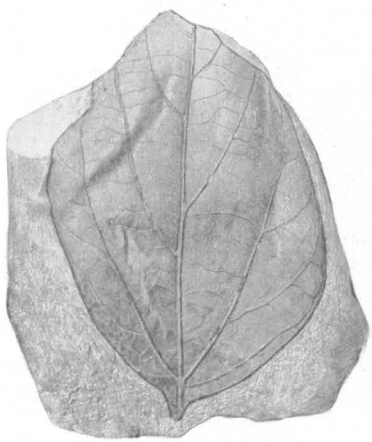

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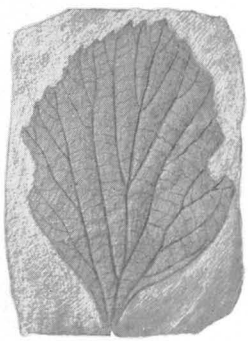
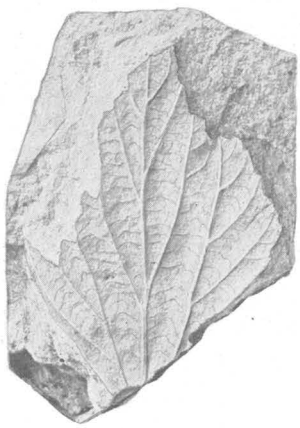


8

DENVER FLORA

1. *Zizyphus distortus* Lesquereux (U.S.N.M. 37848), Dawson arkose.
2. *Nyssa lanceolata* Lesquereux (U.S.N.M. 37794), Dawson arkose.
3. *Diospyros brachysepala* Al. Braun (U.S.N.M. 51055), Denver formation.
4–6. *Fraxinus eocenica* Lesquereux, Denver formation. (After Lesquereux.)
7. *Styrax? laramiensis* Lesquereux (M.C.Z. 1488), Denver formation.
8. *Viburnum richardsoni* Knowlton, n. sp. (U.S.N.M. 37843), Dawson arkose.



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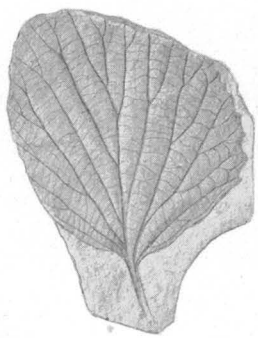

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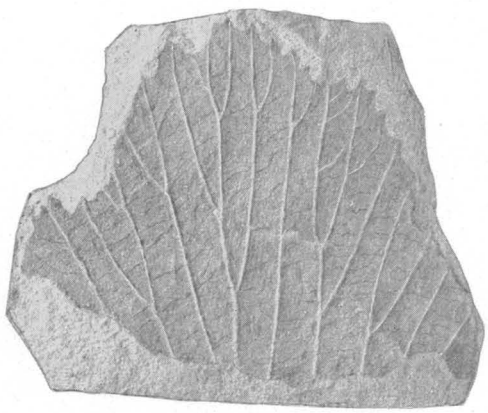

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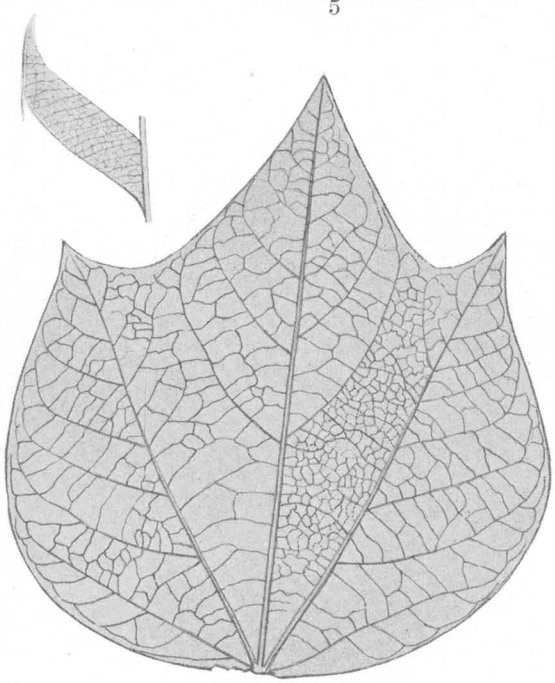

6

DENVER FLORA

1, 3, 4, 5. *Viburnum richardsoni* Knowlton, n. sp. (1, 3, 5, U.S.N.M. 37843; 4, M.C.Z. 1576), Dawson arkose.
2. *Sterculia libbeyi* Knowlton, n. sp., × 1½ (Pr.), Denver formation.
6. *Sterculia saportanea* Knowlton, Denver? formation. (After Lesquereux.)

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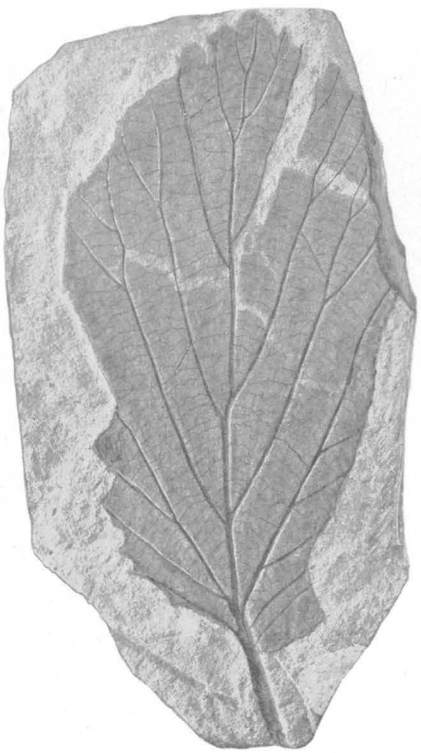

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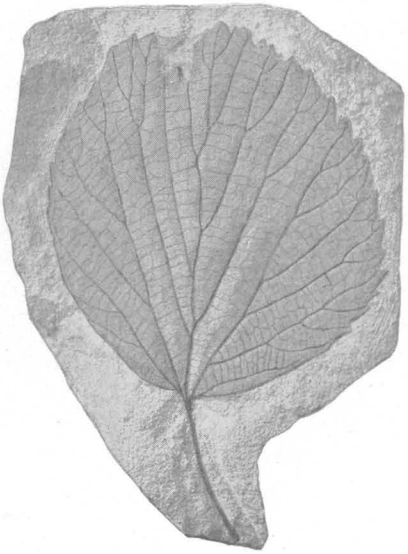

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4

DENVER FLORA

1. *Nyssa? obovata* Knowlton, n. sp. (U.S.N.M. 37795), Denver formation.
2, 3. *Viburnum richardsoni* Knowlton, n. sp. (U.S.N.M. 37843), Dawson arkose
4. *Dombeyopsis magnifica* Knowlton,n. sp. (U.S.N.M. 37755), Dawson arkose.

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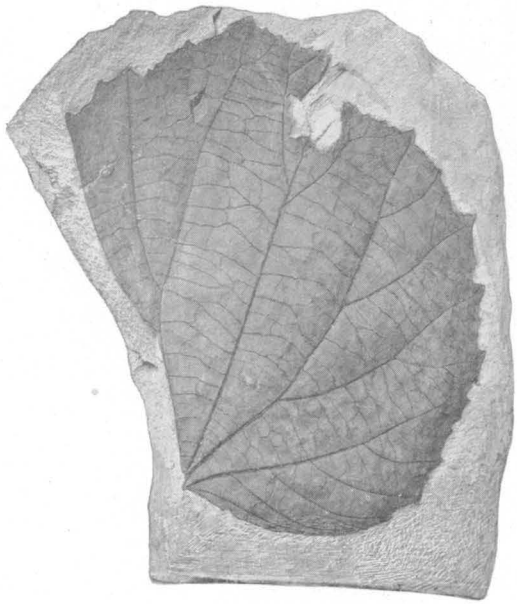

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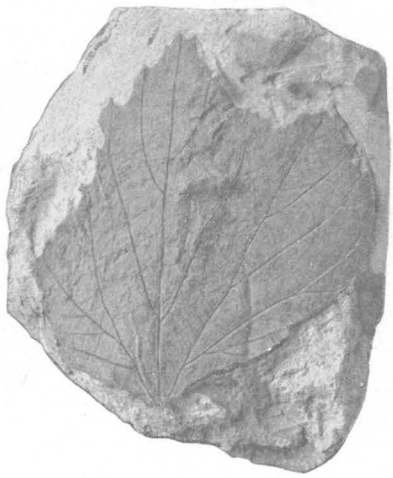

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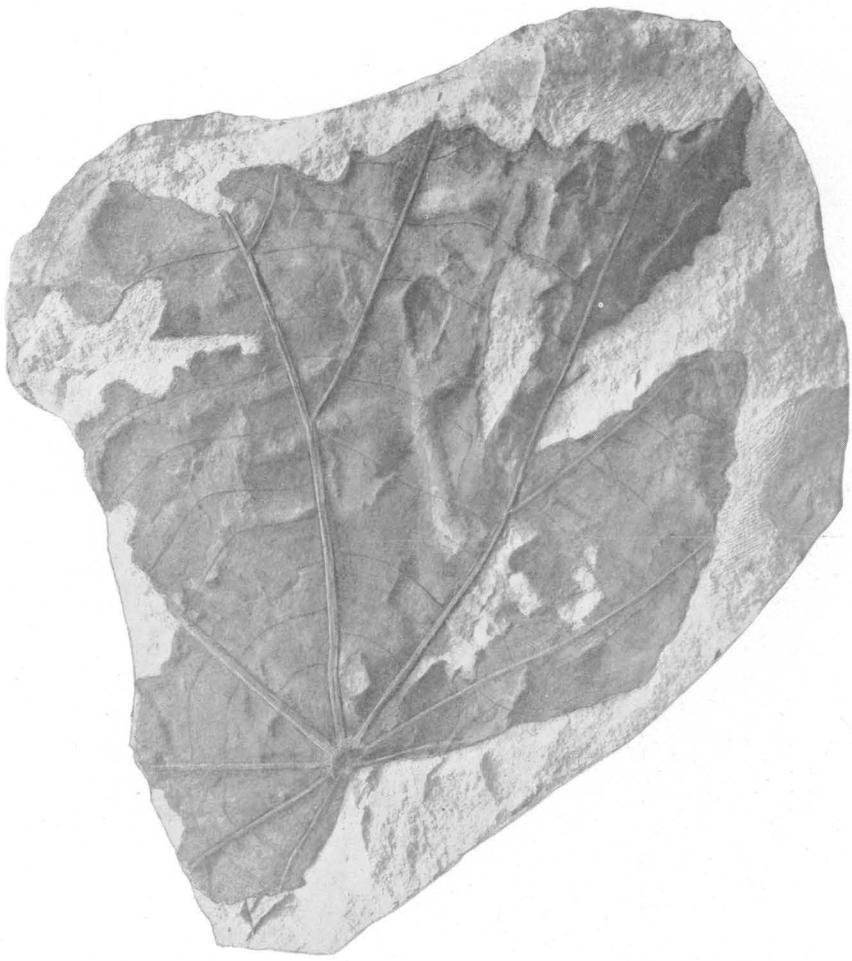

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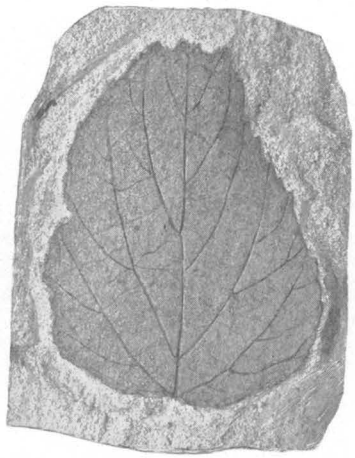

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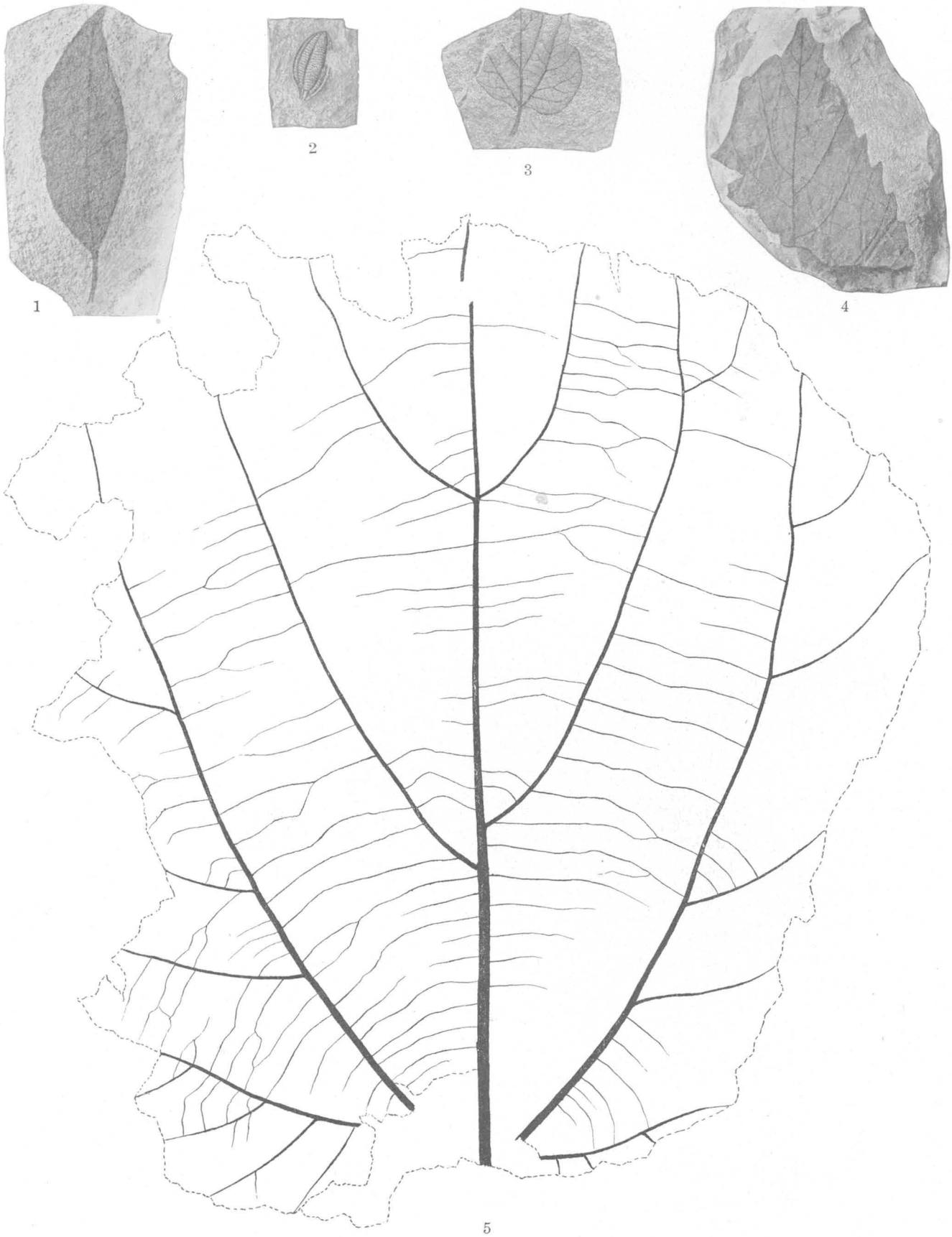
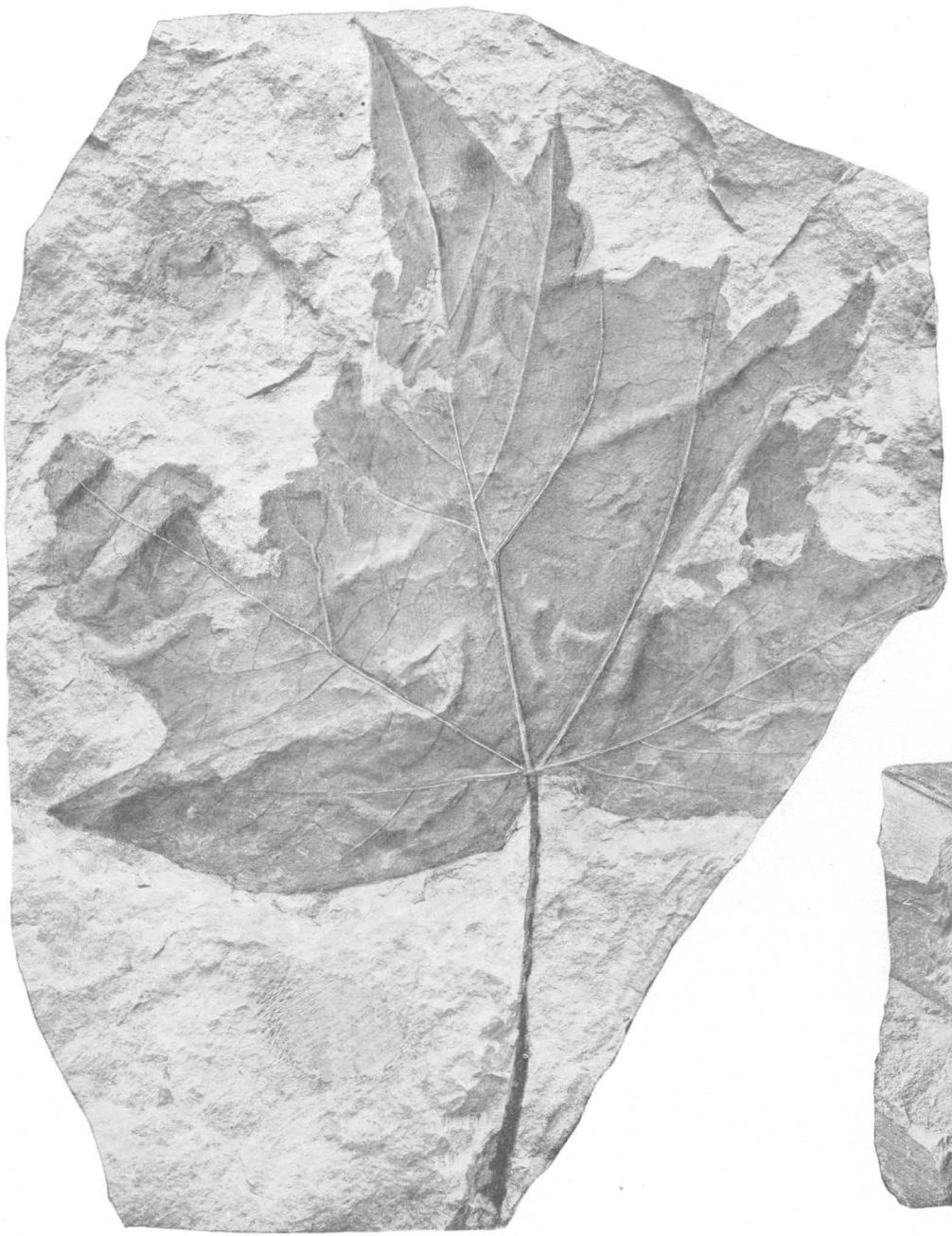
DENVER FLORA

1. *Viburnum contortum* Lesquereux? (U.S.N.M. 37839), Dawson arkose.
2. *Viburnum? heterodontum* Knowlton, n. sp. (U.S.N.M. 37840), Denver formation.
3. *Viburnum lakesii* Lesquereux (U.S.N.M. 37841), Denver formation.
4. *Dombeyopsis magnifica* Knowlton, n. sp. (U.S.N.M. 37755), Dawson arkose.
5. *Viburnum melaenum* Knowlton and Cockerell (U.S.N.M. 37842), Dawson arkose.
6. *Phyllites aristolochioides* Knowlton, n. sp. (U.S.N.M. 37799), Dawson arkose, lower part (in beds=Arapahoe formation).
7. *Phyllites andromeda* Knowlton, n. sp. (U.S.N.M. 37797), Dawson arkose.



DENVER FLORA

1. *Phyllites calhanensis* Knowlton, n. sp. (U.S.N.M. 37800), Dawson arkose.
2. *Carpites quadrivalvis* Knowlton, n. sp. (U.S.N.M. 37722), Dawson arkose.
3. *Phyllites* sp. Knowlton (U.S.N.M. 37802), Dawson arkose.
4. *Phyllites pellucidus* Knowlton, n. sp. (U.S.N.M. 37801), Dawson arkose.
5. *Dombeyopsis? sedaliensis* Knowlton, n. sp., × 2, Dawson arkose, lower part (in beds=Arapahoe formation).



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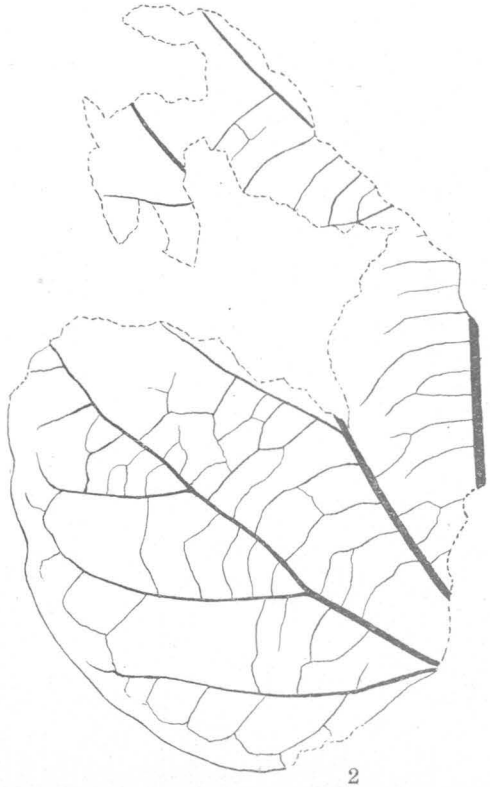

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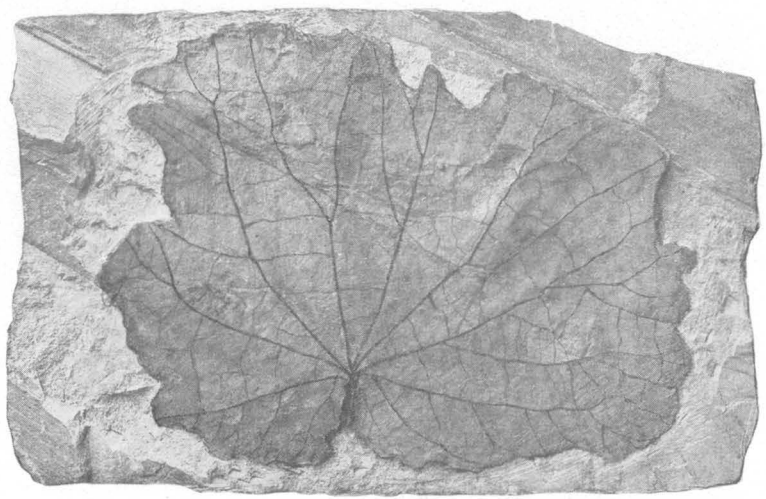

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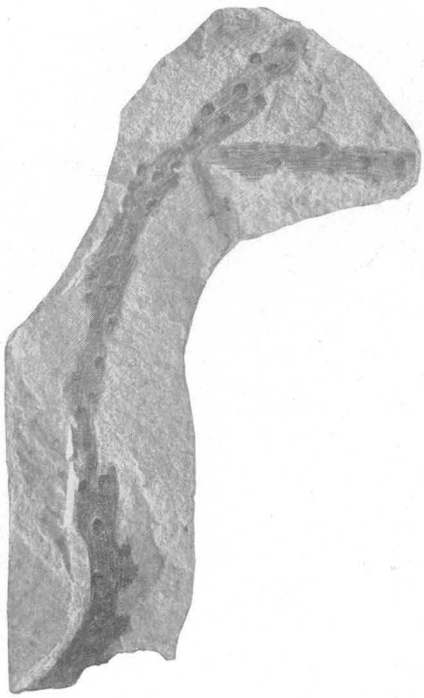
DENVER FLORA

1. *Dombeyopsis magnifica* Knowlton, n. sp. (U.S.N.M. 37755), Dawson arkose.
2. *Phyllites aristolochioides* Knowlton, n. sp., × 2, Dawson arkose, lower part (in beds=Arapahoe formation).
3. *Castalia pulchella* Knowlton, n. sp. (U.S.N.M. 37725), Dawson arkose.

1



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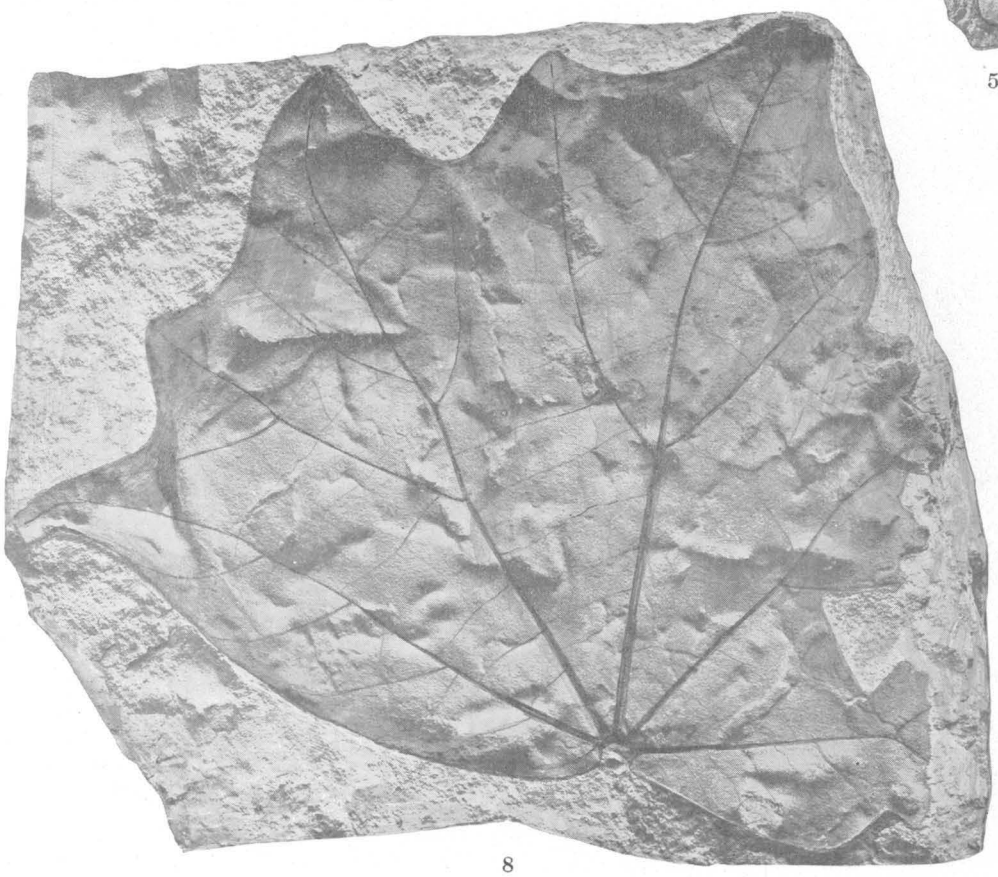

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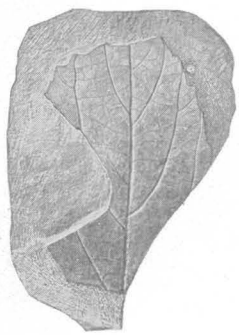
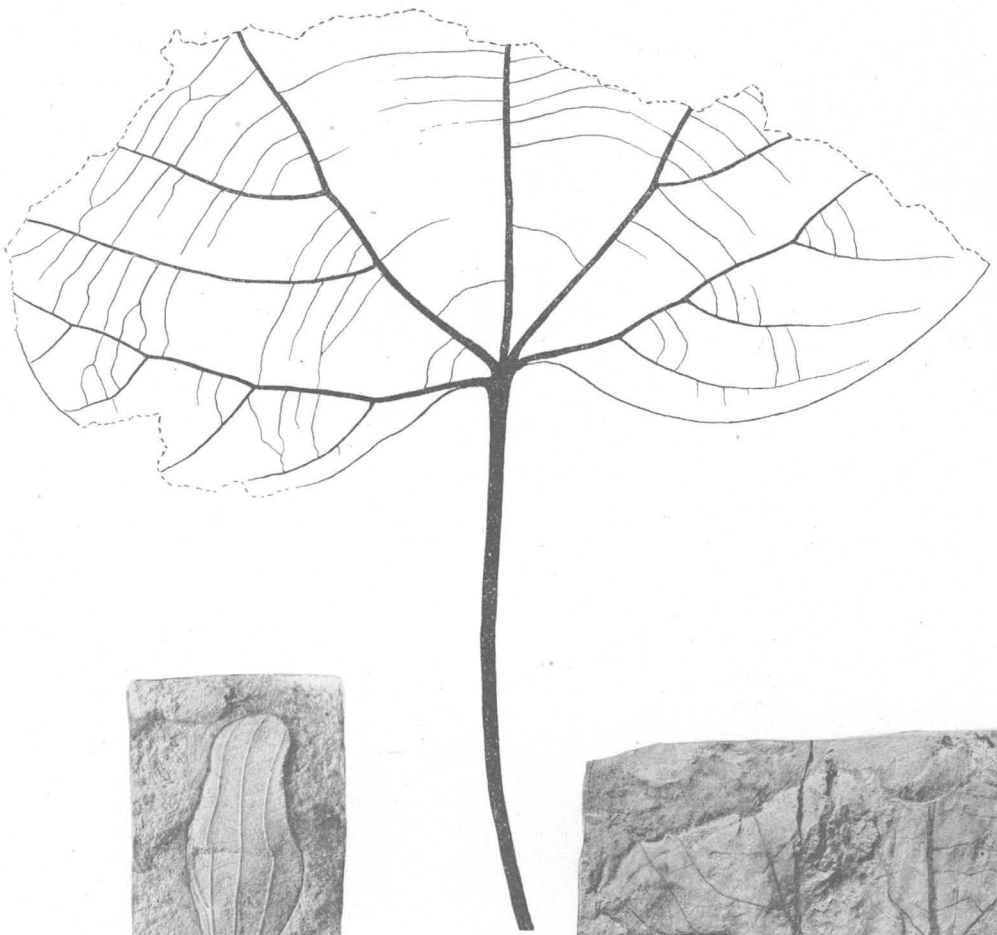


7

DENVER FLORA

1, 2. Decorticated roots (U.S.N.M. 37747), Dawson arkose.
3–5. *Carpites coryloides* Knowlton, n. sp. (U.S.N.M. 37723), Dawson arkose.
6. *Carpites templetoni* Knowlton, n. sp. (U.S.N.M. 37721), Dawson arkose.
7. *Fraxinus* sp. Knowlton (M.C.Z. 1487), Denver formation.
8. *Dombeyopsis magnifica* Knowlton, n. sp. (U.S.N.M. 37755), Dawson arkose.



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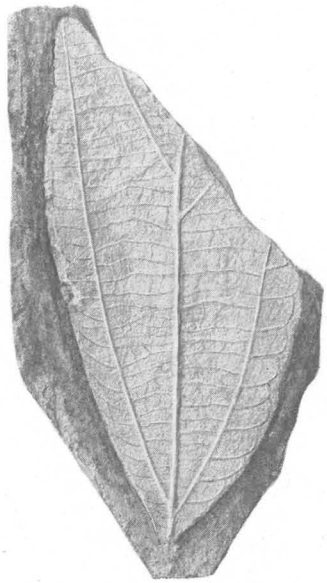

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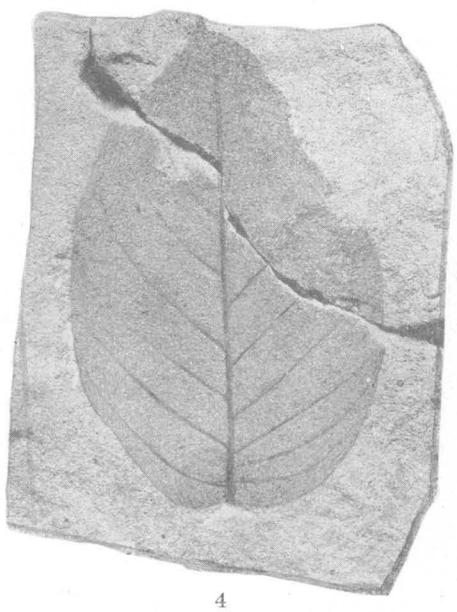

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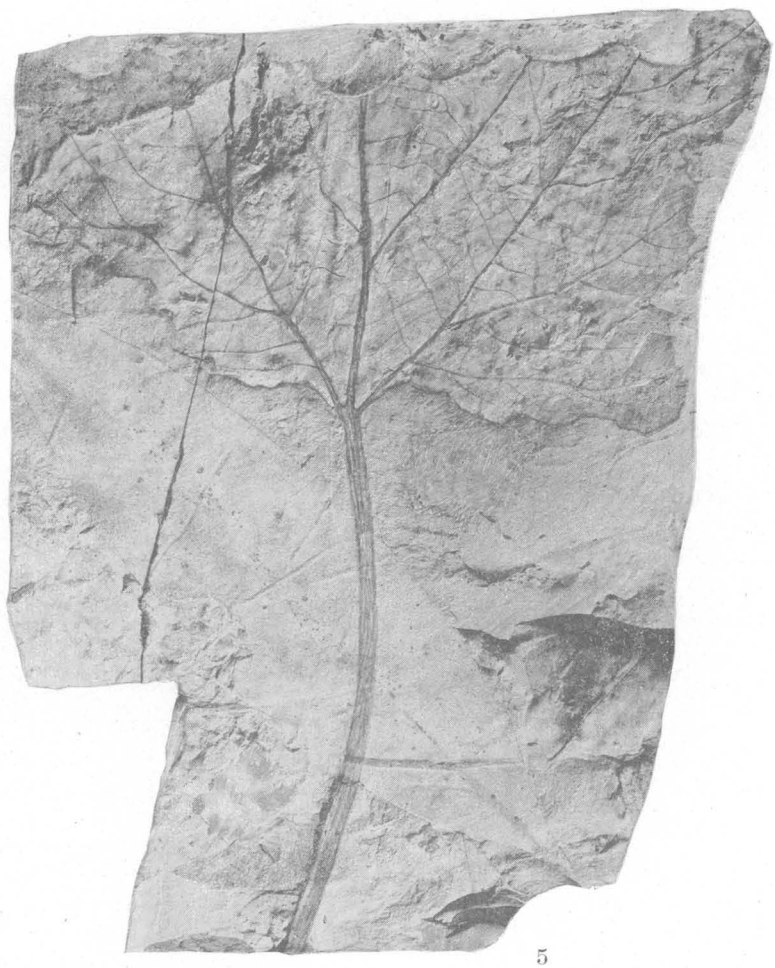

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DENVER FLORA

1. *Dombeyopsis? sedaliensis* Knowlton, n. sp., Dawson arkose, lower part (in beds=Arapahoe formation).
2. *Cinnamomum sezannense* Watelet? (U.S.N.M. 37735), Dawson arkose.
3. *Cinnamomum linifolium* Knowlton (U.S.N.M. 37734), Dawson arkose.
4. *Ficus eldridgi* Knowlton, n. sp., Denver formation, Scranton, Colo.
5. *Phyllites denverensis* Knowlton, n. sp. (U.S.N.M. 37803), Denver formation.

INDEX

Names in *italics* are synonyms; figures in black face refer to descriptions]