Our Native Ferns And Their Allies.

Underwood.

OUR

NATIVE FERNS

AND

THEIR ALLIES

WITH

Synoptical Descriptions of the American Pteridophyta North of Mexico

BY

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PREFACE.

When the writer issued this little book in 1880 as the honest effort of a novice to provide for the study of our ferns a convenient handbook by means of which they might be identified, he had no idea that the first edition would be exhausted within a year, and much less that a sixth edition would ever be called for. Though frequently urged to extend its scope, he has felt that if, with all the traces of its early imperfections of plan, there is still a demand for such a handbook, it is best to leave it in its original form, with only such changes as our changed conceptions of structures, relationships, and definition of species demand. Not only is this preservation of the original plan in harmony with the feeling of sentiment, but it seems the more desirable since the writer is preparing a monograph of all the North American Ferns (including those of the West Indies and the continent as far as the Isthmus), and in this more elaborate work he hopes from a study of a wider range of forms to include many more general matters that our own limited fern flora, though quite diverse, do not furnish a sufficient basis for inclusion here, and others still that would be out of place in an elementary manual.

Changes in this edition are mostly verbal and such as arise from the modifications of nomenclature or the changed ideas of homologies and relations of structures. The chapter on nomenclature has been wholly rewritten and extended, particularly because the present edition more than any other contributes to a modification of generic names.

In the systematic part the sequence has also been modified, bringing the simpler eusporangiate forms first and introducing the desirable distinction between orders and families which botanists have too long confused.

The number of species is considerably increased, owing in part to new discoveries and in part to the seeming necessity of reestablishing the earlier and in many cases clearer views of the earlier writers on ferns, many of whose species have been reduced to synonymy by the English (Kew) school of fern writers whose dictum has hitherto been followed by American fern students. The number of genera has also been increased in accordance with the views of earlier and more scientific fern students.

COLUMBIA UNIVERSITY, June, 1900.

TABLE OF CONTENTS.

INTRODUCTION.

IN the entire vegetable world there are probably no forms of growth that attract more general notice than the Ferns. Delicate in foliage, they are sought for cultivation in conservatories and Wardian cases, and when dried and pressed add to the culture of many a domestic circle by serving as household decorations. They furnish to botanists a broad and inviting field for investigation, and he who examines their more minute structure with the microscope will find deeper and still more mysterious relations than those revealed to the unaided eye. Ferns thus appeal to the scientific element of man's nature as well as to the æsthetic, and while they highly gratify the taste, they furnish food for the intellect in a like degree.

The Fern allies have also played their appointed part in the domestic and decorative economy of this and other generations. The scouring-rushes served our ancestors for keeping white their floors and wooden-ware in the days when carpets were a luxury. The trailing stems of various species of *Lycopodium* have long been valued for holiday decorations ; while their burning spores have flashed in triumphal processions, and have added their glow to the fervor of political campaigns.

In olden time the obscure fructification of the common brake led to many superstitious ideas among the common people, and the older poets have woven these popular notions into our literature. Butler tells in Hudibras of bugbears so often created by mankind :

> "That spring like fern, that infant weed,
> Equivocally without seed,
> And have no possible foundation
> But merely in th' imagination."

Shakespeare only reflects a prevalent belief of his time when he says:

"We have the receipt of fern seed; we walk invisible."

Others allude to the falling of the seed on the anniversary night of the birth of John the Baptist. The old simplers with their lively imagination were impressed by the fancied resemblances of some parts of fern growth to various organs of the human body, and introduced them into their system of specifics. Traces of their influence still remain in the names of some of our common ferns, as spleenwort and maidenhair.

To form a correct understanding of ferns we must study the ferns themselves as well as the text-book, as it is only by direct contact with nature that we gain definite and satisfactory information. The text-book is useful only in giving directions how to investigate. To understand thoroughly an animal we must study its habits in its native haunts. To know its structure and position in the animal kingdom we must carefully dissect a large number of specimens, and study the development of the individual from its beginning. In like manner, to understand fully a fern we must search where nature has planted it, watch it as it uncoils from the bud, matures, produces its fruit, and finally returns to the earth; examine it with needles and lenses, and discover its minute structure and its life-history. These pages, which aim to give an outline of the forms of fern growth, the methods of fruiting, the germination or growth from the spore, and finally the more minute structure of the entire plant, can only be thoroughly understood by taking the ferns in hand and studying them in connection with the text.

Let no one imagine that the study of ferns will be an easy one. Patient application and careful observation are essential to success, yet he who becomes once interested in the work will find a subject that deepens in interest with every step, and even becomes enchanting as he seeks to determine the mysterious processes of fern development and the marvels of fern structure.

OUR NATIVE FERNS AND THEIR ALLIES.

CHAPTER I.

HAUNTS AND HABITS OF FERNS.

Our outward life requires them not,—
Then wherefore had they birth?
To minister delight to man,
To beautify the earth.

—MARY HOWITT.

1. General Characters.—Our native ferns comprise plants varying in height from less than an inch to six or seven feet, or even more. Some are stout and fleshy, others are delicate and even filmy, but most are herbaceous, resembling ordinary flowering plants in the texture of their foliage. While most would be recognized as ferns by even a novice, a few differ so widely from the ordinary typical forms that to an unskilled observer they would scarcely be considered as bearing any resemblance to ferns whatever. The fronds of one of our Florida species resemble narrow blades of grass, and the fertile spikes of another from New Jersey might be mistaken for a diminutive species of sedge. A third from Alabama would, perhaps, be called a moss by the inexperienced, while the "Hartford fern," found from New England to Kentucky, has a climbing stem and broad palmate leaves.

When we add to these peculiar forms of our own country those of foreign lands, and include the immense tree-ferns of tropical regions, we find our early conception of a fern inadequate to cover this diversity of forms. Without attempting an accurate definition of a fern, let it be regarded for present pur-

poses as a flowerless plant, producing spores instead of seeds, possessing more or less woody tissue, and having its leaves coiled in the bud from apex to base. After the necessary study of the structure of some of our common ferns, we will be able to comprehend the more technical definition found later in the work.

2. **Mode of Growth.**—Ferns vary greatly in their method of growth, yet each species has a plan which, within certain limits, is fixed and definite. Some, like the common brake, have their fronds rising from more or less distant portions of the creeping rootstock. Others, like *Asplenium trichomanes*, are tufted, many fronds rising irregularly in a cluster; while still others, like the ostrich-fern (*Matteuccia*), and many shield-ferns (*Dryopteris*), grow in crowns or circles, the later fronds continually rising within the older ones. In the grape-ferns (*Botrychium*) the rootstocks usually produce a single frond each season, the bud for the succeeding year growing within the base of the common stalk.

3. In many there is a tendency to dimorphism, the fertile or fruit-bearing fronds differing to a greater or less extent from the sterile ones. In a few species, like the sensitive-fern (*Onoclea*) and some others, this is carried so far that the sterile and fertile fronds bear no resemblance to each other, and in one instance have been mistaken for different species, and so described. *Osmunda cinnamomea*, *Woodwardia areolata*, our two species of *Cryptogramma*, and *Struthiopteris* offer further examples of this principle of growth.

4. **Variation.**—The same species will often present wide differences in the size of the fronds. This depends to some extent on the character of the soil and the ordinary climatic conditions. For example, the lady-fern (*Asplenium filix-fœmina*), which in ordinary locations grows from two to four feet high, in mountainous regions is sometimes reduced to from three to six inches, when it forms the *var. exile.* In like manner the marginal shield-fern (*Dryopteris marginalis*), usually two or three feet high, is reduced to five inches when growing on rocky cliffs, and yet regularly produces fruit.*

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* *Cf.* Bulletin Torrey Botanical Club, VI. 266 (Oct. 1878).

5. In some cases there is a tendency to variation in size that cannot be referred to soil or climatic influences. The common grape-fern (*Botrychium Virginianum*) will be found in some localities to vary from six inches to two feet in height, all well fruited and matured, and with the extreme sizes growing within a pace of each other in the same soil and with the same environment. The other species of the same genus present similar variations, and judging from size and external appearance alone, a regular gradation of forms might be arranged from the most diminutive undivided forms of *B. simplex* to the largest of *B. Virginianum*.

6. Another tendency to variation is noticed in the forking of fronds either at the summit or at the ends of the branches. The hart's-tongue (*Phyllitis*) is frequently forked at the summit, the walking-leaf (*Camptosorus*) less commonly, while the same tendency is noticed in various compound forms, as *Asplenium angustifolium*, *Cheilanthes lanosa*, *Gymnopteris hispida*, *Dennstædtia*, *Pellæa atropurpurea*, and others. Some of the species of *Botrychium* show the same tendency, especially in their fertile segments. It is probable that all our species will be found to fork under certain conditions. More definite information is desirable with regard to many species that show this tendency, as it doubtless involves the question of ancestry of existing ferns.

7. In those species whose sterile and fertile fronds are unlike, forms often appear that are intermediate between the sterile and fertile fronds, and sometimes even form a graded series from one to the other. This is especially true of the sensitive-fern (*Onoclea*) and the cinnamon-fern (*Osmunda cinnamomea*), and has frequently been the source of so-called "varieties." Whether this variation arises from some peculiarity of environment, or from some inherent tendency to reversion toward an older form, will require more extended observation to determine. One of the varieties of *Botrychium obliquum* seems to have been founded on a condition which is intermediate in structure between the sterile and fertile segments.

8. In a few forms there is an apparent mimicry, one species imitating another in foliage or method of fruiting. In the cinnamon-fern just alluded to, which has a cinnamon-colored

sterile frond totally unlike the fertile, sterile fronds will sometimes be found which are fertile at the apex—the normal method of fruiting in the royal flowering-fern (*Osmunda regalis*); and in turn the royal flowering-fern is sometimes fertile in the middle, in imitation of *Osmunda Claytoniana*.

9. **Time of Fruiting.**—The time of maturing fruit is different among different species, and also varies with geographical location and proximity to tropical climates. In the Northern States some species produce their fruit as early as May (*Osmunda cinnamomea*), and others as late as September (*Lygodium*), but the greater number are best studied in July and August. In the Northeastern States, where the two species of *Filix* abound on limestone rocks, *F. fragilis* matures its spores and withers in June or July, while *F. bulbifera* reaches its maturity only in August or September. In semi-tropical climates, like Southern California and the Gulf States, the time of fruiting is often earlier, sometimes occurring in February or March. Some fronds are killed by the early frosts, while others, like the Christmas-fern, are evergreen, and may be gathered in midwinter.

10. **Local Distribution.**—Ferns are largely dependent for successful growth on the amount of warmth, moisture, and shade to which they are subjected, and we would naturally expect to find them reaching a maximum in size and abundance in warm swamps or shady marshes. While this is in general true, we nevertheless find many species thriving only in rocky places, thrusting their roots into the crevices of the rocks with little earth for their nourishment, and many times exposed to the scorching rays of the sun. Of necessity, such species are of comparatively small size, and likely to be protected in some way against the heat of the sun, and provided with means to retain their moisture in times of drought. Others still are found in wet, rocky ravines, often where moistened by the spray of cascades or waterfalls, and consequently have no such provision against the heat of an extended summer. Certain others thrive in open fields that are comparatively dry and unshaded. One species of Southern Florida is aquatic, having the sterile fronds floating in shallow water. A few species are epiphytic, or grow on other plants, some being found on tree-trunks to the height of 150 or 200 feet!

So, while moisture, warmth, and shade in abundance are the climatic conditions essential to promote luxuriant fern growth, it can and does continue when any or all these conditions are reduced to a minimum.

11. Ferns may then be sought in any of the following situations, and it will be seen that each situation has its characteristic species :

A. Wet swamps or marshes with or without abundant shade.

B. Rich woods, more or less moist.

C. Uncultivated open places and dry hillsides.

D. Moist, rocky ravines or rocky places not subject to summer drought.

E. Exposed rocky cliffs.

F. Standing water.

G. Growing on other plants. (Epiphytic.)

12. In the first location mentioned above, we may find the chain-ferns (*Woodwardia*), many of the spleenworts (*Asplenium*), a few of the shield-ferns (*Dryopteris*), the flowering-ferns (*Osmunda*), as well as the genera *Acrostichum*, *Onoclea*, etc. These include some of our largest and coarsest ferns. A few more delicate in structure are also found here, notably the dainty *Phegopteris dryopteris*.

13. In the second we find a few spleenworts, most of the shield-ferns, the beech-ferns (*Phegopteris*), most of the grape-ferns (*Botrychium*), the maidenhair (*Adiantum*), *Dennstædtia*, and some others. In this situation we find the finest development of foliage and the greatest artistic finish among all the ferns.

14. In uncultivated places and on rocky hillsides we often find the common bracken or brake (*Pteridium*), and also the lady-fern (*Asplenium filix-fœmina*), though these are by no means confined to these locations, the latter growing quite frequently in moist woods, and even in cold, wet swamps. Many other ferns are found occasionally in openings of the forest or recent clearings, where they maintain a sickly existence, sometimes for a series of years. In such locations ferns often become contracted and abnormal in growth, and take on a faded yellow hue from their exposure to the open sunshine.

15. In moist ravines and on rocky banks the bladder-ferns (*Filix*) may be found, with the peculiar walking-leaf (*Camp-*

tosorus), the rare hart's-tongue (*Phyllitis*),* and many of the smaller spleenworts. The long, pendent fronds of our *Filix bulbifera* add greatly to the beauty of our natural ravines, and often serve to conceal the uncouth rocks, or at least draw the attention to that which is more delicate and artistic. On dripping rocks, or where the sides of ravines are kept continually moist by the spray of waterfalls, such delicate pellucid ferns as the filmy-fern (*Trichomanes*) and one *Cryptogramma* may be sought. There seems to be a direct connection between the environment and the texture of the fern. The last two mentioned grow in very damp situations, and are pellucid and almost membranous. The *Filix* in somewhat drier situations is thinly herbaceous, while *Asplenium trichomanes* and *Camptosorus*, requiring less moisture, are more firm, and form the transition to the next group.

16. On dry cliffs we may look for the various species of *Woodsia*, the cloak-ferns (*Notholæna*), the lip-ferns (*Cheilanthes*), and the cliff-brakes (*Pellæa*). Many of these are firm and even leathery in texture, and others are thickly covered on one or both sides with tangled hair or scales, fitting them to survive long periods of drought.

17. Only one of our native species is strictly aquatic, the anomalous *Ceratopteris thalictroides* found in Southern Florida, though *Acrostichum aureum* is often found with its rhizoma rising from the water of salt marshes. *Osmunda regalis* is occasionally found in standing water several inches deep, though this is not usual.

18. Among the epiphytic ferns are several species of *Polypodium*, *P. polypodioides*, *P. Scouleri*, and *Phlebodium*, the last always being associated with the cabbage-palmetto (*Sabal palmetto*). *Vittaria*, *Cheilogramma*, and *Nephrolepis* are also of this class, and are frequently pendent from the same plant, though occasionally found on other tree-trunks. *Cheiroglossa palmata*, another peculiar tropical fern-ally, belongs to the same

* This rare fern seems to show a decided preference for limestone rocks, and thus far has been found only above the geological formation known as the Corniferous limestone. I believe a thorough search for this fern along the outcrops of the formation in Central New York and elsewhere would show a wider distribution than is at present attributed to this species.

list. Even in the streets of Southern cities, *Polypodium polypodioides* is often seen growing with various mosses well up on the trunks of shade-trees. It is only in tropical regions, however, that epiphytes are seen in profusion.

19. These principles of climatic distribution are necessarily modified by the geographic range of species, which must be considered in this connection. For example, *Dryopteris spinulosa* or its varieties form the leading foliage ferns of Northern New England and New York, and *Dennstædtia*, less common in those localities, largely replaces them from Connecticut southward. This subject will be more fully discussed in a later chapter.

LITERATURE.

Most of the American literature bearing on this subject is in the form of short notes which have appeared from time to time in our two botanical monthlies;* a classified summary appears below:

HABITS.—*Botanical Gazette*, I, 2; II, 100; III, 82; IV, 140, 177, 232; V, 27, 30, 43, 48; VI, 161, 295; VII, 86.

DIMORPHISM.—*Torrey Bulletin*, VIII, 101, 109; IX, 6; XIII, 62.

FORKING FRONDS.—*Botanical Gazette*, I, 50; II, 80; III, 39; VI, 220; VIII, 242.—*Torrey Bulletin*, VII, 26, 85; IX, 116, 129; X, 4.

RELATIVE ABUNDANCE:—

DAVENPORT (George E.). A Bit of Fern History. In *Botanical Gazette*, VII, 60–64 (May, 1882).

CULTIVATION:—

JACKSON (Robert T.). Cultivation of Native Ferns. In *Garden and Forest*, I, 317, 318; 330, 331; 340–342; 352–354 (Aug.-Sept. 1888).

ROBINSON (John). Ferns in their Homes and Ours. 12mo, illustrated. Salem, 1878. A valuable outline of fern cultivation, indispensable to those desiring to undertake the cultivation of ferns either in conservatories or Wardian cases.

SMITH (John). Ferns, British and Foreign, 8vo. London, 1879.

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* *Bulletin Torrey Botanical Club* (Columbia University, New York City) and the *Botanical Gazette* (University of Chicago). Many notes in recent years have appeared in *The Fern Bulletin* (Binghamton, N. Y.).

CHAPTER II.

THE ORGANS OF THE GROWING FERN.

Pour bien savoir une chose, il faut en savoir les details.
—La Rochefoucauld.

20. Every one familiar with the forest and its products must have seen the young ferns unrolling from the bud in spring and early summer. It will be noticed that the fronds are coiled from the apex to the base, and form crosiers, so called from their resemblance to the head of a bishop's staff. This method of vernation is called *circinate*, and is rarely found except among ferns. In the grape-ferns and adder-tongues the vernation is straight or merely inclined, thus approximating that of ordinary flowering plants.

21. **Rootstock.**—Ferns usually spring from an underground stem called the *rootstock*. This may be simple or branched, smooth or scaly, horizontal, oblique, or even vertical. In some ferns it is fine and hairlike, while in others it is very large and stout. In some cases the rootstock creeps at the surface of the ground and even rises above it, as in the variety of *Dryopteris contermina* which grows in Florida. In the tree ferns of warmer climates it often forms a trunk fifty feet high, bearing the fronds at the summit, when it takes the name of *caudex*.

22. **Frond.**—The aerial portion consists essentially of a leaf-stalk and blade; the former is technically called the *stipe*, and the latter the *frond*. Though these are usually distinct from each other in appearance, the stipe is sometimes wanting, and in others no distinction can be made between them. Both stipe and frond, or either one, may be glabrous (smooth), pubescent (softly hairy), hairy, woolly, or scaly; when the scales are small and somewhat appressed, the surface is said to be squamous. The careful discrimination of these hairy or scaly appendages becomes a matter of importance in distinguishing many of the species of *Cheilanthes*. In a few of our native ferns

the under surface is covered with a white or yellow powder bearing some resemblance to flour or corn-starch. For this reason a surface of this character is called *farinaceous*. Such is the California gold-fern or "golden back" (*Gymnopteris triangularis*), and several of the cloak-ferns (*Notholæna*), and such are the various gold and silver ferns of conservatories, including some of the richest and most beautiful in the world.

23. The frond may be *simple*, when it consists of a single undivided leaf, as in *Phyllitis* or *Camptosorus*; or *compound*, when it is divided into segments. The exquisite delicacy and the extent to which this dividing is carried in some ferns determines largely their æsthetic value.

The continuation of the stipe through a simple frond is called the *midvein*; through a compound frond is called the *rachis*, and is further distinguished as *primary* when the frond is much compounded. A frond is *entire* when the margin forms an unbroken line; when so cut as to form lobes extending half way or more to the midvein it is called *pinnatifid*; when these incisions extend fully to the midvein the frond is said to be *simply pinnate*, and the divisions are called *pinnæ*. When the pinnæ are cut into lobes the frond is *bipinnatifid* and the lobes are called *segments*, and when these extend to the secondary midveins it is *bipinnate* and the divisions are called *pinnules*. The secondary midvein then becomes a *secondary rachis*. In like manner we may have ferns that are *tripinnatifid* and *tripinnate*, *quadripinnatifid* and *quadripinnate*. The last lobes are designated *ultimate segments*, and the last complete divisions *ultimate pinnules*. All these various forms from entire to quadripinnate are abundantly represented among our native ferns.

24. In some pinnate fronds, as in the oak-fern (*Phegopteris dryopteris*), the lower pair of pinnæ is greatly enlarged and more compound than those above, so that the stipe appears to form three branches bearing similar and nearly equal portions. Fronds of this character are usually triangular or pentagonal in outline, and this method of branching is called *ternate*. It will be readily seen that this is merely a modified form of the ordinary pinnate frond. Throughout the domain of nature there is infinite variety of form and structure, and at the same time unity in plan and conformity to a few generalized types.

25. Venation.—The method of veining admits of great variation, often serving to distinguish species, and more especially the sections of the various genera. In some ferns, like most shield-ferns (*Dryopteris*), the veins are *free*—that is, arising from either side of the midvein they do not unite with any other vein. In some of these the vein is simple (not branched), in others variously forked. In many the veins repeatedly anastomose or unite together, forming a series of network or *areolæ*. This may be somewhat irregular, as in *Onoclea;* or forming a single row of areolæ next to the midvein and thence free to the margin, as in *Woodwardia Virginica;* or forming many uniform areolæ by the parallel transverse veinlets connecting the distinct and parallel primary veins, as in *Campyloneuron phyllitidis*. In case the venation does not appear when examined by reflected light, it may be brought out clearly by holding the frond between the observer and the light, and then using a lens if necessary. A few fleshy species require dissection to show the veins.

CHAPTER III.

FRUCTIFICATION IN FERNS.

"But on St. John's mysterious night,
Sacred to many a wizard spell,
The hour when first to human sight
Confest, the mystic fern-seed fell."

26. Spores and Sporangia.—In the flowering plants (SPERMAPHYTES) seeds are produced by a complex process involved in pollination, the growth of the pollen tube, and the sexual process which results in the embryo of the new plant. The Ferns, on the contrary, produce no flowers. Instead of seeds developed from fertilized ovules, minute spores are produced asexually, from which new ferns are developed by a peculiar process of germination very unlike that

FIG. 1.—Enlarged section through a sorus of *Polypodium falcatum* Kellogg, showing the stalked sporangia.

of flowering plants. These spores are collected in little sacs known as *sporangia* or spore cases. The sporangia in the true ferns (POLYPODIACEÆ) are collected in little clusters on the back of the frond, or are variously arranged in lines along the veins or around the margins (Fig. 1). These clusters of sporangia are called *sori*, and may be naked, as in *Polypodium*, or provided with a special covering known as the *indusium*, as in *Dryopteris* (Fig. 8). The various forms of the sori and indusia serve as the basis for classification into genera and tribes, while each sub-order has its peculiar form of sporangia.

FIG. 2.—Sporangium of *Polypodium vulgare*, L., discharging its spores. Much enlarged.

27. In the POLYPODIACEÆ the sporangia are more or less completely surrounded with a jointed vertical ring or *annulus*, and at maturity burst open transversely by the straightening of the annulus and discharge their copious spores (Fig. 2). The clusters of sporangia are said to be marginal, intramarginal, or dorsal, according as they have their position at the margin or more or less remote from it. They may be roundish, oblong, or linear in shape, or arranged in variously forking lines, or may even be spread in a stratum over the entire under surface of the frond. They are called indusiate or non-indusiate according as they are covered or naked; and the indusia may be inferior (attached below the sorus), as in *Woodsia* (Fig. 9), or superior, as in *Dryopteris* (Fig. 8), or of various intermediate methods of attachment.

28. In the other families of *Filicales* the sporangia are variously arranged. In the HYMENOPHYLLACEÆ or filmy ferns the flattened sporangia are sessile along a filiform receptacle, and are surrounded with a complete transverse annulus. At maturity they open vertically (Fig. 3). In the SCHIZÆACEÆ the sporangia are ovate, sur-

FIG. 3.

FIG. 4.

Fig. 3.—Enlarged sessile sporangium of *Trichomanes radicans* Swz.

Fig. 4.—Sporangium of *Schizæa pusilla* Pursh, showing the apical ring. Much enlarged.

rounded at the apex by a complete annulus, and open by a longitudinal slit (Fig. 4). In the OSMUNDACEÆ or flowering ferns the sporangia are larger, globose, and naked, with the mere trace of a transverse annulus, and open longitudinally.

The various methods of fructification can be best understood by describing the peculiarities of the various genera in regular succession and noting the variations occurring in the sections or sub-genera. By this means we will arrive at a better understanding of the principles of fern classification as discussed in a future chapter. As the subject of venation is closely connected with that of fructification, it will be treated in the same connection.

29. Acrostichum.—In this genus the sporangia are spread in a stratum over the under surface of the upper pinnæ in our solitary species, but in some exotics they cover portions of the upper surface as well. There is no indusium.

30. Polypodium (Fig. 1).—Formerly all ferns agreeing in the possession of roundish naked sori were placed in this genus notwithstanding the fact that the venation was widely different; it seems more logical to regard some of these sections as genera.

In § EUPOLYPODIUM the veins are free, yet are occasionally known to unite,* thus indicating a tendency to vary toward the next section. The sori are generally found at the end of a free veinlet.

In § GONIOPHLEBIUM the veins unite near the margin, forming large areolæ, each containing a single free veinlet which bears the sorus at its end. A tendency to variation is seen in *P. polypodioides*, whose veins are free, as well as in *P. Californicum* in which they are often partly free.

30a. Phlebodium.—In this genus ample areolæ are next the midvein, and frequently in one or more secondary rows, each bearing a single sorus at the junction of two or more veinlets. A large number, however, bear the sori at the end of a single veinlet. From the fertile areolæ to the margin the veins anastomose more copiously.

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* Catalogue of the Davenport Herbarium, p. 8.

30b. **Campyloneuron** has areolæ, each usually bearing two sori; they are found between the parallel primary veins which extend from the midrib to the margin.

31. **Gymnopteris.**—In this genus the sori follow the course of the veins, and consequently vary with the venation, being simple, forked, pinnated, or anastomose with each other. The sori are non-indusiate.

32. **Notholæna.**—In the cloak-ferns the sori are marginal, and provided with no indusia. This genus is linked very closely to *Gymnopteris* on one hand and to some species of *Cheilanthes* on the other. From the latter it is separable only by the absence of the marginal indusium; the two are likely to be confounded by beginners.

33. **Cheilogramma** has simple fronds, the fructification in a continuous sub-marginal line near the apex of the frond.

34. **Vittaria.**—This peculiar genus occupies a somewhat intermediate position between the indusiate and non-indusiate genera, and while usually associated with the latter has considerable claim to be ranked with the former. The fronds are narrow and grass like, bearing the sporangia in an intramarginal groove, often more or less covered by the inrolled edge of the frond. The venation is very obscure.

35. **Adiantum** (Fig. 5).—The maidenhairs have a peculiarly smooth foliage, and usually possess no midvein. The veins are usually flabellate, and after forking one or more times bear the sori at their extremities. The margin of the frond is reflexed, thus forming an indusium which bears the sporangia on its under surface.

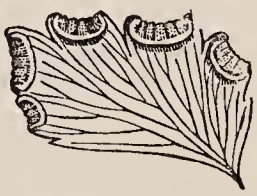


FIG. 5.—A segment of *Adiantum*, showing the sori covered by indusia formed by reflexions of the margin of the frond—From Le Maout and Decaisne.

36. **Pteris** (Fig. 6).—In this genus, now excluding the common brake, the otherwise free veins are united by a filiform receptacle which bears the sporangia. This continuous marginal line of fructification is covered by a membranous indusium formed of the margin of the frond.

37. **Cheilanthes.**—The lip-ferns found within our limits are unequally divided among four sections, all agreeing in bear-

ing the sori at or near the ends of the veins, covered by an indusium formed of the margin of the frond.

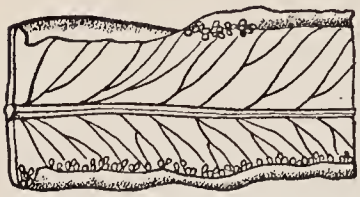


FIG. 6.—*Pteris longifolia* L. Enlarged segment of pinna, showing the vein-like receptacle under the marginal indusium.

In § ADIANTOPSIS the indusia are distinct, and confined to a single veinlet. One of our species varies from the typical species of this section, and has even been assigned to a separate genus.

In § EUCHEILANTHES the indusia are more or less confluent but not continuous, usually extending over the apices of several veinlets.

In § PHYSAPTERIS the ultimate segments are bead-like, and the indusium is continuous all round the margin.

§ ALEURITOPTERIS has the fronds farinose below, and includes a single species somewhat doubtfully assigned to our limits.

38. Cryptogramma has dimorphous fronds, the margins of the fertile being closely rolled toward the midvein, thus covering the confluent sori. At maturity these open flat in order to discharge the spores.

39. Pellæa has representatives of three sections within our limits, all agreeing in possessing intramarginal sori, which finally became confluent and form a marginal line covered by an indusium formed of the margin of the frond.

§ CHEILOPLECTON includes herbaceous species with visible veins and broad indusia.

§ ALLOSORUS includes coriaceous species having wide indusia, while § PLATYLOMA includes species similar in texture, but with extremely narrow indusia and broad segments.

40. Ceratopteris is an anomalous genus from southern Florida, having a few sori arranged on two or three veins parallel to the midvein, and covered by the broadly reflexed margin of the frond. It properly forms the type of a family.

41. Struthiopteris (Fig. 7) is intermediate between those genera in which there is an indusium formed of the revolute margin of the frond and those in which the indusium is remote from the margin. Our single species has dimorphous fronds, free veins, and the fructification in a broad band next the mid-

vein, covered by a continuous and distinctly intramarginal indusium. This genus closely resembles the next in general habit, and is sometimes united with it.

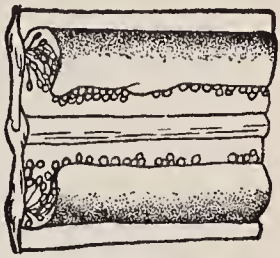


FIG. 7.—*Struthiopteris spicant.* Enlarged section of the contracted fertile pinna, showing intramarginal indusium.

42. **Blechnum.**—In this genus the sori are linear and near the midvein, and are covered by a membranous indusium which is fixed at its outer margin, bursting at its inner margin when the sporangia are mature. A single representative is found within our limits.

43. **Woodwardia.**—Three species of chain-ferns occur within our limits, and each represents a distinct section based on the methods of venation. All have oblong or linear sori more or less sunken in the frond, covered by special lid-like indusia bursting at their inner margins, and arranged in chainlike rows near the midvein, thus giving the popular name to the genus.

§ EUWOODWARDIA has uniform fronds and veins forming at least one series of areolæ between the sori and the margin.

§ ANCHISTEA has also uniform fronds, but with free veins from the sori to the margin while § LORINSERIA has dimorphous fronds, and the veins everywhere uniting to form areolæ, as in the sensitive-fern (*Onoclea sensibilis*).

44. **Asplenium.**—The numerous species of spleenworts are closely related to each other in their methods of fructification, but differ widely in the form, texture, and cutting of their fronds. The sori are placed on the upper side of an oblique vein (sometimes crossing it in § ATHYRIUM), and covered by an indusium of the same shape attached by its edge to the fruiting vein and opening toward the midvein. In some species part of the indusia are double. The veins are free in all our species. In § EUASPLENIUM the sori are straight or slightly curved; in § ATHYRIUM they are often curved, even horseshoe shaped; and frequently cross to the outer side of the fruiting vein.

45. **Phyllitis** bears the linear sori in pairs, one from the upper side of a veinlet and its mate from the lower side of the next. The indusia are attached by their edges to the veins, and folding toward each other appear like a double indusium cover-

ing a single sorus. The veins extend nearly at right angles to the midvein, are free, and usually forked.

46. Camptosorus.—The walking-leaf has oblong or linear indusiate sori, which are irregularly scattered and borne partly on veins parallel to the midvein, and partly on those that are oblique. Those near the midvein are single, those toward the margin are often approximate in pairs and often form crooked lines. The veins are everywhere copiously reticulated.

47. Phegopteris.—In this genus the sori are round and naked as in *Polypodium*, with which this genus was formerly united. The sporangia spring from the back of the veins instead of the apex, as in the latter genus, and the veins are free except in the § GONIOPTERIS, in which they are more or less united.

48. Dryopteris is largely represented in our limits by two well marked groups which it is best now to regard as distinct genera, and two others with characters scarcely less distinct, containing each a single species. In all the sori are roundish, and borne on the back of the veins or rarely at their apex. In DRYOPTERIS the indusium is cordato-reniform or orbicular with a narrow sinus. This at first covers the sorus and is attached by its margin, but later bursts away at the margin but remains attached at the sinus. In some species in this section the indusium becomes shrivelled before the fruit matures, and in this condition might be mistaken for a non-indusiate species (Fig. 8).

FIG. 8. — Under side of a fertile segment of *Dryopteris filix-mas*, with eight sori. *i*, the indusium. Magnified. (After Sachs.)

In **Polystichum** the indusium is orbicular and peltate, being fixed by the centre; the veins are free, as in § NEPHRODIUM.

In **Phanerophlebia** the indusium is the same as in POLYSTICHUM, but the veins tend to unite near the margin, while in **Tectaria** the veins anastomose copiously.

49. Nephrolepis has roundish sori borne at the apex of the upper branch of a free vein, near the margin of the frond. The indusia are usually reniform, fixed by the sinus or base, and open toward the margins of the pinnæ.

50. Filix.—The small bladder-ferns take their popular name from the delicate, hood-like indusium which is attached

by its broad base on the inner side of the roundish sorus and partly under it. Later this is thrown back and withers away. The veins are free, and the fronds have the aspect of species of *Dryopteris*, but are usually more delicate in texture.

51. **Onoclea.**—Two quite dissimilar species have unfortunately been united under this name, which best form two genera. Both have dimorphous fronds, the margin of the contracted fertile frond being strongly revolute, and concealing the fruit. Matteuccia has necklace-shaped pinnæ, crowded confluent sori, and free and simple veins. **Onoclea** has panicled berry-shaped pinnules and copiously anastomosing veins.

52. **Woodsia** (Fig. 9) has roundish sori borne on the back of the veins, with the indusia attached beneath the sporangia and flat and open, or early bursting at the top into irregular laciniæ or lobes. In § EUWOODSIA the indusia are flat and open from an early stage, with their cleft and ciliate margins concealed under the sori. In § HYPOPELTIS the indusium is more conspicuous and encloses the sporangium at first, but soon bursts at the top, forming several jagged lobes.

FIG. 9. — *Woodsia obtusa* Torr. Enlarged section of pinnule, showing venation and inferior indusia.

53. **Dennstædtia.**—In this genus the small globular sorus is borne in an elevated, globular receptacle, and enclosed in an inferior, membranous, cup-shaped indusium. The veins are always free. The genus has been confused with tree-ferns.

54. **Trichomanes** (Fig. 10) has sessile sporangia borne on a filiform receptacle at the summit of a vein. The indusia are tubular or funnel-shaped, with an expanded and often somewhat two-lipped mouth.

FIG. 10.—*Trichomanes radicans* Swz. Enlarged section, showing method of fructification.

55. **Lygodium.**—In our species of climbing-fern the fructification is borne on contracted, forked pinnules occupying the upper portion of the frond. The ovoid sporangia are solitary or occasionally in pairs, and are borne in the axils of the

large, imbricated, scalelike indusia which are fixed by their bases to short, oblique veinlets.

56. Ornithopteris.—In this the two lowest branches of the frond bear panicles of fruit at the end of very long stalks. The ovate sporangia are sessile in two rows along the branchlets of the panicle, without special covering of any kind. In the section represented by our species the veins are free.

FIG. 11.—*Schizæa pusilla* Pursh. Entire plant, natural size.

57. Schizæa.—In this genus the large ovoid sporangia are sessile in double rows along the single vein of the narrow fertile divisions. In our species the pairs of fertile pinnæ form a distichous spike (Fig. 11).

58. Osmunda has the large globose sporangia, short-stalked, and borne on the contracted fertile portions of the frond. In the cinnamon-fern (*O. cinnamomea*) the fertile fronds are entirely distinct from the sterile, yet manifesting a tendency to variation in the *var. frondosa*. In the interrupted flowering-fern (*O. Claytoniana*) the fructification is confined to a few of the middle pinnæ of the frond. In the royal flowering-fern (*O. regalis*) the fructification is borne at the apex of the fronds.

59. Spores.—The spores of ferns constitute the so-called fruit. A spore consists of two* distinct closed sacs and the cell contents, all of which differ from each other not only in structure, but also in chemical composition. The outer layer (*exospore*) consists chiefly of cellulose; the inner layer (*endospore*) contains some albuminous matter in addition, while the cell contents consist chiefly of a thin, colorless, jelly-like substance known as protoplasm, with grains of chlorophyll (the green

* Campbell has recently demonstrated the existence of a third (middle) layer, which is not readily apparent until after germination. *Cf.* Memoirs Boston Soc. Nat. History, IV, 17 *et seq.* (April, 1887).

coloring matter of plants), starch, and oil. The exospore may be smooth or roughened by points, granules, warts, or prickles. The shape varies with different species, yet all are rounded, and most are oblong or at least longer than broad. All are microscopic, and many are of such a shape that they do not appear uniform owing to the various directions from which we view them.

60. The number of spores produced by a single fern is incredible. Lindley calculated that a single frond of the hart's-tongue produced about 80 sori, with an average of 4500 sporangia in each sorus, and each sporangium containing 50 spores, making a total of 18,000,000 spores. The copious green spores of *Osmunda cinnamomea*, or the pale-yellow, powdery spores of a well-developed specimen of *Botrychium Virginianum*, must far exceed this computation. By drying either of these species under pressure between sheets of paper great quantities of the spores may be obtained for examination. Specimens for this purpose should be selected just before the sporangia reach their maturity.

CHAPTER IV.

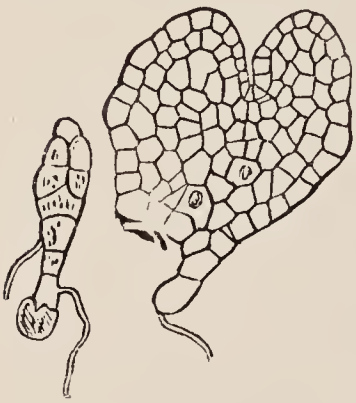
GERMINATION OF FERN SPORES.

Alle Glieder bilden sich aus nach ew'gen Gesetzen,
Und die seltenste Form bewahrt im Geheimniss das Urbild.
—GOETHE.

61. THE germination of the fern spores usually takes place a considerable time after they are discharged from the sporangia, but in *Osmunda*, which develops its fruit early in the season, they commence their growth only a few days after dissemination.

62. **Thalloid Phase.**—In germination the exospore splits along the side, and the protruding endospore, sometimes with its divisions already formed by septa or partitions, forms, not a fern, but a thalloid structure resembling one of the lower

liverworts called the *prothallium*. Different ferns vary in the method of forming this prothallium, some producing it immediately at the spore and others after the formation of a thread-like growth known as the pro-embryo. The prothallium is entirely composed of cellular tissue, and in the true ferns (POLYPODIACEÆ) is broadly cordate or reniform in shape, and bears large numbers of root-hairs from the under part of its posterior portion (Figs. 12, 13).



FIGS. 12, 13.—Prothallium of *Pteris serrulata* Linn. f., showing two stages of growth. (After Moore.)

The prothallium varies in size from less than one tenth of an inch up to one third of an inch in its widest part. On the under surface of the prothallium two sorts of organs are produced which represent the male and female structures, respectively known as *antheridia* and *archegonia*. The position of these organs on the prothallium varies in different sub-orders. In some species, notably the ostrich-fern, the two kinds of sexual organs are produced on separate prothallia, so that the plant becomes diœcious instead of monœcious. In nurseries where ferns are grown for sale immense quantities of prothallia are regularly developed from spores.

63. **Antheridia.**—These are small masses of tissue developed in the same manner as the root-hairs, consisting of a single layer of cells forming the wall, and containing a number of spirally coiled threads, usually with a number of cilia on their anterior coils. At maturity the antheridium swells by the absorption of water and finally bursts its wall, discharging these coiled filaments, which possess the power of locomotion, and for this reason are called *antherozoids*. These antherozoids often drag with them a little vesicle which seems to play no part in the process of reproduction (Fig. 14).

64. **Archegonia.**—The archegonium (falsely called pistillidium) is also a rounded mass of tissue usually less prom-

inent than the antheridia, consisting of an external layer of cells and a large central cell, which soon divides into two. The lower portion, at first the larger, develops into a roundish cell, which is analogous to the ovum among animals, and is called the *oösphere*. The upper portion of the central cell develops between those composing the neck of the archegonium into a canal filled with a sort of mucilage; this finally swells up, forces the cells of the neck apart, and is expelled to aid in attracting

FIG. 14.—Antheridium of *Adiantum capillus-veneris* L., showing the escaping antherozoids. (After Sachs.)

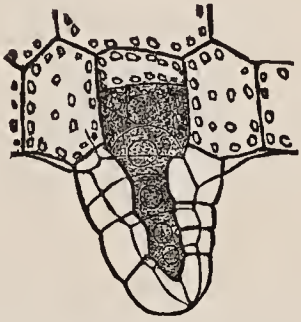


FIG. 15.—Young archegonium of *Pteris serrulata* Linn. f., showing oösphere, neck, and canal-cell. (After Sachs.)

and retaining the antherozoids at the neck of the archegonium. The oösphere is thus left exposed (Fig. 15).

65. Fertilization.—The antherozoids, analogous to the sperm-cells, when discharged from the antheridium swim in the moisture always present on the under surface of the prothallium, swarm in large numbers around the neck of the archegonium, and are retained by the mucilage. Some finally force their way into the canal of the neck, a few reaching the oösphere and disappearing within its substance. There is thus a true sexual generation among ferns, and the formerly appropriate term *Cryptogamia* (hidden marriage) loses its application under the untiring scrutiny of the microscopist. After fertilization the neck of the archegonium closes, and the fertilized

oösphere, now called the *oöspore*, increases in size, and finally develops into a true fern.

FIG. 16. — *Adiantum capillus-veneris* L. Prothallium and young fern seen from below; *pp*, prothallium; *b*, first leaf; *h*, root-hairs of prothallium; *w*, *w'*, first and second roots. (After Sachs.)

66. Pteridoid Phase.—After the oösphere has been fertilized it commences its growth by the ordinary processes of cell multiplication, and for a time remains within the walls of the archegonium, which continue to grow, until finally the interior growth breaks through the walls, differentiated into its first root and leaf. The young fern draws its nourishment from the prothallium for a time, but soon develops root-hairs, which, extending into the soil, maintain thereby an existence independent of the prothallium. The latter growth having accomplished its work, withers away (Fig. 16). The first parts of the root, stem, and frond are very small and comparatively simple in structure, but those formed later are successively larger, and not only bear a closer resemblance to the mature form of the species, but also develop increased complexity of structure. "The fern continues to gain strength, not by subsequent increase of size of the embryonic structures, but by each successive part attaining a more considerable size and development than the preceding ones, until at length a kind of stationary condition is arrived at, in which the newly formed organs are nearly similar to the preceding ones."

67. The complete life-history of a fern illustrates a principle common among the lower forms of animal life known as "alternation of generations." Instead of the direct production of a mature sexual plant, as among the higher forms of vegetation, there is the production of a sexual growth resembling a lower form of vegetation, which in turn is followed by the growth of a mature plant producing its fruit without the assistance of sexual organs.

68. Recapitulation.—To review the life-history of a fern we find the following processes:

A. Production of the spores asexually by the mature plant. (FRUCTIFICATION.)

B. Growth of the prothallium from the spore with or without the development of a pro-embryo. (THALLOID PHASE.)*

C. Production of sexual organs, archegonia (female) and antheridia (male), on the under surface of the prothallium, or on separate prothallia.

D. Fecundation of the oösphere developed in the archegonium by the antherozoids developed in the antheridium. (FERTILIZATION.)

E. Growth of the mature fern in successive stages from the oöspore. (PTERIDOID PHASE.)*

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* The terms "Thalloid Phase" and "Pteridoid Phase" in place of the older terms "sexual generation" and "asexual generation" were first suggested in the first edition of this work (1881). The older terms, although in common use by botanical writers, are decidedly unfortunate and misleading. A generation is properly the production of offspring resembling the parent, or the offspring thus produced, which the prothallium is not and the mature fern is not. The generation proper must then be considered as including the entire life-history of a fern, of which the prothallium and mature fern are successive phases. The terms "sexual" and "asexual" as used in this connection are likewise misleading, as they might apply as well to the origin as to the producing power of the so-called "generation." The prothallium is asexual in origin, but develops sexual organs; the mature fern, on the other hand, produces no sexual organs, but is itself the product of bisexuality. It is now more common to speak of these two phases of growth as the *gametophyte* and *sporophyte* respectively.

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CHAPTER V.

FERN STRUCTURE.

Be it ours to meditate,

. . . . . .

And to the beautiful order of thy works
Learn to conform the order of our lives.

—BRYANT.

69. Tissues.—The life-history of every plant commences in a single cell, and all the complications of vegetable growth depend on two simple processes, viz., the enlargement of individual cells to their full size, and their multiplication by division. The lowest forms of vegetable life consist of a single cell, either globular or elongate. Those of a somewhat higher grade consist of a single row of cells, or at most a single layer; while still higher forms of growth consist of masses of cells variously grouped together and specialized by differentiation from the typical form and character.

70. Cells become specialized or set apart to fulfil a certain function in the economy of plant growth in many ways. Some are lengthened for giving strength to stems or leaves; some have their walls thickened to give rigidity or hardness where protection is needed from injury to more delicate structures within; and some are variously adapted for containing and distributing the secretions or other fluids connected with the circulatory system of plant life. Seven distinct varieties of tissues are recognized by structural botanists, yet some of these are connected with each other by various gradations.

71. Tissue Systems.—The earliest tendency to differentiation of cells is seen in the arrangement of the outer row of cells to form a boundary wall. In higher forms of growth the interior cells tend to form one or more series of string-like rows surrounded by the normal cellular tissue. We thus reach the basis of the classification of vegetable tissues into three groups: (a) *Epidermal System.* (b) *Fibro-vascular System.* (c) *Fundamental System* (Fig. 17). The first and third are common to both ferns and mosses. The second is first seen in the ferns and their allies, where it is a character so constant that it serves as the basis for separating the so-called "vascular" cryptogams from other flowerless plants. These three forms of tissue may be seen by examining a thin cross-section of the stipe of a living fern with the microscope. Longitudinal sections will show still further the character of the tissues composing the fibro-vascular bundle.

72. Roots.—Roots are constantly produced as the root-stock advances, and consist for the most part of little fibrils which are naked for a short distance from the apex in order that they may freely absorb moisture from the earth. The epidermis is also thin, and usually consists of a single layer of small cells. It differs from that of the rest of the plant in having no stomata (77). As the apex continues to grow, the epidermis of the part behind becomes harder, and frequently develops hairs, or more frequently irregular scales.

73. Stipe.—The stipe is made up of the three forms of tissue (Fig. 17), and usually contains several bundles of vascular tissue. In the dried stipe these can be easily seen, by scraping off the external covering of the stem. These bundles of fibres give stability to the fern, and are continued through the rachises and veins, thus forming the framework for the softer portions of the frond. The stipes are sometimes smooth and polished, sometimes hairy or beset with stalked glands, and sometimes densely clothed, especially near the base, with chaffy scales.

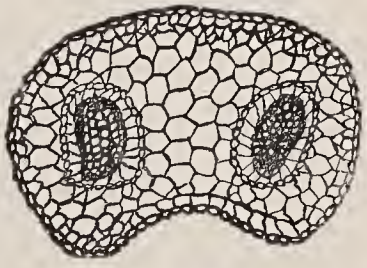

FIG. 17.—Cross-section of stipe of *Filix fragilis* (L.) Underw., showing two bundles of fibro-vascular tissue.

74. **Frond.**—In the HYMENOPHYLLACEÆ the frond consists of a single layer of cells. This condition is also found in the leaves developed along the axis of growth among the mosses to which this sub-order is related in some of its forms. In all other ferns there are several layers of cells variously compacted together, and forming all the varieties of texture —membranous, herbaceous, coriaceous and fleshy. The epidermis is usually easily separable from the underlying tissue, when its peculiar markings can be studied.

75. From the epidermis a great variety of appendages are developed which are all modifications of hairs, and are all included under the term *trichomes*, however different in appearance or distinct in function. These are not confined to the frond, but develop here their greatest variation. They are frequently found on the roots, the rootstock, and the stipe, under the form of root-hairs or scales of various forms. Scales are especially abundant in certain forms of *Dryopteris*, as well as in *Polystichum*, *Cheilanthes*, and other genera.

76. **Trichomes.**—On the fronds the trichomes may be developed as simple unarticulated or articulated hairs, consisting of one or two cells at most. They may appear as stalked glands like those that arise from the stipe of *Cheilanthes Cooperæ* or the margin of the indusium of *Dryopteris spinulosa, var. intermedia;* or they may be developed into scales of intricate cellular structure like those on the under surface of certain forms of *Cheilanthes*, particularly *C. Fendleri* and *C. Clevelandii*. In the true ferns the sporangia are specialized, trichomes developed in clusters (*sori*) along the veins, or spread over the entire surface of the frond, or even arranged in spikes or panicles. The epidermis also develops an excrescence known as the indusium, which consists of a single layer of cells, and is variously arranged as indicated in Chapter III. In some cases a false indusium is provided, which is not a growth from the epidermis, and may consist of several layers of cells.

77. **Stomata.**—If the epidermis covering the under surface of a fern be examined under a high magnifying power, peculiar structures will be seen in the form of semi-elliptical or crescent-shaped cells connected at their apices and separated between. These are the guard-cells of stomata which control the open-

ings to the air-chambers of the plant. The two elliptical cells form the mouth of the passage and expand when moist, allowing the atmospheric gases and watery vapor to escape or enter but close the entrance by contraction in time of drought. The stomata are not confined to the fronds, but are found to a greater or less extent on all aerial portions of ferns and higher plants, as well as on subterranean stems.

78. **Asexual Propagation.**—Besides the ordinary methods of sexual reproduction discussed in Chapter IV., most ferns are propagated by growth of the rootstock under ground, giving rise to a succession of fronds each season. In addition to this, which is common to all perennial plants, there are some methods of reproduction that deserve attention. The first is by

79. **Buds and Bulblets.**—In a few species of conservatory ferns adventitious buds are produced on the surfaces of the fronds. These soon develop into young ferns, and it is not uncommon to see a large number in various stages of growth rising from a single frond. This peculiarity is common among several species of *Asplenium*, especially *A. furcatum* Thunb., and will be sometimes found to occur among some of our native species. Bulblets are found in the axils of the upper pinnæ of our *Filix bulbifera*, which often fall to the ground and develop into new plants after a manner analogous to the development of the axillary buds of the tiger-lily.

FIG. 18.—*Camptosorus rhizophyllus* Link., reduced, showing peculiar method of propagation.

80. Another method is seen in the walking-leaf (*Camptosorus rhizophyllus*), in which the long, attenuated, simple fronds bend over and take root in the adjoining soil in a manner quite analogous to the propagation of strawberries by runners (Fig. 18). The same method of rooting at the apex has also been noticed in *Asplenium pinnatifidum*, *A. platyneuron*, and *Phegopteris reptans*.

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CHAPTER VI.

THE FERN ALLIES.

Beneath my feet
The ground-pine curled its pretty wreath.—EMERSON.

A. THE GRAPE-FERNS AND ADDER-TONGUES.

81. **General Characters.**—These peculiar plants, formerly united with the true ferns, are now regarded as constituting a distinct botanical family. They include mostly small, fleshy, terrestrial plants, and, like ferns, may usually be found in swamps or rich, moist woods. As already noticed (5), there is a marked tendency to variation in the same species, and numerous varieties have been established from the various forms.

82. The sterile and fertile portions of the plant are borne on a common stalk, and either portion may be sessile, long

* See other references at close of Chapter X.

or short stalked, in the various species. In *Ophioglossum* the sterile portion is simple, and in all our species appears like a leaf rising from the common stalk. *Cheiroglossa* has several spikes. In *Botrychium* (Fig. 19) the sterile segment (except in some forms of *B. simplex*) is somewhat pinnately or ternately divided, and in the larger forms of *B. Virginianum* is broadly ternate, with the divisions even tri—quadripinnatifid. The veins are free in the latter genus, but anastomose in the former. This character, however, is frequently obscured by the fleshy texture of the plant.

FIG. 19.—Plant of *Botrychium lunaria*, natural size.

83. Vernation.—As has been before stated, ferns are rolled in the bud from the apex downward (*circinate*), distinguishing them from the higher forms of vegetation. Among the OPHIOGLOSSACEÆ, however, the vernation is either straight, inclined at the apex of one or both segments, or else the fertile segments are folded on the main stalk, making the vernation wholly inclined. Until recently there has been much difficulty in distinguishing the smaller species of *Botrychium*, and some forms seem to connect the smaller ones with the reduced forms of *B. obliquum* and *B. Virginianum*.

Mr. Davenport has investigated the bud characters of these intimately related species, and has made their identification a matter of comparatively easy investigation. The buds may be found enclosed in the base of the common stalk (except in *B. Virginianum*, where they are placed in an upright cavity at one

side), and may be examined with a strong lens. The three divisions are summed up as follows :

"I. Vernation wholly straight. *B. simplex* Hitch. (Fig. 31).

II. Vernation partly inclined in one or both portions. *B. lunaria* Swz. (Fig. 32), *B. boreale* Milde, *B. neglectum* Wood (Fig. 33), and *B. obliquum* Michl (Fig. 34) and its allies.

III. Vernation wholly inclined, in the fertile frond recurved. *B. lanceolatum* Angs. (Fig. 35), and *B. Virginianum* Swz."

The special characters of each species will be found under the descriptions of the *Botrychia* later in this work. The cuts will be valuable for reference, and will enable even beginners to identify the species of this complicated genus with comparatively little difficulty.

FIG. 20. — Enlarged sporangia of *Botrychium Virginianum* Swz.

84. Fructification.—In this order of plants the fructification consists of sporangia, which, unlike those of the true ferns, are not reticulated, possess no trace of a ring, open by a transverse slit, and are variously spiked and panicled (Fig. 20). In the adder-tongues (*Ophioglossum*) the sporangia are large, and cohere in two ranks along the margins of a single spike, opening transversely to discharge their copious sulphur-yellow spores. In the grape-ferns (*Botrychium*) the sporangia are globular and arranged in double rows along the narrow segments, more or less in panicles. In both genera the sporangia are not developed from the epidermal cells, but arise from a transformation of the interior tissue of the leaf. This, with other characters as clearly defined, serves to separate these anomalous plants from the families of true ferns.

85. Germination.—Among the OPHIOGLOSSACEÆ, so far as known, the prothallia are destitute of chlorophyll, develop under ground, and are monœcious. In *Botrychium lunaria* the prothallium is an ovoid mass of cellular tissue, light brown without and yellowish white within. It produces a number of antheridia and archegonia on the upper surface as well as the lower, differing in a few minor points from the true ferns in the method of their development.

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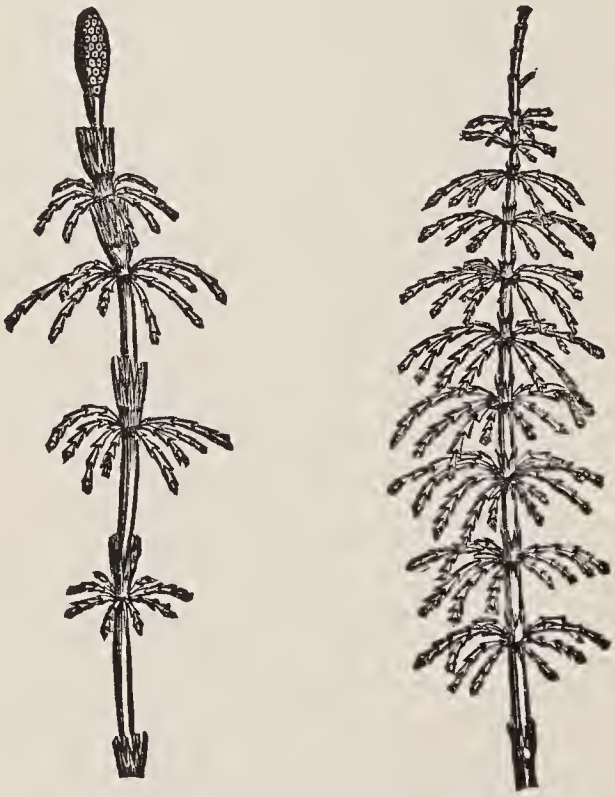
B. THE HORSE-TAILS.

86. General Characters.—The horse-tails or scouring-rushes belonging to the genus *Equisetum* are perennial, rush-like plants, that may be found in damp, gravelly, or loamy soil, some species even growing in shallow water. Our native species vary in height from a few inches up to eleven feet, as seen in some of the larger forms of *E. robustum*. In some species only the root is perennial, the stems which are sent up for producing fruit dying down to the ground every year. In others the stems are evergreen, continuing through the winter. Some species, like the common horse-tail (*E. arvense*), are dimorphous, the fertile stems being simple and destitute of green coloring matter (chlorophyll), while the sterile stems are green and copiously branched. The fertile stems of some other species, as *E. silvaticum*, which are simple at first, after maturing their fruit produce branches and resemble the ordinary sterile stems (Figs. 21, 22).

87. The furrowed stems are hollow, except in *E. scirpoides*, and in addition to the large central cavity there is a series of smaller air-cavities opposite the furrows known as the *vallecular canals*, the furrows themselves being called *valleculæ* and the ridges *carinæ*. Opposite the carinæ there are still smaller cavities known as *carinal canals*. The carinæ vary in number from



FIGS. 21, 22.—*Equisetum silvaticum* L., showing sterile and fertile stems. (From Thome.)

five to fifty in different species. The stems are also jointed, and at each node some species produce a whorl of branches which may be simple or compound. Some species, however, like the common scouring-rush (*E. hiemale*), produce simple stems.

88. The leaves are produced also at the nodes, and by the union of their margins form a short sheath which ends in a row

of teeth. These teeth may be deciduous or persistent, and their number, varying from three upwards, indicates the number of leaves forming the united whorl.

89. Stomata (77) are distributed along the valleculæ either irregularly or disposed in ranges on either side of the valleculæ. The epidermis frequently contains much silica, and the roughened tubercles of some species give the surface a harsh feeling.

90. **Fructification.**—The fructification in *Equisetum* is arranged in cone-like spikes borne at the apex of the fertile stems. These spikes are composed of successive closely-placed whorls of shield-shaped, stalked scales or modified leaves, each of which bears from five to ten one-celled sporangia on its under side. The sporangia open along the inner side to discharge their numerous spores, whose outer coat is spirally split into two bands, forming the so-called *elaters*. The elaters when dry are spread out at right angles to each other in the form of a cross, and probably assist in scattering the spores; when moist they rapidly absorb water, and become closely coiled around the spore.*

91. **Germination.**—The spores of *Equisetum* retaining their powers of germination only a few days, soon develop branched and irregularly lobed prothallia, which are provided with chlorophyll. These are usually dicœcious, the male being smaller, and producing antheridia at the end or margin of the larger lobes. The antherozoids are large, and provided with a peculiar appendage known as the "float." The female prothallium may reach one half inch in length, and develops archegonia on the anterior margin of the fleshy lobes. The process of fertilization is similar to that of ferns.

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* An interesting illustration of this can be seen by placing a mass of fresh spores on a slide uncovered, and examining it with a low power. By breathing on the slide the elaters coil closely about the spore; as soon as the moisture evaporates they uncoil, and in their activity jostle each other in great confusion.

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C. THE CLUB-MOSSES.

92. General Characters.—The club-mosses are chiefly small perennial plants usually growing in dry or moist woods, or even on exposed rocks with little soil for nourishment. Most of the species are somewhat moss-like in habit, as might be suspected from the popular names given to these plants, the genus *Lycopodium* taking the name of club-moss and *Selaginella* that of rock-moss. Various species of *Lycopodium* are also known as ground-pine, ground-fir, ground-cedar, running-pine, etc., from more or less marked resemblances (Fig. 23). In the curious *Selaginella lepidophylla* from Arizona the branches of the closely coiled central stem roll up when dry into a nest-like ball, and when moistened expand so as to appear flat or saucer-

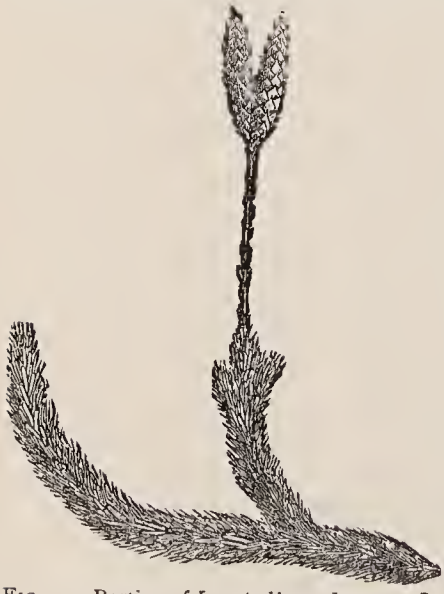

FIG. 23.—Portion of *Lycopodium clavatum* L. ½ natural size. (After Prantl.)

shaped. As the plant retains this power indefinitely, it has sometimes been called "the Resurrection-plant."

93. The stems are usually creeping, yet in some species show a tendency to become erect, and most species send up erect branches which bear the fruit. Most species bear roots at irregular intervals along the under side of the creeping stems, but our solitary species of *Psilotum* is rootless, bearing only underground shoots which perform the functions of roots. The leaves are small and unbranched, in some instances resembling appressed scales, in others resembling the acicular leaves of Conifers, and are arranged in four, eight, or many ranks. In some species the leaves are of one kind, while in others two or even more forms may occur on the same plant. In *Psilotum* the leaves are all rudimentary.

94. **Fructification.**—The fructification of the club-mosses is chiefly borne on upright branches in solitary or clustered (2–5) spikes, which are formed of numerous scales or scale-like leaves, each bearing a single large sporangium in its axil. The sporangia open transversely, and are one-celled, except in *Psilotum*, where they are three-celled. In a few species of *Lycopodium* the sporangia are borne near the summit of the fertile stems in the axils of ordinary leaves. The usual shape of the fruit-bearing scales is represented in Figs. 24–26.

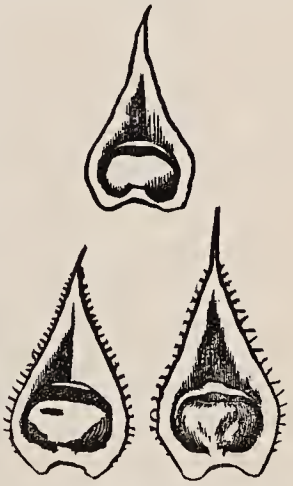

FIG. 24.—Scale of spike of *Lycopodium Carolinianum* L., bearing a sporangium in its axil.

FIGS. 25, 26.—Scales from fertile spike of *Selaginella rupestris* Spring, disclosing two sorts of spores. (After Sprague.)

95. The spores of *Lycopodium* and *Psilotum* are of one kind (Fig. 24), but in *Selaginella* two kinds of sporangia are developed—the *microsporangia*, producing numerous *microspores* (Fig. 25) not unlike the spores of *Lycopodium;* and the *macrosporangia*, producing usually four *macrospores* (Fig. 26), so called from their larger size. This character of *Selaginella*, which it shares with the quillworts and pepperworts soon to be described, serves as the basis for the division of the fern allies into two groups: the

isosporous, producing spores of one kind; and the *heterosporous*, producing spores of more than one kind.*

96. Germination.—The germination of *Lycopodium* is only partially known, as the prothallia have been seen in only three species, and in these they have not been carried through all the stages of development. That of *L. annotinum* is a yellowish-white mass of tissue with a few small root-hairs.† The antheridia and archegonia are developed from the upper side of the prothallium. In *L. cernuum*, Treub‡ found the prothallia much smaller (one twelfth of an inch long), vertical in growth, yellowish below and bright green above. The antheridia and archegonia are found round the summit of the cylindric prothallium.

97. The germination of *Selaginella* is better known. The contents of the ripened microspores are transformed into a mass of tissue consisting of a few cells, one of which remains sterile and is considered a rudimentary prothallium, while the others give rise to antherozoids, and are consequently considered as a rudimentary antheridium. The macrospores, on the other hand, produce a many-celled prothallium, which develop a few root-hairs and numerous archegonia, which after fertilization give rise to a new plant. Two plants are sometimes produced on the same prothallium.

98. The microspores are thus seen to be male and the macrospores female, showing a clearer differentiation of sex in the products of the mature plant than appears in any other group of the fern allies already studied. This may be considered a foreshadowing of the vastly more complicated reproductive processes of the flowering plants. In the method of formation of the embryo the *Selaginella* also differs from all other plants of this group, and approaches the flowering plants.

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* This division, though used by some of the best botanists, is at best an artificial classification, as it separates genera otherwise closely allied to each other.

† *Cf.* J. Fankhauser, *Botanische Zeitung*, 1873, pp. 1–6; Bruchmann, *Botanisches Centralblatt*, XXI (1885).

‡ *Cf.* Treub, *Ann. d. Jard. Bot. d. Buitenzorg*, IV (1884).

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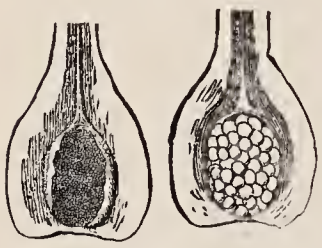
D. THE QUILLWORTS.

99. General Characters.—The quillworts, so named from the appearance of the leaves, are principally inconspicuous aquatic plants of a grass-like or rush-like aspect (Fig. 27). Some species are always submerged — often in several feet of water; others grow in marshy soil or in the shallow margins of ponds or streams, where they become apparently terrestrial in time of low water; while others still are found between high and low water marks, where they will be covered by water at high tide. The leaves are awl-shaped or linear, and are attached to a short fleshy trunk. They vary in number from ten to one hundred in each plant, and in length from two to twenty inches in various species. On account of their resemblance to the immature forms of rushes and other aquatic vegetation of a higher order, they have been very sparingly collected. Many questions of distribution, habits, and life-history may be studied by even amateur botanists in various sections of the country.

FIG. 27.—*Isoëtes lacustris* L., natural size. (Redrawn from Sprague.)

In this way valuable additions to science may be contributed by those whose labor misdirected might be wasted.

100. **Fructification.**—The sporangia of the quillworts, like those of the club-mosses, are sessile in the base of the leaves. The leaf base, sometimes called the sheath, is somewhat triangular from the broad insertion, convex behind and concave in front, where there is a large depression known as the *fovea*, which contains the sporangium. The margin of the fovea rises in the form of a delicate membrane called the *velum*, which in many species lies above the sporangium and encloses it. The sporangia of the outer leaves contain large spherical macrospores; those of the inner contain numerous oblong, triangular microspores. The size and marking of the spores form important characters in distinguishing species.



FIGS. 28, 29.—Two kinds of sporangia in *I. lacustris* L., enlarged. (After Sprague.)

101. **Germination.**—The microspore after remaining dormant through the winter forms a few-celled structure which produces the antherozoids, which are long and slender, and provided with a tuft of cilia at each end. The macrospore produces a prothallium much as in *Selaginella* (97); from this the germ of the mature plant arises after fertilization by the antherozoids.

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See also notes in *Botanical Gazette*, VI, 228.

E. THE WATER FERNS.

102. General Characters.—This group includes plants of very diverse characters. Some, like *Marsilea*, root in mud and produce quadrifoliate leaves. Others, like *Pilularia*, resemble the sterile forms of *Eleocharis*, or other sedges. Others, like *Azolla* or *Salvinia*, float on the surface of water, sending numerous roots into the water. *Marsilea* and *Pilularia* have a circinate vernation like the ferns.

103. Fructification.—The fruit of *Marsilea* consists of a hollow-stalked receptacle known as the *sporocarp*, which is oblong or rarely globose, and bears the sporangia in sori on the inner walls of its two valves. The spores are of two kinds, as in all rhizocarps. The numerous microspores are contained in microsporangia, while the macrospores are solitary in the few macrosporangia.

FIG. 30.—*Salvinia natans* Hoffm., natural size. (Re drawn from Thomé.)

104. The sporocarp of *Pilularia* is globose, containing from two to four cells, which produce microsporangia in the upper portion and macrosporangia below; the microspores are numerous, while a single macrospore is found in each sporangium.

105. In *Azolla* the sporocarps are of two kinds, borne in the axils of the leaves; the larger are globose, and contain numerous microspores, which are aggregated in masses; the smaller are ovoid, and contain a single macrospore.

106. *Salvinia* (Fig. 30), more often seen in cultivation, has the sporocarps borne in clusters on short branches of the floating stem, one or two of each cluster bearing ten or more macrosporangia, each of which contains a single macrospore, the remainder bearing numerous globose microsporangia with numerous microspores.

107. Germination.—In *Marsilea* the antherozoids are produced in a rudimentary prothallium which develops from the microspore and are corkscrew-shaped, consisting of several coils. The prothallium, developed from the apex of the macrospore is a hemispherical mass of tissue, and contains a single archegonium. Much is yet to be learned of the habits and life-history of our native species.

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CHAPTER VII.

CLASSIFICATION AND NOMENCLATURE.

The education of a naturalist now consists chiefly in learning how to compare.
—AGASSIZ.

108. Nomenclature.—The attempts in later years to bring the system of plant nomenclature to a stable basis has resulted in a number of annoying changes in the names of species, and as the present edition contributes something to the matter of change, it may justly be expected to give some reasons for these changes. It is well known that before the time of Linnæus, the method of naming plants and animals was a subject of much embarrassment to science, and the lack of a definite system gave rise to much inconvenience and endless confusion. Linnæus adopted a simple method of naming living organisms, and to him belongs the merit of first extensively and systematically introducing the binomial system of nomenclature which still remains universally in use. Many suppose that this was his own invention, but binomial Latin names for plants were used a hundred years before Linnæus was born. Cornut, for example, in a rare book published in 1635* illustrates two of our common ferns under the names "*Filix baccifera*" and "*Adiantum Americanum*" — probably the first illustrations ever published of American species. Genera existed prior to Linnæus, and he was not always either wise or just in his selection or use of names for those he recognized. For example, he changed the application of some of the names of that acute botanist, Tournefort (1656–1708), who in 1700 published one of the first accounts of genera,† a much more scientific treatise than anything Linnæus ever produced. Linnæus also arbitrarily changed names which his predecessors had used. Mitchell, in

* Canadensium plantarum historia.

† Institutiones rei herbariæ.

1751, had used the name *Angiopteris* for one of our American ferns, but Linnæus arbitrarily substituted one of his own (*Onoclea*) in its place.

109. The Linnæan system involved two names for every organism, a *generic* or group name and a *specific* or individual name. Generic names are often from the Greek, derived from some characteristic of growth or structure (*Cryptogramma, Cheilanthes*), or are Latinized in honor of some botanist or patron of botany (*Woodsia*), or occasionally from some symbolical character (*Osmunda*).

110. Specific names are usually Latin or Latinized, and must agree in gender with the generic name, according to the rules of Latin syntax. Specific names frequently indicate something regarding habit or mode of growth (*bulbifera, tomentosa, atropurpurea*), or may indicate the locality in which the organism was first discovered (*Californica, Ilvensis*). A few take their name from their discoverer, in which case the name is Latinized and takes a genitive ending (*Boottii, Cooperæ*), or else an adjective form (*Goldieana, Wrightiana*).

111. The advantage of this binary nomenclature is at once evident when we consider the immense number of ferns alone, to say nothing of the remainder of the vegetable world and the hosts of the animal creation. By this means organisms of complex structure can be definitely characterized with comparatively few words, and the scientific name once established, is recognized among scientists of all nations and languages.

112. Among some there is a tendency to regard scientific names with disfavor, on the ground that they are long and difficult. But what shall we say of *Geranium*, or *Gladiolus*, or *Fuchsia*, or *Phlox Drummondii*, or a hundred others familiar to every lover of flowers? Are these less difficult than *Adiantum, Notholæna, Woodsia*, or *Pellæa Breweri*? A little reflection will convince a person of sense that such a criticism is unjust.

113. A worse tendency is perhaps that which prompts the introduction of "popular names" for ferns: occasionally a name of this kind is highly appropriate, and deserves wide-spread adoption, as in the case of "Christmas-fern" for *Polystichum acrostichoides*, suggested by Mr. Robinson; the greater part, however, have no merit, and when such monstrosities appear

as "Leather-leaf Polypody" for *Polypodium Scouleri*, "Mr. Goldie's Shield-fern" for *Dryopteris Goldieana*, nomenclature is made cumbrous instead of simple.

114. The Linnæan system, however, did not prove entirely stable. In the early days when communication among botanists was not easy, the same plant would be described independently by two botanists under different names. Or, in other cases, two botanists would independently establish a certain generic group under different names. For example, Swartz separated a group of plants under the name *Botrychium* which Linnæus had included in *Osmunda*, leaving the latter name for the species we now know under that name. In the same year, and in fact in an article immediately following that of Swartz, Bernhardi separated the same two genera, but left the *Botrychium* species under the name *Osmunda*, and took the true *Osmunda* species out under the name *Struthopteris*. But errors of this kind were not the worst that existed. Botanists frequently cancelled good names that already existed, and deliberately substituted some of their own. Lamarck in 1797 called one of our Southern fern allies *Osmunda biternata*; in 1803 Richard called it *Botrypus lunarioides*, recognizing it as belonging to a genus distinct from *Osmunda* and unaware of the establishment of the genus *Botrychium* by Swartz. When Swartz in 1806 published the first manual of all known ferns* he properly transferred this species to his own earlier named genus *Botrychium*, but instead of adopting the oldest specific name he adopted the later one and called this fern *Botrychium lunarioides*. Willdenow enumerated the ferns known to him in 1810† and quoted all three of these names, but rebaptized the plant as *Botrychium fumarioides*. Sprengel, seventeen years later, quoted all these names, including that of Willdenow, and gave the plant still another name, *Botrychium fumariæ*. It will thus be seen that the period of eruption in nomenclature was in the early part of the century instead of the later, and largely on account of these early irregularities of procedure we have recently been undergoing something of an upheaval of nomenclature.

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* Synopsis Filicum, 1806.

† Species Plantarum, vol. 5.

115. Synonymy.—It may also be remarked in this connection that different authors have described the same fern under widely different generic and specific names, owing (1) to the different conceptions that have prevailed at different times as to what constituted generic characters, and (2) to ignorance of what others had already written on species, redescribed as new. For example, the delicate *Woodsia Ilvensis* of Robert Brown was described as *Acrostichum Ilvense* by Linnæus, *Polypodium Ilvense* by Swartz, *Nephrodium rufidulum* by Michaux, *Aspidium rufidulum* by Willdenow, and *Woodsia rufidula* by Beck. Many other species have been as variously classified. The opportunities for errors of this character are much less now than formerly, yet redescription is not unknown in our day.

116. Species.—Goethe tells us that nature knows only individuals, and that species exist only in the school-books. From this extreme there has been every grade of opinion respecting species to the one which regards species as invariable, actual existences, types originally ordained and summoned to existence by the Creator. Linnæus, for example, defined species in these words: "*Species tot sunt diversæ, quot diversas formas ab initio creavit infinitum ens.*" * Various definitions have been given to species, but none accord with the actual practice of systematists, who seem inclined to make a species what they choose; and indeed the existence of various connecting forms between many species distinct under normal conditions makes the practical definition of the term almost an impossibility. We may, however, for practical purposes, regard as a species an assemblage of individuals not differing essentially from each other, and capable of producing like individuals by the ordinary processes of reproduction. A recent writer defines species as "the present aspect of a line of organic development, destined to become something else in the future, as it was something else in the past,"—a definition in accord with the now universally accepted biological doctrine respecting the origin of species. Species among ferns are founded chiefly on differences in the cutting of the fronds and their method of venation.

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* There are as many different species as the Infinite Being created in the beginning.

117. Varieties.—Many forms differing only slightly from the ordinary specific types, and yet capable of transmitting their variations from generation to generation, are regarded as varieties. It was the opinion of a prominent botanist, that all so-called varieties among the lower plants "were purely the result of the accident of environment, and never of cross-fertilization." Since a species which varies in some minor particular is likely to revert to the ordinary form as soon as the normal conditions of soil, moisture, or environment are restored, there is no scientific foundation for the multiplication of varieties to serve as rubbish in works on systematic botany. A true variety is an incipient species in process of formation; when it becomes sufficiently distinct to be regarded as a distinct thing with a certain constancy of characters it is more logical to regard it as a distinct species. In cases where species have been more recently separated from each other in their evolutionary progress, some intermediate forms may still persist. If the typical form is clearly marked, these intermediate forms need not invalidate its specific rank.

118. Genera.—The limits of genera among ferns have given rise to much difference of opinion. The few comprehensive and heterogeneous genera recognized by Linnæus were soon divided by various authors, and other new genera were based on new discoveries resulting from the exploration of newer portions of the world. Adanson, Smith, Roth, Swartz, Bernhardi, Robert Brown, and others added genus after genus, often passing over the work of other post-Linnæan authors and often unwittingly or even purposely renamed genera which had already well-established names. Genera were largely based on the varying arrangement of the sporangia on the veins, as well as the character, shape, and position of the indusia. The English of the Hookerian school who have written on ferns have largely depended on these characters and have tended to recognize fewer genera than others of their countrymen or than are usually recognized by Continental botanists.

119. Presl (1836) was one of the first to establish genera based on the vascular systems of the plants, particularly their methods of venation, and laid the foundation of a more logical classification of ferns. John Smith, whose life had largely been

spent in one of the largest collections of growing ferns, added to Presl's system, characters based on methods of growth. Fee, who gave much attention to the ferns of the West Indies, Mexico, and Brazil, also established numerous genera. To these three writers and to Moore, who followed them, we are indebted for a more liberal and more consistent conception of fern genera. The modern tendency is toward this recognition of a larger number of fern genera, depending on characters drawn from venation and from habit of growth. Such unnatural aggregations of species as have hitherto been grouped together under the name *Gymnogramme*,* because of the fact that the species all had elongated naked sori on the back of the leaf, cannot be tolerated in a system that professes to be founded on natural relationships. Natural genera must contain only species that are more closely related to each other than they are to any other species.

120. **Families.**—Genera are grouped in families according to the characters of the sporangium itself, its method of dehiscence, and especially its origin from the tissues of the leaf. Eight families of ferns, if we include the eusporangiate *Ophioglossaceæ* and the heterosporous *Salviniaceæ* and *Marsileaceæ*, are found in our flora. Besides these there are the *Marattiaceæ*, *Gleicheniaceæ*, and *Matoniaceæ* among the ferns of tropical regions. Families of plants now have the uniform termination *-aceæ*.

121. **Orders.**—Families are grouped into orders based on still wider characters. The plants with fern-like habit make up the order FILICALES, though it is an open question if the eusporangiate types and heterosporous types ought not to be separated as distinct orders. The rush-like species forming the single family *Equisetaceæ* constitute the order EQUISETALES, and the club-moss types, isosporous and heterosporous, form the order LYCOPODIALES.

122. **Principle of Classification.**—The true idea of classification is the grouping together of objects according to essential and fundamental resemblances. Every system is more or less artificial, yet there is a continual approach toward the true

* *Cf.* Hooker and Baker, Synopsis Filicium, pp. 376–390.

natural system, which is the ultimatum of scientific classification. The study of life-histories will continually clear up points of relationship before unknown, and it will not be long before the classification will become fixed and constant. Every real study contributes to this end.

123. **Changes of Nomenclature.**—Exactness of citation is of prime importance, and in later years stability in nomenclature has been an end constantly sought. Nineteen years ago, when the first edition of this work appeared, the serious study of the higher flora of America was largely confined to a single botanical centre, and that centre followed the practice of Kew, the great royal herbarium of England, in adopting names without particular reference to principles of priority. So long as one centre existed, this system was little questioned. But soon new centres of study of our flora were formed, new workers appeared fresh from fields where the study of plants in life had been added to the study of plants in the herbarium. These workers recognized the fact that in neglecting priority and in following no fixed principles of nomenclature, grave difficulties were constantly arising, and confusion followed; they could not follow a system based on so uncertain and variable a standard as the personal system of nomenclature. European botanists, even Englishmen outside of Kew, recognized the same difficulties. There must be a common starting-point accepted; there must be some common principles adopted and followed for taking up generic and specific names. During the past ten years the botanical world has quite generally settled down to 1753 as the starting-point of nomenclature,* and most adopt the principle of priority as fundamental; *i.e.*, each generic group is given its oldest tenable name, and each species bears the original specific name assigned it whether it remains in its original genus or is transferred to some other. Some examples will make this clear if we follow the history of individual species.

124.—A simple case that has been involved in a recent change of name is seen in our Eastern lip-fern (*Cheilanthes*); the

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*This is purely arbitrary and has been selected for convenience merely. Genera and species were clearly defined before this time.

history of this fern is summed up in the following chronological synonymy:

Nephrodium lanosum Michx., 1803.

Cheilanthes vestita Swz., 1806.

Cheilanthes lanosa Watt, 1874.

Watt rightly discarded the specific name given this plant by Swartz, and adopted the earlier specific one given by Michaux. The full name is then written

Cheilanthes lanosa (Michx.) Watt,

the parenthesis noting the fact that the specific name was given by Michaux with a generic combination different from the one in which it now stands.

The practice of a few botanists has been to give a species the first name it bore under a genus. In this case the plant in question would bear the specific name *vestita* so long as it remained in *Cheilanthes*, but if transferred to the genus *Nephrodium* it would have to bear the specific name *lanosum*, and if transferred to some other genus might bear still a third. The absurdity of such a practice is clearly apparent.*

125.—A case slightly more complicated is seen in the hart's-tongue—the *lingua cervina* of the pre-Linnæan botanists. Its chronological synonymy is as follows:

Asplenium Scolopendrium L., 1753.

Scolopendrium vulgare J. E. Smith, 1793.

Phyllitis Scolopendrium Newman, 1854.

Scolopendrium Scolopendrium Karsten, 1883.

The last name is perfectly legitimate although a duplication, and so long as the plant remained in the genus *Scolopendrium* that was its appropriate name. But the genus *Scolopendrium* was founded by Adanson in 1763,† and the generic name *Phyllitis* founded in pre-Linnæan times on the same plant was used since Linnæus at least as early as 1757. This being true, Newman's combination is the correct one to follow, and the full citation would be

Phyllitis Scolopendrium (L.) Newm.

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* For each plant or group there can be only one valid name, and that is always the most ancient if it is tenable.—A. GRAY.

† Not by J. E. Smith, 1793, as usually supposed.

126.—Still more complicated is the ostrich-fern. Its synonymy is as follows:

Osmunda struthiopteris L., 1753.
Onoclea struthiopteris Hoffm., 1795.
Osmunda nodulosa Michx., 1803.
Struthiopteris Germanica Willd.,* 1809.
Struthiopteris Pennsylvanica Willd., 1810.
Matteuccia struthiopteris Todaro, 1866.
Struthiopteris Germanica var. *Pennsylvanica* Lawson, 1889.

Now this case involves several independent problems that are not mere "battles with synonyms": (1) Is the American species the same as the European? (2) Are we to take a superficial resemblance like the rolling of the sporophyll into a necklace-shaped structure as a basis for comparison, and unite a species with leaves growing in crowns from an upright rootstock and having free veins, in the same genus (*Onoclea*) with a plant that has horizontal creeping stems, scattered leaves, and copiously anastomosing veins? These are problems on which human judgment will disagree as it has disagreed in the past. In regard to the latter question the practice of the Kew botanists followed too implicitly by us Americans was adopted in previous editions not without many misgivings. We believe that the two ferns form two as valid generic groups as exist; that there is nothing in common between them to indicate community of origin or even anything but the most distant relationship. They are therefore treated in this edition as two genera. In regard to the question of the identity of the European and American plants, we will say that, having been familiar with our American species from childhood, and having studied the European form in its native soil, we are forced to the conviction that there is but one species on the two continents. If this be the case, whatever the generic name may be, the specific name of our species must be *Struthiopteris*, the Linnæan specific name for the plant.

If we adopt the view that the American plant is distinct from the European, our plant would then bear the specific name

* Applied to the American plant by various authors, but limited by Willdenow to the European plant.

nodulosa, the earliest name; Willdenow in establishing the genus *Struthiopteris* in 1809 incorrectly stating as a fact that the American plant was "eine noch nicht beschriebene aus Pennsylvanien," and not assigning it a name until 1810.

127.—Having thus fixed the specific name, what of the generic? The name *Struthiopteris* cannot be used for this plant, for when Willdenow assigned it to this use it had been used already twice before. In 1760 Scopoli used it for a genus of which *Osmunda spicant* was the type; Bernhardi used it again in 1799* to include the species of the genus we now know as *Osmunda* to separate them from the ill-assorted aggregate which Linnæus had brought together under this name.

Struthiopteris must then stand for a genus which hitherto has commonly been called *Lomaria*, and our ostrich-fern must look farther for a name. *Matteuccia*, proposed by a Sicilian botanist in 1866, appears to be the first tenable generic name, and is here used in that sense.

It will thus be seen that the question of the proper use of botanical names is by no means a simple one. The botanical literature of the world must be ransacked before stability can be reached. An obscure local publication in the Italian language on the plants of Sicily in this case furnishes the generic name for a plant which grows in the northeastern United States!

128. After specific stability is settled comes the equally interesting problem of generic stability which is still more difficult. This, however, involves principles that have never been thoroughly discussed, and this subject will not be considered here,† except to give a single illustration.

In 1799 Bernhardi established a genus of plants under the name *Gymnopteris* based on a single West Indian species which Linnæus first described as *Pteris ruffa*, but afterwards referred

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* Bernhardi's orthography was *Struthopteris*, a fact that has led an over-ardent nomenclaturist to abolish the genus *Osmunda*.

† Those interested in this phase of the nomenclature question will find a paper by the writer on "The Genera of Ferns established prior to 1832," in the Memoirs of the Torrey Botanical Club, VI, 247–283, 1899. On the general question of botanical nomenclature one of the best discussions of the subject will be found in the Bulletin of the Torrey Botanical Club, XXII, 308–329, 1894.

to the genus *Acrostichum*. Ten years later Desvaux established the genus *Gymnogramma*, based on this same West-Indian species, and eleven others with a similar method of forming their sori. Now under any rational system the name *Gymnopteris* must stand for that group of species which includes the *Pteris ruffa* of Linnæus, and it is equally true that it could not be used legitimately for any other group of plants. To illustrate how wide of the mark certain modern usage is, it is only necessary to cite a recent revision of fern names* in which *Gymnopteris* is used for a wholly different group of ferns from that which contains the plant Linnæus called *Pteris ruffa*, and for the group to which *Pteris ruffa* actually belongs a name is selected that was not established until 1844, namely, *Leptogramme* Link, thus passing over two earlier names which had priority!

LITERATURE.

The references to original writings would include all the botanists who have named or classified ferns since the time of Linnæus (1707–1778). Among the more prominent of these we may mention Swartz (1760–1818), Willdenow (1765–1812), Presl (1791–1849), Mettenius (1823–1866), Hooker (1785–1865), Fee (1789–1874), Milde (1824–1871), Al. Braun (1805–1875), and J. G. Baker (–). The following work gives a good review of the various systems:

SMITH (John). Historia Filicum. London, 1875. (Macmillan & Co.)

The American literature bearing on the subject is as follows:

BECK (Lewis C.). Synoptical tables of the Ferns and Mosses of the United States. In *Silliman's Journal*, IV (1829).

DAVENPORT (George E.). Aspidium spinulosum (Swz.) and its varieties. In *American Naturalist*, XII, 707–717 (1878).

—— New species of Ferns. In *Bulletin of the Torrey Bot. Club*, VI, 190, 191 (1877); VII, 50, 51 (1880); VIII, 61, 62 (1881); X, 61, 62 (1883).

* Die natürlichen Pflanzenfamilien. (Engler-Prantl.)

—— Fern notes. In *Bulletin of the Torrey Bot. Club*, VII, 85, 86 (1880); VIII, 88, 89 (1881); IX, 20–23, 68, 69, 99–101 (1882); X, 4–7 (1883); XII, 21–24 (1885); XIII, 81, 82, 129–135 (1886); XV, 225–229 (1888).

EATON (Daniel C.). Ferns of the Mexican Boundary. In *Mexican Boundary Survey* (1857).

—— Ferns of the Southern States. In Chapman: *Flora of the Southern States* (1860).

—— Ferns of the Northern United States. In Gray: *Manual of Botany, 6th edition* (1890).

—— Notes on some of the plants in the herbaria of Linne and Michaux. In *Canadian Naturalist* (1870).

—— New and little known Ferns of the United States. In *Bulletin of the Torrey Bot. Club*, IV, 11, 12, 18, 19 (1873); VI, 33 (1875), 71, 72 (1876), 263–265 (1878), 306, 307, 360, 361 (1879); VII, 62–64 (1880); VIII, 4, 5, 99, 100 (1881); IX, 49, 50 (1882); X, 26–29, 101, 102 (1883).

—— Ferns of North America. Illustrated with colored plates by J. H. Emerton and C. E. Faxon.

—— Ferns of the Southwest. In Wheeler: *Report of the U. S. Geog. and Geol. Surveys west of the 100th meridian*, VI (1877).

—— Vascular Acrogens of California. In Watson: *Botany of California*, II (1880).

GRAY (Asa). On the discovery of two species of Trichomanes in the State of Alabama. In *Silliman's Journal*, 2d ser., XV (1853).

KUNZE (G.). Notes on some Ferns of the United States. In *Silliman's Journal*, 2d ser., VI, 80–89 (1848).

UNDERWOOD (L. M.). American Ferns, I, II. *Bull. Torrey Club*, XXV, 521–541 (1898); XXVI, 205–216 (1899).

The literature relating to exotic species is very extensive. Some of the more important works are the following:

BAKER (J. G.). A summary of the new Ferns which have been discovered or described since 1874. (1892.)

FEE (F. L. A.). Mémoires sur la Famille des Fougères. 4to. (1844–1873.) 289 plates.

HOOKER (W. J.). Genera Filicum. 4to. (1842.) 120 colored plates.

—— Species Filicum. 5 vols. 8vo. (1846–1864). 304 colored plates.

HOOKER (W. J.) and BAKER (J. G.). Synopsis Filicum. 2d ed., 8vo. (1874.) Contains descriptions of all the ferns of the world recognized at Kew to the date of publication.

HOOKER (W. J.) and GREVILLE (R. K.). Icones Filicum. 2 vols. folio. (1831.) 240 colored plates.

METTENIUS (G.). Filices Hort Botanici Lipsiensis. 4to. (1856.)

—— Ueber einige Farngattungen. Five parts. 4to. (1857–1859.)

LUERSSEN (C.). Die Farnpflanzen. In Rabenhort: *Kryptogamen-Flora Deutschlands.* 8vo.

Besides numerous scattered papers by all of the above-mentioned writers, together with Moore, Kuhn, A. Braun, Prantl, Milde, Christ, Jenman, Fournier, and many others.

CHAPTER VIII.

THE FERN'S PLACE IN NATURE.

129. THE popular conception as to what constitutes a plant needs to be considerably enlarged and otherwise modified, for as soon as we commence to look about us after our eyes have been really opened, we find a vast array of forms varying in size and complexity of structure from the simple cells of the yeast-plant that we use in bread-making to the highly organized tree of the forest, and including such diverse forms of growth as the green scums that accumulate on ponds in summer, the gray lichens covering rocks and trees, the puff-balls and mushrooms that seemingly develop in a single night, the mosses, ferns and flowers in all their variety and beauty. Where in all this array of plants do our ferns stand, and what relations do they sustain to other plants? In answering this question we will have to give some account of the various groups of plants, pointing out their structural peculiarities and noting here and there in their appropriate place in the system such forms as are likely to be popularly recognized.

130. Aside from the plants producing flowers, the ferns and the mosses,* all of which are widely known and generally

* It should be noted that even this name is often misapplied. The lichens, which are in no way related to the true mosses, are sometimes popularly called "gray mosses." In "Evangeline" where Longfellow speaks of the trees "bearded with moss" he evidently alludes to the lichen, *Usnea barbata*; the "hanging moss" of the Pacific coast is also a lichen, *Ramalina reticulata*, which has a much more appropriate name in "lace-lichen." The "hanging moss" of the Gulf States, on the contrary, is a flowering plant whose nearest allies are in the pineapple family. Another flowering plant, *Euphorbia cyparissias*, is often called "graveyard moss" in the Northern States. This loose and confusing use of language is to be deplored, and those who know better should assist in relegating these incorrect usages to a merited oblivion.

recognized, we find two types of plants of lower grade which stand out prominently to even the unpracticed eye. Of these the first are mostly green,* and though variously known and named may be called collectively *algæ*. Like the higher plants, these low forms maintain an independent existence, drawing their nourishment directly from the air and water. Of the second group we may find examples in the mildew that spreads its white cobwebby film over the leaves of the lilac, the willow and other plants; or in the rust, red or black, that injures our fields of standing grain; or in the black smut that often replaces the ears of corn and greatly disfigures the plant. Other examples may be seen in the shelving masses that protrude from old stumps or logs, or in the bright scarlet cups that appear on the ground in rich woods in earliest spring. Whatever the color of these forms of plant growth, they may be characterized as *not green*. They represent a group of plants that require nourishment from some source besides air and water; some are parasitic—drawing nourishment from living plants or animals, while others are saprophytic—living on decaying organic matter. Though widely differing in character, we may call them all *fungi*. In addition to these forms are the lichens which are intimately related to some of the groups of fungi and cannot be considered as forming a definite group by themselves.

131. Looking over this array of forms we find that with all their diversity they may be arranged somewhat naturally in four groups as follows, commencing with the highest:

I. SPERMAPHYTES. (Seed-bearing plants.)
II. PTERIDOPHYTES. (Ferns and their allies.)
III. BRYOPHYTES. (Mosses and Liverworts.)
IV. THALLOPHYTES. (Algæ, Lichens and Fungi.)

It will be observed that the last three are all spore producers instead of seed producers like the flowering plants of the first

* Observant visitors at the seaside are familiar with the brown, purple and bright red "sea-weeds" that belong here but have their fundamental green color masked by other coloring matters. These are sometimes called "sea mosses," which is another unfortunate and confusing use of a term which ought to be confined to its particular group.

group; that the second like the first contains plants with a highly organized structure; that the third is like the first two in including plants with a distinct leafy axis, but differs in possessing a less complicated structure; while the last differs from all the others in having no distinction of stem and leaves. To bring out these and other characters more fully, and at the same time to indicate some hints of the leading subdivisions of these great groups of plants, will necessitate a more technical and tabular arrangement.

126. The **Thallophytes** include the lower forms of vegetation whose plant-body varies from a unicellular condition, through filamentous forms to a more or less highly differentiated thallus. While some forms, especially among the higher algæ, assume the habit of a leafy-stemmed plant, none attain to a true differentiation into stem and leaves. The thallophytes, excluding some anomalous groups, may be arranged in three series:

1. SCHIZOPHYTES, or fission plants, reproducing by simple division and either unicellular or made up of thread-like filaments. Two groups are included here:

(*a*) *Cyanophyceæ* (blue-green algæ, nostocs, etc.).

(*b*) *Schizomycetes* (bacteria).

2. ALGÆ, or seaweeds, with mostly sexual methods of reproduction and with the plant body varying in structure from a simple cell to a highly differentiated thallus or thalloid shoot.* Three classes are distinguished which may usually be recognized by their color.

(*a*) *Chlorophyceæ* (green algæ).

(*b*) *Phæophyceæ* (brown algæ).

(*c*) *Rhodophyceæ* (red algæ).

3. **FUNGI**, including moulds, mildews, and mushrooms, dif-

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* The American student is very poorly provided with elementary systematic literature relating to the algæ.

Farlow: Marine Algæ of New England (Report U. S. Fish Comm. 1879), partially covers a limited area of marine forms. For the fresh-water forms *Wolle:* Fresh-water Algæ of the United States, is the only work that has attempted to cover this ground.

fering from the algæ in possessing no chlorophyll, and in the higher forms in the loss of sexual methods of reproduction.* Three classes are distinguished:

(*a*) *Phycomycetes* (algal fungi).
(*b*) *Ascomycetes* (spore-sac-fungi lichens).†
(*c*) *Basidiomycetes* (mushrooms, puff-balls, rusts).

133. The BRYOPHYTES include forms whose plant-body varies from a thallus to a distinct leafy axis containing only a rudimentary fibro-vascular system, if any; their life-history involves two alternating phases: (1) A highly organized sexual phase producing antherids and archegones (Gametophyte); and (2) A spore-producing phase living parasitically on the first and forming spores asexually. Four groups are prominently marked:

1. *Hepaticæ* (liverworts).‡
2. *Anthocerotes* (horned liverworts).‡
3. *Sphagna* (peat mosses).§
4. *Musci* (true mosses).§

134. The PTERIDOPHYTES have a well-developed fibro-vascular system with highly differentiated tissues distributed through a leafy axis. Their life-history involves two phases: (1) A thalloid phase (prothallus) producing antherids and archegones‖ (gametophyte); and (2) A highly developed asexual

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* For an elementary work on the systematic study of the fungi the student can use "Moulds, Mildews, and Mushrooms" by the present writer (Henry Holt & Co.).

† The lichens are mostly ascomycetous fungi parasitic on algæ. *Tuckerman:* North American Lichens, is the best systematic work, but difficult for students.

‡ The Hepaticæ of the Eastern States have been treated by the present writer in Gray's Manual of Botany, 6th ed. Those of the Pacific coast have been elaborately described and illustrated by *Howe:* The Hepaticæ and Anthocerotes of California, *Mem. Torrey Club*, vol. 7.

§ The mosses of North America are treated in synoptical form in *Barnes:* Artificial Keys to the Genera and Species of Mosses (1897). This should be supplemented by the descriptions in *Lesquereux and James:* Manual of the Mosses of North America (1884).

‖ From this common character the Bryophytes and Pteridophytes are sometimes classed together as *Archegoniates*.

phase producing spores (sporophyte). The subdivisions of this group are systematically treated in the latter half of this volume.

135. THE SPERMAPHYTES include the highest forms of the plant world. The plant-body (except in rare cases, like *Lemna* and *Podostemon*) is a well-developed leafy axis containing highly differentiated tissues. The plant is asexual, producing pollen (microspores) in the anthers, and embryo-sacs (macrospores) in the pistils. The sexual or gametophyte stage is greatly reduced, and the process of fertilization of the egg by one of the nuclei of the germinating pollen-grain is too complicated to discuss here. The result of this fertilization is a seed containing an embryo. Three principal groups are recognized:

1. *Gymnospermæ* (conifers, cycads, etc.).
2. *Monocotyledonæ* (grasses, palms, lilies).
3. *Dicotyledonæ* (roses, oaks, maples, asters, etc.).

136. To make the relations of the various groups of pteridophytes to each other and to the lower forms of plant life more apparent than can be done in a lineal classification, we present on the next page an outline of a tentative genealogical tree.

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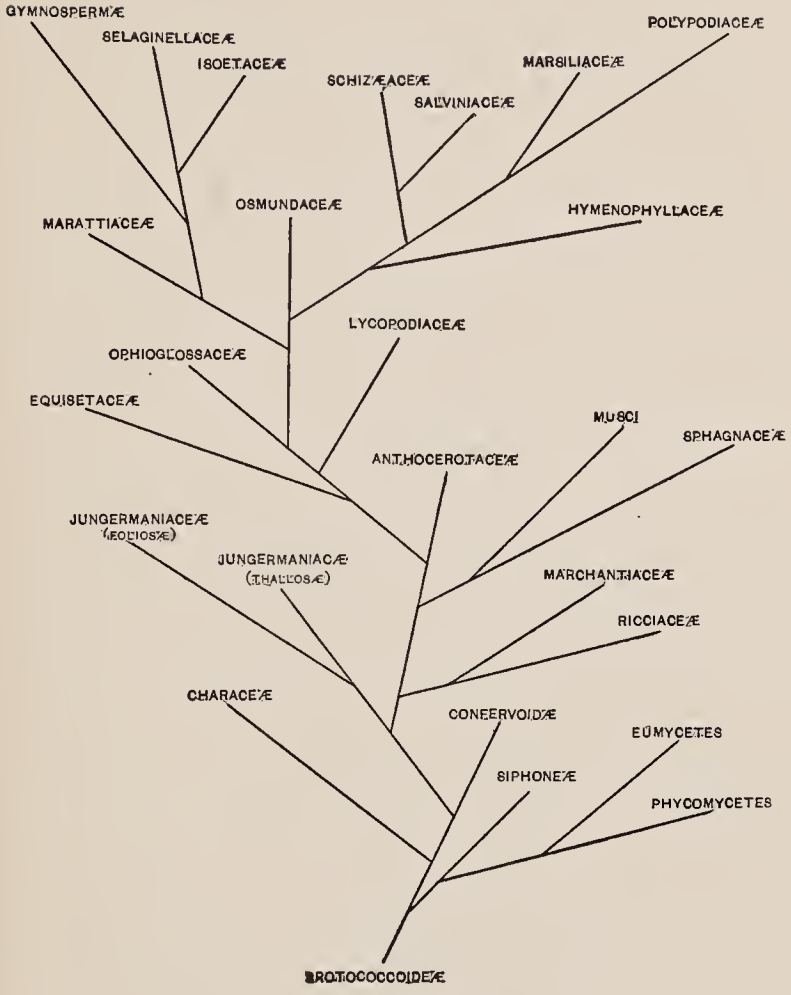

PROVISIONAL PEDIGREE OF THE LEADING GROUPS OF PLANTS.

CHAPTER IX.

DISTRIBUTION IN TIME AND SPACE.

137. Geographic Distribution.—Ferns are found in all parts of the world. The number of described species is not certainly known, and the uncertainty is largely increased for the reason that our best systematists do not agree as to what constitutes a species. Baker places the estimate at about 3000 species. Added to these are 565 fern allies as recognized by the same author. The full number is probably much greater than this very conservative estimate.

From what has been said respecting the climatic conditions of fern growth we would naturally expect to find them most abundant in countries where warmth and moisture predominate. These conditions seem most completely met on tropical islands or in tropical continental areas with insular climates. The little island of Mauritius, having an area of 676 square miles, or less than one third the area of Delaware, has 235 native species, while Java, little larger than New York, has 460. Brazil furnishes 387, and the Isthmus of Panama 117. Comparing these with colder climates, we find 67 in all Europe, and only 26 grow within the borders of the arctic zone.

"Our Native Ferns," as described later in this volume, including those species that are classed in the order FILICES, number 170 species. Adding to these the 22 species of the order OPHIOGLOSSACEÆ, which have frequently been enumerated with the ferns, we have a total of 192 species. The remaining fern allies number 87, making a grand total of 279.

138. Divisions of our Flora.—It has been found convenient to divide the surface of the earth into faunas and floras, limited by the natural distribution of the various species of

animals and plants. These limits are by no means sharply defined, for wherever the limit is made some species will pass beyond it; yet the majority found on one side are different from the majority of those on the other. North America (excluding Mexico) forms the Nearctic realm or fauna (*Regnum Nearcticum*), and the same boundaries may be used in the limitation of our fern flora, although some species from tropical regions invade our borders in Florida, Texas, and Arizona. Leaving out of question the species that are widely distributed over the greater part of our country, many of which are cosmopolitan species, we may divide the Nearctic realm into five provinces, each of which possesses many species peculiar to itself.

139. The provinces* are as follows:

I. BOREAL: inhabiting (with a few exceptions) the northern portion of the United States, extending through Canada and British America, some species even reaching Labrador, Greenland, and Alaska, and nearly all represented also in the northern portions of the Old World.

II. MEDIAL: extending throughout the mountain and hilly region of the States east of the Mississippi, westward to the mountains, and northward into Canada, and in a few instances also inhabiting the Old World.

III. OCCIDENTAL: extending along the western border of the continent from British Columbia to California, in a few cases appearing also in the Rocky Mountain region.

IV. SONORAN: inhabiting the central mountain regions of Western Texas, Arizona, and Colorado, many of the species extending thence into Mexico, and some even to South America.

V. AUSTRAL: inhabiting the border of the Gulf of Mexico, many of the species extending into the West Indies and Tropical America.

140. **Geologic Distribution.**—It is well known that the plants and animals now existing on the earth are not the same in kind as those of former ages. Geologists have carefully studied the stony heart of nature, and have drawn therefrom

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* This division is a slight modification of one proposed by John H. Redfield in 1875. *Cf. Bulletin Torrey Botanical Club*, VI, 1–7.

the story of the development of land and sea, and the successive populations that from time to time have held possession of our globe. Plants furnishing the natural food for animals must have preceded animal life, yet in the earliest geologic ages the remains of animals are far more numerous. The abundance of the deposits of graphite and iron-ore in the earliest or Archæan rocks indicates the existence of extensive plant growth, but the remains are so transformed as to make it impossible to determine the character of this primeval vegetation.

141. In the succeeding Silurian age the fossil remains indicate the existence of algæ or sea-weeds in abundance, and a single small species of ground pine attests the existence of some of the higher *Cryptogamia;* no ferns, however, have been found in America older than the Devonian. Over fifty species of Devonian ferns have been described from the American rocks chiefly, by Principal J. W. Dawson of Montreal.

142. It is in the coal measures, however, that ferns and other *Cryptogamia* are found in the greatest abundance and profusion. Their delicate foliage is impressed on the various rock strata above the beds of coal, and so perfectly are they preserved that not only the methods of fructification but even the microscopic spores have been detected! In the coal measures of the United States and Canada (counting from the base of the Catskill), 381 species of ferns have been described, chiefly by Prof. Leo Lesquereux. The most abundant American genera are *Neuropteris* 45 species, *Pecopteris* 50 species, *Sphenopteris* 31 species, *Pseudopecopteris* 25 species, and *Rhacophyllum* 24 species.

The frontispiece gives an ideal representation of the vegetation of the Carboniferous age. The luxuriant tree-ferns, the *Lepidodendrids*, ancient representatives of the diminutive club-mosses or ground-pines, the *Calamites*, allies of the modern scouring-rushes, and other forms no less wonderful, are seen in their profusion.

143. In the later geologic ages, Mesozoic and Tertiary, ferns are found preserved in the rocks, with the leaves of many trees and shrubs of existing genera. The indications are that

ferns formed a far smaller part of the vegetation of these later ages than in the preceding Carboniferous, and even approximated to that of the present. Six Cretaceous and twenty-four Tertiary species have been catalogued,* including species in the existing genera *Lygodium*, *Pteris*, *Woodwardia*, *Dryopteris*, *Gymnogramme*, etc., as well as some related to genera abundant in earlier formations. No living species is found fossil, unless Dr. Newberry's variety of *Onoclea sensibilis* becomes established.† In the course of geologic history, however, we can trace a gradual approximation to the modern types from the generalized forms of Devonian and Carboniferous times.

144. **Fern Allies.**—*Ophioglossum* dates back to the Tertiary period with one species. The order EQUISETACEÆ have existed since the coal period and the genus *Equisetum* since the Triassic. The order CALAMARIACEÆ, which combined characters of modern *Equiseta* and Conifers, came into existence in the Devonian, but became extinct before the close of the Permian. Illustrations of *Calamites* can be seen at the left-hand corner of the frontispiece, also under the tree-fern in the centre. The club-mosses proper have been in existence since the Devonian, and the genus *Lycopodium* since the Carboniferous. *Selaginella* has never been found fossil, but its near relatives belonging to the extinct orders LEPIDODENDRACEÆ and SIGILLARIACEÆ were very abundant in the Palæozoic era, particularly during the Carboniferous, where they formed the largest part of the forest vegetation, reaching in some instances a height of seventy to one hundred feet. The former possessed characters connecting modern club-mosses with Conifers, while the latter

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* Tenth report, Hayden Geological Survey of the Territories. Washington, 1878.

† Prof. Lesquereux writes me: "Though analogous by the nervation, I doubt the identity on account of the coriaceous character of that fossil fern, which I have not seen in any variety of *O. sensibilis* now living." Principal Dawson, however, writes: "The *Onoclea sensibilis* of the Laramie is truly that species, and I have found with it in our Manitoba formations another modern fern, *Davallia tenuifolia*."

seem to connect the club-mosses with the Cycads. Restorations of *Lepidodendron* may be seen on the left-hand side of the frontispiece, and of *Sigillaria* on the right. *Isoëtes* dates back to the Miocene (Tertiary) and *Marsilia* and *Pilularia* to the same period.

OUR NATIVE PTERIDOPHYTES.

PTERIDOPHYTA Cohn.

Plants containing vascular tissue and manifesting two distinct phases in their life-history: (1) An asexual phase (*sporophyte*) differentiated into stem and leaves, producing spores and developing vascular tissue in bundles throughout their stems and leaves; and (2) A sexual phase (*gametophyte*) developed from the germination of the spore in the form of a cellular thallus (*prothallium*) on which the sexual organs—antheridia and archegonia—are produced; from the egg of the archegonium fertilized by the antherozoids from the antheridia arises the asexual phase from which the characters used in classification are largely drawn. Besides several groups that have become extinct the Pteridophytes are represented by three orders: I. FILICALES, containing the ferns and waterworts; II. EQUISETALES (see p. 126) including the horsetails and scouring rushes; and III. LYCOPODIALES (see p. 130), containing the ground-pines and quillworts.

SYNOPSIS OF THE ORDER FILICALES.

(FAMILIES.)

1. Spores uniform, of one sort 2
   Spores of two sorts (minute microspores and large macrospores) . . . 6

2. Sporangia rising from the tissues beneath the epidermis (eusporangiate), borne in spikes or panicles; vernation straight or inclined.
   Family 1. OPHIOGLOSSACEÆ, p. 66
   Sporangia rising from the epidermal cells (leptosporangiate), borne on the back or margin of a leaf (frond) or rarely in panicles; vernation circinate 3

3. Sporangia sessile, with a complete ring borne on a thread-like receptacle from a cup-like involucre; texture filmy.
   Family 2. HYMENOPHYLLACEÆ, p. 74
   Sporangia borne on the back or margin of the leaf or in spikes or panicles. 4

4. Plants terrestrial 5
   Plants aquatic; sporangia sessile, scattered, in a specially folded leaf.
   Family 5. CERATOPTERIDACEÆ, p. 78

5. Sporangia sessile, ovate, with an apical ring, opening longitudinally, mostly in panicles or solitary under a scale. . *Family* 3. SCHIZÆACEÆ, p. 75

Sporangia with a rudimentary ring, opening longitudinally, in panicles.
Family 4. OSMUNDACEÆ, p. 77

Sporangia stalked, with a complete ring, opening transversely.
Family 6. POLYPODIACEÆ, p. 78

6. Rooting in mud; leaves filiform or quadrifoliate.
Family 7. MARSILEACEÆ, p. 123

Floating; leaves spongy . . . . . *Family* 8. SALVINIACEÆ, p. 125

Family I. OPHIOGLOSSACEÆ Lindl.

Plant-body consisting of stem and leaf, usually from a fleshy sometimes bulbous root, straight or inclined in vernation. Eusporangiate, the sporangia formed of the interior tissues, variously clustered on sporophylls in the form of spikes or panicles, destitute of a ring, opening by a transverse slit into two valves and discharging their copious sulphur-yellow spores. Prothallium (so far as known) subterranean, not green, monœcious. The family contains about six genera, three of which are represented in America.

Our genera may be distinguished as follows:

1. Sporangia in spikes cohering in two ranks. 2
Sporangia free, in compound spikes or panicles; leaf mostly divided. . . . . III. BOTRYCHIUM.

2. Spike solitary; leaf simple, entire, attached to the middle of the common stalk or below; terrestrial. I. OPHIOGLOSSUM.
Spikes several, pendent from near the base of a palmately divided leaf; epiphytic. . . . . II. CHEIROGLOSSA.

I. OPHIOGLOSSUM L. ADDER-TONGUE.

Sporangia large, coriaceous, connate, coherent in two ranks on the edges of a simple spike. Leaf simple, attached at the middle of the main stalk or below, entire; veins anastomosing. Spores copious, sulphur-yellow. Terrestrial. Name from Gr. *ὀφις*, a serpent, and *γλοσσα*, a tongue. Includes twenty or more species, six in our limits.

* *With several equal parallel veins at the base of the leaf, the midvein seldom branched but anastomosing with lateral veinlets.*

† *Leaf ovate to elliptic, large; basal veins, 9—13 or more.*

1. **O. vulgatum** L. Rootstock cylindric, often large and tuberous; leaf ovate to elliptic, often oblanceolate, 1′—4′ long;

base usually long and narrow; basal veins 9—11, the lateral connected above by short oblique veinlets which form long narrow areolæ in the middle of the leaf, and shorter hexagonal ones near the margin and apex, the longer usually with one short straight free veinlet; apex obtuse; spike ¾′—2′ long. Quebec to Florida; also in California.

2. **O. Engelmanni** Prantl. Rootstock cylindric with long brown roots often sheathed at the base; leaf elliptic or lanceolate-elliptic, obtuse but sharply apiculate, 1′—3½′ long; basal veins 13 or more, the outer arcuate; transverse veinlets large, oblique, forming broad oblong-hexagonal areolæ enclosing numerous anastomosing or free veinlets; spike ¾′—1′ long. Virginia and Indiana to Texas and Arizona.

†† *Leaf small, lanceolate; basal veins* 3—7.

3. **O. arenarium** E. G. Britton. Plant 3′—8′ high from a slightly thickened rootstock; leaf 1′—2′ long, ¼′—⅓′ wide, lanceolate with a long tapering base with an obtuse apex; basal veins 5—7, the median straight, the latter nearly parallel connected with short oblique veinlets forming long narrow areolæ with a few faint free or anastomosing veinlets; marginal areolæ shorter and more irregular; spike ½′—1′ long, often twisted, apiculate. Plants gregarious. Holly Beach, New Jersey.

4. **O. Californicum** Prantl. Plants small, 1′–3′ high from cylindric tuberous rootstocks; leaf ½′—1′ long, lanceolate or ovate, acute or obtuse; basal veins 3, the median stronger, the lateral branched; transverse veinlets oblique, forming long narrow areolæ with few or no free veinlets; spike ¼′—½′ long with 10—15 sporangia on either side. Southern California.

** *With few or several unequal veins at the base of the leaf, the midvein branching and commonly continuous to the apex.*

† *Rootstock not thickened; plants* 4′—6′ *high.*

5. **O. Alaskanum** E. G. Britton. Rootstock unknown; leaf 1′—2½′ long, 1′ wide, ovate or ovate-lanceolate, suddenly dilated above the cuneate clasping base, apex obtuse or acute, never apiculate; basal veins 9—11, the midvein usually giving off 1—4 branches; lateral veins divergent from the base, forming regular hexagonal areolæ including several free or anastomosing veinlets; spike ¼′—¾′ long, apiculate with 8—21 sporangia on either side. Unalaska Island (*Turner*).

†† *Rootstock tuberous or globose; plants* 1′—2½′ *high.*

6. **O. pusillum** Nutt. Plants 1′—4′ high from a short slightly tuberous rootstock; leaf small, cuneate-lanceolate or ovate, ¼—⅜′ long, rising near the base of the stem; basal veins 3, the midvein branching by lateral veinlets which form narrow areolæ with no free veinlets; spikes ¼′—½′ long with 6—14 sporangia on either side. (*O. nudicaule* of former edition not of L. fil., which is an African plant; *O. tenerum* Mett.) Georgia to Florida and Louisiana.

7. **O. crotalophoroides** Walt. Plants 1′—4′ high from a large globose rootstock; leaf ⅛′—1¼′ long, concave, broadly ovate and cordate at base, the apex acute; basal veins 5, the midvein rarely branched, the lateral freely anastomosing, forming short hexagonal areolæ with rarely a free veinlet; spike short, broad, ⅛′—½′ long with 4—11 sporangia on either side. (*O. bulbosum* Michx.) South Carolina to Florida and Texas.

II. CHEIROGLOSSA Presl.

Sporangia large, coriaceous, coherent in two ranks on the edges of simple or rarely forked spikes. Leaf palmately lobed, irregular, bearing several spikes at or below its base. Veins anastomosing. Spores copious. Epiphytic. Name from Gr. *χείρ*, hand, and *γλοσσα*, tongue. A single tropical species.

1. **C. palmata** (L.) Presl. Rootstock thick, tuberous, covered with fine woolly chaff; leaf fleshy, 4′—8′ long, on a stem nearly as long, palmately divided into 2—9 broadly spreading lobes, rarely simple and lanceolate; basal veins 5—8, repeatedly branching and anastomosing, forming long hexagonal areolæ without free veinlets; spikes 1—16, on short stalks, 1′ or more long; spores large. On palmettos, Florida and tropical America.

III. BOTRYCHIUM Swz. Grape-fern.

Rootstock very short, erect, with clustered fleshy roots, the bud for the next year's growth usually imbedded in the base of the stipe. Sterile segment of frond pinnately or ternately divided or compound. Fertile segment 1—3-pinnate, with double rows of sessile, naked sporangia. Veins free. Spores copious, sulphur-yellow. Name from Gr. *βοτρυς*, a bunch of grapes, alluding to the clustered sporangia. Contains about thirty species, of which fifteen are found in our limits.

§ 1. EUBOTRYCHIUM. *Bud enclosed in the base of the stalk.*

* *Leaf rising from above the middle of the stem.*

† *Vernation erect in sterile segment; stems thickly sheathed with remnants of former years.*

1. **B. pumicola** Coville, sp. nov. Rootstock vertical, reaching a length of 3½′ and a diameter of 1½″, with an abundance of roots a half line or less in diameter; stem, together with the segments of the frond, reaching a height of 4′, the former about twice the height of the latter, and in ordinary specimens 1″—2″ in diameter, the lower half or two-thirds thickly sheathed with the dark brown remnants of the stems of previous years; frond glaucous, the sterile segment nearly sessile, reaching a length of 1′, ternate, the divisions nearly sessile, the lateral ones about half or two-thirds the length of the middle one, each pinnately parted into fan-shaped somewhat one-sided lobes, these with crenulate margins and usually two to three lobules, the lowermost lobes of the middle division sometimes distinctly pinnatifid into several lobules; fertile segment in most specimens a little longer than the sterile, bipinnate, or one or both the lowest branches sometimes so developed as to indicate a tendency to ternate division; bud with sterile segment erect, the axes of the lobes horizontal.

Growing in pumice soil on the summit of Llao Rock, Crater Lake, Oregon, at an elevation of about 9000 ft. (*Coville and Applegate*, 1898.)

†† *Vernation partly inclined in one or both segments.*

2. **B. tenebrosum** A. A. Eaton. Plant 1′—7′ high, averaging 2½′—3′, one-third of which is below ground; slender, fleshy, light green or yellowish after fruiting, transparent when dry; leaf above the middle of the stem, often immediately under the sporophyll, short-petioled, entire, lobed, or usually with 1—3 pairs of distant alternate lunate decurrent entire segments; the apex emarginate or with a triangular elongation; sporophyll usually short-stalked, simple, or rarely with one or two short, somewhat dilated branches, bearing alternate or nearly opposite clusters of sporanges; spores very large, verrucose; sporophyll not bent in vernation. Rich shady situations, usually among maples at the border of swamps; Massachusetts and New Hampshire to Central New York.

3. **B. lunaria** (L.) Swz. MOONWORT. Plant very fleshy,

2½′—12′ high. Leaf usually sessile, borne at or above the middle of the stem, pinnate with 2—8 pairs of lunate or fan-shaped lobes which vary from crenate to entire and are either close and imbricated or somewhat distant; sporophyll 2—3-pinnate, often dense, 1′—2′ long, often about the height of the sterile; apex only of the leaf bent over the nearly straight sporophyll in vernation. Greenland to Alaska, south to New York, Colorado, and British Columbia.

FIG. 31.—Vernation of *B. lunaria* Swz. (After Davenport.)

4. **B. neglectum** Wood. Plant 2′—12′ high, often very fleshy. Sterile portion borne above the middle of the stem, short-stalked, ovate or oblong, 1—2-pinnatifid or rarely 2-pinnate, with obtuse divisions and narrow toothed segments: midveins disappearing by continued branching; sporophyll 2—3-pinnate, often much branched; spores tuberculate; apex of both leaf and sporophyll turned downward in vernation. (*B. matricariæfolium* of former editions, not of A. Br., and apparently distinct from the species of Europe.) Nova Scotia to New Jersey, west to Ohio and Washington.

FIG. 32.—Vernation of *B. neglectum* Wood. (After Davenport.)

5. **B. boreale** (Fries) Milde. Plant 2½′—7′, smooth, fleshy; sterile segment placed above the middle, sessile, cordate, ovate or deltoid, pinnately parted, acute; lowest segment spreading from a narrower base, ovate or cordate-ovate, acute, all entire, or here and there flabellately incised with acute lobes, or pinnately parted; secondary segments from a narrowed base, ovate, acute, serrate, the upper spreading, quickly decreasing, finally elliptical, acute; fertile segment bi—tripinnate, panicled. Apex of sterile segment bent over inside of the nearly erect fertile one in vernation; divisions of the sterile segment arranged on an angle. Unalaska.

†† *Vernation wholly inclined, recurved in the sporophyll; leaf triangular, sessile.*

6. **B. lanceolatum** (S. G. Gmel.) Angs. Plant 3′—12′ high, somewhat fleshy. Leaf closely sessile near the summit of the stem, ¾′—2′ wide, 3-lobed or broadly triangular and 2-pinnatifid, the ultimate segments lanceolate, acute, oblique, entire or dentate; midvein continuous, with forking veinlets; sporophyll slightly overtopping the leaf, short-stalked, 2—3-pinnate, recurved its whole length with the shorter leaf reclined upon it in vernation. Nova Scotia to Alaska, south to New Jersey, Ohio, Colorado, and Washington. Also in Europe and Asia. June–July.

FIG. 33.—Vernation of *B. lanceolatum* Angs. (After Davenport.)

** *Leaf rising from near the rootstock.*

† *Vernation wholly straight; bud smooth; leaf entire or 2—6-lobed.*

7. **B. simplex** E. Hitchcock. Plant 2′—5′ high, slender, very variable. Leaf ovate, obovate, or oblong, entire, lobed, or pinnately parted, borne near the base of the stem; sporophyll a simple or slightly compound spike, sometimes reduced to only a few sporanges; spores large for the genus, minutely tuberculate; apex of leaf and sporophyll erect in vernation. Nova Scotia to Maryland, west to Wyoming and California (?).

FIG. 34.—Vernation of *B. simplex* Hitchcock. (After Davenport.)

†† *Vernation inclined; leaf ample, ternately compound.*

‡ *Spores maturing in early spring; leaf sessile or nearly so.*

8. **B. biternatum** (Lam.) Underw.—Plant 3′—6′ high, bearing a nearly sessile, broadly triangular ternately compound leaf, 3′—4′ wide, 2′ high; middle division slightly larger than the lateral ones and like them nearly bipinnate; ultimate divisions rather lunate, usually not exceeding 2″—3″ in width, the outer margin crenulate, the lateral margins decurrent into the short branches of the rachis; sporophyll on a rather stout stalk, bipinnate, with a rather broad rachis; bud smooth or slightly hairy, the segments nearly erect. (*B. lunarioides* Swz., *B. fumarioides* Willd., *B. fumariæ* Spreng., *Osmunda biternata* Lam.) South Carolina to Louisiana, apparently not common.

‡‡ *Spores maturing in autumn; leaf long-stalked.*

‖ *Ultimate leaf-segments laciniate, narrow, ½″ or less wide.*

9. **B. dissectum** Spreng.—Plant 6′—15′ high, with slender fleshy stems. Leaf long-stalked from near the base of the stem, with broadly deltoid basal divisions, decompound; secondary pinnæ lanceolate from a broader base, pinnate with laciniate and deeply cut pinnules, the ultimate divisions divergent, often 2-toothed at their apices, usually less than 1 mm. wide; sporophyll long-stalked, 2—3-pinnate; bud pilose, enclosed in the base of the stem, both portions bent in vernation. New England (where a more compact variety is more common) to Virginia and inland to Kentucky and Indiana.

‖‖ *Leaf-segments small, rounded, or obliquely ovate, 1½″—3″ wide; plant small (leaf 1′—2′ wide).*

10. **B. matricariæ** (Schrank) Spreng. Plant 4′—6′ high, with slender fleshy stems; leaf moderately short-stalked, ternate, small, 1′—2′ wide and high, the three divisions similar, bipinnatifid or bipinnate; ultimate segments small, 1½″—3″ wide, rounded or somewhat obliquely ovate, the margins undulate or crenate; sporophylls rather long-stalked for the size of the plant, 2—3-pinnate with large sporanges; bud pilose. Northern New England and New York and northward.

‖‖‖ *Leaf-segments obliquely ovate, large, 5″–10″ long.* (*Eastern.*)

11. **B. obliquum** Muhl. Plant robust, 7′—20′ high; leaf rising from near the base on a stalk 3′—4′ long or more, ternate with the three divisions nearly equal, bipinnate or somewhat tripinnatifid in larger forms, the ultimate segments obliquely ovate or oblong-lanceolate, the terminal one of each division elongate, all 5″—10″ long, 2½″—4″ wide, the margins crenate or serrate; sporophyll long-stalked triquadripinnate; bud densely pilose, both portions bent in vernation. (*B. ternatum* in part, of former editions, not of Swz., which was Thunberg's *Osmunda ternata* from Japan.) New Brunswick to Florida and Mexico and westward to Minnesota.

Fig. 35.—Vernation of *B. obliquum* Muhl. (After Davenport.)

Var. **intermedium** (D. C. Eaton) Underw. Plant larger, the leaf on a shorter stalk 1′—2′

long, the leaf sometimes reaching 6′ each way; lateral divisions smaller than the terminal; ultimate segments similar to the type, but mostly shorter. Northern New York and New England. The limits of this variety are not fully understood.

‖‖‖‖ *Leaf-segments ovate or roundish; plant large and stout.* (Western).

A. *Leaf-stalk short* (1′ *or less*); *segments crowded.*

12. **B. Coulteri** Underw. A stout fleshy plant growing in geyser formations. Roots numerous, fleshy, stout; stem very short, 1′ or less long, very stout, 7″—10″ in diameter, swollen with the contained bud of the succeeding season, soon dividing to form the sporophyll and leaf; petiole very short, 1′ or less long, stout, sulcate in drying; sterile lamina about 6′ wide, the central portion nearly 4′ long, this and the lateral ones tripinnate, or quadripinnatifid; segments obliquely ovate, 5″ or more long, 2″ or more wide, thick, fleshy, the margin entire or slightly repand; veins few, scarcely perceptible; sporophyll about 7′ long; panicle quadripinnate below, the pinnæ crowded, gradually simpler above; sporangia very numerous, bright yellow; spores copious, pale yellow. In geyser basins, Yellowstone National Park; Montana.

B. *Leaf-stalk longer* (4′—6′) *or more; segments more scattered.*

13. **B. occidentale** Underw. Roots fibrous, fleshy; stem short, 1′—2′ long, 2″ or more in diameter; leaf-stalk 4′—5′ long, rather slender; leaf very large, 7′—8′ broad, 5′—6′ high, the lateral divisions bipinnate with about five pairs of mostly opposite pinnæ; terminal division tripinnatifid, gradually simpler above; ultimate segments nearly oval, mostly narrow (under 3″ wide), the margins finely and irregularly crenulate; texture fleshy, the veins indistinct; sporophylls 16′ long, including the panicle, which ranges from 4′—6′, tripinnate almost throughout its entire length; bud densely covered with white silky hairs. Washington, Oregon, and British Columbia.

14. **B. silaifolium** Presl. Plant robust, 15′—2° high; common stem rather short, 1′—2′ long; leaf-stalk; stout 3′—6′ long; leaf very large, 8′—10′ or more wide, 5′—8′ high; formed of a larger central division and two lateral ones; divisions nearly tripinnate; ultimate segments ovate, the lowest outer series

often trilobed; sporophyll long-stalked, much overtopping the leaf, the panicle ample, 5′—8′ long. California to British Columbia.

§ 2. OSMUNDOPTERIS Milde. *Bud pilose, enclosed in a smooth upright cavity at one side of the lower part of the stalk.*

15. **B. Virginianum** (L.) Swz. (RATTLESNAKE-FERN.) Plant from a few inches to two feet high; sterile segment sessile above the middle of the stalk, broadly triangular, thinly herbaceous, ternate; the short-stalked primary divisions once to twice pinnate, then once or twice pinnatifid; lobes oblong, cut-toothed toward the apex; fertile segment long-stalked, bi—tripinnate. Bud pilose, enclosed in a smooth upright cavity at one side of the lower part of the stalk; fertile segment recurved its whole length, the longer sterile segment reclined upon it Reduced forms are *B. gracile* Pursh. (*Botrypus Virginicus* Michx., *Osmunda Virginiana* L.) New Brunswick to Florida, and westward to Arizona and the Pacific Coast.

Family 2. HYMENOPHYLLACEÆ Endl.

Plant body consisting of a creeping stem bearing scattered leaves of a filmy consistency, usually translucent. Sporangia provided with a ring, sessile on a thread-like receptacle which is surrounded at base by a cup-shaped or two-valved involucre. The family contains several genera, mostly of tropical regions, only one of which is represented in our flora.

I. TRICHOMANES Sm. FILMY-FERN.

Sori marginal, terminating a vein, more or less sunken in the frond. Sporangia sessile on the lower part of a cylindrical, filiform, often elongated receptacle. Indusia tubular or funnel-shaped, entire or two-lipped at the mouth. Fronds delicate, pellucid. Name from Gr. *τριχομανες*, the name of some fern, from *τρίχ*, hair, and *μαίνομαι*, producing frenzy, alluding to some supposed property. A tropical and temperate genus containing nearly 100 species.

§ EUTRICHOMANES.

1. **T. Petersii** Gray. Stipes 1″—2″ long; fronds 3″—10″ long, 1″—2″ broad, oblong-lanceolate or obovate, entire or vari-

ously pinnatifid, the younger ones with a few black hairs along the margins; indusium solitary, terminal, funnel-shaped, the mouth expanded and slightly two-lipped, the receptacle included. Winston County, Alabama (*Peters*).

2. **T. radicans** Swz. Rootstock wiry, tomentose; stipes ascending, 1′—3′ long, naked or nearly so, usually broadly winged; fronds 2′—8′ long, 1′—1½′ wide, lanceolate or ovate-lanceolate, bipinnatifid; pinnæ ovate, obtuse, the upper side of the base parallel and appressed to the winged rachis, the lower side cuneate; divisions toothed or divided into linear lobes; indusia terminal on short lobes, tubular or funnel-shaped, the mouth slightly two-lipped; receptacle exserted little or very much. (*T. speciosum* Willd.) Alabama, Tennessee, Kentucky.

Family 3. SCHIZÆACEÆ Presl.

Plant-body consisting of a short or creeping stem (rootstock) bearing clustered or scattered leaves. Sporangia ovate or pyriform, provided with an apical ring, bursting longitudinally at maturity. The family contains about ten genera, three of which are represented in our region.

Our genera may be distinguished as follows:

1. Leaves twining; leaflets in pairs, palmate . . I. LYGODIUM.
   Leaves erect or merely curled 2
2. Sporophylls distinct from the grass-like leaves.
   III. SCHIZÆA.
   Sporophylls borne on the elongate lower pinnæ of an ordinary leaf . . . . . II. ORNITHOPTERIS.

I. LYGODIUM Swz. CLIMBING-FERN.

Sporangia ovoid, solitary or occasionally in pairs, in the axils of large imbricated scale-like indusia, which are fixed by their broad bases to short oblique veinlets. Fronds scandent, twining, bearing stalked and variously lobed divisions in pairs. Veins mostly free. Name from Gr. λυγώδης, flexible, alluding to the scandent stems. Includes 25 species.

§ EULYGODIUM.

1. **L. palmatum** (Bernh.) Swz. Stipes slender, twining; fronds 1°—3° long, the short alternate branches or peti-

oles 2-forked, each fork bearing a round-cordate palmately 4—7-lobed pinnule; fertile pinnules above, contracted, several times forked, forming a terminal panicle; surfaces naked; texture thinly herbaceous. (*Hydroglossum palmatum* Willd.) Massachusetts and New York to Kentucky and Florida.

II. ORNITHOPTERIS Bernh.

Sporangia ovate, sessile, placed in two rows on the back of the very narrow branchlets of the two long-stalked, panicled, lower branches of a pinnately divided frond, the fertile branches in a few species entirely distinct from the sterile frond. Veins free. Name from Gr. ὄρνις, bird, and πτέρις, fern. A genus mostly of tropical America containing about 35 species.

1. O. adiantifolia (L.) Bernh. Rootstock creeping; stipes 1½° long, firm, naked; fronds sparingly pubescent, the two lower branches elongate, pinnately decompound, fertile; sterile portion deltoid-ovate, bi—tripinnate; ultimate segments obovate or cuneate, entire or lobed, striate above with numerous flabellate veins. (*Anemia adiantifolia* Swz.) Florida.

2. O. Mexicana (Kl.) Underw. Rootstock creeping, covered with narrow blackish chaff; stipes slender, scattered, 6′— 12′ long; the two lower branches of the frond fertile, long-stalked, glandular, bipinnate with densely clustered fructification; the rest of the frond like the sterile ones, deltoid-ovate, simply pinnate; pinnæ about six pairs and a rather large terminal one, short-stalked, ovate-lanceolate, subcoriaceous, smooth and somewhat glossy; midrib distinct, veins free, oblique, parallel, closely placed. (*Anemia Mexicana* Klotzsch.) Western Texas.

III. SCHIZÆA Sm. Curly-grass.

Sporangia large, ovoid, striate rayed at the apex, naked, vertically sessile in a double row along the single vein of the narrow divisions of the fertile appendages to the slender and simply linear, fan-shaped, or dichotomously many-cleft fronds. Name from Gr. σχίζειν, to split, alluding to the forked sterile fronds of foreign species. Includes 16 species.

§ Euschizæa.

1. S. pusilla Pursh. Sterile fronds linear, very slender, flattened and tortuous; fertile ones equally slender, 3′—4′ high,

and bearing at top the fertile appendage consisting of about five pairs of crowded pinnæ, forming a distichous spike. New Jersey; Grand Lake, Nova Scotia (*E. G. Knight*); Newfoundland (*De la Pylaie, Waghorne*).

Family 4. OSMUNDACEÆ R. Br.

Plant body a stout suberect stem (rootstock) with clustered leaves. Sporangia with a rudimentary ring, opening longitudially, borne in panicles on altered portion of the leaf. The family contains three genera, only one of which is represented with us.

I. OSMUNDA L. Flowering-fern.

Fertile fronds or fertile portions very much contracted, bearing short-pedicelled, naked sporangia on the margin of the rachis-like divisions. Sporangia large, globular, opening by a longitudinal cleft into two halves, bearing near the apex a few parallel striæ, the rudiment of a transverse ring. Spores green. Named for *Osmunder*, a Saxon name for the divinity Thor. A genus containing six species mostly north temperate.

* *Fronds bipinnate, fertile at the apex.*

1. **O. regalis** L. Stipes tufted, 1°—1½° long, erect, naked; fronds 2°—4° long, 1° or more broad; sterile pinnæ 6′—12′ long, 2—4′ broad; pinnules oblong-ovate to lance-oblong, sessile or slightly stalked; the fertile pinnules cylindrical, panicled; texture subcoriaceous; rachis and both sides naked. (*O. spectabilis* Willd., *O. glaucescens* Link.) Canada to Florida and Mississippi.

** *Sterile fronds bipinnatifid.*

2. **O. Claytoniana** L. Stipes tufted, 1° or more long, clothed with loose woolly tomentum when young, naked when mature; fronds 1°—2° long, 8′—12′ broad; pinnæ oblong-lanceolate with oblong, obtuse divisions; 2—5 pairs of central pinnæ fertile fertile pinnules dense, cylindrical; texture herbaceous. (*O. interrupta* Michx.) Canada to Kentucky, and northward.

3. **O. cinnamomea** L. (Cinnamon-fern.) Stipes densely tufted, 1° or more long, the sterile and fertile fronds dis-

tinct, clothed when young with ferruginous tomentum; sterile fronds smooth when mature, the pinnæ bearing a tuft of tomentum at the base beneath, lanceolate, cut into broadly oblong, obtuse divisions; fertile fronds contracted, bipinnate, with cinnamon-colored sporangia. In *var. frondosa* Gray, some of the fronds are sterile below, and sparsely fertile at the summit. (*O. Claytoniana* Conrad.) New England and Wisconsin to Florida.

Family 5. CERATOPTERIDACEÆ Underw.

Plant body a short succulent stem with copious aquatic roots bearing a rosette of succulent leaves of two sorts. Sporangia irregularly scattered, sessile, with a broad ring or often devoid of one altogether. The family is represented by a single genus and species.

I. CERATOPTERIS Brong. Floating-fern.

Sori placed on two or three veins which run down the frond longitudinally, nearly parallel with both the edge and midrib. Sporangia scattered on the receptacles, sessile, subglobose, with a complete, partial, or obsolete ring. Indusia formed of the reflexed margins of the frond, those of opposite sides meeting at the midrib. Name from Gr. κέρας, horn, and πτέρις, a fern. Contains a single tropical species.

1. **C. thalictroides** (L.) Brong. Stipes tufted, inflated, filled with large air-cells; fronds succulent in texture, the sterile ones floating in quiet water, simple or slightly divided when young, bi—tripinnate when mature; fertile ones bi—tripinnate; ultimate segments pod-like. Southern Florida.

Family 6. POLYPODIACEÆ Presl.

Plant body consisting of a creeping or erect stem (rootstock) bearing scattered or clustered leaves (fronds). Sporangia borne on the back or margin of the leaf in lines or rounded masses (sori), stalked, provided with a vertical elastic ring, breaking open transversely at maturity. Sori either naked

or covered when young with a membranous indusium which is either a special outgrowth of the leaf or is formed from the more or less altered leaf margin. Prothallium green, monœcious or rarely dicœcious. The family contains four-fifths of all the ferns, comprising a hundred or more genera, of which twenty-nine are represented within our limits. They may be distinguished by the following

ARTIFICIAL SYNOPSIS OF GENERA.

1. Sporophyll closely rolled together, entirely unlike the sterile leaf, its segments berry-like or necklace-like 20
   Sori covered with indusia 2
   Sori naked 3
2. Sori marginal, covered with a reflexed portion of the leaf margin . . 10
   Sori dorsal or submarginal, provided with special indusia 14
3. Sori spread in a stratum on the under surface of the leaf.
   I. ACROSTICHUM, p. 81
   Sori roundish, or not more than twice as long as broad 4
   Sori usually linear, always more than twice as long as broad . . . 7
4. Stipes articulated to the rootstock; leaves (in our species) entire or simply pinnate 5
   Stipes not articulated to the rootstock; leaves (in our species) bi—tripinnatifid or ternate . . . . . XXII. PHEGOPTERIS, p. 108
5. Veins free or uniting irregularly (often indistinct). II. POLYPODIUM, p. 81
   Veins copiously uniting (species sub-tropical) 6
6. Primary veins distinct to the edge, connected by parallel transverse veinlets . . . . . IV. CAMPYLONEURON, p. 83
   Areolæ regular, each with two or more free veinlets bearing sori on their apices . . . . . III. PHLEBODIUM, p. 83
   Areolæ copious, irregular with free veinlets spreading variously.
   V. PHYMATODES, p. 84
7. Leaves simple 8
   Leaves pinnate to quadripinnate 9
8. Leaves very narrow, grass-like; veins indistinct, free.
   IX. VITTARIA, p. 89
   Leaves broader; veins anastomosing . . VIII. CHEILOGRAMMA, p. 88
9. Sori marginal, more or less confluent in a marginal band.
   VII. NOTHOLÆNA, p. 85
   Sori dorsal, following the veinlets, simple, forked, or pinnate.
   VI. GYMNOPTERIS, p. 84

10. Sporangia at the ends of the veins, borne on a reflexed portion of the margin of the leaf . . . . . X. ADIANTUM, p. 89
Sporangia borne on a continuous, marginal, vein-like receptacle connecting the apices of the veins 11
Sporangia at or near the ends of unconnected veins, borne on the under surface of the leaf 12

11. With an inner indusium inside the receptacle . XII. PTERIDIUM, p. 91
With no inner indusium ; our species pinnate . . XI. PTERIS, p. 90

12. Fronds conspicuously dimorphous; stipes light-colored.
XIV. CRYPTOGRAMMA, p. 97
Fronds nearly uniform ; stipes usually dark-colored 13

13. Sori on the upper part of the veins, mostly forming a continuous marginal band ; indusium membranous, continuous round the segment.
XV. PELLÆA, p. 97
Sori minute, at the ends of the veins ; indusium interrupted, or if continuous, the ultimate segments usually small and bead-like ; leaves mostly chaffy, woolly, or farinose, . . . XIII. CHEILANTHES, p. 91

14. Sori roundish ; indusia not more than twice as long as broad . . . 15
Sori linear or oblong ; indusia more than twice as long as broad . . 21

15. Indusium superior, attached by the centre or sinus 16
Indusium convex, fixed by a broad base partly under the sorus,
XXVIII. FILIX, p. 119
Indusium inferior 19

16. Sori mostly on the back of the veins 17
Sori at the end of a free vein ; indusium reniform, opening toward the margin of the leaf, which is simply pinnate, the pinnæ articulated to the rachis . . . . . XXVII. NEPHROLEPIS, p. 118

17. Indusia centrally peltate 18
Indusia cordate or reniform, attached by the sinus.
XXIII. DRYOPTERIS, p. 110

18. Veins free, 1—2-forked . . . . . XXIV. POLYSTICHUM, p. 115
Veins 3—5-forked, often uniting in irregular areolæ ; leaf pinnate.
XXV. PHANEROPHLEBIA, p. 117
Veins copiously anastomosing ; leaf trifoliate. XXVI. TECTARIA, p. 118

19. Indusium roundish or stellate, delicate . . . XXXI. WOODSIA, p. 120
Indusium cup-shaped, somewhat two-valved.
XXXII. DENNSTÆDTIA, p. 122

20. Leaves growing in crowns ; veins free . . XXX. MATTEUCCIA, p. 120
Leaves scattered ; veins copiously anastomosing.
XXIX. ONOCLEA, p. 120

21. Sori all parallel to the midribs or rachises 22
Sori all oblique to the midribs 24

Sori partly oblique and partly parallel to the midrib; leaf simple, tapering to a point . . . . . XXI. CAMPTOSORUS, p. 108

22. Veins free 23
Veins reticulate . . . . . XVIII. WOODWARDIA, p. 102

23. Indusium near the margin; sporophyll much contracted.
XVI. STRUTHIOPTERIS, p. 101
Indusium remote from the margin; leaves nearly uniform.
XVII. BLECHNUM, p. 102

24. Sori on the upper side of a veinlet, rarely on both sides.
XIX. ASPLENIUM, p. 103
Sori confluent in pairs, with an apparently double indusium opening in the middle . . . . . XX. PHYLLITIS, p. 107

I. ACROSTICHUM L.

Sporangia spread over the whole surface of the frond or upper pinnæ, or occasionally over both surfaces. Venation anastomosing (our species simply pinnate). Name from Gr. ἄκρος, the summit, and στιχος, a row. A tropical genus containing about five species as here limited.

1. **A. aureum** L. Rootstocks erect, solitary or in masses; stipes cespitose, erect ligneous, 1½°—2½° long, flattish-channelled, with two or three alternate pairs of black indurated spurs, fronds erect, stiff, coriaceous, glossy, light green; 3°—4° long; 1°—1½° wide; pinnæ 12 or more pairs, rather distant; sporangia confined to the upper half or third of the frond; venation fine, oblique to the margin. Southern Florida.

2. **A. lomarioides** Jenman. Rootstocks erect massive; stipes cespitose, erect, subfleshy, 1½°—2½° long, longitudinally ribbed, subangular; fronds erect-spreading, 3°—4° high, 1°—2° wide, slightly reduced at base, suddenly reduced at the apex; pinnæ patent, close or crowded, 25—30 pairs, the face turned upward and transverse with the rachis; sporangia covering all the pinnæ of fertile fronds; areolæ very fine, directed toward the margin. South Florida.

II. POLYPODIUM L.

Sori round, naked, dorsal, in one or more rows each side of midrib, or irregularly scattered. Stipes articulated to root-

stock. Name from Gr. πολύς, many, and πούς, ποδός, foot, alluding to the branching rootstock. The largest, most cosmopolitan genus of ferns, containing 150 or more species.

§ 1. EUPOLYPODIUM. *Veins free; fronds (in our species) pinnate.*

* *Sori large.*

1. **P. vulgare** L. Stipes 2′—4′ long, firm, erect; fronds 4′—10′ long, 1′—3′ broad, cut nearly or quite to the rachis into entire or slightly toothed, usually blunt pinnæ; veins once or twice forked. Larger fronds with their pinnæ sharply serrated and long-pointed form the *var. occidentale* Hook. New England westward to Oregon and southward to Alabama.

2. **P. falcatum** Kellogg. Stipes 5′—8′ long, stramineous; fronds 12′—15′ long, 4′—8′ broad; pinnæ numerous, tapering to a slender point, sharply serrate; sori nearest the midrib; veins with 2—4 veinlets. (*P. glycyrrhiza* D. C. Eaton.) California to British Columbia.

** *Sori smaller, often minute.*

3. **P. plumula** H. B. K. Stipes 1′—4′ long, black, slender; fronds narrowly lanceolate, 9′—18′ long, 1′—2′ broad; pinnæ numerous, narrow, entire, blunt, lower gradually reduced; surfaces naked except the black wiry rachis; veinlets forked, obscure. Florida.

4. **P. pectinatum** L. Stipes rigid 2′—6′ long; fronds elliptical-lanceolate, 1°—2½° long, 2′—6′ broad, cut to the rachis into horizontal, entire or toothed pinnæ, the lower ones much reduced; rachis naked or finely villose; veinlets pellucid, once or twice forked; sori in long rows, of medium size. Florida.

§ 2. GONIOPHLEBIUM Blume. *Veins forming ample regular areolæ (almost imperceptible in No. 5), each with a single distinct free included veinlet, bearing a sorus at its terminus.*

* *Under surface squamous.*

5. **P. polypodioides** (L.) Hitch. Rootstock creeping, covered with small brown scales; stipes 1′—4′ long, erect, densely scaly; fronds 2′—6′ long, 1′—1½′ broad, cut to the rachis into entire pinnæ; texture coriaceous; sori small; veins indistinct. (*P. incanum* Swz.) Virginia to Illinois, and southward.

6. **P. thysanolepis** A. Br. Rootstock slender, firm, densely covered with minute lanceolate scales; stipes 3′—12′ long, erect, scaly; fronds ovate, 3′—9′ long, 2′—3′ broad; pinnæ distant, ascending, blunt, dilated at base (except the lowest), thick, subcoriaceous, covered below with ciliate scales with brown centre and broad scarious border; areolæ and sori in a single series. Huachuca Mountains, Arizona (*Lemmon*), Mexico.

** *Under surface mostly smooth.*

7. **P. Californicum** Kaulf. Rootstock creeping, chaffy; stipes 2′—6′ long, stramineous when dry, naked; fronds ovate to oblong-lanceolate, 4′—9′ long, 1′—5′ broad, cut nearly or quite to midrib into finely-toothed pinnæ; texture papyraceo-herbaceous; sori large; veinlets 4—6 to each vein. (Including *P. intermedium* H. & A.) California.

8. **P. Scouleri** H. & G. Rootstock stout, creeping, scaly; stipes 2′—4′ long, erect, naked; fronds thick, 3′—12′ long, 2′—6′ broad, cut down to rachis into from 5—29 close, blunt pinnæ; texture coriaceous, fleshy when recent; sori very large; veinlets regularly anastomosing forming a single series of large areolæ. (*P. carnosum* Kellogg, *P. pachyphyllum* D. C. Eaton.) California and northward.

III. PHLEBODIUM R. Br.

Sori round, naked, dorsal, borne on the united ends of two or more free veinlets which are included in the ample areolæ formed by the regularly anastomosing veins. Name from Gr. φλεβός, a vein. A small genus of tropical ferns mostly epiphytic.

1. **P. aureum** (L.) R. Br. Rootstock stout, densely scaly; stipes 1°—2° long, castaneous, naked; fronds 3°—5° long, 9′—18′ broad, cut nearly to the rachis into broad entire or slightly undulate pinnæ; areolæ copious. Florida.

IV. CAMPYLONEURON Presl.

Sori round, naked, dorsal, borne in one or more rows either side of the midrib. Primary veins distinct from midrib to margin, connected by parallel transverse veinlets forming regu-

lar arches. Areolæ similar, containing two or more sori. Name from Gr. *καμπύλος*, curved, and *νεῦρον*, a nerve. A tropical genus of about 50 species.

1. **C. phyllitidis** (L.) Presl. Rootstock stout, scaly; stipes short or none; fronds simple, 1°—3° long, 1′—4′ broad, the point acute, lower part gradually narrowed; texture rigid, coriaceous; areolæ in rows of 6—12 from midrib to edge. Florida.

V. PHYMATODES Presl.

Sori round, naked, dorsal, various in position. Veins forming fine, copious, irregular areolæ with free veinlets spreading in various directions. Name from Gr. *φυμα*, a swelling. A tropical genus of about 60 species.

1. **P. Swartzii** (Bak.) Underw. Rootstock wide creeping, slender, covered with linear ferruginous scales; stipes ½′—1′ long, slender, naked; frond simple, 2′—4′ long, ⅛′—¾′ broad, narrowed gradually toward both ends, the edge entire, undulate, or slightly lobed; sori uniserial on free veinlets. (*P. serpens* Swz.) Key Largo, Florida (*Curtiss*).

VI. GYMNOPTERIS Bernh.

Sori oblong or linear, following the course of the veinlets and, like them, simple, forked, pinnate, or variously branching, without indusia. Name from Gr. *γυμνός*, naked, and *πτερίς*, fern. Includes about 25 species, mostly tropical.

* *Veins free, under surface not farinose.*

1. **G. hispida** (Mett.) Underw. Rootstock creeping; stipes grayish, puberulent, 3′—6′ long; fronds 5-angled, 1′—3′ each way, hispid above, tomentose beneath, pinnate; lower pinnæ much the largest, unequally triangular, pinnate; upper pinnæ lobed or crenate. (*Gymnogramme Ehrenbergiana* of former edition not of Klotzsch, *G. podophylla* Hook in part, *G. hispida* Mett.) Texas to Arizona.

** *Fronds farinose below.*

2. **G. triangularis** (Kaulf.) Underw. (GOLDEN-BACK.) Stipes densely tufted, slender, blackish-brown, polished, 6′—12′ long; fronds 2′—5′ each way, deltoid, pinnate; lower pinnæ much the largest, triangular, bipinnatifid; upper pinnæ more or

less pinnately lobed; lower surface coated with yellow or white powder, finally more or less obscured by the fruit. (*Gymnogramma triangularis* Kaulf.) Arizona, California, and northward.

VII. NOTHOLÆNA R. Br. Cloak-fern.

Sori marginal, at first roundish or oblong, soon confluent into a narrow band, without indusium, but sometimes covered at first by the inflexed edge of the frond. Veins free. Name from Lat. *nothus*, spurious, and *læna*, a cloak, alluding to the rudimentary indusia. Includes 37 species.

§ 1. Eunotholæna. *Fronds not farinose beneath, scaly, hairy, or tomentose.*

* *Fronds simply pinnate.*

1. **N. sinuata** (Swz.) Kaulf. Rootstock short, very chaffy; stipes 2′—4′ long, erect; fronds 6′—2° long, 1′—2′ broad; pinnæ numerous, short-stalked, roundish or ovate, entire to pinnately lobed, lower surface densely scaly. Texas to Arizona.

2. **N. ferruginea** (Desv.) Hook. Rootstock creeping, with dark rigid scales; stipes tufted, 2′—4′ long, wiry, blackish, woolly at first; fronds 8′—12′ long, ½′—1′ broad, narrowly lanceolate; pinnæ numerous, ovate, pinnatifid, hairy above, densely tomentose beneath, the wool at first whitish, but becoming ferruginous. (*N. rufa* Presl.) Texas to Arizona.

** *Fronds bi—quadripinnate.*

† *Fronds silky-hairy above.*

3. **N. Parryi** D. C. Eaton. Rootstock short, scaly; stipes 2′—4′ long, dark brown, pubescent with whitish jointed hairs; fronds 2′—4′ long, oblong-lanceolate, tripinnate, lower pinnæ distinct; segments crowded, roundish-obovate, one line broad, densely covered above with entangled white hairs, beneath with a heavier pale-brown tomentum. Utah, California, Arizona.

4. **N. Newberryi** D. C. Eaton. (Cotton-fern.) Rootstock with very narrow dark bristly scales; stipes tufted, 3′—5′ long, blackish-brown, woolly when young, with pale-ferruginous tomentum; fronds 3′—5′ long, lanceolate-oblong, covered most densely beneath with fine whitish hairs, tri—quadripinnate; ultimate segments roundish-obovate, ⅛″—½″ broad. California.

†† *Fronds slightly hispid above.*

5. **N. Aschenborniana** Klotzsch. Rootstock short, creeping; stipes tufted, 2′—3′ long, wiry, ebeneous, densely scaly; fronds 4′—10′ long, 2′—3′ broad, oblong-lanceolate, tripinnatifid; pinnæ lanceolate, cut into linear-oblong, crenate or pinnatifid pinnules; upper surface pale-green, the lower densely matted with linear, ciliate, bright ferruginous scales, beneath which it is subfarinose; sori black. Huachuca Mts., Arizona (*Lemmon*), Texas (*Drummond*), Mexico.

§ 2. CINCINALIS Desv. *Fronds farinose, with white or yellow powder* (*in one species naked*).

* *Fronds farinose below.*

† *Fronds deltoid or pentagonal, barely bipinnate.*

6. **N. candida** (M. et G.) Hook. Rootstock creeping, with rigid, nearly black scales; stipes tufted 3′—6′ long, wiry, black and shining; fronds rather shorter than stipe, deltoid-ovate, pinnate; lowest pinnæ with the lowest inferior pinnules elongate and again pinnatifid, the three or four succeeding pairs lanceolate, pinnatifid into oblong segments, the uppermost pinnæ like the segments of the lower; upper surface green; lower surface whitish farinose; margin slightly revolute. (*N. sulphurea* J. Sm., *N. pulveracea* Kunze.) Southwestern Texas (*Reverchon*); New Mexico (*Wright*).

7. **N. cretacea** Liebm. Rootstock short, oblique, the scales rigid, lanceolate, with a narrow membranous margin; stipes 2′—7′ long, brownish, wiry, scaly when young; fronds 1′—2′ long, broadly deltoid-ovate to pentagonal, tri—quadripinnatifid at base, gradually simpler above; ultimate segments oblong or triangular-oblong, numerous, crowded; upper surface more or less covered with deciduous glands; lower surface copiously farinose with yellow or whitish powder except on the prominent dark-brown rachises; margins more or less recurved, not covering the sporangia; spores globose, black. (*N. Californica* D. C. Eaton.) San Diego County, California (*Cleveland, Parish*); Arizona (*Parry, Lemmon*).

8. **N. Hookeri** D. C. Eaton. Rootstock short, densely covered with rigid lanceolate dark-brown scales; stipes tufted, 4′—8′ long, reddish-brown, wiry, shining; fronds 2′—3′ each way, nearly pentagonal, composed of three divisions; the mid-

dle one slightly stalked, pinnatifid into a few toothed segments, the second pair larger than the first; side divisions bearing a single large pinnatifid basal segment on the lower side, and above it smaller ones like those of the upper side; lower surface covered with pale, yellow powder. Texas to Arizona.

†† *Fronds lanceolate or linear-oblong, bipinnate or tripinnatifid.*

9. **N. Grayi** Dav. Stipes tufted, 1′—4′ long, chestnut-brown, with nearly black, rigid scales below, paler deciduous scales above; fronds 2′—6′ long, ¾′—1¼′ wide, the upper surface sparingly, the lower thickly, covered with white powder; pinnæ short-stalked, unequally triangular-ovate, deeply pinnatifid or divided into one or two pairs of oblong pinnatifid, obtuse pinnules, the remaining portion obliquely pinnatifid with alternate segments; sori brown. Southeastern Arizona to Texas.

10. **N. Schaffneri** (Fourn.) Unde. Rootstock short, stout, with black pectinate scales; stipes 1′—2′ long, brownish-black, with narrow, rigid scales; fronds lanceolate, 5′—8′ long, bi—tripinnatifid, the pinnules numerous, narrow, with narrow dark scales underneath; sori continuous, brown or black. (*N. Nealleyi* Seaton, *Aleuritopteris Schaffneri* Fourn.) Western Texas (*Nealley*).

11. **N. Lemmoni** D. C. Eaton. Rootstock short, scaly, with narrow, rigid, dark-brown chaff; stalks reddish-brown, 4′—6′ long, chaffy only at base with wider scarious-margined scales; fronds 6′—9′ long, 1′—1½′ wide, with numerous deltoid or ovate pinnæ, the lowest a little shorter than the middle ones; upper surface smooth, the lower with white or yellowish powder; sori in a narrow submarginal line. Arizona.

††† *Fronds deltoid-ovate, tri—quadripinnate at base.*

12. **N. nivea** Desv. Rootstock short, chaffy, with narrow scales; stipes tufted, 4′—6′ long, wiry, black and polished;

fronds 3′—6′ long, 1½′—2′ broad, ovate, lanceolate, triangular-ovate or deltoid, tripinnate; primary pinnæ mostly opposite, the rachises nearly straight; pinnules long-stalked; segments roundish, nearly as broad as long, terminal ones larger, entire or 3-lobed; upper surfaces green, smooth, lower densely coated with pure white powder; sori brown, often descending the free veins half-way to the midvein. Arizona, New Mexico.

13. **N. dealbata** (Pursh) Kunze. Segments more numerous, longer than broad, terminal ones rarely lobed; pinnæ commonly opposite; frond deltoid. (*Cheilanthes dealbata* Pursh.) Upper Missouri to New Mexico and Arizona.

14. **N. Fendleri** Kunze. Stipes densely tufted, dark-brown, 3′—5′ long; rachis and all its branches zigzag and flexuous; fronds broadly deltoid-ovate, 3′—5′ each way, quadripinnate below, gradually simpler above; pinnæ alternate; ultimate pinnules oval or elliptical, simple or 3-lobed. Colorado, New Mexico, Arizona.

** *Fronds naked below.*

15. **N. tenera** Gillies. Stipes tufted, brownish, smooth and shining; fronds 3′—4′ long, ovate-pyramidal, bi—tripinnate; pinnæ mostly opposite, distant, the lower ones somewhat triangular; ultimate pinnules ovate, often sub-cordate, obtuse, smooth, and naked on both surfaces; possibly only a form of *N. nivea*. Southern Utah, California.

VIII. CHEILOGRAMMA Blume.

Sori linear, but the line sometimes interrupted, central or submarginal. Veins reticulate. Name from Gr. χεῖλος, lip, and γράμμα, a line. Contains a single species.

1. **C. lanceolata** (L.) Blume. Rootstock creeping; stipes 1′—2′ long; fronds simple, 6′—13′ long, ½′—¾′ broad, tapering both ways, the edge entire or sometimes crisped, midrib prominent; veins immersed, the exterior free and clubbed at their apices; sori ante-marginal, in a continuous line near the apex. (*Pteris lanceolata* L., *Tœnitis lanceolata* R. Br., *Neurodium lanceolatum* Fee.) Old Rhodes Key, Florida (*Curtiss*).

IX. VITTARIA Sm. GRASS-FERN.

Sori linear, continuous, in two-lipped marginal grooves or in slightly intramarginal lines, with the unaltered edge of the frond produced beyond and often rolled over them, but without special indusia. Fronds narrow, grass-like. Veins free. Name from Lat. *vitta*, a fillet or head-band. A tropical genus containing 13 species.

§ TÆNIOPSIS J. Sm.

1. **V. lineata** (L.) Sm. Fronds 6′—18′ long, 1″—5″ broad, narrowed gradually downward to a stout compressed stem, the edge often reflexed; sori in a broad intramarginal line in a slight furrow, the edge of the frond at first wrapped over it. (*V. angustifrons* Michx.) Florida.

X. ADIANTUM L. MAIDENHAIR.

Sori marginal, short, covered by a reflexed portion of the more or less altered margin of the frond, which bears the sporangia on its under side from the approximated tips of free, forking veins. Name from Gr. α, without, and διαίνω, to wet, alluding to the smooth foliage. Includes over 80 species, mostly from Tropical America.

§ EUADIANTUM.

* *Fronds at least bipinnate, pinnules flabellate or cuneate.*

† *Fronds smooth.*

1. **A. capillus-veneris** L. (VENUS' HAIR.) Stipes nearly black, polished, very slender; fronds ovate-lanceolate, delicate, bipinnate, the upper half or third simply pinnate; pinnules and upper pinnæ wedge-obovate or rhomboid, rather long-stalked, the upper margin rounded and more or less incised, crenate, or acutely dentato-serrate, except where the margin is recurved to form the lunulate separated indusia. Virginia, Kentucky, and Florida to Utah and California.

2. **A. tenerum** Swz. Stipes 1° high, erect, glossy; fronds 1°—3° long, 9′—18′ broad, deltoid, tri—quadripinnate; pinnules articulated to their petioles, falling off at maturity, cuneate, the upper edge rounded or somewhat angular, broadly, often rather deeply lobed; sori numerous, roundish, or transversely oblong. Florida.

3. A. **Jordani** C. Muell. Stipes rather stout, nearly black, polished; fronds ovate or deltoid-pyramidal, bi—tripinnate; pinnules and upper pinnæ ample, smooth, or nearly so, rounded or even reniform, upper margin rounded, slightly incised; sori 2—5, transversely linear-oblong, subcontinuous. (*A. emarginatum* of former edition not Hook.)

†† *Fronds pilose, with whitish hairs.*

4. **A. tricholepis** Fee. Stipes smooth, polished, deep black; fronds oval; pinnules roundish, moderately long-stalked; sori few (3—7), of unequal size; indusia very velvety. (*A. dilatatum* Nutt.) Western Texas.

** *Fronds dichotomously forked, with numerous pinnæ springing from the upper side of the two branches.*

5. **A. pedatum** L. Stipes 9′—15′ long, dark chestnut-brown, glabrous; fronds nearly circular in outline; central pinnæ 6′—9′ long, 1′—2′ broad; pinnules triangular-oblong, short-stalked; sori roundish or transversely oblong. North Carolina to California and northward.

Var. **rangiferinum** Burgess. Pinnules longer-stalked and deeply cleft into narrow-toothed lobes on the upper side. Mount Findlayson, British Columbia.

XI. PTERIS L. Brake.

Sori marginal, linear, continuous, occupying a slender filiform receptacle which connects the tips of the free veins. Indusium membranous, formed of the reflexed margin of the frond. Name from Gr. πτέρις, a fern, from πτερόν, a wing, alluding to the prevalence of pinnate fronds. A cosmopolitan genus containing sixty or more species as now limited.

* *Lower pinnæ linear, undivided.*

1. **P. longifolia** L. Stipes 6′—12′ long, clothed more or less below with pale-brown scales; fronds 1°—2° long, 4′—9′ broad, oblong-lanceolate; pinnæ sessile, 2″—5″ broad, linear, entire; veins close and fine, usually once branched; indusium yellowish brown. Florida.

** *Lower pinnæ forked or slightly pinnate below.*

2. **P. Cretica** L. Stipes 6′—12′ long, erect, stramineous or pale-brown; fronds 6′—12′ long, 4′—8′ broad, lateral pinnæ

usually in 2—6 opposite sessile pairs, the sterile ones considerably the broadest and spinulose-serrate, the lower pairs often cleft nearly to the base, into two or three linear pinnules; veins fine, parallel, simple or once forked; indusium pale. Florida.

3. **P. serrulata** Linn. f. Stipes 6′—9′ long, naked, pale or brownish; fronds 9′—18′ long, 6′—9′ broad, ovate, bipinnatifid, the main rachis margined with a wing which is 1″—2″ broad at the top and grows narrower downwards; pinnæ in six or more distinct opposite pairs, upper ones simple, the lower ones with several long linear pinnules on each side, the edge of the barren ones spinulose-serrate; veins simple or once forked. Alabama (*Mohr*), Macon, Georgia, (*Farnell*). An escape from cultivation.

XII. PTERIDIUM Scopoli.

Sori marginal, linear, continuous, occupying a slender filiform receptacle which connects the tips of the free veins. Indusium double; the outer formed of the incurved membranous margin of the frond, as in *Pteris*, and the inner attached within the receptacle and extending beneath the young sporangia. Veins free. Name from Gr. πτέρις, a fern. Two or more species.

1. **P. aquilinum** (L.) Kuhn. Rootstock stout, wide-creeping, subterranean; stipes 1°—2° high, erect, stramineous or brownish; fronds 2°—4° long, 1°—3° wide, ternate, the three branches each bipinnate; upper pinnules undivided, the lower more or less pinnatifid. North America everywhere.

Var. **caudatum** (L.) Kuhn. Pinnules sometimes linear and entire, or with less crowded segments than the type and the terminal lobe linear and entire. (*P. caudata* L.) Florida and Texas. Probably a distinct species.

Var. **pubescens** Underw. Fronds silky-pubescent, tomentose, especially on the under surface; otherwise as in the typical form. (*P. aquilina*, var. *lanuginosa* of former editions, not *P. lanuginosa* Bory.) Utah, California, and northward.

XIII. CHEILANTHES Swz. Lip-fern.

Sori terminal or nearly so on the veins, at first small and roundish, afterwards more or less confluent. Indusium formed of the reflexed margin of the frond, roundish and distinct, or more or less confluent. Veins free. Name from Gr. χεῖλος, a

lip, and ἄνθος, flower, alluding to the lip-like indusia. A genus of 65 species of tropical and temperate zones.

§ 1. ADIANTOPSIS Fee. *Indusia distinct, roundish, confined to the apex of a single veinlet.*

1. **C. Californica** (Nutt.) Mett. Rootstock short, creeping, chaffy; stipes densely tufted, dark-brown, glossy, 4′—8′ long; fronds 4′ or less each way, broadly deltoid-ovate, smooth on both surfaces, quadripinnatifid; lower pinnæ largest, triangular; upper ones gradually smaller and simpler; ultimate segments lanceolate, acute, incised or serrate; indusia membranous. (*Aspidotis Californica* Nutt., *Hypolepis Californica* Hook.) California. *C. Amœna* A. A. Eaton is scarcely distinct.

2. **C. Pringlei** Dav. Rootstock slender, creeping, clothed with linear-lanceolate scales; stipes 1½′—4½′ long, reddish or chestnut brown, scaly at base and sparingly above; fronds 1′—2½′ long, nearly as broad, triangular or ovate-deltoid, bi—tripinnately divided into 5—7 pairs of pinnæ, opposite and spreading in the smaller sterile fronds, alternate and erecto-patent in the larger fertile fronds, naked, dark-green; pinnæ ⅝′—1⅛′ long, the lower unequally deltoid or ovate, bipinnate, the uppermost oblong, pinnate or deeply pinnatifid; pinnules ovate or oblong, pinnately divided or cleft into oblique segments, which are again deeply cleft into cuneate, strap-shaped divisions, those of the largest segments again deeply cut into narrow, obtuse, cuneate lobes, the recurved tips in fertile fronds forming distinct herbaceous involucres with entire or slightly crenulate margins; sori one to each ultimate lobe on the apex of a free veinlet. South-eastern Arizona (*Pringle*).

§ 2. EUCHEILANTHES. *Indusia more or less confluent, usually extending over the apices of several veinlets, but not continuous all round the segments; segments mostly flat, not bead-like.*

* *Segments of the frond smooth.*

† *Pinnæ few, not more than 5—6 pairs.*

3. **C. Wrightii** Hook. Stipes castaneous, slightly chaffy at base, 1′—2′ long; fronds 2′—3′ long, ovate-oblong, tripinnatifid, segments more or less incised; indusium sub-continuous or interrupted, similar to frond in texture. Western Texas to Arizona.

†† *Pinnæ numerous.*

4. **C. microphylla** Swz. Rootstock short, creeping; stipes dark-brown, glossy, rusty pubescent on the upper side, 4′—6′ long; fronds 4′—10′ long, ovate-lanceolate, bi—tripinnate; pinnæ lanceolate, the lowest ones usually largest and more deltoid; pinnules oblong or deltoid-ovate, deeply incised or pinnate; indusium similar in texture to frond, interrupted or subcontinuous. Florida, New Mexico.

5. **C. Alabamensis** (Buckl.) Kunze. Rootstock creeping, with slender brown scales; stipes black with scanty ferruginous wool; fronds 2′—10′ long, narrowly lanceolate, bipinnate; pinnæ close, ovate-lanceolate, the lowest ones not enlarged, usually smaller than those above; pinnules mostly acute, often auriculate on the upper side at the base; indusia pale, membranous, interrupted only by the incising of the pinnules. (*Pellæa Alabamensis* Baker, *Pteris Alabamensis* Buckley.) Virginia, Alabama, Tennessee to Texas and Arizona (*Lemmon*).

** *Segments of the frond glandular viscid.*

6. **C. viscida** Dav. Stipes 3′—5′ long, wiry, blackish, chaffy at the base with narrow ferruginous scales; fronds 3′—5′ long, ½′—1′ broad, narrowly oblong, pinnate, with 4—6 distant pairs of nearly sessile, deltoid, bipinnatifid pinnæ; segments toothed, minutely glandular and everywhere viscid; teeth of segment recurved, forming indusia. California.

*** *Fronds somewhat hairy and glandular, not tomentose.*

† *Fronds deltoid-ovate; stipes stramineous.*

7. **C. leucopoda** Link. Stipes 3′—10′ long, stout, chaffy at base; fronds 2′—7′ long, deltoid-ovate, quadripinnate at base, gradually simpler above, everywhere glandular-puberulent; lowest pair of pinnæ unequally deltoid-ovate, upper ones oblong; pinnules short-stalked; ultimate pinnules divided into minute rounded lobules, strongly revolute when fertile. Texas.

†† *Fronds ovate-lanceolate; stipes brownish.*

8. **C. lanosa** (Michx.) Watt. Stipes tufted, 2′—4′ long, chestnut-brown; fronds 4′—9′ long, 1′—2′ broad, tripinnatifid; pinnæ somewhat distant, lanceolate-deltoid; segments more or less thickly covered with acute hairs; sori copious; indusia formed of the ends of roundish or oblong lobes. (*Nephrodium lanosum* Michx. *C. vestita* Swz.) New York to Kansas and Georgia.

9. **C. Cooperæ** D. C. Eaton. Stipes densely tufted, fragile,

hairy with straightish nearly white articulated hairs, which are usually tipped with a glandular and viscid enlargement; fronds 3′—8′ long, bipinnate, the pinnæ rather distant, oblong-ovate; pinnules roundish-ovate, crenate and incised, the ends of the lobules forming herbaceous indusia. California.

§ 3. PHYSAPTERIS Presl. *Ultimate segments minute, bead-like; indusium usually continuous all round the margin; fronds (in our species) bi—quadripinnate, the lower surface scaly or tomentose or both.*

* *Fronds hairy or tomentose beneath, not scaly.*

† *Upper surface naked or nearly so.*

10. **C. gracillima** D. C. Eaton. (LACE-FERN.) Stipes densely tufted, 2′—6′ long, dark-brown; fronds 1′—4′ long, narrowly ovate-lanceolate, bipinnate; pinnæ numerous, crowded, pinnately divided into about nine oblong-oval pinnules, at first slightly webby above, soon smooth, heavily covered beneath with pale-ferruginous matted wool; indusia yellowish-brown, formed of the continuously curved margin. (*C. vestita* Brack.) California, Oregon, British Columbia, Idaho.

11. **C. lendigera** (Cav.) Swz. Rootstock creeping, covered with narrow scales; stipes rather distant, 4′—8′ long, at first loosely tomentose, at length nearly smooth; fronds 4′—8′ long, ovate-oblong, tri—quadripinnate; ultimate pinnules small, cuneate-obovate, pouch-like from the recurved margins, green above, hairy below. Huachuca Mts., Arizona (*Lemmon*).

†† *Upper surface decidedly pubescent.*

‡ *Stipes tomentose or smooth.*

12. **C. Feei** Moore. Stipes densely tufted, slender, at first clothed with woolly hairs, at length nearly smooth; fronds 2′—4′ long, ovate-lanceolate, tripinnate or tripinnatifid, rarely bipinnate; pinnæ deltoid below, oblong-ovate above, the lowest distant; ultimate pinnules minute, the terminal one slightly largest, crowded; upper surface scantily tomentose, the lower densely matted with whitish-brown, woolly hairs; indusia narrow, formed of the unchanged margin. (*C. lanosa* Eaton, *C. gracilis* Mett., *C. lanuginosa* Nutt, *Myriopteris gracilis* Fee.) Illinois to Texas, Arizona, and British America.

13. **C. tomentosa** Link. Stipes tufted, 4′—6′ long, rather

stout, covered with pale-brown tomentum; fronds 8′—15′ long, oblong-lanceolate, everywhere but especially beneath tomentose with slender, brownish-white, obscurely articulated hairs, tripinnate; pinnæ and pinnules ovate-oblong; ultimate pinnules ½″—¾″ long, the terminal ones twice as large; indusium pale, membranous, continuous. (*C. Bradburii* Hook.) Virginia to Missouri, Texas, and Arizona.

‡‡ *Stipe and rachises covered with very narrow scales.*

14. **C. Eatoni** Baker. Differs from the last in having the stipes and rachises covered with very narrow scales and by the matted tomentum of the upper surface. Arizona.

15. **C. fibrillosa** Dav. Plant 3′—6′ high; rootstock forming dense, entangled clumps of short rhizomes, clothed with dark linear-lanceolate scales, passing gradually into lighter-brown scales, mixed with coarse fibres and tomentum at the base of the stipes; stipes 2′—3′ long, chestnut-brown, terete, at first tomentose with fibrous scales and wool, becoming smooth with age; fronds 2′—3′ long, ¾′—1½′ wide, tripinnate, loosely covered with deciduous tomentum, that along the rachises beneath persistent, tawny, mixed with coarse fibres. (*C. lanuginosa*, var. *fibrillosa* Dav.) San Jacinto Mountains, California (*Parish*).

16. **C. Parishii** Dav. Rootstock creeping, short, clothed with deep-brown linear-lanceolate scales, with darker nearly black mid-nerves; stipes 2′—3′ long, approximate, light to dark-brown, clothed at base with scales similar to those on the rootstock, passing gradually into broader pale-brown or nearly white nerveless scales, with more or less deciduous, slender, pale scales and chaff above; fronds 3′—4′ long, 1′—1¼′ broad, oblong-lanceolate, tri—quadripinnate, with both surfaces scantily clothed with a coarse tomentum; pinnæ alternate, oblong-ovate, obtuse, the lowermost somewhat distant; segments roundish, the terminal ones largest and three-lobed; indusia very narrow, only partially enclosing the sori. San Diego Co., California (*Parish*).

** *Fronds covered beneath with imbricated scales, not tomentose.*

17. **C. Fendleri** Hook. Stipes 2′—5′ long, chaffy with minute slender scales; fronds 3′—4′ long, ovate-lanceolate, tripinnate; scales of primary rachis like those of stipe, those of

secondary and ultimate rachises larger, broadly-ovate, entire or nearly so, usually edged with white, imbricate and overlapping the (¼″—⅛″ broad) sub-globose ultimate segments; these are naked above, and commonly bear at their centre a single broad scale; indusium formed of the much incurved margin. Texas and Colorado to California.

18. **C. Clevelandii** D. C. Eaton. Stipes scattered, 2′—6′ long, dark-brown, scaly when young, but at length nearly smooth; fronds 4′—6′ long, ovate-lanceolate, tripinnate, smooth above, deep fulvous-brown below from the dense covering of closely imbricate, ciliate scales growing on the ultimate segments as well as on the rachises; segments nearly round, ⅛″—½″ broad, the terminal ones larger, margin narrowly incurved. California.

**** Under surface both tomentose and scaly.*

19. **C. myriophylla** Desv. Rootstock very short, scaly; stipes tufted, 2′—6′ high, castaneous, covered with pale-brown scales and woolly hairs intermixed; fronds 3′—8′ long, oblong-lanceolate, tri—quadripinnatifid, smooth or pilose above, beneath matted-tomentose and densely clothed with pale-brown, narrowly ovate-lanceolate, ciliate scales, those of the ultimate segments with long, tortuous cilia; pinnæ deltoid-ovate, narrower upwards; ultimate segments minute, ½″ broad, crowded, innumerable, the margin unchanged, much incurved. Very variable. (*C. elegans* Desv., *C. villosa* Dav.) Texas to Arizona.

20. **C. Lindheimeri** Hook. Rootstock long, slender, chaffy; stipes scattered, 4′—7′ high, blackish-brown, at first covered with scales and woolly hairs; fronds 3′—8′ long, ovate-lanceolate, tri—quadripinnate; ultimate segments ¼″ long, crowded; upper surface white tomentose, lower surface very chaffy, those of the midribs ciliate at base, those of the segments more and more ciliate, passing into entangled tomentum. Western Texas to Arizona.

§ 4. ALEURITOPTERIS Fee. *Indusia more or less confluent; fronds farinose below.*

21. **C. argentea** (Gmel.) Kunze. Stipes tufted, 3′—6′ long, castaneous; fronds 3′—4′ long, 2′ broad, deltoid, bi—tripinnatifid; lower pinnæ much the largest, cut nearly to the rachis; rachis polished like the stipe; upper surface naked, lower thick-

ly covered with white powder; sori numerous, very small. Alaska.

XIV. CRYPTOGRAMMA R. Br. Rock-brake.

Sporangia on the back or near the ends of the free veins, forming oblong or roundish sori, which are at length confluent, and cover the back of the pinnules. Indusium continuous, formed of the membranous, somewhat altered margin of the pinnule, at first reflexed along the two sides and meeting at the midrib, at length opening out flat. Name from Gr. κρυπτός, concealed, and γράμμα, line, alluding to the concealed fructification. A boreal genus of three species.

1. **C. acrostichoides** R. Br. Stipes densely tufted, stramineous; fronds dimorphous, sterile ones on shorter stalks, tri—quadripinnatifid, with toothed or incised segments; fertile ones long-stalked, less compound, with narrowly elliptical or oblong-linear pod-like segments. (*C. crispa, forma Americana* Hook., *Allosorus acrostichoides* Spreng.) Lake Superior, Colorado to California and northward.

2. **C. Stelleri** (Gm.) Prantl. Stipes scattered, 2′—3′ long, stramineous or pale-brown; fronds 2′—4′ long, 1′—2′ broad, ovate, bi—tripinnatifid; pinnæ lanceolate-deltoid, cut to the rachis into a few broad, blunt, slightly lobed pinnules; texture thinly herbaceous, flaccid; indusium broad, continuous, membranous; veins of the fertile fronds mostly only once forked. (*Pellæa gracilis* Beddome and former edition, *A. gracilis* Presl, *Pteris gracilis* Michx., *P. Stelleri* Gmelin.) Labrador to Pennsylvania, Illinois, Colorado, and northward.

XV. PELLÆA Link. Cliff-brake.

Sori intramarginal, terminal on the veins, at first dot-like or decurrent on the veins, at length confluent laterally, forming a marginal line. Indusium commonly broad and membranous, formed of the reflexed margin of the fertile segment. Name from Gr. πελλός, dusky, alluding to the dark-colored stipes. Includes 55 species.

§ 1. Cheiloplecton Fee, Baker. *Texture herbaceous or subcoriaceous, veins clearly visible, indusium broad, in most of the species rolled over the sorus till maturity.*

1. **P. Breweri** D. C. Eaton. Stipes densely tufted, covered with narrow, crisped, fulvous chaff; fronds 2′—6′ long, simply pinnate, the pinnæ short-stalked, 6—8 pairs, membranous, mostly 2-parted, the upper segment larger; segments obtuse, in the fertile frond narrower; indusium continuous, pale; veins repeatedly forked. Colorado to California and southward.

2. **P. occidentalis** (A. Nelson) Rydberg. Rootstock short and thick, densely covered with rusty hair-like scales; stipes cespitose, ½′—1½′ long, dark brown, glabrous, shining, very slender; fronds 1½′—3½′ long, oblong, simply pinnate; pinnæ 2—5 pairs, oblong, mostly obtuse, dark green, shining, firm and somewhat coriaceous, entire or the lower ones with one or two lobes at the base; indusium broad, wholly covering the sori. (*Pellæa pumila* Rydberg, *P. atropurpurea occidentalis* A. Nelson.) South Dakota to Montana and Washington.

§ 2. ALLOSORUS Baker. *Texture coriaceous, the veins not perceptible; indusium broad, conspicuous.*

* *Pinnules or segments obtuse or barely acute.*

† *Fronds pinnate or bipinnate.*

3. **P. atropurpurea** (L.) Link. Stipes tufted, 2′—6′ long, dark-purple; fronds 4′—12′ long, 2′—6′ broad, lanceolate or ovate-lanceolate, simply pinnate or bipinnate below; pinnules and upper pinnæ 1′—2′ long, ¼′ broad or less, nearly sessile, smooth; indusium formed of the slightly altered incurved edge of the pinnules. (*Allosorus atropurpureus* Kunze, *Pteris atropurpurea* L., *Platyloma atropurpurea* J. Sm.) Arizona, New Mexico, Texas to Vermont and northward.

4. **P. aspera** (Hook.) Baker. Stipes slender, 2′—3′ long, with scurfy pubescence, fronds 4′—6′ long, oblong-lanceolate, bipinnate; pinnæ and pinnules deltoid-lanceolate or oblong, pinnules next to main rachis often lobed; all of them rough on both surfaces with short harsh hairs. (*Cheilanthes aspera* Hook.) Western Texas and New Mexico.

†† *Fronds bi—quadripinnate, ultimate segments oval or cordate.*

5. **P. andromedæfolia** (Kaulf.) Fee. Stipes scattered, pale-brown, 2′—12′ long; fronds 6′—12′ long, 3′—6′ broad, ovate, bi—quadripinnate, usually tripinnate; pinnæ rather distant, spreading; ultimate pinnules 2″—5″ long, oval, slightly cordate,

coriaceous, the margin of the fertile ones sometimes revolute to the midrib; veins numerous, parallel. (*Allosorus andromedæfolius* Kaulf., *Pteris andromedæfolia* Kaulf.) California.

6. **P. pulchella** (M. et G.) Fee. Stipes tufted, 3′—8′ long, chaffy at base, nearly black; fronds 3′—9′ long, 1′—5′ broad, triangular-ovate, quadripinnate below, gradually simpler above; lower pinnæ deltoid, narrowly triangular above; ultimate pinnules numerous, 1″—3″ long, oval or often cordate-ovate, stalked, coriaceous, smooth, the edges often much reflexed. (*Allosorus pulchellus* Mart. and Gale.) Western Texas and New Mexico.

††† *Fronds tri—quadripinnatifid; segments linear-oblong; secondary rachises margined.*

7. **P. marginata** (Hook.) Baker. Stipes, 3′—9′ long, castaneous, shining, slightly fibrillose at the base; fronds 4′—6′ long, nearly as broad, deltoid; the lower pinnæ much the largest; indusium broad, continuous, the margins slightly erose; texture chartaceous. (*Cheilanthes marginata* Hook.) Huachuca Mts., Arizona (*Lemmon*).

** *Pinnules mucronulate or decidedly acute.*

† *Fronds narrowly linear in outline, usually bipinnate.*

8. **P. ternifolia** (Cav.) Link. Stipes tufted, nearly black, 2′—6′ long, fronds 4′—10′ long, narrowly linear; pinnæ usually 9—15 pairs, all but the uppermost trifoliate; segments commonly linear, slightly mucronate, coriaceous, sessile or the middle one indistinctly stalked, the edges much inflexed in fertile fronds; indusium broad. (*Pteris ternifolia* Cav.) Western Texas.

9. **P. brachyptera** (Moore) Baker. Stipes 2′—8′ long, purplish-brown; fronds 3′—8′ long, narrow in outline from the ascending secondary rachises, bipinnate; pinnules crowded, 2″—5″ long, oblong-linear, simple or trifoliate, acute or mucronulate; margins inflexed to the midrib in fertile fronds. (*P. ornithopus, var. brachyptera* D. C. Eaton, *Platyloma bellum et P. brachypterum* Moore.) California.

†† *Fronds broader, lanceolate to ovate, bi—tripinnate.*

10. **P. ornithopus** Hook. Stipes tufted, 3′—8′ long, rather stout, dark-brown; fronds very rigid, 3′—12′ long, 2′—3′ broad, broadly deltoid-lanceolate, bi—tripinnate; primary pinnæ spreading or obliquely ascending, linear, bearing 4—16 pairs of trifoliate (varying from simple to 5—7 foliate) mucronulate pinnules, 1⅓″—2″ long; margins inflexed to midrib in fertile fronds. (*Allosorus mucronatus* D. C. Eaton.) California.

11. **P. Wrightiana** Hook. Rootstock short, thick, densely chaffy; stipes crowded, purplish-brown, 4′—6′ long; fronds 3′—10′ long, 1′—3′ broad, lanceolate to deltoid, trifoliate at apex, bipinnate below; pinnæ short with 1—2 pairs of long narrow pinnules besides the terminal one; mucro short, with margin broad and cartilaginous; margins of fertile fronds inflexed to the midrib. Very variable; forms with fronds decreasing to simply pinnate at the apex, and longer but less broadly winged mucro form *var. longimucronata* Dav. (*P. longimucronata* Hook.); forms with pinnules densely crowded are var. *compacta* Dav. Colorado and Texas to California.

12. **P. densa** (Brack.) Hook. Rootstock slender, chaffy with blackish scales; stipes densely tufted, wiry, very slender, castaneous, 3′—9′ long; fronds ovate or triangular-oblong, 1′—3′ long, densely tripinnate; segments 3″—6″ long, linear, nearly sessile, sharp pointed or mucronate, in the fertile fronds entire, with the margin narrowly recurved; in the rare sterile fronds sharply serrate, especially toward the apices. (*Onychium densum* Brack.) Utah (*Jones*), and Wyoming to California, Oregon, and northward; Mt. Albert, Gaspé, Quebec (*Allen*).

§ 3. PLATYLOMA J. Sm., Baker. *Texture coriaceous, the veins usually hidden, the ultimate segments broad and flat, the indusium so narrow as to be soon hidden by the fruit.*

13. **P. Bridgesii** Hook. Stipes 2′—6′ long, tufted, castaneous; fronds 4′—6′ long, 1′ or more broad, simply pinnate; pinnæ 5—18 pairs, mainly opposite, nearly sessile, glaucous green, coriaceous, rounded or cordate at the base; indusium narrow, formed of the whitish margin of the pinna, soon flattened out exposing the broad sorus. California.

14. **P. flexuosa** (Kaulf.) Link. Rootstock creeping, slender; stipes reddish, passing into a more or less flexuous or zigzag

rachis; fronds 6′—30′ long, ovate-oblong, bi—tripinnate; secondary and tertiary rachises usually deflected and zigzag, rusty puberulent or nearly smooth; pinnæ mostly alternate; ultimate pinnules 5″—10″ long, roundish-ovate, or sub-cordate, smooth; margins at first reflexed, soon flattened out. (*Allosorus flexuosus* Kaulf.) Western Texas to California.

15. **P. intermedia** Mett. Rootstock long, wide creeping, slender, chaffy; stipes scattered, 4′—6′ long, pinkish-stramineous, smooth; fronds 5′—10′ long, 3′—8′ wide, ovate-bipinnate; pinnæ nearly opposite, remote; pinnules 2—6 pairs, petiolate, sub-coriaceous, oval or cordate-ovate; veins obscure; rachises often pubescent. Huachuca Mountains, South Arizona (*Lemmon*), Texas (*Nealley*).

XVI. STRUTHIOPTERIS Scopoli.

Sori in a continuous band next the midrib of the contracted pinnæ of the fertile frond, covered till mature by an elongate indusium, either formed of the recurved and altered margin of the pinna or submarginal and parallel to the margin. Veins of sterile frond oblique to the midrib, simple or forked and free. Fronds mostly elongate, of two kinds, the sterile foliaceous, the fertile commonly much contracted. Name from Gr. *στρουθίων*, an ostrich, and *πτερίς*, fern. Genus principally of south temperate zone.

1. **S. spicant** (L.) Scop. (DEER-FERN.) Rootstock short, very chaffy; fronds tufted, erect, sterile ones nearly sessile, narrowly linear-lanceolate, 8′—24′ long, 1′—3′ wide, tapering to both ends, cut to the rachis into oblong or oblong-linear closely set segments, the lower ones gradually diminishing to minute auricles; fertile fronds sometimes three feet high, long-stalked, pinnate; pinnæ somewhat fewer and more distant, longer and much narrower than in the sterile frond; indusia distinctly intramarginal. (*Osmunda spicant* L., *Blechnum boreale* Swz., *Lomaria spicant* Desv.) California, Oregon, and northward.

Some of the specimens from California and Oregon have leaves three or four times as long as those found in Europe, and it is possible that we have two species instead of one.

XVII. BLECHNUM L.

Sori linear, continuous or nearly so, parallel with the midrib and usually contiguous to it. Indusium membranous, distinct from the edge of the frond. Veins usually free. Name from Gr. *βλεχνον*, an old name for some kind of fern. A tropical and south temperate genus, containing 19 species.

§ EUBLECHNUM.

1. **B. serrulatum** Richard. Stipes 6′—12′ long, stout, erect, nearly naked; fronds oblong-lanceolate, 1°—1½° long, 3′—6′ broad, with 12—24 pairs of distinct linear-oblong pinnæ, the margins finely incised; texture coriaceous; veins very fine and close; fertile pinnæ narrower. (*Blechnum angustifolium* Willd.) Florida.

XVIII. WOODWARDIA Sm. CHAIN-FERN.

Sori oblong or linear, sunk in cavities in the frond, arranged in a chain-like row parallel to the midribs of the pinnæ and pinnules and near them. Indusium sub-coriaceous, fixed by its outer margin to the fruitful veinlet and covering the cavity like a lid. Veins more or less reticulate. Named for *Thomas J. Woodward*, an English botanist. Contains six species, mostly north temperate.

§ 1. EUWOODWARDIA. *Fronds uniform, the veins forming at least one series of areolæ between the sori and margins.*

1. **W. radicans** (L.) Sm. Caudex stout, erect, rising a little above the ground; stipes stout, 8′—12′ long; fronds 3°—5° long, sub-coriaceous, pinnate; the pinnæ 8′—15′ long, 2′—4′ broad, oblique to the rachis, pinnatifid nearly to the midrib; segments spinulose-serrate; veinlets forming a single row of oblong sorus-bearing areolæ next the midvein, besides a few oblique empty areolæ outside the fruiting ones, thence free to the margin. California, Arizona.

§ 2. ANCHISTEA Presl. *Fronds uniform, the veins free between the sori and the margins.*

2. **W. Virginica** (L.) Sm. Stipes stout, 12′—18′ long; fronds oblong-lanceolate, 12′—18′ long, 6′—9′ broad; pinnæ linear-lanceolate, 4′—6′ long, ¾′—1′ broad, cut nearly to the rachis into linear-oblong lobes. (*W. Banisteriana* Michx., *Blechnum*

Carolinianum Walt., *B. Virginicum* L., *Doodia Virginica* Presl.) Canada and Florida westward to Michigan and Arkansas.

§ 3. LORINSERIA Presl. *Fronds dimorphous, veins everywhere forming areolæ.*

3. **W. areolata** (L.) Moore. Sterile frond with slender stipes, 9′—12′ long, 6′—8′ broad, deltoid-ovate, with numerous oblong-lanceolate sinuate pinnæ; rachis broadly winged; fertile frond with an elongate, castaneous stem; pinnæ 3′—4′ long, narrowly linear. (*W. onocleoides* Willd., *W. angustifolia* Sm., *Acrostichum areolatum* L.) Maine to Florida, Michigan, Arkansas.

XIX. ASPLENIUM L. SPLEENWORT.

Sori oblong or linear, oblique, separate; indusium straight or rarely curved, opening toward the midrib when single, sometimes double. Veins free in all our species. Name from Gr. α, without, and σπλήν, spleen. A cosmopolitan genus containing nearly 350 species.

§ 1. EUASPLENIUM. *Veins free, simple or branched; indusium straight or slightly curved, attached to the upper side of a vein.*

* *Fronds simple.*

1. **A. serratum** L. Fronds growing in a crown from a short, stout, erect rootstock, 1½°—2½° long, 2′—4′ broad, simple, spatulate or linear-oblanceolate, the margin crenulate or irregularly but finely serrate, sub-coriaceous; midrib prominent, keeled and often blackish purple beneath; veins closely placed, free, once forked; sori elongate, following the veins of the upper half of the frond from near the midrib half-way to the margin; indusia single, the free edge entire. Florida.

** *Fronds pinnatifid or pinnate below, tapering to a point.*

2. **A. pinnatifidum** Nutt. Stipes tufted, 2′—4′ long; fronds 3′—6′ long, 1′—1½′ broad, lanceolate, pinnatifid, or pinnate below, tapering to a slender prolongation above; lobes roundish-ovate, or the lowest pair acuminate; sori numerous. Pennsylvania to Illinois, Kentucky, and Alabama.

3. **A. ebenoides** R. R. Scott. Fronds 4′—9′ long, broadly lanceolate, pinnatifid, pinnate below; apex prolonged and slender; divisions lanceolate from a broad base, the lower ones

shorter; stipes black and polished, as is the lower part of the midrib, especially beneath. Schuylkill River, above Manayunk, Pennsylvania (*Scott*); Havana, Alabama (*Miss Tutwiler*); Canaan, Connecticut (*Adam*); near Poughkeepsie, New York (*Lown*), Jackson County, Illinois (*Patterson*).

**** Fronds once pinnate.*

† *Pinnæ* $\frac{1}{4}'$—$\frac{3}{4}'$ *long, mostly blunt.*

‡ *Rachis chestnut-brown or blackish.*

4. **A. platyneuron** (L.) Oakes. Stipes 3′—6′ long, chestnut-brown, nearly naked; fronds 8′—16′ long, linear-lanceolate; pinnæ 20—40, lanceolate, subfalcate, or the lower oblong, $\frac{1}{4}'$—1 long, the dilated base auricled on the upper or both sides; sori often 10—12 on each side. (*A. ebeneum* Ait., *Polypodium platyneuron* L.) Florida and Kentucky northward to Canada.

5. **A. parvulum** Mart. & Gale. Fronds tufted, erect, rigid, 4′—10′ long, narrowly linear-lanceolate; stipe and rachis black and shining; pinnæ numerous, oblong, obtuse, entire or crenulate, auricled on the upper side, nearly sessile; middle pinnæ longest, the lower gradually shorter and deflexed; sori short. Virginia and Florida to Arkansas and New Mexico.

6. **A. trichomanes** L. Stipes densely tufted, purple-brown, shining; fronds 3′—8′ long, $\frac{1}{2}'$ or more broad, linear; pinnæ 15—30 pairs, nearly opposite, roundish-oblong or oval, the two sides unequal, obliquely wedge-truncate at the base, attached by a narrow point, the edge slightly crenate. Eastern United States to the Pacific coast.

7. **A. vespertinum** Maxon. Rhizome short; stipes purplish-brown, tufted, $\frac{1}{3}'$—$1\frac{1}{2}'$ long; fronds 3′—9′ long; pinnæ 20—30 pairs, subopposite or alternate, subsessile, oblong-linear or oblong, slightly reduced below, more or less auricled at base, the basal vein once or twice forked; margins regularly and coarsely crenate-serrate, each lobe containing a simple vein; sori short, 8—12 to each pinna; indusium crenate; spores ovoid with closely reticulated winged ridges. Southern California.

8. **A. monanthemum** L. Stipes densely tufted, 3′—6′ long, chestnut-brown; fronds 6′—12′ long, narrow, with 20—40 pinnæ on each side; pinnæ crenate above, abruptly narrowed

at base, often auricled, the lower much reduced; texture subcoriaceous; veins flabellate; sori 1—2, linear-oblong, parallel with lower edge of pinnæ. Huachuca Mountains, Arizona.

‡‡ *Rachis green.*

9. **A. viride** Huds. Stipes densely tufted, 2′—4′ long, naked, the lower part chestnut-brown; fronds 2′—6′ long, ½′ broad, with 12—20 pinnæ on each side, which are ovate or rhomboidal in outline, the upper edge narrowed suddenly at the base, the lower obliquely truncate, the outer part deeply crenate; rachis naked; sori copious. Vermont, Canada, and New Brunswick.

10. **A. dentatum** L. Stipes tufted, 2′—6′ long, naked, ebeneous below; fertile fronds 2′—3′ long, 1′ broad, with 6—8 pairs of stalked, oblong-rhomboidal pinnæ, the lower side truncate with a curve, the outer edge irregularly crenate; sterile fronds smaller on shorter stipes; rachis naked; sori copious in parallel rows. Florida, South Carolina.

†† *Pinnæ only* 2—5, *linear-cuneate.*

11. **A. septentrionale** (L.) Hoffm. Stipes dense, tufted, 3′—6′ long, slender, naked, ebeneous toward the base; fronds irregularly forking, consisting of two to five narrowly linear rather rigid segments, which are entire or more frequently cleft at the end into a few long narrow teeth; sori elongate, placed near the margin, usually facing each other in pairs, commonly only two or three to each segment. Ben Moore, New Mexico (*Bigelow*); Middle Mountains, Colorado, Arizona.

††† *Pinnæ numerous, linear or linear-oblong, acute or acuminate.*

12. **A. angustifolium** Michx. Stipes 1° or more long, brownish, slightly scaly below; fronds 1½°—2° long, 4′—6′ broad, lanceolate-oblong, flaccid; pinnæ 20—30 pairs, linear-lanceolate, acuminate, entire or crenulate, those of the fertile frond narrower; texture thinly herbaceous; sori linear, 20—40 each side of the midvein. New England to Kentucky and Wisconsin.

13. **A. firmum** Kunze. Stipes 4′—8′ long, erect, grayish, naked; fronds 6′—12′ long, 3′—4′ broad; pinnæ 12—20 pairs, oblong-lanceolate, the point bluntish, the margin inciso-crenate, the upper one narrowed suddenly at the base, the lower

one obliquely truncate; sori short, falling short of both mid-vein and margin. Florida, Arizona.

**** *Fronds bi—tripinnatifid.*

† *Texture somewhat coriaceous.*

14. **A. ruta-muraria** L. Stipes tufted, 2′—4′ long, naked; fronds ovate-deltoid, 1′—2′ long, bi—tripinnate below, simply pinnate above; the divisions rhombic-wedge-shaped, toothed or incised at the apex; veins flabellate; sori few, elongate, soon confluent. Vermont to Michigan and Kentucky.

15. **A. montanum** Willd. Stipes tufted, 2′—3′ long, naked; fronds 2′—5′ long, ovate-lanceolate, pinnate; pinnæ 3—7 parted below, incised or toothed above; veins obscure; sori short, the basal ones sometimes double. Lantern Hill, Connecticut, and Ulster County, New York, to Georgia, Kentucky, and Arkansas; Cuyahoga Falls, Ohio (*Kirby*).

16. **A. Glenniei** Baker. Stipes densely tufted, ½′—1′ long, castaneous; fronds 3′—4′ long, bipinnate; pinnæ 20—25 pairs, lanceolate, the lower gradually reduced; pinnules 5—6 pairs, toothed or externally sub-entire. Huachuca Mountains, Arizona (*Lemmon*).

17. **A. fontanum** (L.) Bernh. Stipes 1′—3′ long, slightly scaly at base; fronds 3′—6′ long, ½′—1′ wide, tapering both ways from above the middle; pinnæ 10—15 pairs, their segments deeply dentate with spinulose teeth; sori one or two to each segment. Lycoming County, Pa. (*McMinn*), Springfield, Ohio *Spence*).

†† *Texture thinly herbaceous or membranous.*

18. **A. Bradleyi** D. C. Eaton. Stipes tufted, 2′—3′ long, ebeneous, as is also the lower half of rachis; fronds 3′—7′ long, pinnatifid; pinnæ 8—12 pairs, the lowest not reduced, the largest pinnatifid with oblong lobes toothed at the tip; sori short. Ulster County, N. Y., Lancaster, Pa., Kentucky, Tennessee, and Arkansas.

19. **A. myriophyllum** Mett. Rootstock short; stipes tufted, 2′—6′ long; fronds 3′—10′ long, lanceolate, bi—tripinnate; segments entire or 2—3-lobed, bearing a single vein and sorus. Forms with fronds narrowly linear, ¾′—1′ wide, and

widely ascending, 7—8-lobed pinnæ, are var. *Biscaynianum* D. C. Eaton. Florida.

20. **A. cicutarium** Swz. Stipes tufted, 4′—8′ long, greenish, naked; fronds 6′—15′ long, 4′—6′ broad, with 10—15 horizontal pinnæ on each side, the lower ones 2′—3′ long, 1′ broad, cut down to the rachis into linear or oblong segments, which are once or twice cleft at the apex; rachis compressed and often winged; sori principally in two rows. Florida.

§ 2. ATHYRIUM Roth. *Veins free; sori more or less curved, sometimes horseshoe-shaped, often crossing to the outer or lower side of the fruiting veinlet.*

21. **A. thelypteroides** Michx. Stipes long, erect, stramineous; fronds 1°—2° long, 6′—12′ broad, bipinnatifid; pinnæ linear-lanceolate; segments crowded, oblong, minutely toothed; sori 5—6 pairs to each segment, slightly curved, the lower ones often double. New England to Kentucky and Illinois.

22. **A. filix-fœmina** (L.) Bernh. (LADY-FERN.) Stipes tufted, 6′—12′ long, stramineous or brownish; fronds delicate, 1½°—3° long, broadly oblong-ovate, bipinnate; pinnæ 4′—8′ long, lanceolate; pinnules oblong-lanceolate, pointed, more or less pinnately incised or serrate, distinct or confluent on the secondary rachises by a very narrow and inconspicuous margin; sori short; indusium straight or variously curved. Widely distributed from the Eastern States to the Gulf of Mexico, Arizona, and California.

23. **A. cyclosorum** Rupr. Larger, often 12′—16′ wide; sori mostly curved so as to appear circular, with a narrow sinus. Idaho to Washington.

XX. PHYLLITIS Ludwig. HART'S-TONGUE.

Sori linear, elongate, almost at right angles to the midvein, contiguous by twos, one on the upper side of one veinlet, and the next on the lower side of the next superior veinlet, thus appearing to have a double indusium opening along the middle. Name from Gr. *φύλλον*, a leaf, alluding to its simple form. Includes five species.

1. **P. scolopendrium** (L.) Newm. Stipes 2′—6′ long, fibrillose below; fronds oblong-lanceolate from an auricled heart-

shaped base, entire or undulate, 7′—18′ long, 1′—2′ wide, bright green. (*Scolopendrium* Smith, *Asplenium scolopendrium* L.) Chittenango Falls and Jamesville, New York; Woodstock, New Brunswick (*Sutton*), Owen Sound, Canada (*Mrs. Roy*), Tennessee.

XXI. CAMPTOSORUS Link. Walking-leaf.

Sori oblong or linear, irregularly scattered on either side of the reticulate veins of the simple frond, those next the midrib single, the outer ones inclined to approximate in pairs, or to become confluent at their ends, thus forming crooked lines. Name from Gr. καμπτός, curved, and σωρός, a heap. Includes only two species.

1. **C. rhizophyllus** (L.) Link. Fronds evergreen, tufted, spreading or procumbent, 4′—9′ long, lanceolate from an auricled, heart-shaped or often hastate base, tapering above into a slender prolongation which often roots at the apex. Var. *intermedius* Arthur is an interesting form, differing mainly from the typical forms in having the base acute, without proper auricles and with a single fibro-vascular bundle in the stipe. (*Antigramma rhizophylla* J. Sm., *Scolopendrium rhizophyllum* Hook., *Asplenium rhizophyllum* L.) New England to Wisconsin and southward; the variety in Iowa.

XXII. PHEGOPTERIS Fee. Beech-fern.

Sori small, round, naked, borne on the back of the veins below the apex. Stipe continuous with the rootstock. Veins free or reticulate. Name from Gr. φηγός, a beech-tree, and πτερίς, a fern. Includes 95 species.

§ 1. Euphegopteris. *Veins free.*

* *Fronds triangular, bipinnatifid; pinnæ sessile, adnate to a winged rachis.*

1. **P. phegopteris** (L.) Unde. Stipes 6′—9′ long; fronds longer than broad, 4′—9′ long, 4′—6′ broad, hairy on the veins especially beneath; pinnæ linear-lanceolate, the lowest pair deflexed and standing forward; segments oblong, obtuse, entire, the basal ones decurrent and adnate to the main rachis; sori near margin. (*P. polypodioides* Fee, *Polypodium phegopteris* L., *P. connectile* Michx.) New England to Virginia and westward.

2. **P. hexagonoptera** (Michx.) Fee. Stipes stramineous, naked; fronds as broad as long or nearly so, 7′—12′ long, slightly pubescent, and often finely glandular beneath; upper pinnæ oblong, obtuse, toothed or entire, the very large, lowest pinnæ elongate and pinnately lobed; sori near the margin or some between the sinus and the midrib. (*Polypodium hexagonopterum* Michx.) Canada to Illinois, Kentucky, and Florida.

** *Fronds oblong-lanceolate, tripinnatifid; rachis wingless.*

3. **P. alpestris** (Hoppe) Mett. Rootstock short, erect or oblique; stipes 4′—10′ long, with a few brown spreading scales near the base; fronds 1°—2° long, pinnæ deltoid-lanceolate, the lower ones distant and decreasing moderately; pinnules oblong-lanceolate, incised and toothed; sori small, rounded, submarginal. (*Polypodium alpestre* Hoppe, *Aspidium alpestre* Swz.) California and northward; Idaho (*Sandberg*).

*** *Fronds ternate, the three divisions petioled; rachis wingless.*

4. **P. dryopteris** (L.) Fee. (OAK-FERN.) Rootstock slender, creeping; fronds broadly triangular, 4′—8′ wide; the three primary divisions 1—2-pinnate; segments oblong, obtuse, entire or toothed; sori near the margin. (*Polypodium dryopteris* L., *Nephrodium dryopteris* Michx.) Northeastern United States to Virginia, and westward to Oregon and Alaska.

5. **P. Robertiana** (Hoffm.). Stipes 6′—10′ long, stramineous, glandular; fronds 6′—8′ long, 5′—7′ wide, deltoid-ovate in outline, bipinnate, lowest pair of pinnæ far the largest, pinnatifid or again pinnate; upper pinnæ smaller, pinnatifid, lobed, or entire; sori copious, forming submarginal rows around the segments. (*P. calcarea* Fee.) Minnesota (*Cathcart*), Decorah, Iowa (*Holway*), Northeast Territory (*Macoun*), Idaho.

§ 2. GONIOPTERIS Presl. *Veins pinnate, the lower veinlets of contiguous groups uniting.*

6. **P. tetragona** (Swz.) Fee. Rootstock creeping; stipes 6′—18′ long, naked or slightly villose; fronds 1°—2° long, 6′—12′ broad; pinnæ numerous, spreading 3′—6′ long, the lowest narrowed at the base and sometimes stalked, deeply pinnatifid; texture thinly herbaceous; rachis and under surface finely pubescent; sori in rows near the midrib. Marion County, Florida (*Reynolds*).

7. **P. reptans** (Swz.) Eaton. Rootstock short, creeping; stipes 3′—10′ long, clustered, gray-stamineous, slender, naked; fronds 4′—12′ long, membranous, softly hairy with branched or stellate hairs, oblong-lanceolate, pinnate with nearly or quite sessile, oblong, crenately pinnatifid pinnæ, the apex pinnatifid, often elongate and rooting; veins pinnate, simple, the basal veinlets often anastomosing; sori on the middle of the veinlets, rather small, sometimes with a minute rudimentary indusium. (*Polypodium reptans* Swz., *Aspidium reptans* Mett.) On calcareous rocks, on left bank of Withlacoochee River, 15 miles N.E. from Brooksville, Florida (*J. Donnell Smith*).

XXIII. DRYOPTERIS Adans. Shield-fern.

Sori round, borne on the back or rarely at the apex of the veins. Indusium flat or flattish, cordato-reniform and attached by the centre or sinus. Veins nearly always free. Stipe continuous with the rootstock. Name from Gr. δρῦς, oak, and πτερίς, a fern. (*Aspidium* Swz. in part.) A cosmopolitan genus containing 150 species.

* *Fronds thin-membranous; veins simple or once forked.*

† *Lowest pinnæ gradually reduced to mere lobes.*

‡ *Fronds in a crown from a stout, creeping rootstock.*

1. **D. Montana** (Vogl.) Ktze. Rootstock oblique, scaly; stipes short, scaly below; fronds 1½°—2° long, broadly lanceolate, tapering below, glandular; pinnæ 2′—3′ long, deeply pinnatifid, the lower slightly more distant; sori medium size, nearly marginal; indusia more or less toothed at the margin. (*Polypodium montanum* Vogl., *P. oreopteris* Ehrh.) British Columbia (Macoun), Unalaska (Turner).

2. **D. Nevadensis** (Eat.) Unde. Rootstock creeping, densely covered with the persistent bases of former stalks; stipes short, scaly below; fronds 1½°—3° long, lanceolate, with pinnæ linear-lanceolate from a broad base, and crowded segments slightly hairy on the veins and with minute resinous particles; sori small, nearer the margin than the vein; indusium minute, furnished with a few dark-colored marginal glands and with jointed hairs on the upper surface. California.

‡‡ *Rootstocks stout, erect, forming a short caudex; fronds in a crown.*

3. D. contermina (Desv.) Ktze., *var.* strigosa (Fee) Unde. Rootstock often extending a foot above the ground; stipes very stout, narrowly wing-margined near the base; fronds 1°—4° long, lanceolate, caudate-acuminate, much narrowed at the base; pinnæ sessile, narrowly lanceolate from a broader base, deeply pinnatifid, the under surface dotted with resinous globules; veins simple; sori near the margin with minute glandular somewhat pilose indusia. Fort Meade, Florida.

‡‡‡ *Rootstocks slender, creeping; fronds scattered.*

4. D. Noveboracensis (L.) Gray. Rootstocks wide creeping; fronds 1°—2° long, 4′—6′ broad, tapering both ways from the middle; pinnæ lanceolate, sessile, ciliate, and finely pubescent beneath; veins simple or those of the basal lobes forked; sori near the margin; indusium minute, gland-bearing. (*Polypodium Noveboracense* L., *Aspidium thelypteroides* Swz.) North Carolina to Arkansas and northward.

†† *Lower pinnæ little smaller than those above.*

‡ *Veins forked.*

5. D. thelypteris (L.) Gray. Rootstock creeping; fronds lanceolate, scarcely narrower at the base, 1°—2° long, 4′—6′ wide, membranous; pinnæ lanceolate, with obtuse segments which often appear acute from the strongly revolute margin; veins regularly once or twice forked; sori crowded, 10—12 to each segment; indusium slightly glandular or glabrous. (*Polypodium thelypteris* L.) New Brunswick to Manitoba south to Texas and Florida.

‡‡ *Veins simple.*

6. D simulata. Dav. Rootstock slender, brownish; fronds 8′—20′ long, 2′—7′ wide, oblong-lanceolate, tapering to an acuminate apex; pinnæ 12—20 pairs, lanceolate, the segments obtuse, entire, slightly revolute in the fertile frond, finely pubescent, especially near the midribs; sori rather large, somewhat distant, 4—10 to each segment; indusia finely glandular at the margins. New Hampshire, Massachusetts,

7. **D. patens** (Swz.) Ktze. Rootstock stout, bearing several fronds at the growing end; fronds 2°—3° long, 4′—10′ broad, ovate-oblong, softly pubescent beneath; pinnæ closely placed, linear-acuminate, lowest pair somewhat deflexed, all cut three fourths of the way to the midrib; segments numerous, acutish, basal ones longest; veinlets evident, lowest ones of adjoining segments often uniting; sori near the margin; indusia very pubescent. (*A. molle* Kunze.) Florida to California.

** *Texture firmer or sub-coriaceous, veins forking freely.*

† *Fronds pinnate; pinnæ cut into spreading triangular lobes; sori confluent.*

8. **D. unita** (L.) Ktze., *var.* **glabra** (Mett.) Unde. Stipes 1½° long, brownish, naked; fronds 1½° or more long, 5′—8′ broad; pinnæ narrow, cut from one third to half-way down into sharp, pointed lobes; lower pinnæ not reduced; veins pinnate in the broad lobes with 6—8 veinlets on each side, the lower ones of contiguous groups united; sori near the ends of the veins principally in the lobes. Florida.

†† *Fronds bipinnatifid or bipinnate; indusia rather large; segments not spinulose.*

‡ *Fronds small, narrowly lanceolate.*

9. **D. fragrans** (L.) Schott. Fronds 4′—12′ high, glandular-aromatic; pinnæ linear-oblong, pinnately parted; segments toothed or nearly entire, nearly covered beneath with the very large thin imbricate indusia, which are orbicular with a narrow sinus, the margin ragged and sparingly glanduliferous. (*Nephrodium fragrans* Rich.) New England, New York to Wisconsin, and northward.

‡‡ *Fronds larger, mostly 2°—4° high.*

A. *Fronds bipinnatifid or nearly twice pinnate; indusia large, thinnish and flat,*

10. **D. Floridana** (Hook.) Ktze. Stipes 6′—10′ long, sparingly clothed with ovate scales; fronds lanceolate, 18′—20′ long, 5′—8′ broad; fertile pinnæ confined to the upper half of the frond, narrowly lanceolate, cut down to the narrowly winged secondary rachises into oblong, distinct pinnules; the sterile pinnæ broader, shorter, and sub-deltoid below, less

deeply cut. (*Aspidium Floridanum* D. C. Eaton, *Nephrodium Floridanum* Hook.) Florida.

11. **D. cristata** (L.) Gray. Fronds linear or lanceolate in outline, 1°—2° long; pinnæ short, 2′—3′ long, triangular-oblong or the lowest nearly triangular, deeply pinnatifid; segments 6—10 pairs, finely serrate or cut-toothed; sori as near the midvein as the margin; indusia smooth, naked. (*A. Lancastriense* Spreng., *Nephrodium cristatum* Michx., *Lastrea cristata* Presl.) Canada to Arkansas.

Var. **Clintoniana** (Eat.) Unde. Fronds much larger, 2½°—4° long; pinnæ oblong-lanceolate, broadest at base, 4′—6′ long, 1′—2′ broad, deeply pinnatifid; segments 8—16 pairs, crowded or distant, linear-oblong, obscurely serrate; veins pinnately forking, bearing the sori near the midvein. (*D. Goldieana celsa* Palmer.) New England, New York, and westward.

12. **D. Goldieana** (Hook.) Gray. Fronds broad, 2°—4° long; pinnæ 6′—9′ long, broadest in the middle, pinnately parted; the segments about 20 pairs, oblong-linear, sub-falcate, serrate with appressed teeth; veins bearing the sori very near the midvein; indusia very large, orbicular with a narrow sinus. (*Nephrodium Goldieanum* Hook., *Lastrea Goldieana* J. Sm.) Canada to Kentucky.

B. *Fronds mostly bipinnate; indusia convex, without marginal glands.*

13. **D. filix-mas** (L.) Schott. (MALE-FERN.) Rootstock stout; fronds in a crown, 1°—3° high, broadly oblong lanceolate, slightly narrowed toward the base, bipinnatifid or bipinnate; pinnules oblong, smooth, polished beneath, the larger ones pinnately incised; sori large, near the midvein, commonly on the lower half or two thirds of the segment; indusia firm, smooth; rachis more or less chaffy. (*Nephrodium filix-mas* Rich., *Lastrea filix-mas* Presl.) Canada to Colorado, Arizona, California, and Oregon.

14. **D. marginalis** (L.) Gray. Fronds nearly coriaceous in texture, 6′—2° long, ovate-oblong; pinnæ lanceolate, broadest just above the base; pinnules oblong or oblong-falcate, entire or crenately toothed; sori close to the margin. (*Polypodium marginale* L., *Nephrodium marginale* Michx., *Lastrea margi-*

nalis J. Sm.) Northern United States and Canada.

††† *Fronds bipinnate or tripinnatifid; segments spinulose-toothed.*

15. **D. rigida** (Hoffm.) Unde., *var.* **arguta** (Kaulf.) Unde. Rootstock short, stout; fronds in a crown on chaffy stalks, half-evergreen, smooth above, paler and more or less glandular beneath, 1°—3° high, ovate-lanceolate or triangular-lanceolate, bipinnate; pinnæ broadly oblong-lanceolate, the lowest ones broadest, scarcely shorter than the middle ones; pinnules oblong, incised or doubly serrate with spinulose teeth; indusia firm, convex, the edge bearing short-stalked glands. (*A. argutum* Kaulf.) California, Oregon, British Columbia.

16. **D. spinulosa** (L.) Ktze. Stipes with a few, pale, deciduous scales; fronds ovate-lanceolate, bipinnate, the pinnæ oblique to the rachis, elongate-triangular, the lower pairs broadly triangular; pinnules oblique to the midrib, connected by a very narrow wing, oblong, incised, or pinnatifid with lobes spinulose toothed; indusia smooth without marginal glands. (*Nephrodium spinulosum* Desv., *Lastrea spinulosa* Presl.) Canada and Northern United States.

Var. **intermedia** (Willd.) Unde. Scales of the stipes brown with a darker centre; fronds oblong-ovate, bi—tripinnate; pinnæ spreading, oblong-lanceolate, the lowest unequally triangular-ovate; pinnules crowded, pinnately divided; margin of indusium denticulate and beset with stalked glands. (*A. intermedium* Willd., *A. Americanum* Dav.) Canada to Tennessee.

Var. **dilatata** (Hoffm.) Unde. Scales of stipes large, brown with a darker centre; fronds broadly ovate or triangular-ovate, oftenest tripinnate; pinnules lance-oblong, the lowest often much elongated; indusia smooth and naked. (*A. dilatatum* Swz., *A. campylopterum* Kunze., *Nephrodium dilatatum* Desv., *Lastrea dilatata* J. Sm.) A dwarf form is *var. dumetorum*. Canada and New England to Oregon.

17. **D. Boottii** (Tuck.) Unde. Scales of stipes pale brown; fronds elongate oblong or elongate lanceolate in outline; pinnules broadly oblong, very obtuse, the lower pinnatifid, the upper and smaller merely serrate; indusia minutely glandular.

(*A. spinulosum*, var. *Boottii* Gray.) New England, New York, and northward.

18. **D. patula** (Swz.) Unde. Stipes 8′—12′ long, stramineous, scaly at base; fronds pale green, 1°—2° long, 6′—12′ broad, ovate-lanceolate; pinnæ lanceolate or the lower subdeltoid; rachis and both surfaces naked; sori in rows midway between edge and midrib; indusium conspicuous, naked. (*Nephrodium patulum* Baker, *N. Mexicanum* Hook. Distributed by Lemmon as *A. Karwinskyanum*.) Huachuca Mountains, Arizona (Lemmon).

XXIV. POLYSTICHUM Roth.

Sori round, borne on the back or rarely at the apex of the veins. Indusium flat or flattish, peltate, i.e., fixed at the centre and becoming free all around the margin. Veins all free. Name from Greek πολυς, many, and στιχος, a row. Includes 25 or more species.

* *Fronds simply pinnate.*

† *Fronds scarcely stalked, linear-lanceolate.*

1. **P. lonchitis** (L.) Roth. (HOLLY-FERN.) Fronds 9′—20′ long, rigid; pinnæ 1′ or more long, broadly lanceolate-falcate or the lowest triangular, strongly auricled on the upper side, the lower obliquely truncate, densely spinulose-toothed; sori contiguous and near the margin. Canada and Wisconsin to Utah (*Jones*), Castle Lake, Siskiyou County, California (*Pringle*), Mt. Peddo, Washington (*Suksdorf*), and northward.

† † *Fronds long-stalked, lanceolate.*

2. **P. acrostichoides** (Michx.) Schott. (CHRISTMAS-FERN.) Stipes 6′—8′ long, clothed below with pale-brown lanceolate scales; fronds ½°—2° high, 3′—5′ broad; pinnæ linear-lanceolate, somewhat falcate, half-halberd-shaped at the base, serrulate with appressed bristly teeth; the fertile ones contracted and smaller, bearing contiguous sori near the middle, soon covering the entire surface. A form with cut-lobed, often strongly falcate pinnæ, set obliquely to the rachis, and with the tips of nearly all bearing sori, is the *var. incisum* Gray. (*Nephrodium acrostichoides* Michx.) New England to Florida, Mississippi, and northward.

3. **P. munitum** (Kaulf.) Underw. Rootstock stout; stipes growing in a crown, densely chaffy at base, more or less naked above, the rachises with smaller scattered scales; leaf 10′—15′ long, 2′—3′ wide, with close, sharply serrated horizontal pinnæ, which are sharp-pointed and slightly falcate, strongly auricled on the upper side at base, the serrations bristle-pointed; sori in a single row rather near the margin. Idaho to British Columbia and California.

Var. **inciso-serratum** D. C. Eaton. Fronds taller, up to 6° long, with chaffy stipes; pinnæ 3′—5′ long, attenuate, the margins sharply serrate. California and Oregon.

Var. **imbricans** D. C. Eaton. Stipes naked, stramineous; fronds narrow, the pinnæ 1′ long, oblique, imbricated, the serratures ending in short points. Northern California to Washington.

** *Pinnæ partly pinnatifid below.*

4. **P. scopulinum** (D. C. Eaton) Maxon. Rootstock short; stipes 2′—6′ long, cespitose, densely scaly at base (scales pale), with small scattered scales on the rachis; fronds 6′—10′ long, 1½′—2′ wide, pinnate, the pinnæ with usually one pair of pinnules at the base; the margin serrate with incurved teeth, the apex blunt-rounded; sori in a single row either side of the midrib and nearer the rib than the margin; indusia large, somewhat lobed. California and Oregon.

5. **P. Californicum** (D. C. Eaton) Underw. Stipes 4′—6′ long, clustered, densely chaffy at base, at length nearly naked above; rachises more or less clothed with narrow scales; fronds 10′—12′ long, 2½′—3′ wide, pinnate; lower pinnæ again pinnate in the lower half, the lowest upper pinnule of each pinna enlarged, the upper half of the pinna pinnatifid, incised, or serrate with a spinose margin; upper pinnæ incised at base and serrate at the tips; sori 1—3 on each pinnule or lobe, commonly two on the same side of the vein. California.

*** *Fronds bipinnatifid or nearly bipinnate.*

6. **P. Lemmoni** sp. nov. Rootstock short, ascending; stipes densely clustered, densely chaffy at base, with pale cinnamon-brown scales, 2′—6′ long, with more or less scattered scales above; fronds 7′—10′ long, 1½′—3′ wide, bipinnatifid or nearly

bipinnate in the lower third; pinnæ closely placed, ovate, rounded at the ends, made up of 8—10 oval pinnules or divisions besides the terminal one, obtuse, not armed; sori one or two to each pinnule. (*Aspidium mohroides* and *Dryopteris moroiides* of previous editions, not *A. mohroioides* Bory, an allied but very distinct plant of the Southern Hemisphere.) Near Mt. Shasta, California (*Lemmon*).

**** *Fronds large, fully bipinnate.*

7. **P. aculeatum** (Swz.) Roth. Stipes 6′—8′ long, densely scaly at base; lamina 18′—24′ long, 6′—10′ wide, bipinnate; pinnules sharply serrate, incised, or the lowest pinnatifid, the upper basal serration or lobe more pronounced like a small auricle, all ending in an acuminate bristle-tip; under surface pilose with slender hairs. California.

8. **P. Braunii** (Spenner) Lawson. Stipes growing in a crown, densely chaffy; fronds lanceolate, 12′—18′ long, with numerous horizontal oblong-lanceolate pinnæ, the lower gradually reduced in size and obtuse; pinnules ovate or oblong, truncate and almost rectangular at the base, sharply toothed, beset with long, soft, and chaffy hairs; rachis with light brown chaff. (*Aspidium Braunii* Spenner.) Maine to New York and northward.

XXV. PHANEROPHLEBIA Presl.

Sori round, borne on the back of forking veins. Indusium flat or flattish peltate, opening all round the margin. Veins several times forking, often united to form areolæ. Name from Greek φανερός, distinct, and φλεβος, a vein. Eight species are known from tropical America.

1. **P. auriculata** Underw. Rootstock short, creeping, densely covered with the bases of the persistent stipes; stipes stramineous, 4′—7′ long, with abundant dark-brown lanceolate scales which become narrower above and almost hair-like; pinnæ 10—16, the terminal about like the lateral, 2′—3′ long, 1′ or less wide; lateral pinnæ unequal at base, the lower angle obliquely truncate, the upper usually developed into a well-marked auricle; margins strongly serrate or sometimes more deeply incised, the teeth ending in sharp prickles projecting

from the margin at an angle of 30°—40°; texture thin; veins free, 1—3-forked; sori in two more or less clearly marked rows with scattering sori between them and beyond the outer row. (*Aspidium juglandifolium* of former editions, not of Kunze.) Texas to Arizona.

XXVI. TECTARIA Cav.

Sori round, borne on the back of the frond. Indusium peltate, opening all around the margin. Veins everywhere anastomosing, forming copious areolæ, with free included veinlets. Name from Latin *tectum*, a roof. A small tropical genus.

1. **T. trifoliata** (L.) Cav. Stipes tufted, 1° or more long, brownish, scaly at base; fronds 12′—18′ long, 6′—12′ broad, with a large ovate-acuminate terminal pinna narrowed or forked at the base, and one or two lateral ones on each side, the lowest mostly forked; primary veins distinct to the margin; areolæ fine, copious, with free included veinlets; sori in rows near the main veins; indusia orbicular, peltate. (*Aspidium trifoliatum* Swz.) Florida, Western Texas.

XXVII. NEPHROLEPIS Schott.

Sori round, arising from the apex of the upper branch of a vein, usually near the margin. Indusia reniform or roundish. Veins all free, the fronds simply pinnate, the pinnæ articulated at the base, and bearing white cretaceous dots on the upper surface. Name from Gr. *νεφρώς*, a kidney, and *λεπίς*, a scale. A tropical and sub-tropical genus containing seven species.

1. **N. exaltata** (L.) Schott. Stipes 4′—6′ long, naked or slightly scaly; fronds 1°—6° long, 3′--6′ broad; pinnæ close, lanceolate, the edge entire or slightly crenate, the upper side auricled at the base, the lower rounded; rachis nearly naked; sori sub-marginal; indusia firm, distinctly reniform. Florida; frequent in cultivation.

2. **N. acuta** (Swz.) Presl. Stipes 4′—8′ long, naked or slightly scaly; fronds 2°—4° long, 8′—12′ broad; pinnæ 4′—8′ long, ½′—1′ broad, acute, entire or slightly crenate, the upper side auricled, the lower rounded at base; rachis and both sides nearly naked; sori submarginal; indusia suborbicular, subpel-

tate. South bank of Miami River, Florida. March, 1887 (*Holden*).

XXVIII. FILIX Adans. Bladder-fern.

Sori roundish, borne on the back of the veins. Indusium delicate, hood-like, or arched, attached by a broad base on the inner side partly under the sorus, early opening, free at the other side, and thrown back or withering away. Veins free. Name from Lat. *filix*, a fern. (*Cystopteris* Bernh. and former editions.) Found in the temperate zones of both hemispheres; contains five species.

* *Fronds ovate-lanceolate, bi—tripinnate.*

1. **F. bulbifera** (L.) Underw. Stipes 4′—6′ long; fronds lanceolate, elongate, 1°—2° long, bi—tripinnatifid, pinnæ lanceolate-oblong; pinnules crowded, toothed or pinnatifid; rachis wingless, often bearing bulblets underneath; indusia short, truncate on the free side. (*Aspidium bulbiferum* Swz., *Nephrodium bulbiferum* Michx.) New England to Virginia and North Carolina.

2. **F. fragilis** (L.) Underw. Fronds oblong-lanceolate, 4′—8′ long, 1′—2½′ broad, bi—tripinnate; pinnæ and pinnules lanceolate or ovate in outline, decurrent along the margined or winged rachis; indusia tapering or acute at the free end. Narrower, less divided specimens, barely bipinnate with obtuse and bluntly toothed pinnules form the *var. dentata* Hook. Like many other so-called varieties it passes insensibly into the typical form. (*Aspidium tenue* Swz.) New England to Arizona, California, and northward.

** *Fronds deltoid-ovate, tri—quadripinnate.*

3. **F. montana** (Lam.) Underw. Rootstock slender, creeping; stipes 6′—9′ long, slender; fronds about 6′ each way; lowest pinnæ deltoid-lanceolate, much larger than those above, their inferior pinnules 1′—1½′ long; segments cut to the rachis into oblong lobes, deeply and sharply toothed; sori numerous. Colorado (*Brandegee*), north shore of Lake Superior, Labrador (*Butler*), Mt. Albert, Gaspé, Quebec, and northward to Alaska.

XXIX. ONOCLEA L.

Sori round, borne on the back of the veins of the contracted fertile frond, and quite concealed by their revolute margins. Indusium very thin membranous, hemispheric or hood-like, fixed at the inferior side of the sorus. Fronds conspicuously dimorphous. Name from Gr. *ονος*, a vessel, and *κλειειν*, to close, alluding to the fertile fronds. A single species.

1. **O. sensibilis** L. (SENSITIVE-FERN.) Fertile fronds bipinnate, much contracted; pinnules short, usually rolled up and converted into berry-shaped closed involucres, and forming a one-sided panicle; sterile fronds broadly triangular, deeply pinnatifid into lanceolate-oblong pinnæ; veins copiously anastomosing. In *var. obtusilobata* Torr. the sterile fronds are again pinnatifid, more or less contracted and revolute, and bear a few sori. New England to Florida and Kansas.

XXX. MATTEUCCIA Todaro.

Sori round, borne on the veins of a contracted fertile frond, concealed by their revolute margins. Fronds growing in a crown, dimorphous. Veins free. Name from *Carlo Matteucci*, an Italian professor of physics. Contains two or three species.

1. **M. struthiopteris** (L.) Todaro. (OSTRICH-FERN.) Fertile fronds 1°—1½° long, simply pinnate with necklace-shaped pinnæ formed of the strongly revolute margins; sterile fronds 2°—6° long, growing in a crown, broadly lanceolate, bipinnatifid, the lowest pinnæ gradually much shorter; veins pinnate, free and simple; sori crowded, confluent. (*Onoclea struthiopteris* Hoffm., *Struthiopteris Pennsylvanica* Willd., *S. Germanica* Willd., *Osmunda struthiopteris* L.) New England to Illinois.

XXXI. WOODSIA R. Br.

Sori round, borne on the back of simply forked free veins. Indusium inferior, thin and often evanescent, either small and open, or early bursting at the top into irregular pieces or lobes. Named for *Joseph Woods*, an English botanist. A genus of high temperate or boreal latitudes including 15 species.

§ 1. EUWOODSIA. *Indusium minute or evanescent, open and*

flat from an early stage, concealed under the sorus, its margin cleft into slender hairs or cilia.

* *Stipes obscurely jointed near the base; cilia of the indusium long, inflexed over the sporangia.*

† *Fronds thickly clothed underneath with rusty bristle-like chaff.*

1. **W. Ilvensis** (L.). R. Br. Fronds broadly lanceolate, smoothish above, pinnate; pinnæ crowded, sessile, pinnately-parted, the crowded segments oblong, obscurely crenate; sori near the margin, somewhat confluent when old. (*W. rufidula* Beck., *Acrostichum Ilvense* L., *Polypodium Ilvense* Swz., *Nephrodium rufidulum* Michx., *Aspidium rufidulum* Willd.) Virginia to Kentucky, westward and northward.

†† *Fronds glabrous or nearly so.*

2. **W. alpina** (Bolt.) S. F. Gray. Stipes and rachis often slightly hairy; fronds linear-lanceolate, pinnate; pinnæ cordato-ovate, pinnatifid with few (5—7) broadly obovate entire lobes. Vermont, New York, and northwestward. (*W. hyperborea* R. Br.)

3. **W. glabella** R. Br. Smooth and naked throughout; fronds linear, tapering slightly below, 2′—5′ high, pinnate; pinnæ deltoid or ovate, the lower rather remote, cut into 3—7 rounded or subcuneate entire lobes. Vermont, New York, and northward.

** *Stipes not jointed; cilia of the indusium very short, hidden by the sporangia.*

4. **W. scopulina** D. C. Eaton. Rootstock short, creeping, very chaffy; stipes 2′—4′ long, puberulent like the rachis and under surface of the frond with minute flattened hairs and stalked glands; fronds lanceolate, 4′—8′ long, pinnate; pinnæ numerous, oblong-ovate, pinnatifid with 10—16 short ovate or oblong toothed divisions; indusia very delicate, deeply cleft into laciniæ which terminate in short hairs. Colorado, Arizona, California, Oregon, and northward.

5. **W. Oregana** D. C. Eaton. Stipes and fronds smooth; fertile fronds taller than the sterile ones; pinnæ triangular-oblong, pinnatifid; segments oblong or ovate, toothed or crenate; teeth often reflexed and covering the submarginal sori; indusia

very minute, divided almost to the centre into a few beaded hairs. Arizona, Utah, Colorado, Oregon, and northward.

6. **W. Mexicana** Fee. Stipes 2′—3′ long, smoothish or with a few scattered scales; fronds 3′—9′ long, lanceolate; pinnæ sub-opposite, triangular-lanceolate, pinnately divided into finely-toothed segments, the teeth in young fronds ending in delicate, semi-transparent, ciliated tips; sori near the margin, broad, confluent; receptacles dot-like, scales of indusium four, laciniate, narrow, dividing at the end into articulated hairs; sporangia nearly sessile. Arizona, New Mexico.

§ 2. HYPOPELTIS Torr. *Indusium conspicuous, at first enclosing the sporangium, but early opening at the top and splitting into several spreading jagged lobes.*

7. **W. obtusa** (Spreng.) Torr. Stipes 3′—6′ long; fronds broadly lanceolate, minutely glandular-hairy, 6′—12′ high, nearly bipinnate; pinnæ rather remote, triangular-ovate or oblong, pinnately parted; segments oblong, obtuse, crenately toothed, the lower ones pinnatifid; veins forked. (*W. Perriniana* H. & G., *Aspidium obtusum* Willd., *Cheilanthes crenata* Kunze, *Hypopeltis obtusa* Torr.) Smaller and more glandular forms are *var. glandulosa* Eaton (*W. Plummeræ* Lemmon). New England to Kentucky, Kansas, and Arizona.

XXXI. DENNSTÆDTIA Bernh.

Sori small, globular, marginal or intramarginal. Sporangia borne in an elevated, globular receptacle, enclosed in a membranous, cup-shaped indusium, which is open at the top, and on the outer side partly adherent to a reflexed toothlet of the frond. Named for Dennstædt, a German botanist, 1738–1822. Includes about 20 species, long confused with the arborescent genus *Dicksonia*.

§ SITOLOBIUM J. Sm.

1. **D. punctilobula** (Michx.) Bernh. Rootstock slender, creeping, naked; stipes stout, chaffless; fronds 1°—2½° long, 5′—9′ broad, ovate-lanceolate and pointed, usually tripinnatifid; pinnæ lanceolate, pointed; pinnules cut into oblong and obtuse cut-toothed lobes; rachis and under surface minutely glandular and hairy. (*Dicksonia punctilobula* Gray and former editions; *D. pilosiuscula* Willd.) Canada to Alabama.

Family 7. MARSILEACEÆ R. Br.

Perennial plants rooted in mud, with a slender creeping rootstock and either filiform or 4-parted, long-petioled leaves. Fructification consisting of sporocarps borne on peduncles, which rise from the rootstock near the leaf-stalk or consolidated with it and containing both macrospores and microspores. Consisting of two genera both found in this country.

I. Marsilea L. Sporocarps ovoid; leaves quadrifoliate.

II. Pilularia L. Sporocarps globose; leaves filiform.

I. MARSILEA L.

Sporocarps ovoid or bean-shaped, composed of two vertical valves having several transverse compartments or sori in each valve, the sori composed of both macrosporangia and microsporangia. Sporocarps also provided with a ring which at the opening of the valves swells and tears the sori from their position. Leaves quadrifoliate on slender petioles; the sporocarps peduncled and rising from the petiole or from the rootstock at the base of the petiole. Named for *Aloysius Marsili*, an early Italian naturalist. Contains about 40 species, four occurring within our limits.

* *Sporocarps 2—6 on each peduncle.*

1. **M. quadrifolia** L. Plant usually slender, 5—12 cm. high; leaflets variable, 4—14 mm. wide, 5—15 mm. long, margins entire, smooth, or rarely with scattered hairs when young; sporocarps 2 (rarely 3) on a branching peduncle, which is usually attached to the stipe near its base, but sometimes as much as 2 cm. above; young sporocarp with short yellowish-brown hairs, later becoming naked and dark purple; lower tooth obtuse, upper small, acute or obtuse; sori, 8 or 9 in each valve. Bantam Lake, Litchfield County, Connecticut (*Dr. T. F. Allen*), from whence it has been cultivated in several localities.

2. **M. macropoda** Engelm. Plant robust, 10—25 cm. high; leaflets large, 2—5 cm. long, 2 cm. wide or less, usually undulate, clothed with white hairs on both sides when young, becoming smoother with age; sporocarps 2—6, on erect branching peduncles, ascending, densely villose, 6—8 mm. long, 5—6 mm. wide; raphe short, the lower tooth obtuse, the upper in-

conspicuous or wanting; sori, 10 in each valve. (*M. macropus* A. Br.) Texas, New Mexico.

** *Sporocarps* 1 (*rarely* 2) *on each peduncle.*

3. **M. uncinata** A. Br. Plant 6—20 cm. high; leaflets nearly smooth, entire, 10—16 mm. long; sporocarps 6 mm. wide, 8 mm. long; peduncles 15—30 mm. long, 2—4 times the length of the sporocarps; raphe long, terminating in two approximate teeth, the upper longer and mostly uncinately curved; sori, 13—14 in each valve. Western Louisiana (*Hale*), Dallas, Texas (*Reverchon*).

4. **M. vestita** Hook. & Grev. Plant 3—6 cm. high; leaflets entire or slightly toothed; sporocarps 4—7 mm. long, 3—5 mm. wide; raphe short, lower tooth short and blunt, the upper acute, a little longer, sometimes curved; paleæ varying from soft, dense and spreading to short and appressed, in *mucronata* forms, where it is sometimes wanting; sori, 6—11 in each valve, a very variable species. (Includes *M. mucronata* A. Br.) Arkansas (*Nuttall*), Kansas (*Watson*), Texas, Arizona (*Lemmon*), California, Nevada (*Watson*), Oregon (*Hall*), Washington, Montana *Watson*), Dakota (*Nicollet*), Florida (*Underwood*).

5. **M. tenuifolia** Engelm. Plant much more slender, 5—15 cm. high; leaflets narrow (2—4 mm. wide), more or less falcate, the apex often somewhat truncate and unequally toothed, villose with appressed hairs; sporocarps single, 5—8 mm. long, 4—5 mm. wide, the teeth divergent, subequal; sori, 9—11 in each valve. A rare species only once collected. Pierdenales, Texas (*Lindheimer*), Western Texas (*Wright*).

II. PILULARIA L. Pillwort.

Sporocarps globose, longitudinally 2—4 celled, dehiscent from the apex; cells with parietal cushions bearing in the upper portion microsporangia and below these numerous macrosporangia containing solitary macrospores. Leaves filiform from a slender creeping rootstock, the sporocarps subsessile or peduncled or in the axils of the leaves. Named from Lat. *pilula*, a pellet. Includes six species widely distributed.

1. **P. Americana** A. Br. Leaves setiform, 1′ long; sporocarps 1″ in diameter, attached by the side to a short, descend-

ing peduncle, 3—4-celled; macrospores 13—17 in each cell, not constricted in the middle. Santa Barbara, California (*Mrs. Cooper*), Arkansas (*Nuttall*), Oregon (*Leiberg*).

Family 8. SALVINIACEÆ.

Floating plants with a more or less elongate and sometimes branching axis bearing apparently distichous leaves. Sporocarps soft, thin-walled, two or more on a common stalk, 1-celled, with a central, often branched receptacle which bears macrosporangia containing a single macrospore, or microsporangia containing numerous microspores. Consists of the two following genera.

I. **Salvinia** Schreb. Leaves 6″—9″ long, with a distinct midrib.

II. **Azolla** Lam. Leaves minute, numerous, closely imbricate, deeply lobed.

I. SALVINIA Schreb.

Floating annuals with slender stems bearing small two-ranked leaves. Sporocarps arranged in clusters, globose, membranous, 1—2 of each cluster containing 10 or more macrosporangia, the others containing numerous smaller microsporangia. Named for *Salvini*, a Florentine professor. Contains thirteen species, one of which is found with us.

1. **S. natans** Hoffm. Leaves oblong, horizontal, rounded or slightly cordate at base, ½′—1′ long, bright green above, the under surface matted with brown, pellucid hairs; sporocarps 4—8 in a cluster. (*Marsilia natans* L.) Bois Brulé Bottoms, Perry County, Missouri (*Demetrio.*) Reported by Pursh from Central New York; the exact station unknown.

II. AZOLLA Lam.

Small, moss-like plants with pinnately branched stems covered with minute, imbricate, 2-lobed leaves, and emitting rootlets beneath. Sporocarps of two kinds, borne in the axils of the leaves. Smaller sporocarps ovoid, containing a single macrospore at the base. Larger sporocarps globose, producing from the base many pedicelled sporangia, containing several masses

of microspores. Named from Gr. ἄξειν, to dry, and ὄλλυμαι, to destroy. Includes five species.

1. **A. Caroliniana** Willd. Plants ¾′—1′ long, reddish or greenish; cuticle of macrospores finely granulate; masses of microspores with rigid septate processes. New York to Florida, Arizona and Oregon.

2. **A. filiculoides** Lam. Fronds 1′—2′ long, often erect-crowded; cuticle of macrospores with large discoid tubercles; masses of microspores with rigid processes without septa. La Honda, California, and possibly widely distributed in that state since most of the material recently collected in California appears to be this species. The plants often grow in densely crowded masses and are usually much larger than the Eastern species.

The order EQUISETALES contains only a single family made up of rush-like plants often growing in wet places or in sand.

Family 1. EQUISETACEÆ DC.

Plant-body rush-like, often branched, with jointed, usually hollow stems rising from subterranean rootstocks, the sterile leaves reduced to sheaths at the joints, the fertile forming a short spike terminating the stem. Prothallium above ground, green, variously lobed, usually dicœcious. Represented at present by only one genus.

I. EQUISETUM L. Horse-tail. Scouring-rush.

Perennial plants with extensively creeping rootstocks. Stems simple or branched, furrowed lengthwise, hollow, and provided with an outer circle of smaller cavities opposite the furrows as well as a second and smaller series opposite the ridges. Sporangia adhering to the under side of the shield-shaped scales of the spike, one-celled, opening down the inner side. Spores furnished with two slender filaments attached by the

middle. Name from Lat. *equus*, horse, and *seta*, a bristle. Contains about 25 species, widely distributed.

§ 1. EUEQUISETUM. *Stems annual, stomata scattered.*

* *Stems of two kinds, the pale or brownish fertile stems appearing earlier than the herbaceous sterile ones; fruiting in spring.*

† *Fertile stems simple, soon withering.*

1. **E. arvense** L. (HORSETAIL.) Sterile stems green, rather slender, 1°—2° high, 6—19 furrowed; branches numerous, long, mostly simple, 4-angled, minutely roughened, lowest joint commonly longer than the sheath of the stem; fertile stems 4′—10′ high, light brown, the loose scarious sheath mostly distant, whitish, ending in about 12 brown acuminate teeth; spike rarely over 1′ long. (*E. boreale* Bong.) Virginia to California and northward to Greenland.

2. **E. telmateia** Ehrh. Sterile stems ivory white or greenish, stout, 2°—6° high, 20—40 furrowed; branches very numerous, erect-spreading, simple, 4—5 angled, the ridges rough and sulcate, the lowest joint shorter than the sheath of the stem; fertile stems 10′—15′ high, white, many-furrowed, the loose brownish sheaths elongate, deeply 20—30 toothed. (*E. fluviatile* Sm., *E. eburneum* Schreb., *E. maximum Auct.* not of Lam.) California, Oregon, and northward.

†† *Fertile stems when older producing herbaceous branches, only the naked apex withering.*

3. **E. pratense** Ehrh. Sterile and finally the fertile stems producing straight, simple branches; sheaths of the stem with about 11 short, ovate-lanceolate teeth, those of the branches 3-toothed. (*E. umbrosum* Willd., *E. triquetrum* Bory., *E. Drummondii* Hook.) Michigan, Wisconsin, and northward.

4. **E. silvaticum** L. Sterile and fertile stems usually 12-furrowed, producing compound branches, the branchlets curved downward; sheaths loose, those of the stem with 8—14 bluntish teeth, those of the branches with 4—5, and of the branchlets with 3 divergent teeth. Virginia to Michigan, and northward to Labrador.

** *Stems of one kind, herbaceous; branches simple or none, fruiting in summer.*

† *Sheaths somewhat loose.*

5. **E. palustre** L. Stems slender, 10′—18′ high, very deeply 5—9 grooved, the grooves separated by narrow, wing-like ridges, roughish; sheaths with about 8 lance-awl-shaped, whitish margined teeth; branches few in a whorl, with mostly 5-toothed sheaths. (*E. pratense* Reichenb.) Western New York and Wisconsin to British Columbia and northward.

6. **E. litorale** Kuhl. Stems slightly roughened, 6—19 grooved, the carinæ convex; sheaths sensibly dilated above, the uppermost bell-shaped; leaves convex, angled beneath, separate at the commisural groove; teeth herbaceous, membranous at the margin, narrow, lanceolate; branches of two kinds, the 4-angled hollow, the 3-angled solid, first joint a little longer or shorter than the sheath of the stem; spores abortive, elaters usually wanting. Bay of Quinte, Canada (*Macoun*); Vermont (*Pringle*); Oswego River, New York (*Wibbe*).

†† *Sheaths appressed.*

7. **E. fluviatile** L. Stems 2°—3° high, slightly many-furrowed, smooth, usually producing upright branches after fructification; sheaths appressed, with about 18 dark-brown, short, acute, rigid teeth; air-cavities wanting under the grooves, small under the ridges. Includes *E. limosum* L. (*E. uliginosum* Muhl., *E. heleocharis* Ehrh.) Virginia to Washington Territory and northward.

§ 2. HIPPOCHÆTE. *Stems perennial, evergreen; spikes tipped with a rigid point; stomata in regular rows; fruiting in summer.*

* *Stems tall and stout, usually many-grooved.*

† *Branches numerous, regularly whorled.*

8. **E. ramosissimum** Desf. Stem grooved, more or less roughened, 6—26 furrowed; ridges marked with bands; sheaths dilated, teeth not grooved, leaving a triangular, rarely truncate margin; leaves 3—4 carinate; branches usually copious and whorled, 4—9 angled; series of stomata in 1—4 lines. British Columbia (*Lyall*).

9. **E. Mexicanum** Milde. Stems rough, slender, inclined or somewhat erect; 20—24 furrowed, the ridges very narrow; sheaths long, cylindric, truncate; teeth grooved; leaves flat; branches more or less irregularly whorled, 6—9 angled; stomata

in a single series. Southern California in open cañons (*McClatchie*).

†† *Branches rare except when the main stem is broken.*

‡ *Stems rough, tuberculate.*

10. **E. robustum** A. Br. Stems 3°—11° high, sometimes nearly 1′ thick, 20—48 furrowed; ridges roughened with a single series of tubercles; sheaths short, marked with black girdles at base and at base of the caducous teeth; ridges of sheaths tricarinate. Ohio to California and northward.

11. **E. hiemale** L. (SCOURING-RUSH.) Stems 1°—4° high, 8—34 furrowed; ridges rough, with two indistinct lines of tubercles; sheaths rather long, marked with one or two black girdles; ridges of the sheath obscurely quadricarinate. North America generally.

‡‡ *Stems smoothish, scarcely tuberculate.*

12. **E. lævigatum** A. Br. Stems 1°—5° high, pale green, 14—30 furrowed; ridges almost smooth; sheaths elongate, enlarged upward, marked with a black girdle at the base of the mostly deciduous white-margined teeth, rarely with a second; ridges of sheath with central keel and rarely faint lateral ones. North Carolina to California and Oregon.

** *Stems slender, tufted,* 5—10 *grooved.*

13. **E. variegatum** Schleich. Stems ascending, 6′—18′ long, usually simple from a branched base, 5—10 furrowed; sheaths green, variegated with black above, the teeth 5—10, tipped with a deciduous bristle; central air-cavity small. Bellows Falls, New Hampshire (*Carey*), Niagara Falls to Illinois and northward to Greenland and Alaska.

14. **E. scirpoides** Michx. Stems filiform, very numerous, 3′—6′ high, flexuous and curving, mostly 6-furrowed, with acute ridges; sheaths 3-toothed, the bristle tips more persistent; central air-cavity wanting. New England to Pennsylvania, Illinois and northward.

The order LYCOPODIALES contains three families which may be distinguished as follows:

1. Spores of one sort . . *Family* 1. LYCOPODIACEÆ, p. 130.
   Spores of two sorts, powdery microspores and larger macrospores 2
2. Terrestrial; plants with leaves in four or more ranks.
   Family 2. SELAGINELLACEÆ, p. 137.
   Aquatic, with leaves in clusters.
   Family 3. ISŒTACEÆ, p. 142.

Family I. LYCOPODIACEÆ Lindl.

Moss-like, terrestrial plants with small, lanceolate or subulate, sometimes oblong or roundish, simple leaves, arranged in two to many ranks on trailing or sometimes erect, usually branching stems. Sporangia 1—3-celled, solitary in the axils or the leaves, or on their upper surface. Spores of one kind, minute. Prothallia (so far as known) mostly subterranean, with or without chlorophyll, monœcious. Contains four genera, the following within our limits:

Leaves well developed, in 4—many ranks; sporangia 1-celled. I. LYCOPODIUM.

Leaves minute, abortive; sporangia 3-celled. . II. PSILOTUM.

I. LYCOPODIUM L. CLUB-MOSS.

Perennial, terrestrial plants, with evergreen, one-nerved leaves arranged in 4—16 ranks. Sporangia coriaceous, flattened, reniform, one-celled, opening transversely, situated in the axils of ordinary leaves, or with fruit-bearing leaves modified into bracts which are arranged in spikes either sessile or peduncled. Spores copious, minute, sulphur-colored, inflammable. Named from Gr. λύκος, wolf, and πούς, foot, without obvious application. Contains nearly one hundred species.

* *Plants with mostly upright stems, with alternating zones of leaves and sporophylls.*

† *Leaves hollow at their bases and appressed.*

1. **L. selago** L. Prostrate portion of stem very short, abundantly rooting, soon curving upward and dichotomously branching to form compact tufts (2′—7′ high) of vertically

placed branches with dense foliage; leaves more or less appressed, or at least upwardly directed, triangular (1½″—4″) to linear-acuminate (½″ × 5′) or aciculate, broadest at the hollow base, gradually tapering to the acuminate apex, entire; sporophylls shorter than the leaves, triangular; sporangia reniform; plant very frequently gemmiparous. Mountains of North Carolina, northward and westward to Greenland, Idaho, Washington, and Alaska.

†† *Leaves flattened at their bases and ultimately more or less reflexed.*

2. **L. porophilum** Lloyd & Underw. Prostrate portion of stems short, abundantly rooting, curving upwards, then dichotomously branching 1—3 times to form a rather dense tuft (2′—4′ high) of vertical stems, densely clothed with spreading or reflexed leaves; leaves (3″—5″ × ½″) very slightly broadened above the middle and similarly contracted toward the base, those between the strobilar regions shorter (3″—4″), broadest at the base, but very gradually tapering, entire or very minutely denticulate; sporangia compressed reniform; sporophylls minutely denticulate above the middle or entire, acuminate; plant often gemmiparous. Sandstone rocks, Wisconsin, Indiana, Kentucky, and Alabama.

3. **L. lucidulum** Michx. Prostrate portion of stems longer (2′—6′), frequently rooting, curving upward, and dichotomously branching 1—3 times to form a loose cluster, 4′—8′ high, of a few densely leafy vertical stems, or the stems occasionally occur single; leaves reflexed, 4″—5″ × 1″ or less wide, linear-obovate, broadest above the middle, from which point they gradually taper to the ½″ wide base; margin erose denticulate above the middle, acute; sporophylls 2″—4″ long, linear, acute, entire, or sometimes slightly denticulate; sporangia depressed reniform; plant often gemmiparous. South Carolina to Newfoundland and Minnesota.

** *Plants with more or less extended horizontal stems; the sporophylls aggregated into terminal strobiles.*

† *Sporangia subglobose; sporophylls similar to the foliar leaves.*

‡ *Sporophylls short* (2″—3″).

4. **L. inundatum** L. Stems creeping horizontally or arching, about 4′ long, simple, or once or twice forking, slender, 1″ or less in diameter, roots produced toward the end of the annual growth; leaves linear-lanceolate, entire, acute, curved upward; those of the peduncles straight, entire, more slender, and tapering; peduncles 2″—3½′ long or the strobiles sessile; strobiles 4″—1½′ long; sporophylls triangular, usually entire, or sometimes toothed just above the base, then somewhat contracted; sporangia subglobose. Pennsylvania and Illinois, northward and westward to British Columbia and Alaska.

Var. **Bigelovii** Tuck. Plant larger and more abundantly branching, with more slender stems and slightly longer leaves, which are entire or toothed. New England to Nova Scotia.

5. **L. adpressum** (Chapm.) Lloyd & Underw. Stems prostrate and frequently rooting or slightly arching and rooting toward the end, 7′—16′ long, simple or occasionally pinnately branching, thick (about 1½″ in diameter); leaves thicker and more rigid than in the last, lanceolate-acuminate, upwardly curving, the margin irregularly toothed, the teeth often compound below the middle of the leaf; peduncles 4′—10′ long, usually tall, slender, leafy with more or less appressed subulate-toothed leaves below and similar entire leaves above; strobiles narrow, about 1½″ in diameter and ¾′—3′ long; sporophylls 3″ long with a broad base, suddenly contracted above into a narrow subulate apex, usually more or less toothed near the base; sporangia subglobose. Massachusetts to Florida and Louisiana.

‡ ‡ *Sporophylls longer* (4″—5″), *usually much-toothed.*

6. **L. pinnatum** (Chapm.) Lloyd & Underw. Stems pinnately branching, elongate (8′—12′) and very slender (½″—1″) with five gum canals, and evident dorsiventral character, no air-spaces; leaves (4″ × ½″) thin, linear-lanceolate, slightly curved, long-toothed, those of the upper side smaller, all somewhat contracted at the base; those of the peduncles similar but more gradually tapering to the apex; peduncles 10′—16′ long, slender, very leafy; strobiles 1′—5′ long, 2½″ thick, with spreading sporophylls, similar to the peduncular leaves, but longer

and more gradually tapering; sporangia subglobose. Georgia, Florida, Alabama, Mississippi.

7. **L. alopecuroides** L. Stems 20′ or more long, $1\frac{1}{8}''$—2″ thick, with an arching habit, rooting near the end, the vertical peduncles arising from the arches; air-spaces numerous, densely leafy; leaves $2\frac{1}{2}''$—$3\frac{1}{2}''$ long, thicker than in the last, lanceolate-acuminate spinulose on the sides of the stem to linear-lanceolate on the upper and lower side, margin long-toothed, the lower surface usually very hairy near the base; leaves of the peduncles similar; peduncles 8′—12′ long, densely leafy and scarcely distinguishable from the stems; strobiles 1′—4′ long, $2\frac{1}{2}''$ thick, when ripe with reflexed sporophylls similar to the peduncular leaves but not hairy on the under side, longer (5″—6″) and more gradually tapering. Long Island to Florida and Mississippi, mostly near the coast.

†† *Sporangia transversely compressed, reniform; sporophylls entirely unlike the foliar leaves.*

‡ *Leafy stems short, prostrate, leaves lying nearly in one plane, none beneath.*

8. **L. Carolinianum** L. Stems 6″—4′ long, slender, prostrate, pinnately branching, rooting occasionally from the under side; leaves strongly dimorphic, the apparently lateral ones large, ovate-lanceolate, falcate, recurved, broadest below the middle, with a midrib asymmetrically placed, thin, entire, acute; leaves of the upper side smaller, subulate with a broad base; leaves of the peduncles reduced to small subulate more or less appressed bracts; peduncles long, 2′—11′ long, slender with few usually whorled or scattered bracts; strobiles 6″—2′ long with sporophylls triangular or somewhat contracted above the base, entire or erose margins; sporangia subglobose. New Jersey to Florida and Mississippi.

‡ *Stems with abundant erect or ascending leafy branches.*

‖ *Aerial portions dendroid.*

9. **L. obscurum** L. (GROUND-PINE.) Horizontal stems extensively creeping underground, giving off single vertical stems which by repeatedly branching produce a bushy mass of foliage, 5′—10′ high; leaves spreading and upwardly curving,

linear-lanceolate and twisted especially above so as to lie in a vertical plane, acute, mucronate, on the lower branches in 8 rows, on the terminal in 6 rows; strobiles sessile; sporophylls broadly ovate, papery, and erose-margined, acuminate with a subulate apex; sporangia reniform. (*L. dendroideum* Michx.) North Carolina to Canada, Minnesota, Montana, and Alaska.

10. **L. cernuum** L. Stems 8′—14′ long, procumbent or arching, with clustered roots at points of contact with the ground, branching often in different planes, the terminal branchlets often strobile-bearing and nodding; leaves cylindric, slender, subulate, spreading, and upwardly curving; strobiles sessile, 2″—3″ long, nodding, with small sporophylls ovate-acuminate, thin, with deeply fringed margins; sporangia minute, spherical, transversely compressed. Mississippi, Alabama, and Florida near the coast.

‖ ‖ *Aerial portions trailing with clustered branches.*

A. *Leaves in 6—8 rows.*

11. **L. annotinum** L. Prostrate stems a yard or more long, extensively creeping along the surface, very rarely pinnately branching, stiff, rooting, leafy, with frequent aerial branches 6′—10′ tall, which fork 1—3 times or not at all, producing slender erect branches, which are usually strobile-bearing; leaves in 8 rows, uniform in shape throughout the plant, longest in the aerial parts, where they spread horizontally, or are finally somewhat reflexed with upwardly curving apices, lanceolate to linear-lanceolate, broadest at or above the middle, serrulate, acute, or pungent; strobiles sessile upon the leafy vertical branches, thick, with broadly ovate sporophylls, the latter with erose margins and subulate tips. The so-called var. *pungens* has stiffer, shorter, more erect leaves. Massachusetts and Pennsylvania, northward and westward to Colorado, Idaho, Washington, and Alaska.

12. **L. clavatum** L. (RUNNING-PINE.) Prostrate stems 3°—6° long, creeping extensively along the surface of the ground, very leafy, sparingly rooting, branching horizontally, with frequent aerial stems which are immediately ascending or at first prostrate, then ascending, producing pinnate branches of the second and third order, lax, some of them produc-

ing stout peduncles, 3′—5′ long, with subulate bristle-tipped bracts, producing 3—4 strobiles; leaves linear, acute, bristle-tipped, entire, or minutely denticulate, those of the horizontal stems strongly denticulate; sporophylls deltoid, erose subulate-tipped; sporangia reniform. Pennsylvania to Minnesota, Oregon, and northward.

B. *Leaves in five rows; stems slender.*

13. **L. Sitchense** Ruprecht. Prostrate stems, 8′—12′ long, on the surface or a little buried, sending up frequent aerial stems, which branch several (4—6) times to form compact masses of vertical terete branches, 2′—3′ high, with occasional stronger strobile-bearing branches; leaves lanceolate with a broad base, spreading and curving upward, thick, entire, acute, excurrent in five rows on the branchlets; peduncles short (less than 5″), very slender, with a few subulate bracts, or none, the strobiles then sessile upon strong leafy branches; sporophylls broadly ovate, erose, with long acuminate to subulate apices. Labrador to New York, Idaho, Washington to Alaska.

C. *Leaves in four rows on flattened dorsiventral stems.*

1. *Branches convex on both sides; leaves all alike.*

14. **L. sabinæfolium** Willd. Prostrate stems creeping along the surface, with numerous aerial stems which soon branch 3—4 or 5 times to form a loose clump of erect (or straggling) dorsiventral branches; leaves subulate, slightly spreading, curved upwards, with thin apices, in four rows on the flattened terminal and subterminal branchlets, those of the lateral rows thicker and more curved than those of the upper and lower rows; peduncles (5″—2′ long), on stronger terete branches, their subulate bracts whorled or scattered; strobiles 1′ long, with broadly ovate sporophylls with short acute apices; sporangia reniform. Northern New England, Ontario, and Prince Edward's Island.

2. *Branches with under surface flat or concave.*

15. **L. complanatum** L. Rhizomes extensively creeping along the surface, the branches spreading out horizontally, forming fan-shaped tufts; leaves in four rows, those of the upper and lateral rows, cuspidate, with spreading apices,

bright green, those of the under row reduced to spreading cuspidate apices; peduncles usually forking twice, the second forking 1″—2″ from the first; strobiles 7″—12″ long; spores ripening late in August or in September. Canada to Maryland and northwestward to Washington and Alaska.

16. **L. chamæcyparissus** A. Br. Rhizomes creeping below the surface; primary shoots weak, often becoming decumbent, the axis repeatedly forking, regularly producing innovations the second season; leaves in four rows, all much alike, those of the lateral rows somewhat incurved beneath, glaucous green; peduncles usually twice forked, the second forking 4″—9′ from the first, spreading and curving upward; strobiles 2, 3, or usually 4, 10″—14″ long; spores ripening early in August. Maine to Georgia, Minnesota.

17. **L. alpinum** L. Prostrate stems 8′—20′, on or near the surface; aerial stems numerous and branching several times to form dense clumps 2′—3′ of markedly dorsiventral branches with glaucous foliage; occasional strobile-bearing branches (peduncles) thicker, terete, and usually projecting above the general mass; leaves of the peduncles subulate, those of the purely vegetative branches trimorphic, those of the upper row narrowly ovate, acute, those of the lateral rows thick, with one nerve asymmetrically placed, truncate, acute, falcate, curved toward the under side, those of the under row trowel-shaped; strobiles sessile, 5″—10″ long, with ovate acute sporophylls; sporangia reniform. British Columbia, Alaska, Greenland.

XI. PSILOTUM R. Br.

Perennial plants, terrestrial or growing on trees. Stems dichotomously branched with minute alternate leaves, or apparently leafless. Sporangia sessile, 3-celled, opening at the apex into 2–3 valves. Spores farinaceous, oval, or elongate-reniform. Name from Gr. *ψίλος*, naked, alluding to the abortive leaves. Contains four species, mostly tropical.

1. **P. nudum** (L.) Griseb. Stems erect, 8′—10′ high, triquetrous at base, many times forked at apex; ultimate divisions triquetrous-winged; leaves remote, awl-shaped, less than 1″ long; sporangia in spikes. (*P. Floridianum* Michx., *P. triquetrum* Swz., *Lycopodium nudum* L.) South Florida; Bluffton, South Carolina (Mellichamp).

Family 2. SELAGINELLACEÆ.

Plant-body leafy, terrestrial, moss-like, with branching stems and minute scale-like leaves. Sporangia one-celled, solitary, axillary, some containing microspores, and others macrospores. Contains a single genus largely tropical.

I. SELAGINELLA Beauv.

Fructification arranged in spikes. Sporangia minute, subglobose, opening transversely; some containing usually 4 globose macrospores, and others smaller, filled with numerous microspores. Leaves 4—many ranked. Name a diminutive of *Selago*, an ancient name of some species of *Lycopodium*, which this genus resembles. Contains about 335 species widely distributed; seven are found within our limits.

§ 1. EUSELAGINELLA. *Stem leaves of one kind, many-ranked; bracts uniform.*

* *Stems spreading or creeping.*

† *Stems 1′—4′ long.*

‡ *Stems rooting at base only.*

1. **S. selaginoides** (L.) Link. Sterile stems prostrate-creeping, small and slender; fertile stems thicker, ascending, simple, 1′—3′ high; leaves lanceolate, acute, spreading, sparsely spinulose-ciliate; bracts lax, ascending, lanceolate or ovate-lanceolate, strongly ciliate. (*S. spinosa* Beauv., *Lycopodium selaginoides* L., *L. ciliatum* Lam.) New Hampshire to Colorado and northward to Greenland.

‡ *Stems sending out roots their entire length.*

‖ *Leaves ending in a conspicuous white awn.*

2. **S. rupestris** (L.) Spring. Stems creeping, 2′—4′ long, more or less flexuous, the apices ascending, subsecund, abundantly emitting roots throughout their entire length; primary branches mostly short with 3—6 shorter secondary ones; leaves closely imbricate, about 8-ranked, spreading at the apex of sterile stems, narrowly lanceolate, one sixth of a line wide, deeply channeled dorsally, ending in a subflexuous spinulose white awn nearly $\frac{1}{2}''$ long; margins each with 6—9 slender cilia; spikes

sharply quadrangular, 5″—8″ long, about ½″ in diameter; bracts similar in texture to the leaves but broader at the base, with a shorter and stouter terminal awn and usually with more cilia on the margin. New England and Ontario, southward to Alabama and westward to California and British Columbia.

Var. **Fendleri** Underw. Differs from the Eastern forms of the species in its lax, less crowded leaves, which are tipped with a shorter white awn and their margins with short denticulate cilia; the spikes are flabby and flexuous and the macrospores are more coarsely areolate. Colorado and New Mexico.

3. **S. densa** Rydberg. Densely tufted; sterile branches very short, crowded, and generally incurved; leaves densely crowded, many-ranked, 1½″—2½″ long, linear or needle-shaped in age, slightly flattened and grooved dorsally, the margin ciliate, tipped with a white bristle nearly 1″ long; fertile branches erect, ½′—¾′ long; bracts imbricated, thick, triangular-ovate, deeply grooved dorsally, ciliate on the margin and tipped with a white bristle half as long as that of the leaves. Western Nebraska to Montana and southward in the mountains.

4. **S. bryoides** (Nutt.) Underw. Stems very slender, prostrate, rooting the entire length, with short lateral branches, ultimately forming a dense tuft; leaves appressed, rigid, cinereous, slightly grooved, with 6—8 minute divergent or erect spines on either side; spike short, twice the diameter of the stem, with broadly ovate, acute scales; macrospores pale lemon-colored, the lower portions with reticulate rope-like ridges, the upper surfaces papillose; microspores usually on distinct spikes, dark orange, with prominent spinules. (*S. cinerascens* A. A. Eaton, *Lycopodium bryoides* Nutt.) Southern California.

‖ ‖ *Leaves blunt or ending in a minute green point.*

5. **S. Watsoni** Underw. Stems short, 1½′—2½′ long, creeping, sparingly short-branched, rooting throughout the entire length; leaves rather short, stout, deeply channeled dorsally, ending abruptly in a short, stout, smooth, mostly curved green awn, 0.25—0.35 mm. long; margins with few cilia or none, when present not exceeding 0.07 mm. in length; spikes ½′—1′ long, sharply quadrangular, the bracts broader at base, lanceolate-ovate to ovate, with shorter and stouter awns. High mountains of Utah, Nevada, and California.

6. **S. mutica** D. C. Eaton. Stems creeping, rather rigid, 3′—6′ long, divided and pinnately branched; leaves glaucescent, six-ranked, closely imbricated, half a line long, oblong-ovate, convex, and slightly grooved on the back, obtuse, and without a terminal seta, the margins ciliated with 10—15 spreading cilia on each side, which are 0.12 mm. long or longer; spikes scarcely thicker than the branches, quadrangular, the bracts broader than the leaves and pointed or even obscurely mucronate. Colorado, New Mexico, and Arizona.

†† *Stems spreading, 8′—12′ long, rooting only at the base.*

7. **S. tortipila** A. Br. Stems 8′—12′ long, more or less flexuous, with the elongate primary branches compound, rooting only near the base; leaves loosely imbricate, about six-ranked, narrowly lanceolate, scarcely channeled dorsally, ending in a contorted or irregularly coiled elongate hair-point; margins with 6—12 very short cilia on either side; spikes very short (2″—2½″), borne at the ends of ordinary branches, subquadrangular, but with loosely spreading broadly ovate-lanceolate bracts, which are dorsally channeled and bear marginal cilia and terminal hairs similar to those of the stem-leaves. Broad River, North Carolina (*Rugel*), Cæsar's Head, South Carolina (*J. D. Smith*).

** *Stems pendent, flaccid.*

8. **S. struthioloides** (Presl.) Underw. 1°—6° long, pinnately much branched; leaves loosely imbricate, scarcely 1″ long, linear-lanceolate, convex and grooved on the back, acute, sparsely spinulose-denticulate, not bristle-tipped; spikes quadrangular, very slender; macrosporangia scarce. (*S. Oregana* D. C. Eaton, *Lycopodium* Presl.) Port Orford, Oregon (*Kautz*); Tilamook Valley, Oregon (*Howell*); probably in Northern California.

** *Stems erect or ascending.*

† *Spikes ¾′—1½′ long; plant rooting in sand.*

9. **S. arenicola** Underw. Deeply rooting in sand with fine copious roots, often 6′—8′ long; stems slender, branching, erect or ascending, densely cæspitose, 2′—3′ high, emitting copious brown wiry roots a little distance above the base; leaves closely appressed, narrowly lanceolate, 0.25 mm. wide,

deeply channeled dorsally, terminated by a spinulose white awn 0.35—0.50 mm. long; margins with numerous short cilia; spikes 2—3 cm. long, slender, sharply quadrangular, the bracts broadly lanceolate, spreading at maturity with copious marginal cilia (15—20 on either side); microspores very abundant throughout the length of the spike, globose-tetrahedral, 0.036—0.039 mm. in diameter, bright yellow or pale orange. (*S. arenaria* Underw., not Baker.) In sand, Florida, Texas?

†† *Spikes ½′ or less long; plants growing on rocks.*

10. **S. rupincola** Underw. Stems suberect, somewhat flexuous, 3′—5′ high, rooting only from near the base, pinnately branching, the secondary branches mostly very short; leaves channeled dorsally, closely imbricate, spreading only near the growing tips of the stem, glaucous or cinereous green, tapering toward the apex and ending in a long white denticulate spine 1 mm. or more long; margins strikingly long-ciliate, 15—20 on either side; spikes ½′ or less long, borne laterally on the branches, scarcely quadrangular, the bracts closely resembling the ordinary stem-leaves, so as to render the spikes scarcely distinguishable except for the axillary sporangia; macrospores dark-yellow, 0.24—0.27 mm. in diameter, strongly and deeply pitted reticulate. New Mexico and Arizona.

11. **S. Bigelovii** Underw. Stems slender, 4′—8′ long, mostly ascending, flexuous, usually with short ascending primary branches; secondary branches infrequent and mostly very short; stems rooting only near the base; leaves about six-ranked, appressed-imbricate, usually with a distinct dorsal channel, narrowly lanceolate, tapering gradually into a densely spinulose white awn often 0.7 mm. long; margins with 12—15 cilia on either side, which are directed forward and usually less than 0.050 mm. long; spikes obtusely quadrangular, mostly on short lateral branches 5 mm. or less long, the bracts short, broadly ovate but otherwise like the leaves. Southern California.

‡ 2. STACHYGYNANDRUM Baker. *Stem leaves of two kinds, spreading in two planes, those of the upper plane smaller and more ascending; bracts uniform.*

* *Main stems decumbent; root fibres extending to upper nodes.*

† *Stems persistent; leaves rigid, firm in texture.*

12. **S. Douglasii** (H. & G.) Spring. Stems 3′—12′ long, branches 2′—6′ long, bi—tripinnately divided; leaves of lower plane 1″ long, obliquely oval, obtuse, faintly nerved; leaves of upper plane half as long, oval, incurved, ending in a short point, both sparingly ciliate at base; spikes 6″—12″ long, quadrangular, terminal; bracts deltoid-cuspidate, strongly imbricate. (*Lycopodium Douglasii* H. & G., *L. ovalifolium* H. & G.) Northern California to British Columbia.

†† *Stems mostly annual, fugacious; leaves mostly membranous, flaccid.*

13. **S. apus** (L.) Spring. Stems 1′—4′ long, slender, angled on the face, prostrate, creeping, much-branched, flaccid; leaves of the lower plane spreading above, the lower reflexed, ovate, acute, serrulate, not distinctly ciliate; leaves of the upper plane ovate, shortly cuspidate; spikes 3″—6″ long; bracts ovate, acute, membranous, strongly serrulate, acutely keeled in the upper half. Canada and New England to Rocky Mountains, and southward to Florida and Texas.

14. **S. Ludoviciana** A. Br. Stems slender, copiously pinnate, flat both sides, 4′—6′ long, lower branches slightly compound; leaves of lower plane rather distant except at tips of branches, spreading, ovate-oblong, sub-acute, firmer in texture than in preceding, serrulate, not distinctly ciliate; leaves of upper plane half as long, obliquely oblong, cuspidate; spikes 3″—6″ long; bracts ovate-lanceolate, strongly keeled. (*S. apus*, var. *denticulata* Spring, where it may belong, the differences possibly due to climatic conditions.) Covington, Louisiana (*Drummond*); Aspalaga, Florida (*Curtiss*, No. 3799 in part).

** *Stems densely tufted, rolling into a nest-like ball when dry; roots confined to base of stems.*

15. **S. lepidophylla** Spring. Stems 2′—4′ long, densely tufted, pinnately branched to the base, the pinnæ ascending, sub-flabellately compound; leaves of the lower plane closely imbricate, ascending, obliquely ovate, obtuse, thick, rigid, minutely ciliate, green above, paler below, becoming reddish-brown in age; leaves of upper plane nearly as long, obliquely ovate, obtuse; spikes 3″—6″ long, quadrangular; bracts deltoid, acutely keeled. Texas to Arizona.

16. **S. Pringlei** Baker. Outer stems 3′—4′ long, the inner gradually shorter, flabellately branched, light green above, pale below; branchlets close, 1″—2″ wide; leaves of the lower plane crowded, oblong, about 1′ long, including the conspicuous horny white awn; leaves of upper plane slightly smaller, somewhat oblique; spikes short with uniform bracts. Chenate Mountains, Texas (*Nealley*).

S. pilifera A. Br. is reported by Mr. Baker from Texas, but it has not been found there recently.

Family 3. ISOETACEÆ.

Plant-body consisting of a bilobed or trilobed trunk emitting dense tufts of roots, and sending up a compact rosette of rush-like leaves, submerged, amphibious or sometimes growing in moist soil. Sporangia sessile in the axils of the leaves, some containing macrospores and others microspores. Contains a single genus widely distributed.

I. ISOETES L. QUILLWORT.

Stem or trunk a more or less depressed, fleshy corm, rooting just above its bilobed or trilobed base, covered above with the dilated and imbricated bases of the awl-shaped or linear leaves. Sporangia large, orbicular or ovoid, plano-convex, very thin, sessile in the axils of the leaves and united at the back with their excavated bases; those of the outer leaves filled with spherical macrospores; those of the inner leaves filled with minute and powdery, grayish, obliquely oblong and triangular microspores. Name from Gr. ισος, equal, and ετος, year. Contains about 50 species, of which sixteen are found within our limits.

NOTE.—The measurements of the spores are given in millimetres; mm. = .03937 inch.

§ 1. *Submerged, rarely above water in driest seasons; leaves quadrangular without peripheral bast-bundles; velum incomplete.*

* *Stomata absent.*

1. **I. lacustris** L. Leaves 10—25, stout, rather rigid, obtusely quadrangular, acute but scarcely tapering, dark or olive-

green, 2′—6′ long; sporangia orbicular—broadly-elliptic, with a narrow velum; ligula triangular, short or somewhat elongate; macrospores 0.50—0.80 mm. in diameter, marked all over with distinct or somewhat confluent crests; microspores smooth, 0.035—0.046 mm. long. Var. *paupercula* Engelm. has fewer, thinner and shorter leaves and smaller spores, the microspores somewhat granulate, 0.026—0.036 mm. long. (*I. macrospora* Durieu.) Catskill Mountains, New York (*Schweinitz*), Echo Lake, New Hampshire (*Tuckerman*), Fresh Pond, near Cambridge, Massachusetts (*W. Boott*), Uxbridge, Massachusetts (*Robbins*), Brattleborough, Vermont (*Frost*), Lake Superior (*Porter*). The variety from Grand Lake, Middle Park, Colorado (*Engelmann*) and Castle Lake near Mt. Shasta, California (*Pringle*).

2. I. pygmæa Engelm. Leaves 5—10, stout, rigid, bright-green, ½′—1′ long, abruptly tapering to a fine point, with very short often almost square epidermal cells; sporangia orbicular with a narrow velum; macrospores 0.36—0.50 mm. thick, marked with minute, rather regular, distinct or rarely confluent warts; microspores brown, almost smooth, 0.024—0.029 mm. long. Mono Pass, California (*Bolander*).

3. I. Tuckermani A. Br. Leaves 10—30, very slender, tapering, olive-green, 2′—3′ long, the outer recurved; sporangia mostly oblong, white or rarely brown-spotted, the upper third covered by the velum; macrospores 0.44—0.56 mm. thick, the upper segments marked with prominent, somewhat parallel and branching ridges, the lower half reticulate; microspores smooth or nearly so, 0.026—0.032 mm. long. Mystic River, Mystic, Spy, and Horn Ponds, near Boston, Massachusetts.

** *Stomata present.*

4. I. Macounii A. A. Eaton. Leaves 5—12, 1′—2′ long, stout, acuminate, with occasional stomata near the apices, reddish green; basal wings wide; ligula triangular-lanceolate; sporangia orbicular, 1″—1½″ in diameter, one-fourth to three-fourths covered by the velum, thickly pale-spotted; macrospores 0.3—0.57 mm., sparsely covered with very stout, short, blunt, or confluent spinules, which become small papillæ near the equator and on the upper half appear on the commissures; microspores elliptical, 0.035 by 0.027 mm., or sometimes slightly

larger, finely and densely papillose, or rarely blunt tuberculate. Pools on an extinct volcano, Atka Island, lat. 52° N., long. 175° W. (*Macoun*).

5. **I. echinospora** Durieu, *var.* **Braunii** (Dur.) Engelm. Leaves 13—15, erect or spreading, tapering, green or reddish-green, 3′—6′ long, generally with few stomata toward the tip only; sporangia orbicular—broadly-elliptic, spotted, ½ to ¾ covered by the broad velum; macrospores 0.40—0.50 mm. thick, covered with broad, retuse spinules, sometimes somewhat confluent and then dentate and incised at the tip; microspores 0.026—0.030 mm. long, smooth. (*I. Braunii* Durieu.) Nova Scotia, New England, New York, New Jersey, Pennsylvania, Ontario, Michigan (*Gillman*), Head of Bear River, Utah (*Watson*), Greenland (*Vahl*).

Var. **robusta** Engelm. Stouter; leaves 25—70, 5′—8′ long, with abundant stomata all over their surface; velum covering one half of the large, spotted sporangia; macrospores 0.36—0.55 mm. thick. Lake Champlain, north end of Isle La Motte (*Pringle*).

Var. **Boottii** (A. Br.) Engelm. Leaves 12—20, erect, bright-green, 4′—5′ long, with few stomata mostly near the tip; sporangia nearly orbicular, pale-spotted, ⅔ or more covered by the broad velum; macrospores 0.39—0.50 mm. thick, with longer, more slender and delicate, generally simple spinules; microspores 0.026—0.030 mm. long. (*I. Boottii* A. Br.) Round Pond, Woburn, and in brook in Tofit Swamp, Lexington, Massachusetts (*Boott*).

Var. **muricata** (Dur.) Engelm. Leaves 15—20, flaccid, green, 6′—12′ long, with very few stomata; sporangia broadly oval, pale-spotted, about half covered by the velum; macrospores 0.40—0.58 mm. thick, with shorter and more confluent, sometimes almost crest-like spinules; microspores 0.028—0.032 mm. long, slightly rough on the edges. (*I. muricata* Durieu.) Woburn Creek and Abajona river near Boston, Massachusetts (*Boott*).

6. **I. Bolanderi** Engelm. Leaves 5—25, erect, soft, bright-green, tapering to a fine point, 2′—4½′ long, with thin walls and generally few stomata; sporangia broadly oblong, mostly unspotted, with a narrow velum; ligula triangular; macrospores

0.30—0.45 mm. thick, marked with minute low tubercles, rarely confluent into wrinkles; microspores deep-brown, 0.026—0.031 mm. long, spinulose, rarely smooth. (*I. Californica* Engelm.) Western Colorado (*Brandegee*), Utah, California, to Washington.

§ 2. *Amphibious, partially emerged; stomata always present.*

* *Peripheral bast-bundles absent.*

† *Velum partial.*

7. **I. saccharata** Engelm. Trunk usually flat, depressed; leaves 10—20, awl-shaped, spreading, olive-green, 2′—3′ long; sporangia oblong, spotted, with a narrow velum; ligula triangular; macrospores 0.40—0.47 mm. thick, covered with very minute, distinct warts, which are sometimes a little confluent; microspores papillose, 0.024—0 028 mm. long. Banks of Wicomico river, below Salisbury, and of Nanticoke river, Eastern Maryland (*Canby*).

8. **I. riparia** Engelm. Leaves 15—30, slender, rather rigid, deep-green, 4′—8′ long, with numerous stomata; sporangia mostly oblong, distinctly brown-spotted, $\frac{1}{4}$ or $\frac{1}{3}$ covered by the velum; macrospores 0.45—0.65 mm. thick, marked with isolated or anastomosing, jagged crests; microspores more or less tuberculate, 0.028—0.032 mm. long. Banks of Delaware River from Burlington to Wilmington, Delaware; Uxbridge, Massachusetts (*Robbins*); Brattleborough, Vermont (*Frost*); Maine (*Chickering*); Crow River, Hastings County, Ontario (*Macoun*).

†† *Velum complete.*

9. **I. melanospora** Engelm. Trunk flat, only slightly bilobed; leaves 5—10, distichous, slender, tapering, light-green, 2′—2$\frac{1}{2}$′ long; sporangia orbicular or almost obcordate, $\frac{1}{2}$″—1″ long, entirely covered by the velum; ligula short triangular, obtuse; macrospores 0.35—0.45 mm. long, roughened with distinct or rarely somewhat confluent warts, dark-colored; microspores smoothish or slightly papillose, 0.028—0.031 mm. long. In shallow excavations in granite rock, Stone Mountain, Georgia (*Canby*).

** *Peripheral bast-bundles present.*

† *Velum partial or entirely wanting.*

10. **I. foveolata** A. A. Eaton. Amphibious from a bilobed

or rarely trilobed base; leaves 15—70, stout, 2′—6′ long, pinkish even when dry or rarely dark green; stomata scattered found only near the tips; no peripheral bast-bundles; monœcious or becoming dicœcious; velum covering one-fourth or one-third of the sporange; ligule round-ovate; sporanges thickly sprinkled with dark cells which are often collected in groups; macrospores 0.380—0.560 mm. in diameter, covered beneath with very thick-walled reticulations, the openings appearing like little pits; reticulations elongate on the upper surface of the spore; microspores dark brown, 0.022—0.035 mm. long, densely reticulate and usually slightly papillose. In muddy banks of the Pautuckaway River, Epping, and East Kingston, New Hampshire.

11. **I. Eatoni** Dodge. Amphibious from a large trunk 1′—4′ in diameter. Leaves of the submerged plant 20—200, varying in length up to 28′, marked with an elevated ridge on the ventral side; leaves of the emersed plant shorter, 3′—6′ long, stomata abundant; peripheral bast-bundles irregular in occurrence or often wanting; velum covering one-fourth of the sporange; polygamous; sporanges large, 10 by 4 mm., pale, spotted; macrospores small, 0.3—0.4 mm. in diameter, marked with convolute labyrinthine ridges and cristate on the angles of the inner face; microspores 0.025—0.030 mm. in diameter, smooth or slightly papillose. In mud flats, East Kingston and Epping, New Hampshire.

12. **I. Dodgei** A. A. Eaton. Plant amphibious from a 2-lobed trunk. Leaves 10—75, 8′—18′ long, when submersed, erect or spirally ascending when scattered; emersed leaves 4′—6′ long, tortuous and often interlaced, with numerous stomata and usually four bast-bundles; velum narrow, covering from one-fifth to one-fourth of the sporange; sporanges thickly sprinkled with dark brown cells; macrospores more numerous on submersed plants, globose 0.5—0.675 mm. in diameter, sparsely covered with irregular crests which at maturity separate into irregular groups leaving bare spaces, serrate or spinulose at the top; microspores more numerous on emersed plants, 0.022—0.040 mm. in diameter, ashy, papillose. In mud flats, East Kingston, New Hampshire; Pennsylvania.

13. **I. Engelmanni** A. Br. Leaves 25—100, light-green,

9′—20′ or more long, with abundant stomata; sporangia oblong—linear-oblong, unspotted, with a narrow velum; ligula elongate from a triangular base; macrospores 0.40—0.52 mm. thick, delicately honeycomb-reticulated; microspores usually smooth, 0.024—0.028 mm. long. Var. *Georgiana* Engelm. has fewer leaves and larger (0.48—0.56 mm. thick) macrospores. New England and New York, Missouri and Illinois; the variety in Horseleg Creek, Floyd County, Georgia (*Canby*).

Var. **gracilis** Engelm. Leaves 8—12, often submerged, 9′—12′ long, the bast bundles often quite small or only two present. New England; Passaic River, New Jersey (*Ennis*).

Var. **valida** Engelm. Leaves 50—200, keeled on the upper side, 18′—25′ long; sporangia often linear-oblong 4″—9″ long, $\frac{1}{3}$ to $\frac{2}{3}$ covered by the broad velum; macrospores 0.32—0.48 mm. thick; microspores spinulose, 0.024—0.027 mm. long. Warrior's Mark and Smithville, Pennsylvania (*Porter*); Wilmington, Delaware (*Canby*).

14. **I. Howellii** Engelm. Leaves 6—30 or even 50, 2′—8′ long, with numerous stomata and four bast bundles; velum variable, usually narrow in outer leaves, narrowly oblong on inner leaves, usually densely spotted, and shining dark brown or black; sheath fuscous brown, deeply grooved; ligula vary from short triangular to 2″ long; macrospores 0.48 mm. in diameter, covered rather sparingly with low blunt isolated or confluent crests; microspores 0.02—0.03 mm. in diameter, light-brown, covered with low blunt tubercles or spines. (*I. nuda* Engelm., *I. Underwoodii* Henderson.) Dalles of the Columbia, Oregon (*Howell*) to western Idaho (*Henderson*).

†† *Velum complete.*

15. **I. flaccida** Shuttleworth. Leaves 10—35, light-green, 15′—2° long, submerged, floating on the surface or wholly emerged; sporangia oval, 2″—3″ long, entirely covered by the velum; macrospores 0.30—0.42 mm. thick, covered with many or rarely few, large flattish tubercles, distinct or confluent into labyrinthiform wrinkles. Var. *rigida* Engelm. is smaller, with more slender, erect, dark-green leaves, 5′—6′ long. Lake Immonia, near Tallahassee, Florida (*Rugel*); also near Manatee, Florida (*Garber*). The variety at Lake Flirt, Florida (*Garber*).

Var. **Chapmani** Engelm. Leaves about 30, floating, 18' long; sporangia orbicular; macrospores 0.44—0.55 mm. thick, almost smooth on the upper side; microspores slightly papillose, 0.027—0.030 mm. long. Near Mariana, Florida (*Chapman*).

§ 3. *Terrestrial; leaves nearly triangular, with abundant stomata and peripheral bast-bundles, thick dissepiments and small air-cavities.*

* *Trunk bilobed; velum partial or almost wanting.*

16. **I. melanopoda** J. Gay. Polygamous; trunk sub-globose, deeply bilobed; leaves 15—60, slender, stiff, erect, bright-green, usually black at base, 5'—10' or more long; sporangia mostly oblong, 2''—5'' long, spotted, with a narrow velum; ligula triangular-awl-shaped; macrospores 0.25—0.40 mm. thick, with depressed tubercles often confluent into worm-like wrinkles, or almost smooth; microspores spinulose, 0.023—0.028 mm. long. Var. *pallida* Engelm. is larger, with pale leaf-bases and broader velum. Ringwood and Athens, Illinois (*Hall*); Clinton, Iowa (*Vasey*); Limestone Gap, Indian Territory (*Butler*). The variety at Houston, Texas (*Hall*).

17. **I. maritima** Unde. Monœcious; trunk small, only slightly bilobed; leaves 8—15, rigid, green, 1'—2' long, $\frac{1}{2}$''—$\frac{2}{3}$'' wide; sporangia oval, 2'' long, $1\frac{1}{4}$'' wide, brownish white, one third to one half covered by the velum; ligula small; macrospores 0.42—0.48 mm. thick, densely spinulose, the spines blunt, rarely confluent; microspores smooth, white, 0.32—0.35 mm. thick. In salt marsh, Alberni, Vancouver Island (*Macoun*).

18. **I. Butleri** Engelm. Dicœcious; trunk sub-globose; leaves 8—12, rigid, bright-green, 3'—7' long; sporangia usually oblong, spotted, with a very narrow velum or none; ligula awl-shaped from a triangular base; macrospores 0.50—0.63 mm. thick, marked with knobs or warts, distinct or sometimes confluent; microspores papillose, dark-brown, 0.028—0.038 mm. long. Var. *immaculata* Engelm. is larger, with unspotted sporangia, and spinulose microspores, the macrospores 0.40—0.56 mm. In saline flats, near Limestone Gap, Indian Territory

** *Trunk trilobed; velum nearly or quite complete.*

19. **I. Nuttallii** A. Br. Trunk almost globose, slightly grooved; leaves 20—60, slender, bright-green, 3′—9′ long, with only three peripheral bast bundles; sporangia oblong or oval, entirely covered by the velum; macrospores variable, 0.25—0.50 mm. thick, densely covered with minute but rounded warts, or rarely almost smooth; microspores papillose, brown, 0.025—0.028 mm. long. (*I. opaca* Nutt., *I. Suksdorfii* Baker.) Oregon, Washington; western Idaho (*Geyer*). Vancouver Island (*Macoun*); California (*Brandegee*).

20. **I. Orcutti** A. A. Eaton. Trunk slightly trilobed, globose; leaves 6—15, 2′—4′ long, 3″—3½″ broad, triangular, slightly winged at base, with two weak bast bundles and rarely with lateral ones; velum entire; ligula lunate or semicircular; macrospores very small, 0.24—0.32 mm. in diameter fuscous when wet, cinereous or glaucous when dry, polished, the surface finely pitted as with pin points; microspores dark-brown, 0.022—0.035 mm. long, spinulose. On mesas at San Diego, California (*Orcutt*).

21. **I. minima** A. A. Eaton. Trunk trilobed, 1½″—2″ wide, 1″—1½″ high; leaves 6—12, ¾′—1½′ long, slender, with four peripheral bast bundles; sporangia unspotted, 2″ long; velum ⅜—¾ covering the sporangium; macrospores globose, 0.29—0.35 mm. in diameter, covered with short, slender blunt spinules, the equatorial commissure pectinate with polished spinules; microspores papillose or sparingly spinulose, white, 0.026—0.031 mm. long. In damp places, Waverly, Spokane County, Washington (*Suksdorf*).

ABBREVIATIONS.

ADANS.....M. Adanson.
AIT.....W. Aiton.
ANGS.....J. Angstrœm.
BEAUV.....P. de Beauvais.
BERNH.....J. J. Bernhardi.
BIGEL.....J. Bigelow.
BRACK.....W. D. Brackenridge.
A. BR .....,..A. Braun.
R. BR.....R. Brown.
BONG.....Bongard.
BRONG.....A. Brongniart.
CAV.....A. J. Cavanilles.
CHAPM.....A. W. Chapman.
DAV.....G. E. Davenport.
DC.....A. P. DeCandolle.
DESF.....R. L. Desfontaines.
DESV.....N. A. Desvaux.
EHRH.....F. Ehrhart.
ENDL.....S. L. Endlicher
ENGELM.....G. Engelmann.
H. & A.....Hooker and Arnott.
H. & G.....Hooker and Greville.
HBK..Humboldt, Bonpland and Kunth.
HITCH.....E. Hitchcock.
HOFFM.....G. F. Hoffman.
HOOK .....W. J. Hooker.
HUDS.....W. Hudson.
HUMB.....Baron von Humboldt
JUSS.....A. L. Jussieu
KAULF.....G. F. Kaulfuss.
KOCH.....W. D. Koch.
KUHL.....Kuhlewein.
L.....C. von Linne [Linnæus].
LAM.....J. B. de Lamarck.
L'HER.....C. L. L'Heritier.
LIEBM.....F. Liebmann.
LINDL.....J. Lindley.
LINN. F.....C. Linnæus (son).
MART. & GALE...Martens and Galeotti.
METT.....G. Mettenius.
MICHX .....A. Michaux.
MUHL.....G. H. E. Muhlenberg.
NECK.....N. J. Necker.
NUTT.....T. Nuttall.
PLUM.....C. Plumier.
REICHENB.....H. G. L. Reichenbach.
RICH.....C. L. M. Richard.
SCHLEICH..... Schleicher.
SCHREB.....J. C. D. Schreber.
SM.....J. E. Smith.
J. SM .....J. Smith.
SPRENG..... K. Sprengel.
SWZ..... O. Swartz.
THUNB..... C. P. Thunberg.
TORR..... J. Torrey.
TUCKERM .....E. Tuckerman.
UNDE.....L. M. Underwood.
VAILL..... S. Vaillant.
VENT.....E. P. Ventenat.
WALL..... N. Wallich.
WALLR..... F. W. Wallroth.
WALT.....T. Walter.
WILLD.....K. L. Willdenow.

Gr..... Greek.
Lat..... Latin.
cm.....centimetre.
mm.....millimetre.
var.....variety.
•..... feet.
′..... inches.
″..... lines.

GLOSSARY AND INDEX.

M

N

O

P

Q

R

S

Sessile (Lat. *sedere*, to sit), without a stalk or petiole.

Setiform (Lat. *seta*, a bristle, and *forma*, form), bristle-like.

Shield-fern. *V.* **Dryopteris.**

Sigillariaceæ, 63.

Sinuate (Lat. *sinus*, a bending), having the margin alternately bending inward and outward.

Sinus (Lat. a bending), a recess or bay; the re-entering space between two lobes.

Sorus (plu. *sori*) (Gr. σωρός, a heap or cluster), the clusters of fruit in the POLYPODIACEÆ.

Spatulate (Lat. *spatula*, a little spoon), shaped like a spatula.

Species, 44.

Specific Names, 41.

Spermaphytes (Gr. σπέρμα, a seed, and φυτόν, a plant), 10, 20, 50.—Literature of, 59.

Spinulose (Lat. *spina*, a thorn), thorny.

Spleenwort. *Vide* **Asplenium.**

Sporangium (plu. *sporangia*) (Gr. σπορός, a seed, and ἄγγος, a vessel), the case or capsule enclosing the spores, 10.

Spore (Gr. σπορός, seed), the fruit of the higher cryptogams, produced asexually, 10, 18.

Sporocarp (Gr. σπορός, seed, and καρπός, fruit), the fruit-bearing receptacle in *Marsilia*, etc.

Squamous (Lat. *squama*, a scale), with appressed scales.

Stellate (Lat. *stella*, a star), star-shaped.

Stipe (Lat. *stipes*, a stock), the stem of a frond, 8, 25.

Stoma (plu. *stomata*) (Gr. a mouth), the breathing pores of plants, 26, 33.

Stramineous (Lat. *stramen*, straw), straw-colored.

Struthiopteris, 101; also 2, 14, 81.

Sub- (as a prefix), about, nearly, somewhat.

Subulate (Lat. *subula*, a shoe maker's awl), awl-shaped.

Superior, higher, applied to indusia that are attached above the sorus as in *Dryopteris*.

Synonymy, 44.

T

Tænitis. *Vide* **Cheilogramma.**

Tectaria, 118; also 16, 80.

Ternate (Lat. *terni*, three each), branching into three nearly equal divisions.

Tertiary Age, Pteridophytes of, 63.

Thallophytes (Gr. θαλλός, a young shoot, and φυτόν, a plant), a group of plants including the lichens, fungi, and algæ, 50.

Thalloid (Gr. θαλλός, a young shoot, and εἶδος, form), having the form of a thallus, *i. e.*, no leafy axis.

Thalloid Phase, 19.

Tissues, 24.

Tissue Systems, 25.

Tomentose (Lat. *tomentum*, a stuffing of wool), covered with matted woolly hairs.

Tomentum (Lat. a stuffing of wool), the dense matted woolly hair found on some ferns as many species of *Cheilanthes*.

Tri- (Lat. *tris*, three), (as a prefix) three, thrice.

Trichomanes, 74; also 6, 11, 17.

Trichomes (Gr. θρίξ, hair), hairs, variously modified as scales, indusia, sporangia, etc., produced from the epidermal cells, 26.

Triquetrous (Lat. *triquetrus*), three-angled.

Truncate (Lat. *truncare*, to cut short), cut off abruptly.

Tufted, growing in clusters.

U

Undulate (Lat. *undula*, a little wave), wavy-margined.

V

W.