AN

INTRODUCTION

TO

THE STUDY

OF

CRYPTOGAMOUS PLANTS.

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OF

CRYPTOGAMOUS PLANTS.

IN LETTERS.

BY

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AN

INTRODUCTION TO THE STUDY

OF

CRYPTOGAMOUS PLANTS.

LETTER I.

GENERAL CHARACTERISTIC OF CRYPTOGAMOUS VEGETABLES.

THE indefatigable zeal, my dear young friend, with which you have availed yourself of my former instructions in the most fascinating of all natural sciences, has afforded me the greatest pleasure, and I am really happy in complying with the wishes you so warmly express for the continuance of my assistance. The offerings you have hitherto made with me at the shrine of Flora have confined you to the open and luminous threshold of her temple; I shall now endeavour to guide you to the secret recesses of her sanctuary, that you may be initiated into the mysteries of cryptogamous vegetation.

"NATURE," says Pliny, the author of the most comprehensive Cyclopædia of antiquity, "never appears more perfect and wonderful than in her minutest works;" a maxim, of the truth of which you will be the more convinced, the further you proceed with me in the investigation of the structure and œconomy of the small cryptogamous plants.

When you shall have carefully explored the apparently imperfect organization of these, then only will you be enabled to judge with correctness and precision of the nature of vegetables in general.

You know, my dear friend, that Linnæus was the first by whom the Ferns, Mosses, Lichens, and Fungi were arranged in one class, which he called *Cryptogamia*, because in these plants the organs of fructification are more difficult to be discovered than in the rest of the vegetable creation. It cannot, however, be denied that this definition is not quite satisfactory, since the limits are not marked in it with sufficient precision to exclude other plants foreign to that class, but whose organs are likewise so concealed as to elude the sight of the common observer. Of this you have the most familiar example in the Fig, where the flowers are shut up within the fruit itself, which it is necessary to dissect in order to discover them. In a similar manner these lie imbedded within the nearly closed receptacle of the less known trees, the Mithridatea, the Perebea *guianensis* of Aublet, and the Trumpet tree (Cecropia *peltata*). In Phyllachne *magellanica*, Justicia *parviflora*, and in several grasses, the sexual organs are so minute, that we are only enabled to discern them with the assistance of powerful magnifyers.

It is for this reason that among the moderns a very celebrated botanist has pro-

 posed

posed another definition of cryptogamous plants, but which, I must confess, appears still more incorrect and deficient in precision. According to him, the cryptogamous are distinguishable from the ordinary or phænogamous plants, by not being furnished with true anthers, but only with naked and dispersed pollen. The latter term is meant to denote the fecundating matter itself, while the word *anther* always implies a membranous receptacle enclosing that prolific powder, as in the generality of plants. It is, however, incorrect to attribute such naked pollen only to the plants of the last class of the Linnean system; for the Asclepiadeæ are also destitute of anthers in the above acceptation of the term: their twin-pollen is of a solid nature, and dissolves as soon as brought into contact with the stigma. Besides, it is only in some few genera of the class Cryptogamia that we are enabled to state with any degree of certainty, which of the visible parts really fulfil the office of fecundation. In

Pilularia,

Pilularia, Salvinia, Marsilea, and the Musci frondosi, no doubt appears any longer to prevail, as to the real existence of those parts; but it is precisely in these plants that it appears less justifiable to speak of a naked pollen than in the Asclepiadeæ. Even granting the experiments of Hedwig warrant the conclusion that the Musci frondosi are actually provided with an obvious fructifying apparatus, this still consists in real membranous vessels, which emit the pollen in the same manner as we observe in most other plants. In the Ferns the existence of separate fecundating organs is not yet demonstrated, and the Lichens and Fungi are perhaps entirely destitute of them. The above definition is, therefore, not admissible; and hence I consider it safer to retain for the present the one proposed by Linnæus: the exceptions to it, above alluded to, though sufficient to lessen, do not altogether destroy, its validity.

On considering the external structure and correspondence of their most obvious parts,

parts, the plants of this class are found to constitute several natural orders or families, which are mutually related to each other, and approach more or less to other families of phænogamous plants. The Ferns bear affinity to the Palms, as may be seen for instance in the Sago-palm (Cycas *circinalis*), which agrees in many respects with some species of Onoclea and Botrychium, two genera of the natural order of Ferns. This latter order shows, however, very little affinity to others of the cryptogamous class.

The Mosses resemble, in their external appearance, some plants of the phænogamous classes, such as our Saxifraga *bryoides*, *Burseriana*, *muscoides*, *hypnoides*, Lithophila *muscoides* of Swartz, Azorella *cæspitosa* of Vahl, Phyllachne *magellanica*, Mnium *biflorum*, Donatia *fascicularis* Forst., Misandra *Commersonii*, and several polar plants, which at first view might, by the less experienced botanist, be mistaken for Mosses. The Mosses, by means of Tetraphis *pellucida*, and Andreæa *rupestris*, unite with the Hepaticæ,

Hepaticæ, which, through Riccia, approach to the Lichens; while these latter, in the genus Bæomyces, partake of the nature of the Fungi. Thus the attentive observer can every where trace natural affinities among these remarkable assemblages of plants.

A circumstance in which most of the cryptogamous plants agree, is, that while they are destitute of distinctly developed organs of fructification, their propagation is more generally effected by elongation, buds, tubers, and other kinds of roots, than by dissemination. For though they are provided with true seeds (as we know to be the case in Ferns, Mosses, and Hepaticæ) which, when scattered spontaneously, or sown by the hand of man, will germinate and grow up into plants; yet this is of rarer occurrence than their propagation by lateral elongation. How much the whole structure of the Ferns, and partly also of the Mosses and Hepaticæ, is calculated for the latter mode of reproduction, I shall have an opportunity of proving to you hereafter.

By

By means of this mode of propagation, so universal that even the cryptogamous aquatic plants partake of it, this family shows some affinity to the Zoophytes. And, indeed, De Saussure and Vaucher of Geneva have made the interesting observation that a species of Conferva, found on stones, walls, and old wood, as also in fresh water, where it generally forms a thick felt-like texture, may be seen constantly to move in all directions, when exposed to the influence of light and warmth. Vaucher makes it a new genus called Oscillatoria, of which twelve species are enumerated in a work lately published by him on the Fresh-water Confervæ*. These organic bodies, which are indeed true Zoophytes, consist of infinitely minute, simple filaments, mostly closely annulated, and pointed at one end. They are propagated neither by means of eggs, nor seeds, nor buds, but simply by the separation of the rings. Their movement is by no means a

* Histoire des Conferves d'Eau douce. Genève, 1803. 4to.

regular

regular one, like the tremulous motion of Hedysarum *gyrans*, for instance, but irregular and changeable, as we usually observe it in the animal kingdom.

The transition of one organical kingdom of nature into the other, and the impossibility of separating the two by an exact line of demarcation, becomes still more obvious to those who, with Needham, Priestley, and Ingenhousz, have observed the metamorphosis of the animalcula infusoria into real Confervæ. To make this experiment, no particular infusions are required; a vessel filled with pump water, and exposed to the sun, without being agitated, is sufficient for the purpose. First of all a delicate green covering is seen to be formed on the surface of the water, consisting of numberless and infinitely minute molecules, that manifest animal motion; these, after some time, disappear, and are transformed into vegetable filaments, which, like all green surfaces of plants, yield oxygen gas when exposed to the influence of the sun.

Obviously

Obviously close as the approach of these cryptogamous vegetables is to the animal kingdom, the affinity which several others bear to unorganized nature, as it is called, appears equally striking. Only look at the herpetic Lichens, (Pulveraria, Lepraria, Spiloma Achar. Method. Lich.) or the lettered Lichen (Opegrapha) of our rocks and trees, subject them to your microscope, and you will scarcely find any thing that can lead you to suspect the presence of vegetable nature: there is no cellular texture, no observable organs of fructification, no fruit; nor do these substances produce oxygen gas when exposed to the sun. They are distinguished from saline efflorescence merely by a little difference in their form; and occupying indeed the lowest degree on the scale of organical bodies, are as it were the first rudiments of vegetation.

A modern respectable author * wishes to extend the appellation of Zoophytes to the whole class of cryptogamous plants, which,

* Treviranus in his "Biologie," vol. i. p. 415. seq.

united

united with the Zoophytes strictly so called, (viz. the Actiniæ, Asteriæ, Sea pens, Corals, Gorgoniæ, and Animalcula infusoria) he proposes to erect into a third kingdom intermediate between the animal and vegetable. He has, however, not assigned any reasons for such a change, except the dissimilarity that subsists between the cryptogamous and phænogamous plants, especially with regard to the organs of propagation, which in the former, according to Dr. Treviranus, resemble those of the Zoophytes in this, that they consist of a mere congeries of ovula. This, however, is an erroneous idea; for, in many families of cryptogamous plants, the apparatus for propagation is by no means limited to a mere congeries of ovula, as in the Musci frondosi and Hepaticæ for instance; while in others not even ovula are observable, as in many Lichens, the Pulverariæ, Spilomata and Confervæ, which appear to be only propagated by lateral elongation.

With regard to their constituent parts, we find that some of them are similar to,

while

while others differ widely from, the phæno-gamous vegetables. The Ferns appear to differ the least. Several of them are eatable, containing a considerable proportion of saccharine matter, gelatine and mucilage. The inhabitants of New Zealand feed upon the roots of Cyathea *medullaris*, Pteris *esculenta*, and Polypodium *dichotomum*; in the East Indies the same part of Diplazium *esculentum* is used for food. Our Polypodium *vulgare* contains, besides astringent extractive matter, in which gallic acid is predominant, a great quantity of mucilage and sugar. The same constituent parts, but combined with resinous extractive matter, are found in Aspidium *Filix mas*, in Pteris *aquilina*, in Adiantum *Capillus*, in Scolopendrium *officinale*, in Asplenium *Ceterach*, *Trichomanoides*, and *Ruta muraria*. In many of these Ferns the gallic acid is so abundant, that an infusion, for instance, of Scolopendrium *officinale*, when added to a solution of vitriolic iron, immediately produces a precipitate of a dark brown colour.

The

The peculiar and often very intense smell diffused by Ferns, proves the presence of essential oil: on cutting across a fresh stalk of Polypodium *aureum* you will perceive a smell like that of the leaves of peaches, which equally announces the presence of a combination of water and carbon, such as exists in the aromatic plants containing essential oils.

That the Ferns yield potash after combustion is a fact sufficiently known; but they likewise furnish oil, or in its place resinous extractive matter, combined with potash in such quantity, that in England and Sweden the ashes of the burnt roots of Pteris *aquilina* are made into balls, and used by the common people as a substitute for soap *. That, finally, tannin is also contained in the Ferns, appears from the use to which, in some countries, the roots of Aspidium *aculeatum*, Athyrium *Filix femina*, and Pteris *aquilina* are applied by tanners.

* Liljeblad's Utkast til en Svensk Flora. Upsala, 1798, 8vo. p. 390.

The

The Mosses are very poor in these generally predominant component parts; their chemical analysis furnishing only some gummose extractive matter; and, combined with this, gallic acid is found in Polytrichum *commune*; and a considerable proportion of calcareous earth in Hypnum *Crista castrensis*, and Neckera *dendroides**.

Still less have I to say of the chemical composition of the Hepaticæ: the only remarkable circumstance I find is, that Targionia *hypophylla*, when cut into pieces, diffuses a strong smell of turpentine; a proof that it contains essential oil.

The Lichens are much more remarkabable with regard to their component parts. By far the greatest part of those that are more complicated in their structure (Lecidea, Parmelia, Cetraria, Cornicularia, Bæomyces,) are eaten by animals, and in part also by men; such as Cetraria *islandica* and Bæo-

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* Humboldt's Aphorismen aus der chemischen Physiologie der Pflanzen, p. 105, 106.

myces

myces *rangiferinus*. The former, or the Islandic moss, as it is commonly called, contains a considerable portion of saccharine mucilage, united with bitter, gummose, and a small proportion of extractive matter, but is destitute both of gelatine and starch (*amylum*)*. Parmelia *prunastri*, in Alexandria, is added to meal, and the taste of the bread is much improved by it †. Even Gyrophora *vellea* is used as food, in times of scarcity, by the inhabitants of Canada.

Most of the Lichens contain also a considerable quantity of colouring principle, which, being a pure extractive matter, is soluble in water, and obtained by simple infusion; but is not in this state sufficiently adherent to woollen stuffs, on which account, in dyeing, either acids, urine, or alum, are previously added. For this purpose the archil (Parmelia *Roccella*) is the most generally

* Cramer, Diss. de Lichene Islandico, p. 14. (Erlangæ, 1780). —Ebeling, Diss. de Quassia et Lichene Islandico, p. 42.

† Forskohl, Flora Ægypt. Arab. p. 193.

known; but Urceolaria *calcarea*, Parmelia *tartarea*, *saxatilis*, *muscicola*, *Parella*, likewise furnish a beautiful red colour, and are made use of for dyeing. In the northern countries, a yellow dye is also prepared from Cetraria *juniperina*, Lecidea *pustulata*, Parmelia *vulpina*. That, lastly, the Lichens contain a considerable portion of tannin, appears from the use which tanners make of Parmelia *pulmonacea* in the Ukermark, as well as of several other plants of this order in Norway and Sweden.

Of the cryptogamous aquatic plants, the Fuci show the most remarkable component parts; they contain so considerable a quantity of soda, that, in the Isle of Mull, on the coast of Scotland, many families obtain a livelihood by this article. In many places, especially in the island of Jura, the Fucus *vesiculosus* is burnt for the sake of obtaining its kelp, which constitutes an important article of commerce. It is usual for the inhabitants of this island likewise to cover their cheeses with

with these ashes, and thus to supply the place of salt*. This Fucus *vesiculosus*, as also F. *saccharinus*, *digitatus*, *serratus*, *furcellatus*, *canaliculatus*, *palmatus* and *nodosus*, contain so great a quantity of saccharine matter and vegetable mucilage, that, in the northern countries, they are used as food for the cattle, and in Iceland (at least Fucus *saccharinus* and *palmatus*) for man himself.

As for the Fungi, they contain much resinous extractive matter, which, particularly in Boletus *Laricis*, constitutes the basis of the acrid purging quality. Others, particularly Agaricus *campestris*, abound in sugar and vegetable mucilage, and are on this account eatable. Humboldt has proved that most of the Fungi contain so large a proportion of hydrogen as to supersaturate the surrounding atmosphere.

So much, my dear friend, for the general notions respecting the knowledge of crypto-

* Turner's Synopsis of the British Fuci, vol. i. p. 134.

gamous plants. I shall soon proceed to make you acquainted with the separate orders of this class.

LETTER II.

ON THE GEOGRAPHICAL EXTENT AND PLACES OF GROWTH OF THE FERNS.

YOU have frequently expressed surprise at my great predilection for Ferns, my zeal in examining their structure, and the eagerness with which I endeavour daily to add to my already extensive collection of them. "How can a man," you used to exclaim, "take so lively an interest in a family of plants so deficient in variety, and whose exterior has so little to recommend them!" But this surprise, my dear friend, will cease as you gain a deeper insight into the infinitely diversified œconomy and structure of even our indigenous species; and, on beholding the incomparable

parable beauty of the royal Cyathea *arborea*, *medullaris*, Dicksonia *integra* and *squarrosa*, or of the inexpressibly delicate and tender Trichomanes *pusillum*, *trichoideum*, Hymenophyllum *hirsutum* and *ciliatum*, you will yourself feel an exquisite delight.

The examination of Ferns is a source of real pleasure also, in so far as almost in every genus we find a different apparatus employed by Nature for obtaining their reproduction. This diversified organization clearly shows, that those laws which the boldness of the human mind has ventured to prescribe to Nature in her modes of achieving that purpose, are least applicable to the individuals of this family of plants.

In all the plants of the first twenty-three classes of the Linnæan system, we find the presence of two differently formed organs requisite for the reproduction of the species; but most of the Ferns display nothing in their structure that can prove in them the existence of such a combination; and in the others, the parts which we suspect to cause the fecundation of the ovaries are totally different in their form from those of all other vegetables. Another remarkable circumstance is, that the whole structure and œconomy of those Ferns which have hitherto fallen under my observation, are altogether so peculiar to themselves, that the most interesting results might be derived from the study of them, if the northern latitudes, in which we live, afforded opportunities of examining a greater number in a living state.

The good father Plumier, in his three voyages to the West Indies, made it his particular object to discover new Ferns, on which he published a separate work. It is highly desirable that a man of Olof Swartz's scientific knowledge, systematic genius, and indefatigable zeal, should examine with the same view the tropical islands of Asia, America and New Holland; for, indeed, the islands between the tropics are the only true native countries of the Ferns.

Of from five to six hundred species of Ferns known to us, more than one half are

natives

natives of the Antilles; Plumier has collected in Martinique and St. Domingo alone, a hundred and sixty species, to which Swartz has added upwards of a hundred new ones from Jamaica, after Browne and sir Hans Sloane had discovered there as many before him, but without having given perfect descriptions of them. The Philippine and Caroline islands cannot fail to possess an immensely rich treasure of Ferns; and it is really a matter of regret that, since the Jesuit Kamel transmitted from thence some species to the rich apothecary Petiver, who published them in his work, the treasures of those fertile islands have not been examined by any scientific botanist. The two Forsters, though Ferns appear to have less engrossed their attention than other vegetables, found nearly two hundred species of them on the islands of the South Sea. From the Moluccas and the isles of Sunda we find some Ferns in the work of Rumpf and Rheede, but unquestionably many remain perfectly unknown to European botanists. And that

a vast

a vast treasure of these plants still awaits the collector at Madagascar, may be easily guessed by those who are acquainted with the climate of that fertile island.

On casting a view over our northern regions, we find that Sweden (according to Liljeblad) affords only twenty-seven species, of which Polypodium *hyperboreum*, Sw. (Acrostichum *alpinum*, Lilj.) alone has not yet been found in Germany. Of this latter country the catalogue is rather richer, the number of its Ferns amounting to nearly forty species; but of which Athyrium *alpinum*, *montanum*, *fontanum*, *regium*, *rhæticum*, Adiantum *Capillus*, Acrostichum *Marantæ*, Marsilea *quadrifolia* and Scolopendrium *officinale* are not met with in the northern parts of Germany. England, on the other hand, on account of its more temperate climate, can boast of a far greater number. Trichomanes *pyxidiferum* (originally a native of the West India islands), Hymenophyllum *tunbridgense*, Asplenium *murinum*, which has also been found in St. Helena and Jamaica;

maica; Aspidium *lobatum* and *fragrans*, Athyrium *fontanum*, &c. occur in the Floras of that island. Thus the number of Ferns appears to increase in proportion to the greater warmth and humidity of the countries.

In Siberia and other great continents of Asia, Africa and America, the number of Ferns is proportionally small. Michaux, in his extensive tour from Florida to Hudson's-bay, found only between forty and fifty species. They are rather more plentiful in the streights of Panama and in Guiana, where considerable heat and moisture combine to favour their growth.

The Ferns, therefore, next to the Palms, are the tenderest fosterlings of Nature, and stand the most in need of her parental care; being seen to thrive only in countries particularly favoured by Flora.

We find the same care shown in determining their places of growth. By far the greater part of Ferns are met with in moist spots; out of which they will not thrive. Of the German species, the following are found

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in very humid and shaded places: Athyrium *Filix femina* and *fragile*, Aspidium *spinulosum* and *cristatum*, Blechnum *boreale*, Polypodium *Phegopteris* and *Dryopteris*, Onoclea *strutheopteris*, Pteris *crispa*. Almost the sole exceptions are, Aspidium *Filix mas* and Pteris *aquilina*; both of these not only thrive in any soil, but are found in abundance on the most arid heaths. Asplenium *Ruta muraria*, *septentrionale* and *trichomanoides*, also Polypodium *vulgare*, notwithstanding they occupy our rocks, may still be said to inhabit moist places, since the humidity of the atmosphere is no where precipitated in greater abundance than on the northern side of the rocks, where these Ferns strike root among the Mosses.

In all tropical islands the Ferns occur only in shady woods, and on the borders of brooks and springs; Asplenium *obtusifolium* is, indeed, found in the midst of the clear fountains and springs of Martinico. The only exceptions to this are, Acrostichum *furcatum*, and Adiantum *aculeatum*. The tropical

pical Ferns, moreover, are partial to the trunks of old trees covered with moss, which they climb up and completely overspread, leaving no appearance of their roots; or they are suspended from the branches in the same manner as Parmelia *jubata* is in our thick forests. In a similar way grow many species of Trichomanes and Hymenophyllum, as also Polypodium *suspensum*, *crispatum*, *scandens*, *lycopodioides*, *heterophyllum*, *serpens*, *crassifolium* and *lanceolatum*, Aspidium *parasiticum*, Acrostichum *citrifolium* and *sorbifolium*, with many others.

The numerous family of Ferns is most conveniently arranged according to the form of their seed-vessels; which are either surrounded with an articulated ring, (fig. 2.) or are without this part. The former, in general, bear their seeds on the lower surface of the leaves, while the latter usually form proper spikes, to which the capsules are affixed. Under the name of *Pteroideæ*, I distin-

distinguish from the real Ferns several vegetables that have but little affinity with them; bearing in part their sexual organs at the roots, and also differing essentially in other important points.

In some of my future letters I shall treat of the particular œconomy and peculiar structure of Ferns, and the genera related to them.

LETTER III.

ON THE ŒCONOMY OF THE ROOTS AND STALKS OF THE FERNS.

As most of the Fern's multiply by means of radical offsets, it follows that the apparatus necessary for their propagation must be looked for in the roots. This apparatus consists in a peculiar incrassation, or in real tubers, from which issue the new roots and stalks. The tubers in Ferns are of a still more simple structure than in other vegetables,

tables, for a section of them (as may be seen at fig. 1.) displays nothing to the eye but a very solid and dense cellular texture, replete with granulated precipitates of the vegetable juices, which exist here in a very concentrated state; and, on this account, it is in these tubers that the peculiar smell of the Ferns is most intense.

A remarkable circumstance with regard to the incrassated roots and tubers of Ferns is, that those parts are surrounded, but more especially towards the upper end, with a quantity of close, dry, and chaffy paleæ, (fig. 1. *cc.*) like the dry bristles of the bulbs of some Ixias and many umbelliferous plants. It might appear that these paleæ or chaffy scales serve the purpose of protecting the tubers against the injuries of cold; but this cannot be the case, as the tubers and roots of most of the Ferns which inhabit hot tropical countries are likewise provided with them. The fact is, that, like all hairy and chaffy pubescence on the stalk and leaves of Ferns,

Ferns, they are nothing but prolongations of the epidermis protruded by the impulse of the superabundant juice.

You are acquainted with the fabulous accounts given in old herbals, of the Tartarian sheep growing upon a stem, and devouring all the vegetables within its reach. This chimerical being, known by the name of *Baromez*, was first explained by Linnæus. There is found in eastern Chinese Tartary a Fern furnished with thick tubers, which, being surrounded on all sides with a yellow wool and thin chaffy scales, are often raised so high above ground, that the roots beneath bear some resemblance to legs fixed in the soil. The roots of this Fern, whose genus is not yet ascertained, spreading around to a considerable extent, and perhaps preventing other plants from growing near it, it is not at all surprising that superstitious imagination should transform this vegetable into a voracious sheep. A figure, though probably an imaginary one, of the Baromez, may

be

be seen in "Botanical Dialogues between Hortensia and her four Children," vol. i. pl. 5. p. 128.

From the incrassated parts of the principal roots and the tubers issue the proper fibrous roots, which, in most Ferns, are of a brown colour, branched, and prolonged into loose extremities of a somewhat lighter tint. The roots of most other plants are furnished towards their extremities with fine fibres, which serve for absorbing moisture from the soil; but in the Palms, Ferns, and the Najades, I have always found the ends of the roots, instead of being furnished with these fibres, covered by a loose lighter-coloured *calyptra*, which has, in Lemna, particularly attracted the attention of naturalists. Weber is certainly widest from the truth in considering these little caps, which cover the roots of Lemna, as a part of its inflorescence*. Micheli was of opinion, that this part served the purpose of keeping the

* Spicilegium Floræ Gottingensis, p. 25.

plant

plant afloat and protecting its roots *. Roth approached nearer the truth, when he maintained the use of this calyptra to be to prevent the absorption of the coarser fluids †.

The finding the calyptra at the roots of several other plants, and my microscopical investigations, have convinced me that this part is the organ of absorption itself. In the Date-palm, and in Ferns, it consists wholly of a loose membrane, composed of a collection of equally loose absorbing papillæ. These latter closely resemble the *ampullæ*, as they are called, in the villous coat of the intestinal canal in the animal body; and the comparison between the roots of vegetables with the lacteals of animals, is in some degree strengthened by this disquisition. The loose incrassated ends, or the calyptræ of the roots of Ferns are, therefore, the actual organs of absorption.

The tubers of the Ferns have also, in common with the tubers of other plants, the

* Nova Plantarum Genera, p. 16.

† Tentamen Floræ Germanicæ, vol. ii. p. 430.

pro-

property of protruding their young offspring in all directions, which, by means of radical prolongations, remain in constant connexion with the mother plant, until this is entirely decayed.

Several Ferns produce their tubers not only under ground, but likewise above it: the lower part of the stem is often entirely surrounded with them; and not seldom (as in Davallia *canariensis*, Polypodium *aureum*, &c.) the young tubers are displayed on the surface of the ground. By being thus exposed to the air, they probably acquire greater solidity, and their juices become more concentrated.

But what appears still more remarkable is, that in several Ferns the stems, axils of leaves, and even the leaves themselves, throw out either tubers or new roots: in Athyrium and Asplenium *bulbiferum*, real tubers are observable below the leaves and in their axils; in Polypodium *reptans*, as well as in Woodwardia *radicans*, roots are produced at the top of the frond; and the same phænome-

non

non may be seen in Cœnopteris *rhizophylla* and Asplenium *rhizophorum*, when their leaves are bent towards the ground. And that the stem should strike root is so very common, that I need only mention as examples most of the species of Trichomanes, or Polypodium *scandens* and *stigmosum*.

From this it appears, that the lateral elongation (as physiologists call it) is a phænomenon not at all uncommon in Ferns: that, however, their reproduction is likewise effected by seeds, I shall prove more circumstantially hereafter.

The principal stalk of Ferns is often called *stipes*, a term which is likewise, and very properly, given to the same part of the Palms. It ought to be mentioned here, that this stipes always issues from the tuber or root in a curled or spiral form. Ehrhart informs us, that the same form may be seen in the germination of the seeds of Ferns; but my own observations, made indeed in indigenous species only, do not coincide with those of this naturalist. It is, however, an interesting

esting fact, that, as far as I know, not one instance can be adduced of a deviation from the spiral evolution which takes place in the stems rising from the tubers and roots of Ferns; and that even those genera which are merely related to the Ferns, such as Pilularia and Marsilea, prove equally constant to this law.

The differences of the stem with regard to size, strength, and external appearance, are very numerous. In tropical countries, especially in the West India islands, we find Fern-trees not unlike Palms, the stems of which attain the height of upwards of eighty feet: to these giants among the Filices belong Cyathea *arborea*, *aspera*, Polypodium *armatum*, and Pteris *aculeata*. The last-mentioned species is of such considerable dimensions, that, according to father Plumier, the circumference of its trunk equals that of the body of a full-grown man. There are, on the other hand, many species of Trichomanes and Hymenophyllum, Trich. *pusillum*, *muscoides* and *membranaceum*, for instance, which scarcely exceed a few lines in length, and have a stalk proportionably delicate.

Though the trunk of Ferns will often grow to so considerable a height, yet it is scarcely ever seen to divide into branches; but, just as in the Palms, a crown of simple leaves is produced at its summit, with foot-stalks issuing from the centre. Some few species, however, are considerably branched; such as Adiantum *aculeatum*, which, in the islands of Martinico and St. Domingo, overruns the fields, as brambles do with us.

The stem of Ferns is either smooth or rough, beset with chaffy scales, or even with thorns. The smoothness of the surface of the stalk is generally united to a dark brown or black colour, which has a beautiful effect upon the eye in Adiantum *pedatum* and *Capillus*, in Asplenium *trichomanoides*, Pteris *atropurpurea*, and others. The smooth stems of Ferns are usually concave on one side and convex on the other, as may be seen in many of our indigenous species; the cause of which lies in their internal structure.

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In most of our indigenous Ferns the stem is beset with paleæ or chaffy scales, which at first, whilst that part is still rolled up, are soft and hair-like, but afterwards become dry and scariose. This chaff is found the thickest and strongest on the trunks of Aspidium *Lonchitis*, *fragrans*, *rigidum*, *aculeatum*, as also of Athyrium *Filix femina*, Aspidium *Filix mas*, *Oreopteris*, Polypodium *Dryopteris*, Pteris *crispa*, Asplenium *Ceterach*; and among the exotic Ferns, of Aspidium *vestitum* and *drepanum*. Others are furnished with it only towards the base, as Asplenium *fragile* and *regium*.

Instead of this chaff, the stem of some Ferns is beset with soft hairs, sometimes covering the whole surface of the plant. Among the German species, Athyrium *montanum*, found in the mountains of Tyrol, furnishes the only instance of such a hairy stem; but it is a very common occurrence in the tropical Ferns, as in Acrostichum *crinitum*, *villosum*, *muscosum*, Hemionitis *palmata*, Polypodium *asplenifolium*, *punc-*

 tatum,

tanum, Aspidium *aristatum*, *villosum*, Pteris *trichomanoides*, Lonchitis *hirsuta*, Adiantum *villosum*, *hispidulum*, Dicksonia *flaccida*, *multifida*, *strigosa*, *japonica*, *marginalis*, Hymenophyllum *sericeum* and *hirsutum*, Osmunda *hirta*, and others.

In some Ferns, but only in those between the tropics, the stem is furnished with scales, which are either the remains of the former leaf-stalks, or excrescences produced by the superfluous juices. Such scales are found in Asplenium *squamosum*, in Acrostichum *furcatum*, *sorbifolium*, *squamosum*, and in Marattia *alata*.

Lastly, the stems of tropical Ferns are not unfrequently beset with thorns and prickles; of which we have instances in Pteris *aculeata*, Polypodium *armatum*, Lonchitis *aurita* and *repens*; as also in Cyathea *horrida* and *aculeata*, in Adiantum *furcatum* and Davallia *fumarioides*.

A circumstance worthy to be noticed here is, that in some Ferns the stem is entirely wanting; the frond issuing in this case from the

the tuber or root, and having as it were no stipes but its own stalk, which runs out into the mid-rib. I am not acquainted with any example of this structure among the Ferns of the more northern parts of Europe; for in Scolopendrium *officinale* the stalk, though very short, is sufficiently obvious: but in the British Hymenophyllum *tunbridgense*, and Trichomanes *pyxidiferum*, the fronds are seen almost in contact with the roots. Within the tropics this circumstance is a much more usual occurrence, not only in the species of the above-mentioned genera, but also in other Ferns; for instance, in Pteris *tricuspidata* and *furcata*, Vittaria *lineata*, Polypodium *Phyllitidis* and *crassifolium*, Asplenium *serratum*, and some others.

I shall now proceed to the consideration of the internal structure of the stem, which affords many remarkable peculiarities. On dissecting the principal stems and stalks of other trees and plants, we generally find beneath the epidermis a green bark; next to this the liber; then the concentric rings of

spiral

spiral vessels, which are converted into alburnum and wood, and only united by means of transverse cells; and lastly, in the centre of all these coats, a loose cellular cylinder, commonly called the pith. But quite a different succession of parts takes place in the Ferns; for though in these the green bark is also found beneath the epidermis, yet the spiral vessels are never observed in cohering concentric rings, but for the most part in separate bundles, each surrounded by its proper coat of a brown colour. A horizontal section of Polypodium *aureum* (fig. 3.) will show you from ten to twelve of those white angular bundles enclosed in their membranes.

From a longitudinal section (fig. 4.) it appears, that the brown membrane entirely encloses the above-mentioned bundles of spirals; and if you make use of a magnifying glass, the same bundle will distinctly present itself as in fig. 5. But on subjecting a very thin and transparent section of these white bundles to a higher power of your microscope,

scope, you will discover a congeries of spiral vessels (fig. 6. *cc*), the form of which is very different from that of the same vessels in other plants. They indeed exhibit spiral circumvolutions when part of the congeries is forcibly separated, but their form is that of tape; a circumstance not observable in other plants. The tape being furnished with very minute apertures, it has, in its natural compressed and aggregated state, the appearance of spurious tracheæ (*treppengänge**), as is shown in fig. 9, taken from Asplenium *patens*. Besides these vessels, there are within the brown membrane other bundles of close, narrow, and straight canals (fig. 6. *b*), increasing in capacity as they approach the surface (fig. 6. *d*). The brown membrane (*a*), at its external surface, is furnished with prominent minute hooks, by means of which

* No English term being yet framed for denoting those ducts, which the German physiologists call *treppengänge*, the translator has here adopted that of Mirbel, *fausses trachées*, (spurious tracheæ,) though he must allow that it is in some respects objectionable.

it

it appears to attach itself to the surrounding cellular texture.

What has been said above of the situation of the bundles of spiral vessels, applies chiefly to the stem of Polypodium *aureum* and Aspidium *patens*; but other Ferns differ somewhat with regard to the arrangement of those parts. In the stem of Aspidium *Filix mas*, *spinulosum*, *aculeatum*, and of Pteris *serrulata*, we constantly observe a determinate number of bundles, generally five, which are inclosed within brown membranes, and placed in a circle round the centre of the stem. The centre itself in most of these Ferns, in their young state, is, indeed, composed of a cellular texture, of the same consistence with the exterior bark; but as soon as the frond is completely developed, the central cellular substance becomes soft, floccose, and as spongy as the pith of quick-growing plants, such as grasses, the umbelliferæ, or the common elder. This pith in some species abounds so much, and is so rich in mucilage, that it constitutes an article of of food: thus we know that the New Zealanders eat the roots and stalks of Cyathea *medullaris* and of Polypodium *dichotomum*, and the poorer natives of Tahiti, those of Pteris *esculenta*, both raw and roasted.

In the arborescent Ferns, the spiral vessels are disposed in angular bundles, and united by a dark brown membrane, which sometimes surrounds them in a simple, sometimes in an undulated, line. This circumstance explains what Plumier says of Cyathea *arborea*: "Quand on coupe cette tige en travers, on la trouve remplie d'une chair blanche, ferme, douçastre, pleine d'un suc blanc et gluant, et toute entourée d'un aubier noir, dur presque comme de l'ebène, et dont les détours et les sinuosités forment comme un lacis admirable;" and of Cyathea *aspera*: "J'ai aussi remarqué, que la chair du dedans de la tige est un peu plus ferme et plus dure, et que ces veines noires qui l'entourent en façon d'aubier, ne forment point de lacis, quand on coupe la tige en travers, mais bien une espèce de marqueterie

terie formée par des pièces noires et dures presque comme de l'ebène, et courbée en façon d'un arç de Turquie."

The smaller the stems of Ferns are, the fewer of these separate bundles with their brown envelopes appear. The slender stalks of Adiantum *pedatum*, of Asplenium *septentrionale* and *trichomanoides*, as also of the species of Trichomanes, contain scarcely more than a single bundle of spiral vessels, which ascends along the centre of the stalk.

In most other Ferns, whose stem is of moderate bulk, the spiral bundles are all disposed on one side; while the other side, containing the pith only, bends inward, and thus forms a channel. On examining the stalks of our indigenous Asplenium *Ruta muraria*, Adiantum *nigrum*, Athyrium *fontanum*, *Filix femina*, *Thelypteris*, Aspidium *Oreopteris*, *Filix mas*, *aculéatum*, *spinulosum*, Polypodium *Dryopteris* and *Phegopteris*, you will distinctly see that one side is convex, the other depressed or concave.

The circumstance that the spiral vessels of the

the Ferns generally appear as spurious tracheæ, indicates a very concentrated quality of the sap, and the commencement of their becoming ligneous. That the juices contained in these spurious tracheæ are highly concentrated, appears from the strong aromatic smell that is diffused in cutting through them, and which, in Polypodium *aureum*, resembles the scent of the flowers of peaches. In other vegetables, the bark and the cellular substance alone afford this smell. It appears, therefore, that the ascending tubes of the Ferns contain already the concentrated carbon supersaturated with hydrogen;—elements requisite for the formation of the sexual organs. On the other hand, in the cellular texture of the Ferns are found more crude oxygenated juices, containing a larger proportion of saccharine matter than is usually met with in other plants.

Why the spurious tracheæ of the Ferns can take up more concentrated juices, may be accounted for by the circumstance of the stems rising from thick solid tubers, in

which

which the humidity of the earth, absorbed by the roots, is elaborated, and undergoes previous changes; the oxygen of the carbonated water enters the loose cellular texture, while the carbon, uniting with hydrogen, is conveyed into the ascending tubes.

This construction throws some light also on the peculiar origin of the seed-vessels of the Ferns, which take their rise immediately from the ribs of the frond, or the continuation of the spurious tracheæ. The ascending spiral vessels in these vegetables are therefore qualified to form, or at least to contribute to the formation of, the fruit itself; whilst, in other plants, the influence of the cellular texture in the formation of the fruit is indubitable.

A circumstance not to be left unnoticed here is, that the above-mentioned brown membrane, surrounding the bundles of spurious tracheæ, is probably of use in preserving the concentration of the juices in them, by preventing the immediate admixture of the crude juices of the cellular texture with the more elaborate sap contained in those vessels. And, indeed, we find that in very young fronds this membrane is much less developed than in those more advanced ones, which are already furnished with seeds; whence it appears probable to me, that in the young plants of this order those bundles of vessels are in closer connexion with the cellular texture than in old stems, the bundles of which can often be drawn out without any of the cellular texture adhering to them. This experiment you may easily make in autumn with the stems of Aspidium *Filix mas* and Athyrium *Filix femina.*

And now, my dear friend, does it appear to you that I have succeeded in solving the mystery of the œconomy of the stems of Ferns?—I am far from thinking so myself, though the theory I have submitted to you appears to me the most plausible. But in order to throw more light upon this intricate subject, it is necessary carefully to dissect and investigate a great number of very different genera and species of Ferns; and it would

would appear assuming in any botanist, who, as is the case with me, cannot boast of having examined in a living state more than a dozen species (besides those indigenous in Germany), to pretend to offer a complete and satisfactory explanation of the œconomy of these vegetables. I may, however, expect, that my having attempted a path hitherto untrodden by any physiologist, will plead an excuse for unavoidable imperfection. I shall, therefore, in my next letter, proceed to the examination of the leaves of Ferns.

LETTER IV.

STRUCTURE AND ŒCONOMY OF THE LEAVES OF FERNS.

The subject of this letter, no less important than difficult, will, according to my promise, be the examination of the leaves and leaf-like expansions of the stem, which have received the general appellation of frond (*frons*).

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The external appearance of this frond is different in different Ferns; but the qualities in which they all agree are their being thin, membranous, and netted with veins. We observe the thickest in Polypodium *crassifolium*, Scolopendrium *officinale*, and Pteris *pedata*: but even in these they are not succulent, and clearly display their veined structure. They are thinnest in the genus Trichomanes: in the lovely T. *crispum* the transparency, the beauty and regularity of its veined net-work are really wonderful.

Of entirely leafless Ferns scarcely any instance is known to us: the two species of Schizæa only, namely, *dichotoma* of Smith, and *bifida* of Willdenow, are destitute of foliaceous expansions; and Psilotum *triquetrum*, a plant related to the Ferns, is furnished with mere loose scales, shreds or shavings (*ramenta*), instead of leaves. Examples of very delicate linear or capillary leaves are afforded by Trichomanes *trichoideum* and Pilularia *globulifera*.

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The size of the leaves of Ferns is various; but some of the tropical species exceed all others in this respect. The single leaves of Polypodium *crassifolium* and *Phyllitidis*, of Asplenium *serratum* and Vittaria *lineata*, are generally three feet long; a length of two feet is common to several, as to Pteris *grandifolia* and Polypodium *repens*. If the whole frond be considered as one leaf, we find a great number, such as those of Pteris *aquilina*, Polypodium *aureum*, &c., that are from four to five feet long.

The colour of the leaves, at least that of the upper surface, is almost in all instances green: Aspidium *cordifolium* affords the only exception that I know of; the leaves of which, when young, are of a bright red, but afterwards change to green. The lower surface of the leaves frequently varies in colour: it is perfectly white in Acrostichum *Calomelanos*, Cyathea *dealbata*, Pteris *trichomanoides* and *argentea*; as if it were strewed over with meal in Pteris *farinacea* of Vahl; beautifully yellow in Acrostichum *sulfureum* and *chryso-*

chrysophyllum, as also in Adiantum *pulverulentum*; of a blueish green or glaucous colour in Polypodium *pruinatum*, *glaucum*, and *dichotomum*; grayish white in Polypodium *stellatum*, and clothed with a whitish wool in Polypodium *acrostichoides*.

Sometimes the superfluous juices of the Ferns exude at the surface of their leaves in the form of scales, hairs, and chaff. In fig. 21. *b*. you see one of the scales of Grammitis *lanceolata* magnified. These are still larger and more numerous in Polypodium *squamatum* and Acrostichum *squamosum*; and Pteris *furcata* has the whole lower surface of its leaves closely beset with them.

Hairs, both soft and rigid, are still more common than scales; these are usually on the under side of the leaves, but not unfrequently also both surfaces are clothed with them. Examples of such hairy leaves are afforded by Aspidium *patens*, *molle*, *coriandrifolium*, *pubescens*, *villosum*, *hispidum*, Polypodium *ilvense*, Acrostichum *crinitum*, *villosum*, *hirtum*, Lonchitis *hirsuta*, Adiantum *hispidulum*, *caffrorum*, Davallia *hirsuta*, Dicksonia *integra* and *polypodioides*, Trichomanes *crinitum*, Hymenophyllum *sericeum* and *hirsutum*, Osmunda *hirsuta*, Lygodium *venustum*.

It is the young shoots, whilst as yet curled, that more particularly abound with these hairs, which are usually furnished with a gland or a drop at the point. Such pubescence, you know, is common to almost all young shoots, and generally a criterion of superabundant humours. When, therefore, Hedwig first considered those glandulous hairs as fecundating anthers, he was not less mistaken, than when he ascribed the same function to the yellow resinous grains that exude on the surface of Athyrium *Thelypteris*. For, besides that such glandulous hairs and yellow grains are met with in many other plants, they usually make their appearance at a time at which we know that impregnation cannot possibly take place: an objection sufficient to refute the hypothesis.

No less common than hairs are paleaceous scales covering the under surface of the leaves. These form a dense coat in Asplenium *Ceterach* and Acrostichum *Marantæ*; but are of rather a thinner growth in Aspidium *aculeatum*, *Lonchitis*, Polypodium *hyperboreum*, *Phegopteris*, *armatum*, and Asplenium *cordatum*.

In no tribe of plants are pinnated leaves of so common occurrence as in the Ferns: among those indigenous in Germany, there is, indeed, but one with a simple frond, viz. Scolopendrium *officinale*; for Isoetes *lacustris*, Pilularia *globulifera*, and Ophioglossum *vulgatum* do not really belong to the same natural order. Among the tropical species there are many simple-leaved ones, but by far the greater number of them have their leaves divided and pinnate.

The leaves of Ferns, as stated above, are all veined. A modern vegetable anatomist, Mirbel, is of opinion that, as the Ferns belong to the monocotyledonous vegetables, or such as have but one seed-lobe, (as the Grasses, Palms, Liliaceæ, &c.) the veins of

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the leaves must on that account generally run parallel to each other. This parallel direction of the lateral veins is indeed observable in several Ferns, as in Danæa *alata*, Marattia *fraxinea*, Angiopteris *evecta*, Asplenium *serratum*, Pteris *grandifolia*, our indigenous Scolopendrium *officinale*, and many others; but there is a far greater number in which the veins of the frond form a net-work, such as we see in the leaves of other plants. The beautiful veined net-work of Trichomanes *crispum*, of Pteris *comans*, Polypodium *tenellum* (fig. 7.) and Polypodium *scandens* (fig. 8.) will convince you of the truth of this assertion. Even our common Aspidium *Filix mas* sufficiently proves, that Nature has by no means prescribed such a law as that pointed out by the French naturalist; nor indeed is it proved that the Ferns germinate with one seed-lobe only:—a subject on which I shall hereafter have to make further remarks.

What appears most worthy of observation in the leaves of Ferns is, that the veins termi-

terminate in the clusters of seed-vessels themselves, with which the mid-ribs are, however, scarcely ever seen to have immediate connection; for it is only in Blechnum and Woodwardia that the lines of capsules are placed on both sides of the mid-rib; and in Acrostichum and Onoclea the whole under surface of the frond is beset with them. In other cases the secondary veins, by bursting on the under surface of the leaf, give rise to the little clusters of seed-vessels, which, without any involucre from the epidermis, cover the same veins in double rows: this occurs in Hemionitis and Grammitis. Those clusters are oftentimes not found at the primary transverse veins, but at the secondary anastomosing branches which connect the parallel veins; as, for instance, in Meniscium. Not unfrequently, part of the epidermis of the lower surface of the frond is elevated into an involucre or covering to the capsules, as in Asplenium, Cænopteris, and Diplazium.

Another very remarkable circumstance with

with regard to the distribution and form of these veins is, that their extremities are generally thickened, and in this state represent glandular transparent bodies, situated within the substance of the frond, but more towards its upper than towards its under surface. These thickened points of the veins you will distinctly see (fig. 7, 8.) in Polypodium *tenellum* and *scandens*; and I have observed them still more striking in a species of Aspidium, which I call *martinicense* (Hemionitis maxima, linguæ cervinæ adfinis, *Plum. fil. tab.* 145). In the other Ferns, whose secondary veins run parallel to each other from the mid-rib towards the margin, this latter is constantly beset, opposite to the clusters of capsules, with the same glandular bodies that appear in the form of the knobbed ends of the bundles of veins. Such knobbed terminations I have observed in our Pylypodium *vulgare*, in Scolopendrium *officinale*, in Blechnum *occidentale*, *procerum*, *punctulatum*, *boreale*, in Woodwardia *angustifolia*, in Cyathea *commutata mihi*, (Filix altera,

altera caudata et spinosa *Plum. fil. tab.* 14.) and, lastly, in Danæa *alata*, Marattia *lævis* and Angiopteris *evecta*. Having examined the vessels of some species in a living state, namely, of Polypodium *vulgare, aureum*, Scolopendrium *officinale*, and Blechnum *occidentale*, I shall here give you the results of my examination.

If, at the time when the frond is completely developed, you cut a fine slice from the surface of the epidermis, at the place which exhibits the thickened sub-pellucid ends of the vessels, and subject it to the microscope, each of the knobs appears like a cluster of oblong, gray-coloured bodies, such as you see them in Polypodium *aureum*, fig. 10, in Blechnum *occidentale*, fig. 11. *a*, *b*., and in Polyp. *vulgare*, fig. 12. In the second of these species, these bodies, in the knobbed ends of the veins, are most striking: they appear transversely striped or furrowed; which is not the case in other Ferns.

In Polypodium *vulgare*, Blechnum *boreale* and *occidentale*, the knobs are seen at the ends

ends of all the bundles of veins, even in the steril fronds; but in Scolopendrium *officinale* they are present in those leaves only which bear clusters of capsules on their lower surface.

My worthy friend, professor Bernhardi, of Erfurt, in a paper lately published on the fructification of Ferns*, has declared the thickened extremities of the vessels to be the anthers or male organs of these plants. If, in addition to what he himself observed, he had seen the small gray-coloured bodies, such as my microscope represented them to me, and, moreover, that these bodies (in Polyp. *aureum*, fig. 13.) appear to be spread over the ovaria, he would, perhaps, have considered his theory as perfectly established.

It would be out of place here to enter into a minute examination of Bernhardi's hypothesis, and to state all the objections to which it is open; but allow me to advance

* Schrader's Journal für die Botanik, No. 1, and in Konig and Sims's Annals of Botany, vol. i. p. 107.

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the following brief observations: The thickened terminations of the veins are, comparatively speaking, of rare occurrence in Ferns, and so exactly correspond in their interior structure with the glandular parts of other vegetables, that it is difficult not to consider them as real glands. I own, indeed, that I have not found the above minute gray-coloured bodies in the glands of any other plant except Crassula *pellucida*; but in this they are so very obvious, as to oblige me to draw the inference, that in Ferns they cannot be intended to effect the impregnation of the ovaries.

It is indeed a circumstance worth remarking, that, if we compare those parts in the leaves of Ferns with the glands in other vegetables, we shall find that many of the latter (for instance, those of Myrsine *africana*, Tagetes *Ozolis mihi*, &c.) are entirely unconnected with the spiral vessels or veins of the ribs of the leaves, and imbedded in the midst of the cellular texture; whereas in the Fern-leaves the glandular knobs are con-

stantly

stantly seen at the extremities of the veins. But, on the other hand, we have instances enough in the leaves of our plums and peaches, as also in those of the poplar and Ailanthus *glandulosa*, of marginal glands having immediate connexion with the ribs of the leaves, and consequently with spiral vessels.

I have endeavoured above to show, that the ascending canals and spurious tracheæ of the Ferns differ from the spiral vessels of other plants, in being the reservoirs of the concentrated proper juices, freed of their oxygen; and that, therefore, they contain and deposit immediately the elements necessary for fecundation. If this be the case, it appears equally probable, that in those ascending canals (which form the ribs of the fronds) carbon and hydrogen may combine in such a manner as to effect fecundation, while the surplus may be deposited and accumulate in the thickened extremities of the bundles of vessels. We know that carbon and hydrogen are the essential component principles of the

the fecundating fluids of all vegetables; whether their combination produce real oil and wax, or those solid concretions which, in the shape of minute vermicular bodies, appear within the thickened extremities of the vessels in the leaves of Ferns.

You see, my dear friend, that this theory is not altogether in opposition to the one given by Bernhardi, but that it takes in a rather more extended view of the œconomy of these vegetables. I have only to add, that though those concretions or precipitates from the proper juices of the Ferns probably act an important part in the fructification of the Ferns, I am far from considering them as indispensably requisite in all cases; I even think that they may be present or wanting in one and the same Fern, according to the greater or less abundance of nourishment it receives; and, indeed, Scolopendrium *officinale* actually exhibits no such conformation of the extremities of their vessels in some of its leaves, however obvious it may appear in others.

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But I dismiss this subject, in order to subjoin a few words respecting the epidermis of the leaves. This part, in the Ferns, and many plants related to them, (such as Lygodium, Botrychium, Osmunda,) has a beautiful reticular appearance, occasioned by the adhering portions of the septa and interstices of the subjected cellular texture, as you may see it in a small detached piece of the epidermis of Polypodium *vulgare* (fig. 14.). In this you will likewise observe the minute absorbent fissures surrounded by their glandulous margin, such as they appear all over the lower surface of the leaves. The absorption of the moisture of the air appears, therefore, to be much assisted by this organization.

LETTER V.

ON THE IMPREGNATION OF THE FERNS, AND THE GENERATION OF THEIR SEEDS.

It is not long that naturalists have been satisfied that the Ferns, besides their other modes of multiplying, are likewise propagated by dissemination. Formerly, and even so late as the sixteenth century, it was the generally adopted opinion that these vegetables are entirely destitute of seeds. It is merely to popular superstition that we owe the preservation of a belief in the existence of Fern-seeds; for this dust was gathered by the people on the night before midsummer, and made use of for different magical purposes. It was also generally known that this seed is uncommonly fine, and almost invisible; whence Shakespear, in his Henry IV., makes Gadshill say: "We have the receipt of Fern-seed; we walk invisible."

Bock

Bock (or Tragus, as he is commonly called,) is, I believe, the first botanist who mentions the seed of Ferns; he assures us "that, without any superstitious notions, he had often in vain sought for it, but found it abundantly on midsummer eve, though he had not availed himself of any spell, incantation, or magic figures*." Valerius Cordus is of opinion, that the Ferns must be destitute of seed, because they are without flowers; but he allows that the dust on the lower surface of their leaves propagates the species: and this, he adds, may be said of all the Ferns we know†. With more certainty, the dust of the lower surface of the fronds is considered as a real collection of seeds by John Baptist Porta, the famous magical philosopher of Naples‡. The rest of the writers of the sixteenth century positively deny the existence of real seed in Ferns; and, among them, Fabius Columna

* Tragi Kräuterbuch, durch Melchior Sebitz. p. 433. (Strasburg, 1630.)

† Annotationes in Dioscoridem, lib. ii. c. 177. p. 170.

‡ Phytognom. p. 239, 240. (Neap. 1588. fol.)

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particularly, on account of the ill success that had attended his endeavours to make the dust of their leaves germinate*.

Though the botanists of the seventeenth century agree upon the whole with John Bauhin in respect to the existence of real seeds in Ferns, yet they did not arrive at certainty, until Morison† had actually observed those of Scolopendrium *officinale* and Osmunda *regalis* to germinate, and Grew‡ and Malpighi§ had subjected them to microscopical examination. The two latter naturalists, with Swammerdam‖, examined the dust on the lower surface of the leaves of Ferns almost at the same time, and found that it consisted of an aggregation of small capsules, each surrounded by a jointed elastic ring, by the contraction of which the capsule, when arrived at maturity, opened, and scattered its almost invisible seeds (fig. 2.)

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* Phytobasanus, p. 66. (ed. Florent. 1744. 4to.)

† Historia Plantarum, tom. iii. p. 565. 593.

‡ Anatomy of Plants, p. 200.

§ Anatomia Plantarum, p. 72, 73. tab. 51. fig. 299.

‖ Biblia Naturæ, p. 826.

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After advancing thus far, botanists next attempted to discover the sexual parts also. That excellent observer Micheli was the first who observed the capillary glands on the undeveloped fronds, which he considered as possessing the function of anthers*; an opinion which Hedwig adopted, and illustrated by elegant engravings† from Blechnum *boreale*, Asplenium *Trichomanes*, *Ruta muraria*, Scolopendrium *officinale*, Aspidium *Filix mas*, and Athyrium *Filix femina*, Polypodium *Phegopteris* and *Dryopteris*. But that these capillary glands, which occur so generally through the vegetable kingdom, cannot possibly be the fecundating organs of the Ferns, is so obvious, that such an hypothesis can require no further refutation than what has been given above.

John Stehelin‡ and Hill§ took the elastic

* Catalogus Plantarum Horti Florentini, App. p. 135.

† Theoria Generationis Plantarum Cryptogamicarum, ed. 2. p. 94. 97, 98. tab. 5. 7.

‡ Histoire de l'Académie des Sciences de Paris, an. 1730. p. 87, 88.

§ Vegetable System, p. 144.

articu-

articulated ring of the seed-vessels to be the fecundating organs, maintaining that they had observed true pollen explode from it: but most probably what they looked upon as pollen was, in fact, the real seed; and, indeed, the ambiguous term of "sperm," made use of by the former of these authors, shows that his ideas respecting the parts in question were not altogether very clear. Notwithstanding this, Schmiedel adopted a similar opinion, and supposed the saffron-coloured fluid within the ring to be the fecundating principle*. In another place†, however, this naturalist attributes the same function to a viscid matter, exudating, in yellow grains, on the lower surface of the leaves of Aspidium *Thelypteris*; in which he is likewise followed by Hedwig‡.

Gleichen§ fancied he had discovered the

* De Buxbaumia, in Dissert. Botan. Argum. p. 57. (Erlangæ 1783-4.)

† Icones et Analyses Plantarum, p. 47, 48.

‡ Loc. cit. p. 95, 96. tab. 6.

§ Das Neueste aus dem Reiche der Pflanzen, p. 24.

 anthers

anthers of the Ferns in those apertures of the epidermis, which we now know to be organs of absorption—a theory much on a par with that of the capillary glands: and, lastly, Kölreuter* attributed the function of male organs to the involucre of the aggregate capsules in many Ferns, without considering that there is nothing in the organization of that membrane which can warrant such an opinion; not to mention that the capsules of many Ferns are entirely destitute of such an involucre.

The opinion of Maratti, although it has lately obtained some celebrity, by the reprinting of his treatise in Germany†, merits no serious refutation, since we find that at one time he regards the involucres of the Aspidia, at other times the seed-vessels themselves, as flowers and anthers; all which he endeavours to illustrate by bad and partly imaginary figures.

The propagation of Ferns from seed has

* Entdecktes Geheimniss der Kryptogamie, p. 79.

† Huperz de Filicum Propagatione Diss. Gotting. 1798.

of

of late been observed by Ehrhart*, Lindsay†, and myself. Ehrhart's observations were made on Aspidium *spinulosum*, which he saw germinate in the autumn with one seed-lobe: it is well described by him as, in this state, bearing resemblance to the species of Blasia and Anthoceros. He likewise observed this mode of germinating in Aspidium *Filix mas* and Athyrium *Filix femina*. But the best and most accurate account of the germination of Fern-seeds sown in pots, is communicated by Lindsay, whose residence in Jamaica was very favourable to these experiments. The seeds, without exception, sprang up very readily, with one seed-lobe only. The whole process consisted in sowing the seeds on the surface of the mould, and keeping them moist and warm. In this way Ferns are now cultivated both in France, according to Thouin, and in England.

Last spring I received, through the kindness of Dickson, a quantity of Fern-seed

* Beyträge zur Naturkunde, vol. iii. p. 75.

† Transactions of the Linnean Society, vol. ii. p. 93. seq.

 from

from Ternate, among which was Dicksonia *integra*, and several other species: but though I think I treated these seeds according to all the rules prescribed, yet not one of them came up; and, indeed, I have not in any one instance succeeded by this process. I have, however, been more successful in observing spontaneous germination in Athyrium *Filix femina*; for, making an excursion, in the month of October 1803, to the woody declivity of a hill near Halle, with a view of gathering some Jungermanniæ, I observed in several places, on removing the fallen leaves that covered the ground, young seedling plants, which, never having met with before, I considered as a new species of Blasia. But how great was my surprise soon after to find sprouting up from the centre of these round cellular leaves, small fronds of Ferns! Rejoicing in this lucky discovery, I carried home with me several of these seedlings, and immediately made from them the drawing I here adjoin, on the exactness of which you may safely rely. Fig. 17, *a*, shows the seedling plant,

plant, with its cotyledon, natural size; and fig. 17, *b*, the same magnified by a double lens. To me these seed-lobes appeared to be actually divided, and thus to partake more of a dicotyledonous nature; having, however, examined the embryo of that one Fern only, I am far from disputing the correctness of the numerous observations of Lindsay, the results of which are contrary to my single observation.

It still remains to add a few words on the progress that has been very lately made by botanists with regard to the sexual parts of the Ferns. Bernhardi and myself imagined about the same time, that we had discovered the true anthers of these plants; but I am now convinced that both our theories were far from being correct. Examining, in 1801, the very young leaves of Pteris *serrulata*, upon removing the involucres, I discovered among the tender ovaries, which were not yet furnished with the elastic ring, single scattered succulent filaments, as represented in fig. 15. It cannot be objected that these

fila-

filaments are of the same nature with the ovaries, or that they are to be converted into such; for I constantly observed them to wither and disappear as soon as the capsules, approaching maturity, distinctly displayed the surrounding annulated ring. I afterwards found the same filaments in Pteris *aquilina*, *longifolia*, *cretica*, and in Asplenium *Trichomanes*; but in all other Ferns I have in vain sought for them: for though Asplenium *septentrionale* shows something like them below the involucre, yet it would appear, from fig. 16, that these filamentose bodies may be rather considered as germens in the first stage of their growth.

My present opinion of these filaments is, that they are undoubtedly of great utility in the formation of the ovaries; and perhaps the reason why they are so general in the Pterides is, because, on account of the uninterrupted accumulation of the capsules, a superabundance of juices is conveyed thither, which it is necessary should be modified by means of these succulent filaments previous

to

to the elaboration of the fructifying matter. These organs, therefore, may with great propriety be compared to the succulent filaments scattered among the sexual parts of the Mosses, in which, too, they serve for the preparation of the fluids essential to fructification. Other Ferns, that have no such continued lines of capsules, appear to be destitute of these succulent filaments: I must, however, confess, that many species of Onoclea, Blechnum, Acrostichum, Asplenium, Hemionitis, Meniscium, &c., in this respect, still remain unexamined.

I once more return to Bernhardi's theory. This botanist considers the thickened ends of the vessels, before spoken of, as anthers; and as they are usually placed nearer to the upper than the under surface of the leaf, he thinks that impregnation takes place on the former. If this were really the case, there must necessarily be vessels to convey the fecundating matter from the anthers to the ovaries; but no such vessels are as yet discovered: on the contrary, the bundles of vessels

vessels are in connexion with the ovaries before they terminate in these glandulous knobs. This may be seen, as distinctly as possible, in Polypodium *scandens* (fig. 8.); and it appears exactly the same in a great number of other Ferns. In some the bundles of vessels may be observed to divide, one branch proceeding to the ovaries, the other terminating in the incrassated points, as is shown in fig. 7. Hence it seems that the granulated substance precipitated from the proper juices, and accumulated in the thickened extremities of the vessels, cannot again return to the ovaries; nor is this required, for as much of it as was necessary for the fructification had already been deposited there.

If to all this you add the other facts given above, I have no doubt but you will agree with me that the Ferns afford an additional example of both the infinite abundance, and the admirable simplicity, of the means by which one and the same end is often accomplished by Nature.

LETTER VI.

GENERAL ARRANGEMENT OF THE FERNS.

Since we are still ignorant of many essential parts in the fructification of Ferns, the systematical arrangement of their genera cannot rest upon the same principles as in the other classes of vegetables, in which the generic characters are derived from the calyx, the corolla, the stamens, the pistil, the nectaries, the shape of the fruit, and the seeds; parts that, in the Ferns, are either entirely wanting, or, from their nature, do not display a great variety in their forms.

The only character that can be derived from the shape of the fruit, in the classification of the Ferns, is the presence or want of the annulated ring of the seed-vessels. From this, therefore, they may be divided into *Annulatæ* (with a ring) and *Exannulatæ* (without a ring): but this is an artificial, not a natural character; for the genus Onoclea, whose

whose seed-vessels are annulated, approaches very near to Osmunda, whose capsules are without a ring; and Polypodium is closely related to Marattia, Pteris to Angiopteris, Asplenium to Danæa.

Besides, the limits between these two divisions cannot be drawn with exactness; Schizæa has no articulated ring, but a sulcated striped capsule, and therefore is exactly intermediate between the *Annulatæ* and *Exannulatæ*.

The Ferns with rings are again subdivided into such whose capsules are furnished with an involucre, and such as are destitute of it. This part, called *involucrum* or *indusium*, is a continuation of the epidermis; for, in its first stage, it appears organized and furnished with the same minute apertures that are observed in the upper cuticle of the leaves; but as soon as it is elevated by the swelling of the capsules, all vestiges of organization disappear, and the interstices of its cellular texture approach so close as to form the membrane represented in fig. 15.

The

The genera are divided according as this involucre opens outwards or inwards; it must, however, be confessed, that this circumstance is not so essential or constant as is imagined by some botanists. Thus, in Asplenium, the involucres usually separate towards the midrib of the frond; but there are several species (such as Asplenium *Hemionitis*, *caudatum* and *tenerum*), in which the separation of the involucre takes place both in an inward and outward direction.

I shall now proceed to give you a table of the genera of this natural order, with the exclusion of those that are not true Ferns, but only resemble them in some particulars.

FERNS,

1. *With annulated Capsules.*

A. *Without Involucre.*

1. Acrostichum (Fig. 18).

The numerous capsules cover the whole lower surface of the frond or single fertile leaves, which often differ in shape from the steril ones.

2. Gram-

2. GRAMMITIS (Fig. 21).

Capsules disposed in straight, straggling lines within the elongated secondary veins of the frond.

3. MENISCIUM (Fig. 20).

Capsules within the transversal veins, or anastomosing bundles of vessels, issuing from the ribs, mostly disposed in crescent shapes.

4. HEMIONITIS (Fig. 19).

Capsules following the veins of the frond also in their ramifications, the lines often crossing each other or forming net-work.

5. POLYPODIUM (Fig. 8, 9).

Capsules disposed in round scattered spots.

B. *With Involucre.*

6. ONOCLEA.

Capsules covering the whole lower surface of the frond; the fertile frond different in shape from the steril one.

Involucre originating from the margin of the leaf is turned inwards.

7. BLECH-

7. Blechnum (Fig. 34).

Capsules in uninterrupted lines, running parallel with the midrib of the frond.

Involucre opening inwards.

8. Pteris (Fig. 26).

Capsules in an uninterrupted line along the margin of the frond.

Involucre opening inwards.

9. Vittaria.

Capsules in an uninterrupted line along the disk or margin of the frond.

Involucre double, the one opening towards the margin, the other towards the midrib of the frond.

10. Asplenium (Fig. 23).

Capsules in lines parallel to each other, situated exactly upon the secondary veins of the frond.

Involucre opening towards the midrib, rarely towards the margin of the frond.

11. Lind-

11. Lindsæa (Fig. 28).

Capsules in an uninterrupted line, bowed outward, at the margin of the frond.

Involucre opening outwards.

12. Cænopteris (Fig. 24).

Capsules in short straight interrupted lines at the margin, usually in the sinuses, of the frond.

Involucre opening towards the margin.

13. Lonchitis (Fig. 27).

Capsules in interrupted crescent-shape, curved lines at the margin, in the sinuses of the frond.

Involucre opening towards the midrib, being a duplicature of the margin.

14. Scolopendrium (Fig. 25).

Capsules in straight parallel lines between the secondary veins of the frond.

Involucre double, opening towards both sides over the lines.

15. Diplazium.

Capsules in scattered lines close to the midrib and crossing each other.

Involucre double, opening from the middle towards both sides over the lines.

16. Woodwardia (Fig. 29).

Capsules in short interrupted lines, or oblong spots, arranged on both sides of the midrib.

Involucre arched, opening inwards.

17. Adiantum (Fig. 37).

Capsules in separate spots, or interrupted lines, on the margin of the frond.

Involucre, formed by the margin of the frond turned in, opens towards the midrib.

18. Aspidium (Fig. 22).

Capsules in scattered, round spots on the whole lower surface of the frond.

Involucre a round, or kidney-shaped membrane, fixed in the centre, and opening all around.

19. ATHYRIUM (Fig. 30).

Capsules in small, scattered, round spots on the whole lower surface of the frond.

Involucre fixed on one, mostly the inner, side, and commonly opening towards the margin.

20. DICKSONIA (Fig. 31).

Capsules in small, scattered, round spots at the margin of the frond.

Involucre double: one originating from the attenuated margin of the frond, opening towards the midrib; the other originating from the surface, and opening outwards.

21. CYATHEA (Fig. 32).

Capsules in small, round, scattered spots on the whole lower surface of the frond, and mostly fixed to a central columnar receptacle.

Involucre surrounding the capsules in the form of a cup, open at the top.

22. DAVALLIA (Fig. 33).

Capsules in small, scattered, roundish spots near the margin.

Invo-

Involucre originating from the frond itself, scale-shaped, truncated, and opening outwards.

23. Trichomanes (Fig. 35).

Capsules in separate spots at the margin of the leaf, over which they project a little; fixed to a small central column.

Involucre urn-shaped, of one valve, opening outwards.

24. Hymenophyllum (Fig. 36).

Capsules disposed in separate spots at the margin of the frond, over which they rather project; fixed to a short central column.

Involucre flat, and of two valves.

2. *Capsules without Rings.*

A. *Capsules one-celled.*

25. Schizæa.

Capsules striated, disposed in two rows on the back part of a spike-shaped appendage of the frond, surrounded by bundles of hairs.

 26. Os-

26. Osmunda (Fig. 38).

Capsules globose, pedicled, radiate-striated or wrinkled, with a hinge at the joining of the valves; either occupying the whole lower surface of the contracted frond, or disposed in the shape of a raceme or panicle, and opening with two valves.

27. Lygodium (Fig. 39).

Capsules among scales, in two-ranked little spikes, issuing from the margin of the frond: they are radiate-striated or wrinkled, and open laterally, longitudinally, or transversely.

23. Gleichenia.

Capsules, three or four together, sunk in a hollow of the frond; each of them dividing into two valves faintly striped.

29. Angiopteris.

Capsules disposed, by fives or sevens, in two lines along the secondary ribs of the frond.

B. *Cap-*

B. *Capsules many-celled.*

30. DANÆA.

Capsules narrow-oblong, transversely sunk in the substance of the leaf, parallel to each other; their cells opening in double rows upwards.

31. MARATTIA.

Capsules oval, scattered on the lower surface of the leaf; cells opening in double rows upwards.

This table of the genera of the Ferns differs very little from that of the excellent Swartz, in Schrader's Botanical Journal*: where I have deviated from him, I think it has not been without good reason, as will appear to you hereafter.

* Konig and Sims's Annals of Botany, vol. i. p. 422.

LETTER VII.

ON THE GENERA OF FERNS WITHOUT INVOLUCRE: ACROSTICHUM, GRAMMITIS, MENISCIUM, HEMIONITIS, AND POLYPODIUM.

Those Ferns whose fructifications are without an involucre, instead of this part are usually provided, on the lower surface of the leaves, with bundles of hairs, among which the capsules nestle. Instances of this you have in Acrostichum *Marantæ* (fig. 18.) and Hemionitis *reticulata* (fig. 19.), as also in Acrostichum *Lingua*, *villosum*, *hirtum*, *squamosum*, *crinitum*, *muscosum*, *velleum*, *furcatum*; in Hemionitis *palmata* and *rufa*; in Polypodium *piloselloides*, *stellatum*, *acrostichoides*, *stigmosum*, *tricuspe*, *squamatum*, *incanum*, *hyperboreum*, *ilvense*, *armatum*.

I. ACROSTICHUM.

The chief character of this genus consists in its capsules, closely united, occupying the whole lower surface of the leaf. In order to find out if a Fern with such crowded capsules really belong to Acrostichum, it should be examined in its young state, when the seed-vessels just begin to be formed; for, after these are arrived at maturity, we often find them occupying the whole surface, though in the beginning they were disposed in lines or spots. Hence Linnæus's Acrostichum *ilvense*, *polypodioides*, *punctatum*, *lanceolatum*, Thunberg's Acrost. *hastatum*, Liljeblad's Acrost. *alpinum*, are real species of Polypodium; Linnæus's Acrost. *septentrionale* is an Asplenium, as the capsules originally appear disposed in a line, and covered with an involucre which is wanting in the genus Acrostichum. Acrost. *viviparum* L. is a Cœnopteris; Acrost. *rufum* L. an Hemionitis; Acrost. *thalictroides* L. a Pteris; Acrost. *areolatum* L. a Woodwardia; Acrost. *aculeatum* L. a Davallia; Acrost. *barbatum* L. an Osmunda; Acrost. *pectinatum*, *dichotomum* and *spicatum*, of the same author, belong to the genus Schizæa.

Acro-

Acrostichum *gramineum* and *serrulatum* of Swartz (Prodr. Floræ Ind. occid.) are species of Grammitis; Acrost. *nemorale* of Lamarck is Blechnum *boreale*. The last-mentioned Fern has, by some authors, (Roth, Flora German. tom. i. p. 445; Willdenow, Flora Berolin. n. 877.) been taken for an Acrostichum, because the fructification, when ripe, covers the whole lower surface of the leaf; but, if examined more early, the capsules are seen to be disposed in uninterrupted lines on both sides of the mid-rib, and covered by an involucre. Thus, I have in my herbarium several specimens of Aspidium *auriculatum*, in which the whole lower surface of the leaf is closely beset with capsules; yet, as the involucres remain on the spots of capsules, it is evident that they belong to the genus Aspidium.

Acrostichum bears the greatest affinity to Onoclea, since, in both these genera, the whole lower surface of the leaf is covered with capsules; but the latter is furnished with an involucre, formed by the turning

down

down of the margin of the leaf, and opening inwards; while the former is without this part. In Onoclea, too, the fertile leaves are clearly distinct from the steril ones by being contracted and narrower, and also differently formed. At the same time, several species of Acrostichum so closely approach Onoclea in this respect, that, without attention to the involucre, it must be doubtful to which of the two genera they ought to be referred. Thus Acrost. *sorbifolium* (Plumier's Fil. tab. 117.) has fertile leaves, totally distinct from the oblong-ovate, sharply-toothed steril ones, by being very narrow, entire, and linear. The Fern called Osmunda *cervina*, (Plumier's Fil. t. 134.) from Martinico, I must consider either as a species of Acrostichum or Onoclea, its capsules being distinctly annulated, though its involucre is not quite evident.

A similar difference subsists between the fertile leaves of Acrostichum *trifoliatum*, which are entire and almost linear, and the steril ones, which are serrated and nearly lanceo-

lanceolate. Also in Acrost. *muscosum*, *quercifolium*, *auritum* and *heterophyllum*, the fertile leaves are narrower and almost linear, while the steril ones are ovate or lanceolate. Still more remarkable this diversity of the leaves appears in Acrost. *peltatum* (Plum. Fil. tab. 50. A.) and *biforme*; in the former, the steril ones being digitate, with lobes very small and linear; the fertile ones, on the other hand, kidney-shaped, rounded, and rather notched at the margin: in A. *biforme* we find them nearly the same, except that the first leaf is constantly larger, oblong, and divided into lobes.

The reason of this diversity of form can only be looked for in the unequal distribution of the nutritious juices in the leaves. So close an accumulation of the capsules as occurs in Acrostichum and Onoclea necessarily requires a great proportion of juices, whence the substance of the leaves is deprived of its due share; their lobes, the serrated and dentated margins, as consequences of a copious influx of the sap, cannot be developed

veloped in the fertile fronds, their whole stock of juices being employed in the formation of the fruit. We find, however, an exception to this rule in Acrostichum *bifurcatum* (Osmunda *bifurcata* Jacquin Collect. vol. iii. tab. 20. f. 2.). The steril fronds are described as having linear, while the fertile ones are furnished with ovate, leaves; but this species has never fallen under my observation.

Almost the only species of Acrostichum hitherto found in Europe is A. *Marantæ*, (fig. 18.) very much resembling Asplenium *Ceterach* L. at first sight, (both having the lower surface of their fronds closely beset with a brown-red chaff) but distinguishable from it by having a stem the length of from a span to a foot, of a brown-red colour, while Asplenium *Ceterach* has a very low stem, scarcely two inches long, and clothed by the decurrent continuation of the leaves. But the principal difference between these two Ferns is in the form of the frond, which in Acrost. *Marantæ* is bipinnate; the single

leaflets

leaflets are nearly opposite, those on the same side confluent at their bases, where they are here and there furnished with a small foliaceous or tooth-shaped process. Asplenium *Ceterach*, on the other hand, consists only of a pinnatifid frond, with lobes confluent below, and blunt. A still more essential character is, that in Acrostichum *Marantæ* the seed-vessels occupy the whole lower surface of the leaf, while in Asplenium *Ceterach* they are disposed in short parallel lines that issue from the secondary veins of the leaf.

Acrost. *Marantæ* has not yet been found in Germany, but in the Valteline in Switzerland, as also in Spain; while Asplen. *Ceterach* is found in Nassau, about Jena, Leipzig, in the Tyrol, &c.

Polypodium *ilvense* cannot well be mistaken for Acrost. *Marantæ*, since in it only spots of seed-vessels are seen on the margin of the leaf, while the lower surface is far less closely beset with chaff, but only here and there with single scariose scales.

Besides

Besides this species of Acrostichum, the tropical countries have furnished about thirty more, described by botanists. To these I add Polypodium *furcatum* of Swartz *, which Linnæus more properly referred to Acrostichum, because its seed-vessels are by no means disposed in scattered spots, but occupy, closely crowded, the whole lower surface of the frond, being at the same time intermixed with fine bundles of hairs, as is the case in most species of Acrostichum. Willdenow and Swartz have lately proposed to separate this and another species, Polypodium *dichotomum*, from the annulated Ferns, and to refer them to those without an articulated ring. I must, however, contradict these celebrated botanists, since, on subjecting these seed-capsules to the compound microscope, I can clearly distinguish the annulated rings; but, from their being very broad, the capsules, when viewed through

* Since made into a genus, Mertensia, by Willdenow, together with some other species of Polypodies, in Act. Holm. 1804.—Tr.

the

the single magnifier, have the striated appearance of those of Schizæa.

II. GRAMMITIS.

This genus, of which the species figured is the *lanceolata*, (fig. 21.) is only indigenous in the West Indies. The oblong scattered lines of seed-vessels, covered by small involucres, distinguish it from other genera of Ferns. It approaches nearest to Hemionitis, in which, however, the lines of fructification are branched and cross each other. In Vittaria, indeed, they are likewise oblong lines, mostly parallel with the mid-rib of the leaves, but that genus is furnished with a double involucre. All the known species of Grammitis, which are six in number *, were discovered and determined by the excellent Swartz.

* Now increased to twelve by the addition of Asplenium *Ceterach* L., *aureum* Cav., Acrost. *cordatum* Thunb., Polypod. *leptophyllum* L., and Grammitis *cheilanthoides* and *elongata*, the last of which appears to be the same with fig. 21, above referred to.—Tr.

III. ME-

III. MENISCIUM.

The genus Meniscium, of which the species *triphyllum* is represented in fig. 20, ranks with the most remarkable of this natural order, its lines of fructification being crescent-shaped, and situated on the transverse veins or anastomosing bundles of vessels, in an opposite direction to the secondary veins. Schreber has very properly separated this genus from others under the above name, derived from the Greek word *meniskos*, a crescent. Plumier was the first who found one of the species referred to it (M. *reticulatum*) in Martinico, and, in describing it, speaks of a "pellicule blanchastre, qui se perdant par l'accroissement des vesicules qu'elle couvre, fait voir tous ces espaces remplis dun tas d'une poussière semblable à de la farine pouillée*." From this description it would appear that M. *reticulatum* is provided with an involucre; but we should

* Plumier, Fougères d'Amérique, p. 90.

put

put more confidence in the accurate Swartz, who denies the presence of such a covering to the seed-vessels. Linnæus is less justifiable in having referred this species to Polypodium, than Jacquin in considering it as an Asplenium; from which genus, should an involucre be found, it cannot be separated.

IV. HEMIONITIS.

This likewise ranks among the most elegant genera of Ferns. From the drawing of Hemionitis *reticulata*, (fig. 19.), you see that the lines of fructification are divided in the same manner as the ribs of the leaf from which they take their origin. In other species, where the ribs of the leaves cross each other, the same may be seen in the lines of seed-vessels. In Hem. *rufa* the leaves contract so much towards the base, that but little can be observed of those lines; whence Forster called this species Osmunda *discolor*; it having been referred before, by Linnæus, first to Pteris, and afterwards to Acrostichum. Of the eight known species, one only, a native of Japan, is found without the tropics.

V. POLYPODIUM.

The genus Polypodium, such as established by Linnæus, who paid no attention to the form or presence of the involucre, is now divided into five genera, viz. Polypodium, Aspidium, Athyrium, Dicksonia, and Cyathea. Even two species of Adiantum were by Linnæus for some time referred to Polypodium,—a genus which, therefore, with him, contained by far the greatest number of species of any in this natural order. In latter times this extensive genus was first begun to be divided by the worthy Roth; and after him, still more judiciously, by Smith and Swartz. At present we arrange under Polypodium those Ferns only whose seed-vessels are placed on the lower surface of the leaves, in round heaps or spots, without any vestige of an involucre. Of these there are six in Europe:

1. POLYPODIUM *vulgare*—with pinnati-

fid

fid frond, whose leaflets or lobes are oblong, obtuse, and somewhat serrated; the root thickly beset with brown scales or chaff.

This species is found on the decayed trunks of trees, and on the northern side of our rocks. There are varieties of it with gashed lobes, and one which, in the fertile soil of England and the plains of Montpelier, attains an uncommon size, height, and width; having its leaflets unequally and deeply jagged. Linnæus considered this as a distinct species, and called it P. *cambricum*; but Smith has shown it to be a mere variety of P. *vulgare*.

2. Polypodium *hyperboreum*—with bipinnatifid frond, covered underneath with stiff hairs; leaflets one pair, cuneiform, 3--5-lobed: lobes slightly crenated. The spots of fructification are generally so confluent in this species, that it was a very pardonable error of Liljeblad to refer it to the genus Acrostichum. This little plant, whose height scarcely exceeds two inches, has hitherto been

been found only at Luleo in Lapland*. It was first described in the Memoirs of the Stockholm Academy of Sciences (year 1793, p. 201.), and afterwards in Liljeblad's Swedish Flora, p. 390.

3. POLYPODIUM *ilvense*—With bipinnatifid frond, slightly beset with chaff underneath: the leaflets are oblong and obtuse, the lateral lobes ovate, blunt, slightly notched, and opposite. The dots of fructification are disposed near the margin, and so confluent, that this Fern might be mistaken for a Pteris, but never for an Acrostichum. The whole plant is scarcely four inches long, and has a weak stem, which is also beset, at the upper part, with chaff. It is distinguished from the preceding species by its taller growth, and the greater number of leaflets of the frond; the latter having only one pair.

This species is not frequently met with in Germany, and only in alpine countries, such as the Alps of Salzburg and Carinthia, on

* It is probably P. *arvonicum*, which is a native of Britain. Vide Smith's Flora Br. 1115.—TR.

the Giant's and Hartz mountains. In Sweden, it is pretty common on the north side of the Alps (Fjällar) that separate Sweden from Norway. It is likewise found in Wales and the north of Scotland*; and plentifully, as it is said, on the rocks of the isle of Elba in the Tuscan Sea, to which it owes its name. A figure of it, though not a good one, is given in Flora Danica, t. 391.

4. POLYPODIUM *leptophyllum*—With bipinnate, smooth fronds, and cuneiform, rounded leaflets divided into lobes, the lower surface of each of which is furnished with a single spot of seed-vessels. This beautiful little Fern, in height about a hand-breadth, was first discovered by Tournefort in the neighbourhood of Toulon, on the northern side of the rocks. (Magnol, Hort. Monspel. p. 5, 6.—Gerard, Flora Gallo-Prov. p. 70.) My own specimens were gathered on the Hyeres isles. In Portugal and Spain this species was found by Grisley and Bar-

* The British species, however, appears to be P. *arvonicum* according to Smith's Flora Brit. l. c.—TR.

relier:

relier: the latter botanist has given the best figure of it in his Icones Plantarum, tab. 431*.

5. POLYPODIUM *Phegopteris*—With bipinnatifid frond, beset underneath with hairs, and fine scattered chaff; the upper leaflets confluent, those near the base connate with one another and the principal stalk, so as to form a sort of irregular square; the lowermost leaflets commonly reflex. This species is about one foot in height, and its stem is beset, at the upper part only, with scattered chaffy scales. Not having been able to discover, in any one specimen, that it is furnished with an involucre, as Roth maintains, I must still consider it as a species of Polypodium.

It is found throughout Germany, and, indeed, in most European countries as far north as Lapland, but does not appear to be an inhabitant of the southern countries. Linnæus states that he has received specimens from Canada, but I suspect this to have been another species, Polypodium *connectile*

* This is since referred by Swartz to his genus *Grammitis*, and figured in Synopsis Filicum (1806), pl. 1. fig. 6.—TR.

 of

of Michaux, which is distinct from P. *Phegopteris* merely by having its stem more closely beset with chaff. There is an indifferent figure of P. *Phegopteris*, in Bolton's Filices Britannicæ.

6. Polypodium *Dryopteris*—With nearly tripinnate triangular frond, which commonly is also three-branched; the whole frond is triangular, the secondary leaflets are lanceolate, and those of the third order oblong, blunt, and mostly crenated. The dots of fructification are generally situate near the margin. The stem is entirely smooth, and constantly divides at the top into three branches. Its height is from a foot to a foot and half. Grows in shady woods throughout Germany and a great part of Europe.

Bolton's figure of this species (Fil. Brit. tab. 28.) is tolerably good; but the P. *Dryopteris* of Flora Danica, t. 759, quoted as such even by Linnæus, cannot be considered as the same. In this figure the whole stem is clothed with leaflets, and the leaflets of the third order are ovate and acuminate: perhaps

haps it is meant to represent Aspidium *spinulosum.*

As to the exotic species of this genus, they exceed seventy, and most are natives of the West Indies. About twenty-five have a simple frond; which, in some species, is of two different shapes; thus, for instance, in P. *piloselloides* and *heterophyllum*, the steril leaves are ovate or rounded, and sessile, but the fertile ones lanceolate. In several species, such as P. *acrostichoides*, *stigmosum*, *polycarpon*, *punctatum*, the spots stand so closely together as to give the appearance of an Acrostichum; but, with care, they may still be discerned. The same, however, is not the case with Polyp. *furcatum*, whence I have thought it proper to refer this Fern to the genus Acrostichum.

Twenty-one species have a pinnatifid frond, and are also, nearly without exception, natives of the Indies, or the South-sea islands. One species of this division, Polypodium *virginianum*, I have long ago considered as a slight variety of our P. *vulgare*, and I now

find

find that Michaux (Flora Bor. Amer. ii. p. 271.) is of the same opinion. Thirteen species have a pinnated, and ten* a double or multipinnated frond.

I possess specimens of a new species collected in Pensylvania, and which I call P. *obtusum*; it has a bipinnate frond; the leaflets of the first and second order are obtuse, the former ovate, the latter oblong, lobed and serrated, and in the sinus of each lobe is a small heap of capsules. The stem is thinly beset with chaffy hairs. Length of the whole delicate plant from one to five inches.

In my specimens of Forster's Polypodia, *invisum* and *pennigerum*, though Swartz refers them to the genus Aspidium, I have not been able to discover the least vestige of an involucre.

Most species of this genus show the thickened ends of the bundles of vessels so distinctly, that, in P. *latifolium*, *pectinatum*, &c.,

* The above proportions have changed, since more than 100 species of Polypodium are enumerated by Swartz in his Synopsis Filicum.—Tr.

for

for instance, even those vessels that do not extend towards the margin of the fronds, terminate in such glandular bodies. This circumstance still lessens the probability of their being anthers.

LETTER VIII.

ON THE GENERA WITH INVOLUCRES: ONOCLEA, BLECHNUM, PTERIS, VITTARIA, ASPLENIUM.

VI. ONOCLEA.

THE genus Onoclea was established by Linnæus from two Ferns only, which are so distinct from each other, that they cannot be suffered by any botanist, who examines them more closely, to remain united: for, indeed, Gleichenia, with its two-valved capsules, joined by threes, and having no ring, has nothing in common with Onoclea *sensibilis*, whose spots of fructification occupy the whole

whole lower surface of the frond, and are covered by a proper involucre, being the continuation of the margin of the leaf. On the other hand, Linnæus separated from this genus the Onoclea *Struthiopteris* and *capensis*, referring them to Osmunda, though both agree, in many respects, with Onoclea *sensibilis*, and differ much from Osmunda *regalis*.

I have above shown, that the genus Onoclea is nearest allied to Acrostichum, and is only distinct from it in having an involucre, which originates from the margin of the leaf. It is also more common in this than in any other genus of Ferns for the fertile fronds to contract round the fructifications, and adopt a very different and narrower form. What I have said respecting Acrostichum, is also applicable to this genus; namely, that many other Ferns may easily be mistaken for Onocleæ, unless examined before the fructification shall have arrived at perfect maturity, when the seed-vessels will often occupy the whole lower surface of the frond. Pteris

crispa

crispa has a long time been called Onoclea; and Hoffmann described Blechnum *boreale* for Onoclea *Spicant.* Blechnum *procerum*, when its fronds are full of ripe capsules, perfectly resembles an Onoclea. There is but one species of this genus indigenous in Europe, viz.

ONOCLEA *Struthiopteris*—Its steril fronds are bipinnatifid; the first leaflets are long, lanceolate, and again nearly divided down to the mid-rib into secondary leaflets, which are elliptical, rounded, entire and obtuse. From the centre of several of these steril fronds, grown together in a tuft, issue thicker stems, whose fronds, though likewise pinnate, do not come to perfection, but remain contracted, and have their lower surface thickly covered with seed-vessels. The steril fronds are about one foot and a half high; the fertile ones, more humble, scarcely attain the height of nine inches.

This Onoclea is one of the rarer German Ferns; it occurs in shady forests, on the Hartz and Giant-mountains, in the Tyrol, as also in Sweden, Norway, Russia, &c. Almost the only figure we know of it, is that in Flora Danica, tab. 169, which, however, does not rank among the best drawings of that work.

From North America we have two species of this genus, viz. Onoclea *sensibilis* and *nodulosa* of Michaux. The former is distinguished by the anomalous form of its fronds; the steril ones being either pinnate, with the upper leaflets confluent at their bases, or the whole frond is pinnatifid, with rather gashed lobes; while the fertile fronds, much more delicate than the others, are bipinnate, with leaflets rolled up like globules, giving to the whole the appearance of an Osmunda or Botrychium. But on opening these globular leaflets, annulated seed-vessels appear, which prove the plant not to belong to either of these genera.

The Onoclea *sensibilis* is a native of Pensylvania, Virginia, Carolina and Florida. It is remarkable for possessing the singular quality to wither soon after being touched by the human

human hand. I have frequently made the experiment, and always with the same result. As it endures the touch of other things, without being at all affected, it appears probable to me that the perspiration of the human body alone exerts an injurious influence on this plant. A figure of it is found in Morison's Hist. vol. iii. S. 14. tab. 2. fig. 10.

Onoclea *nodulosa* is mistaken by Michaux for Acrostichum *areolatum* L., which belongs to the genus Woodwardia; but Osmunda *caroliniana* is a synonym of it. It consists of a pinnate frond, the leaflets of which are linear and pinnatifid; while the leaflets of the fertile frond are almost knotty-jointed, from the single lobes of the leaflets contracting round the fructification. This species, a native of the shady and swampy forests of Carolina, has not yet been figured.

VII. BLECHNUM.

This genus is easily known, as soon as its fructifications begin to be formed, by the

 unin-

uninterrupted and mostly double lines of seed-vessels running parallel with the midrib on both sides, and by the involucre opening inwards. I refer you to what I have said above respecting its sometimes adopting the appearance of an Acrostichum or Onoclea, when the capsules have arrived at perfect maturity.

There is, in the north of Europe, a beautiful species of this genus, Blechnum *boreale* (Osmunda *Spicant* Linn.). The fertile fronds differ also in this Fern from the steril ones. The latter are nearly pinnate, with lanceolate, entire, somewhat falcated leaflets rather curved upwards; the fertile fronds, double the length of the former, are distinctly pinnate, with very narrow linear leaflets, bearing each on its lower surface, on both sides of the midrib, a line of seed-vessels covered by an involucre. Its smooth brown stem is also furnished, towards the lower part, with some short, leaf-like appendages.

This species is met with in many parts of Germany, England, Denmark, Norway

and

and Sweden. Good figures of it are given in Flora Danica, tab. 99. [English Botany, pl. 1159.]

Besides this, we know several tropical species; one from Florida, another from the Cape of Good Hope, &c. Blechnum *occidentale*, a native of the West India islands, having a pinnate frond, with opposite leaflets, notched at the base, and upper leaflets confluent, thrives better in our hot-houses than many other Ferns. Blechnum *australe*, from the Cape, with pinnate frond, and leaflets cordate-lanceolate, rough at the margin, and furnished at the top with an herbaceous dagger-point. Blechnum *orientale*, from the East Indies, with sword-shaped, narrow, alternate leaflets. Blechnum *serrulatum*, a native of Florida, with pinnate frond, and long, lanceolate, acuminate, sharply-toothed leaflets. These are the more common species, to which I add Blechnum *procerum* (Osmunda *procera* of Forster), a Fern very remarkable in its construction; the one side of its stem, which is clothed all over with chaff,

chaff, bears steril, oval-lanceolate, sharply-toothed leaves, with parallel incrassated vessels; while the leaves on the other side of the stem are fertile, and completely linear.

VIII. PTERIS.

The genus Pteris, of which nearly eighty species are known, is distinguishable from all others by its uninterrupted marginal lines of fructification, and an involucre from the inflected margin, and consequently open on the inner side. In some species (Pteris *Adscensionis* and *atropurpurea*), these lines are, indeed, interrupted, but they are not situated in the sinuosities of the leaves alone, which, if they were, would make those species belong to the genus Lonchitis. Pteris differs from Lindsæa by the involucre being open towards the midrib, while that of Lindsæa separates outwards. When the leaflets are so small as to become entirely covered by the seed-vessels, the plants at an advanced period resemble Onoclea; as is the case, for instance, in Pteris *crispa*.

The

The most remarkable European species are:

1. PTERIS *cretica*—With pinnate frond, lowermost leaflets three-parted, upper ones simple, all of them lanceolate, somewhat falcate, serrated, and narrowest at the base. In the isle of Candia this Fern attains the height of two feet. The best figure we have of it is in Tournefort's Institutiones Rei Herbar. tab. 321.

2. PTERIS *aquilina*—With pinnate frond, lanceolate repand leaflets, the lowermost pinnatifid, the uppermost much smaller. The stem is often five feet high, and divides at the top into fronds, which are often tripinnate, and two or three feet broad. This Fern, a native of all Europe, and even of North America as far as Hudson's-bay, is contented with any soil, but particularly abounds in forests; it is not, however, confined to shady places, multiplying every where prodigiously.

The Latin name of this Fern is derived from the circumstance of a transversal sec-

tion

tion made through the root showing the spiral vessels, inclosed in their brown membrane, in the form of a cross or of a spread-eagle.

The figure of it in Blackwell's work, pl. *525*, is not particularly exact. [Engl. Bot. pl. 1679.]

3. Pteris *crispa*—With bipinnate fronds of double form; the steril ones shorter, about six inches long, with roundish, deeply-gashed, obtusely-crenate leaflets; the fertile ones, three or four inches longer, with oblong-linear, entire leaflets, having, when mature, the whole of their backs entirely covered with seed-vessels. At an earlier period, however, it appears clearly that the capsules only run in lines along the margin, and are covered with an involucre opening inwards. Some botanists, for want of examining the leaf in the young state of the capsules, and, at the same time, overlooking the ring, have imagined this species to be an Osmunda; it was afterwards joined with Onoclea; Lamarck, I believe, first referred

ferred it to the genus Pteris. (Flore Française, vol. i.)

This species belongs to the more rare Ferns of Germany; it has been found in Silesia, near Herborn, and in Salzburg. In Sweden, it grows on the alps at Torneo, and in Jamtland; it also occurs in Norway, Dauphiny, and in Westmoreland, Scotland, and Wales.

The figure given of this species in Flora Danica, tab. 496, and by Bolton, pl. 7, do not express with sufficient exactness the segments of the steril leaves. [Engl. Bot. pl. 1160.]

Among the exotic species, the different shape of the fertile from that of the steril frond is no rare circumstance. Pteris *piloselloides*, in the East Indies, has inverse ovate and lanceolate leaves; the former are steril, the latter fertile. Pteris *thalictroides*, also a native of the East Indies, has steril leaves doubly pinnatifid, and fertile ones pinnate, with linear two-ranked leaflets. In Pteris *denticulata* the steril leaves are dentate, the fertile ones entire. Pteris *hetero-*

 phylla

phylla (Adiantum *hexagonum* Linn.) has its steril leaves serrated, but the fertile ones only angulated and dentated at the point; while, on the other hand, in Pteris *auriculata* the barren leaves are entire, and the fertile ones crenated.

Among the exotic species are two arborescent ones, viz. Pteris *aculeata*, a native of Martinico, and Pteris *esculenta* of the Society Isles.

IX. VITTARIA.

This genus agrees with Pteris and Hemionitis in having uninterrupted lines of fructification either along the margin or in the middle of the frond, but is distinct from both in being furnished with a double involucre; the one separating towards the margin, the other towards the midrib of the frond. A somewhat similar double involucre is found in Scolopendrium, in which, however, the lines of fructification are parallel to each other, and disposed between the secondary veins of the leaf.

This

This genus is, for the most part, a native of the tropics. Vittaria *lineata* is most frequently found in the West India islands, especially in St. Domingo; Vittaria *lanceolata* in Jamaica, and Vittaria *ensiformis* in the Isle of France and De la Réunion. All three are remarkable for the great simplicity of their frond: it is linear and long in V. *lineata*, lance-shaped in V. *lanceolata*, and linear-sword-shaped in V. *ensiformis*.

The best figures of the species of Vittaria are given by Swartz in the New Memoirs of the Society of Naturalists*.

X. ASPLENIUM.

The character of Asplenium, as represented from A. *salicifolium*, in fig. 23, is indeed very determinate, and in this, and in other cases where it is equally distinct, admits of no doubt as to the genus. But when we find that in Asplenium *tenerum* almost all the involucres separate outwards,

* Neue Schriften der Gesellschaft Naturforschender Freunde zu Berlin, vol. ii. pl. 4.

or that, in A. *Hemionidis* and *caudatum*, some separate inwards, others towards the margin, though the lines of fructification occupy the middle of the frond, and not the margin as in Cænopteris, the validity of the generic character is rather shaken. It cannot, however, be altered without creating new confusion, since most of the species agree in having parallel lines of fructification, with an involucre separating inwards.

We proceed, first, to treat on such of the species as are natives of Europe.

1. ASPLENIUM *septentrionale* (Acrostichum *septentrionale* Linn.)—With short, smooth and slender frond, dividing above into linear leaflets bifurcated or jagged at the tips. The lines of seed-vessels often appear close to the margin on the reverse of the very narrow leaflets; whence Smith first thought of referring this species to Pteris: but the fact is, that the involucre by no means originates at the margin; neither is the fructification disposed in an uninterrupted series along the whole margin of the

leaf,

leaf, but the lines of capsules are confined to each pointed linear lobe. The reason why it has been frequently considered as a species of Acrostichum is, because in the very narrow leaves the whole reverse page is often completely covered with seed-vessels; but, on examining them in a less advanced state, before the fruit is developed, both the involucre and the line of fructification are very distinct. This latter is for the most part solitary, and its involucre separates towards the slender midrib; but the broader lobes being furnished with two lines of capsules, these are often so confluent, that they appear to form a single line, with two involucres, one of which separates outward, the other inward. It was this circumstance that induced Roth to consider A. *septentrionale* as a congener of Scolopendrium: the examination, however, of very young and tender fronds shows that this opinion is not well founded.

The height of the whole plant is from one inch to a short span (Spithama). It is not

not unfrequent throughout Europe, in the crevices of rocks on a northern aspect. The figure of it in Bolton's Filices, tab. 8, is not a very good one; that of Flora Danica, tab. 60, is better. [Engl. Bot. pl. 1017.]

2. ASPLENIUM *Hemionitis*—With fronds cordate-hastate, entire, five-lobed, and with smooth stalks. The whole plant scarcely attains the height of half a foot, and bears some resemblance to our Scolopendrium. Clusius received it from Rome, where it grows on old walls, and figured it in his Rariorum Stirpium Historia, lib. vi. p. 214. It is also said to be a native of Spain.

3. ASPLENIUM *Ceterach*—With pinnatifid frond, and lobes alternate, confluent, blunt, and thickly clothed on the lower surface with chaffy scales. I have before (p. 89) alluded to the resemblance between this Fern and Acrostichum *Maranta*, and their differences. Having, in the same place, also mentioned the habitats of A. *Ceterach*, I have here only to add, that it is badly figured by Bolton, pl. 12, better by Plumier, (Fougères

gères d'Amérique, tab. B. fig. 3.*) Some botanists have referred this Fern to Scolopendrium; though, in reality, it has but one involucre, which constantly separates towards the midrib.

4. Asplenium *marinum*—With pinnate frond, and leaflets ovate, oblique, unequal, and wedge-shaped at the base, lobed above, bluntly rounded at the top, and crenate along the whole margin.

This plant, scarcely a few inches high, is indigenous to Great Britain, where it is found in Anglesea and other parts of the southern coast; as likewise in the islands of the Archipelago, St. Helena and the West Indies. It is figured by Bolton, and in English Botany, pl. 392.

5. Asplenium *viride*—With pinnated frond, roundish, blunt leaflets, crenate along the whole margin, deeply gashed, oblique at the base, and furnished above with a prominent lobe. The stalks are brownish only near

* Scolopendrium *Ceterach*, English Botany, pl. 1244.—Tr.

the

the ground; from thence to the top they are entirely of a green colour.

This species, which approaches near the following, is very scarce in Germany, except on the Alps of Tyrol and Carinthia; in Britain it has been found in North Wales, Yorkshire and Westmoreland. It is tolerably well figured in Bolton's Filices, tab. 14.

6. Asplenium *Trichomanes*—With pinnate frond, and roundish, slightly crenate leaflets. Though in this species also a roundish lobe is sometimes found at the upper part of the rhomboid base of the leaflet, as in the preceding species, to which it bears great resemblance; yet it is easily to be distinguished by the brown colour of the whole stalk, and by the leaflets not being deeply gashed.

This is one of the most common Ferns, found on the north side of our rocks and throughout Europe in great abundance. Figures of it are given in Flora Danica, tab. 119, in English Botany, pl. 578, and in Bolton's Filices, tab 13.

7. As-

7. ASPLENIUM *Adiantum nigrum*—With almost tripinnate frond; primary leaflets ovate-lanceolate, and lengthened point; those of the second order oblong, obtuse, sharply serrate, and the lowermost again divided into similar leaflets of the third order.

The whole plant grows to the height of from a long span to nine inches; its thin red-brown stalk is much longer than the triangular frond. This is one of the scarcer Ferns of Germany.

It is figured in Flora Danica, tab. 250, and by Bolton, pl. 17; but neither of these figures expresses the delicate division and fine serrature of the leaflets.

8. ASPLENIUM *Ruta muraria*—With alternate twice-compound frond, whose leaflets are cuneate-rhomboid, usually three-lobed or three-parted, obtuse, and serrate or crenate towards the point.

This little plant, seldom exceeding a few inches in height, grows abundantly on old walls throughout Europe. There are good

figures

figures of it both in Flora Danica, tab. 190, and in Bolton's Filices, tab. 16 ; but I prefer that of the former.

9. ASPLENIUM *Breynii*—With alternate nearly decompound frond ; leaflets cuneate, and gashed at the point. It is not unlike the preceding species, but much higher (about nine inches in length) ; the fronds, properly speaking, are doubly pinnate, the leaflets very narrow, often three-cleft, and gashed at the top.

James Breynius was the first who found this species near Langen-Schwalbach, and gave a very good figure of it in his Exoticarum Plantar. Centur. 1. tab. 97 ; it is also well figured by Wulfen in Jacquin's Miscell. vol. ii. tab. 5. fig. 2. It has been since found by other botanists in Germany ; whence Haller and Weiss call it Asplenium *germanicum*. Linnæus and Wulfen have it under the name of A. *alternifolium*.

10. ASPLENIUM *lanceolatum*—With bipinnate frond, whose primary leaflets are ovate-

ovate-lanceolate, with points lengthened out; they divide into obovate, sharply-toothed leaflets, wedge-shaped at the base.

The stem is higher than that of the other European species of Asplenium, and thinly beset with chaff. The secondary leaflets do not extend to the midrib, but are connected with each other at their bases.

This species is a native of Great Britain: it has been found on Mount Snowden in Wales, in Yorkshire, &c.; and a figure of it is given in English Botany, pl. 240.

Among the exotic species of Asplenium, we know four that are propagated by means of bulbs contained in the frond itself, whence the points of their leaves are seen to strike root; these are, A. *rhizophyllum*, *rhizophorum*, *proliferum* and *bulbiferum*.

It remains for me to mention two species I preserve in my herbarium, of which I have not any where found clear descriptions; both are natives of Virginia. The one, which I call Asplenium *pycnocarpum*, has a pinnate frond, with the lower leaflets alternate, and the

the upper ones opposite, all of them lanceolate-linear, serrate towards the point, rather rhomboid-truncate at the base, and thickly beset on their lower surface with close lines of seed-vessels. It is probably not the A. *angustifolium* of Michaux's Flora Boreali-Americana, vol. ii. p. 265, the leaflets of which are described as entire.

The second species, bearing great resemblance to Athyrium *Filix femina*, I call Asplenium *Athyrium*. Its frond is bipinnate; the primary leaflets lanceolate, and fixed immediately to the stalk, which is completely smooth; the secondary leaflets are oblong-lanceolate, pinnatifid, with the lobes again serrate and gashed. The smoothness of the stem, and particularly the parallel lines of fructification on the lower surface of the leaves, clearly indicate it to belong to the genus Asplenium. I suspect this to be Nephrodium *asplenioides* of Michaux (Flora Bor. Americ. vol. ii. p. 269.)

LETTER IX.

ON THE GENERA WITH AN INVOLUCRE: LINDSÆA, CÆNOPTERIS, LONCHITIS, SCOLOPENDRIUM, DIPLAZIUM, WOODWARDIA, AND ADIANTUM.

XI. LINDSÆA.

THIS genus was first established by Dryander, in the Transactions of the Linnean Society, vol. iii. p. 40, its species having before been referred to Adiantum. Upon first view one might as easily take the species of Lindsæa to belong to Pteris as to Adiantum, the lines of fructification being at the margin of the leaf, which is often bent outwards; there is, however, usually a narrow space between the lines of fructification and the margin: besides, the involucre does not originate from the margin (as in Pteris and Adiantum), but from the disk of the leaf, opening towards the margin. By means of the last-mentioned character, this genus

approaches

approaches the next, Cænopteris, in which, however, the lines of capsules are straight, and near the sinuses of the leaves.

We are at present acquainted with fourteen species of Lindsæa, mostly natives of the West Indies, Guiana, and the South Sea Islands. Aublet already, in his Flore de Guiana, tab. 366, has given a tolerably good idea of its character, in his figure of Adiantum *sagittatum*; but, for establishing it as a genus, we are indebted to Dryander, who enumerated most of its species in the above quoted Transactions. I have given here, in fig. 28, a faithful representation of Lindsæa *trichomanoides*, the Adiantum *cuneatum* of Forster.

XII. CÆNOPTERIS.

This genus was first established by Bergius, in the Acta Petropolitana, ann. 1782, pars poster. p. 248. 250—It is characterized by short, straight, marginal lines of fructification, generally situated in the sinuses of the leaf, and involucres originating from the disk,

disk, and opening towards the margin. Fig. 24 exhibits its generic character in a secondary leaflet of Cænopteris *Odontites*. But it is not seen quite so distinctly in Cænopteris *cicutaria*, in which several lines of capsules are pretty distant from the margin, and, indeed, in some, the involucre separates inwards: this Fern, therefore, is intermediate between Asplenium and Cænopteris.

The species of this genus have a wide range; they are natives not only of the West Indies, and the tropical islands of the South Sea, but also of New Zealand, the Cape of Good Hope, Japan, and the Mascarenhas. They have generally been mistaken for species of Asplenium, Trichomanes or Adiantum.

XIII. LONCHITIS.

The crescent-shaped lines of fructification at the margin of the sinuses of the leaves, with involucres separating inwards from the margin, are the characters that distinguish this from the other genera. The genus to which

which it is most allied is Pteris; from which, however, it differs in this, that, even in adult specimens, the lines of capsules never extend beyond the sinuses of the leaf: for although in several species of Pteris, while in a young state, these lines of fructification are confined to single places of the margin, or to the sinuses (as in Pteris *Adscensionis* and *podophylla*), yet, when the plant is arrived at maturity, they are seen to extend much further along the margin.

The four known species of this genus inhabit the West Indies and the South Sea Islands. For an example of the generic character, taken from Lonchitis *hirsuta*, see fig. 27.

XIV. SCOLOPENDRIUM.

The straight parallel lines of fructification are situated between the secondary ribs of the frond, and covered by a double involucre, turned in from both sides, as you see it in fig. 25, *a*, *b*. We are acquainted with only one species to which this character is perfectly

perfectly applicable; for although several species of Asplenium, in the more advanced stage of their growth, seem to be furnished with a double involucre, such as Asplenium *septentrionale*, *Ceterach*, *Ruta muraria*, *Breynii*, *lanceolatum*, *serratum*, *cultrifolium*, &c., yet this does not justify our referring them to Scolopendrium.

It is in Scolopendrium *officinale* alone that we find from the beginning two involucres, which, originating from the disk on both sides of the lines of seed-vessels, are extended over them. This plant is furnished with simple tongue-shaped fronds, cordate at the base; its stems are short and scaly. The fronds are from a span to upwards of a foot long, and of firm texture: the transverse vessels of the fertile leaves are incrassated at their extremities. In a rich soil they often divide at the top into lobes that are sometimes branched or palmated.

This plant bears great resemblance to the Roman Asplenium *Hemionitis*, except that the latter is hastate at the base, and its fructification has not a double involucre.

The common Hartstongue is not a native of the more northern countries; it is met with in the south of Germany, as far north as Grimma in Saxony, and Thuringia, growing on moist walls and rocks. There are several figures of it, such as in Plumier's work, pl. A. fig. 4, in that of Bolton, pl. 11, and in John Bauhin's Historia Plantarum, vol. iii. p. 748.

XV. DIPLAZIUM.

A very singular and distinct genus; resembles in its habit several species of Asplenium, but differs from them in having its lines of fructification scattered along the midrib, and crossing each other; and particularly in being furnished with a double involucre, which originates from the secondary vein, and opens outwards on both sides. This form of the involucre, therefore, is the reverse of that of Scolopendrium.

There

There are only three species known of this genus, two of which are natives of Jamaica; the third, Diplazium *esculentum*, of Ceylon*.

XVI. WOODWARDIA.

This genus in its habit resembles Blechnum, with which it has indeed been formerly confounded; but in Blechnum the fructification is in uninterrupted lines along both sides of the midrib; while in Woodwardia it is in separate, oblong spots, arranged in a regular row along the midrib; besides, the involucre is vaulted, which in the former genus is flat. In Blechnum *procerum*, indeed, the lines of capsules are sometimes, though rarely, interrupted; but then the involucres are not vaulted.

The species of this genus are widely extended; we are acquainted with three from Virginia and Maryland, Woodwardia *angustifolia*, *virginica* and *radicans*, the latter

* Swartz loc. cit. enumerates nine species, having added the Calypterides of Bory de St. Vincent.—Tr.

of which is also a native of Madeira; with two from Japan and China, W. *japonica* and *orientalis*, of the former of which, fig. 29 is at least a better representation than that given by Thunberg in his Flora Japonica, tab. 35, which, from the lines of fructification being erroneously represented as uninterrupted, conveys the idea of a Blechnum.

XVII. ADIANTUM.

The generic character of Adiantum is very determinate, and approaches only to that of Lindsæa: the capsules are disposed in interrupted lines or oblong spots along the margin of the frond, which, by turning inward over the fructification, forms the involucre. The affinity of this genus to Pteris, as far as relates to habit, is so great, that some species, such as Adiantum *caffrorum*, *fragrans* and *multifidum* might at first sight be easily mistaken for Pterides; but a more accurate examination shows that the lines of fructification are by no means uninterrupted.

These

These lines or oblong spots are so exactly covered by the margin of the frond, that it gives an appearance as if the capsules were actually grown together with this involucre: but this is not the case, at least in some species, such as the above-mentioned Asplenium *fragrans* and *Caffrorum*, which, on that account, have a greater resemblance to the genus Pteris. The drawing of the generic character (fig. 37.) is taken from Adiantum *aculeatum*, which has been, in my opinion, erroneously referred to the genus Davallia*.

There are but two European species of Adiantum, unless we consider Madeira as belonging to Europe, where a third is found:

1. ADIANTUM *Capillus*—With doubly-compound frond, whose leaflets are wedge-shaped, rounded at the top, and divided into lobes, each of which turns in over a spot of seed-vessels. The stalk is shining, red-brown, and divided into several branches.

* This is not Davallia *aculeata*, but D. *dumosa* of Swartz, who gives his reasons for not referring it to the genus Adiantum in his Synopsis Filicum, p. 354.—TR.

Grows

Grows in Austria, Switzerland, England, the south of France, Italy and Greece.

It is figured in Bolton's Filices, but much better in Jacquin's Miscellanea, vol. ii. p. 7. [Engl. Bot. 1564.]

2. ADIANTUM *fragrans*—With bipinnate frond, and ovate, obtuse leaflets, without hairs underneath, divided into roundish lobes. The stem is smooth, and clothed only towards the base with chaffy scales. This species is very like Adiantum *Caffrorum*, except that in the latter the lower surface of the leaflets and the whole stem are closely beset with stiff hairs. The whole frond scarcely exceeds a span in length, and, when recently dried, diffuses a very agreeable smell.

It is found on the Hyeres isles, in the neighbourhood of Montpelier and Toulon, and in Madeira.

According to Hudson, Adiantum *trapeziforme* has been likewise looked upon as an European plant, for Lightfoot pretended to have found it in Scotland; but Bolton has shown, that what those botanists considered

dered as such is nothing but Asplenium *marinum.*

Among the exotic species of this genus in my possession is one as yet undetermined, of which I shall here add a short description.

I call it Adiantum *vestitum*; it was discovered by Bosc d'Antic in Carolina. Has a tripinnate frond, thickly clothed all over with fine woolly hairs; the primary leaflets are ovate-lanceolate, the secondary linear, crenated, and their margin turned in over the spots of fructification. Bosc calls this species Acrostichum *hispidum**.

LETTER X.

ON THE GENERA OF FERNS WITH INVOLUCRES: ASPIDIUM AND ATHYRIUM.

The genera Aspidium and Athyrium, so rich in species, were referred by Linnæus to his Polypodium, on account of bearing their fructi-

* Cheilanthes *vestita.* Swartz Synopsis Filic. p. 128.—Tr.

fructification in scattered round spots on the under surface of the leaves. If, however, according to Smith's opinion, it be necessary to attend to the presence and form of the involucre, it must be allowed that Roth's attempt to divide the Linnæan genus Polypodium into *three*, merits our applause, though he certainly did wrong to incorporate Smith's Cyathea with them. In his Flora of Germany, that botanist distinguishes such species of Polypodium as have a kidney-shaped involucre fixed in the centre (Polystichum), from those in which the involucre is fixed at one side, and only opening at the opposite side of the spots of fructification (Athyrium). From the latter, however, he separated still more German Polypodies, to which he gave Smith's name of Cyathea, without considering that the character of the real Cyathea is a cup-shaped involucre opening above, and a columnar receptacle, to which the seed-vessels are attached. This latter circumstance is not found in any of the European Ferns; and hence Roth's Cyatheæ are real Athyria,

Athyria, having an involucre separating laterally and destitute of a column. This genus forms a connecting link between Aspidium and Asplenium, as is particularly shown in my Asplenium *Athyrium*.

Swartz has also united the Athyria and Polysticha of Roth under the general name of Aspidium, making a sub-division for the Athyria, or those furnished with a lateral involucre. But in this respect I have taken the liberty to deviate from him, since, if the form and separation of the involucres are once adopted for generic distinction, the species of Athyrium and Polystichum must of necessity be kept apart. In the former the involucre separates laterally, while in the latter it is target-shaped, separating in its whole circumference. I further think it proper to change the name Polystichum for Aspidium, which, however, has not the same latitude as the Aspidium of Swartz, but comprises only those species of Polypodium that have a kidney-shaped involucre fixed at the centre.

We

We shall in this place confine ourselves to the European species.

XVIII. ASPIDIUM.

1. Aspidium *Lonchitis*—With pinnate frond, whose leaflets are lanceolate, almost crescent-shaped, furnished at the base, on the upper side, with a projecting pointed lobe; they are serrated all around, and ciliated with sharp bristles. The stem is very thickly clothed with long chaffy scales, and the leaflets are continued almost down to the root. The whole plant, about one foot long, is found on the woody mountains of Silesia, Bavaria, Salzburg, Tyrol, Switzerland, on the Snowden in Wales, and up as far as the Norwegian and Swedish alps (Fjallar).

There is a figure of this species in Flora Danica, tab. 497, in which, however, the chaffy scales are not close enough; and a much inferior one in Bolton's Filices, pl. 19. [Engl. Bot. 797.]

2. Aspidium *Oreopteris*—With nearly pinnate frond and leaflets opposite, lanceo-

late,

late, with oblong, obtuse, entire lobes, the lowermost of which (nearest to the chief stalk) are the longest; their lower surface is thickly clothed with hairs, and the spots of capsules are disposed in a row close to the margin of the frond. The stalk is covered below with chaffy scales, and above with hairs. The whole plant, attaining the height of about a foot, is frequently enough found with us on woody hills. It is best figured in Flora Danica, t. 1121, where all the distinctive characters are very well expressed [Engl. Bot. 1019].

This species may be easily confounded with others: it bears great resemblance to Aspidium *patens*, *noveboracense*, *limbatum*, *marginale*, and Athyrium *Thelypteris*; particularly to the first, which agrees in every respect with A *Oreopteris*, except that the spots of fructification are not confined to the margin, but occupy the whole under-surface of the lobe. Aspidium *noveboracense* likewise approaches very near it; but its stalk is perfectly smooth. Asp. *limbatum* is still

more

more distinct by the serrated margins of its leaflets, the lowermost of which are auriculated. Asp. *marginale* has, indeed, marginal fructifications, and the division of the frond is nearly the same; but the lobes of the leaflets are sinuate-repand, and upon the whole much broader; the stalk, too, is very smooth. But this Fern has been most frequently mistaken for Athyrium *Thelypteris*; the attentive observer will, however, soon find a good distinguishing character in the lobes of the leaflets, which, in A. *Thelypteris*, are not blunt and flat, but pointed and reflected downwards, as also in that their whole lower surface is covered with seed-vessels: and, lastly, it may readily be seen that the involucre of the last-mentioned Fern separates on one side only.

Small specimens of this species bear some resemblance to Polypodium *ilvense*, and perhaps Bellard's P. *limbospermum* is nothing else; but the lower surface of the leaves of A. *Oreopteris* is never beset with chaffy scales: add to this the presence of an involucre,

volucre, which is entirely wanting in P. *il-vense.*

3. Aspidium *fragrans*—With bipinnate frond, the primary leaflets ovate-lanceolate, the secondary very narrow, sharply-toothed, and their lower surface thickly clothed with scales, and with the involucres of the spots of capsules. The stem, about one foot long, is closely beset with broad, chaffy scales.

The whole plant has the smell of raspberries. It grows on the Baikal, and in Jeniseisk in Siberia. Hudson also found it in England; and Bolton is wrong in pronouncing Polypodium *fragrans* Huds. to be a variety of his Polyp. *Thelypteris* (our Aspidium *Oreopteris*). I received my specimens of this plant from the late Aiton, who observes that it is a native of Britain.

4. Aspidium *cristatum* (Polypod. *Callipteris* of Ehrhart)—With nearly bipinnate frond, primary leaflets ovate-oblong, secondary oblong, sharply serrate, and somewhat gashed. The stalk is thinly beset with chaffy scales;

scales; the whole frond has a lanceolate form.

This Fern is among the more rare; though, according to Roth, there is no want of it in the swampy woods of Oldenburg and Bremen. Timm found it in Mecklenburg; Ehrhart in the Hanoverian territory. The best figure of it is given by Afzelius in the Transactions of the Stockholm Academy, for the year 1787, pl. 9. It has often been confounded with the following.

5. Aspidium *rigidum*—With bipinnate fronds, the primary leaflets alternate, ovate-lanceolate, pinnated, the secondary leaflets oblong, obtuse, sharply toothed, or doubly serrated; involucres of a reddish colour; stem thickly clothed with brown scales; by which, together with the less breadth and deeper serrature of the leaflets, this species is distinguished from the preceding. It has hitherto been found only in Salzburg and in the neighbourhood of Darmstadt.

6. Aspidium *aculeatum*—With bipinnate frond; primary leaflets narrow-lanceolate and pinnate;

pinnate; secondary leaflets half-sagittate or crescent-shaped, beset all around with spinous teeth, and furnished at one side of the base with a projecting pointed lobe. The stalk is thickly clothed with brown, chaffy scales. The spots of fructification, when in an advanced state of maturity, usually cover the whole surface of the frond.

This Fern is a native of the woody mountains of the Hartz, Franconia, Tyrol, Wales, &c., and is tolerably well figured by Bolton, pl. 26. [Engl. Bot. 1562.]

7. ASPIDIUM *spinulosum* (Polypodium *cristatum vulgo*)—With bipinnate frond, whose primary leaflets are lanceolate and alternate; secondary leaflets likewise alternate, and of the same shape, but pinnatifid, with oblong, rather pointed lobes, acutely serrated or toothed at the margin. The stalk is white, smooth. and thinly beset with brownish-yellow chaffy scales, and rather swoln at its ramifications.

This species is very common, and has been taken up, on account of unimportant variations,

tions, under different names: when the ramifications of the stem and the lowermost leaflets are rather widened, it is Hoffmann's Polypodium *dilatatum*, which is the same with Roth's Pol. *multiflorum*, with Leers's and Leyser's Pol. *cristatum*, and with Bellardi's Pol. *aristatum*. The two first-mentioned authors, moreover, distinguish Polypodium *spinosum* from Polyp. *dilatatum* or *multiflorum*; but the distinctive characters they give of them are so unimportant, that there are numberless instances of the transition from one into the other, as is proved by my own dried specimens.

Aspidium *spinulosum* is distinct from the above described Asp. *cristatum* by its more multiplied division, and much looser growth; from Aspid. *aculeatum* by its smoother stalk, and the different form of its leaflets. The idea of Weiss, that it is merely a variety of Athyrium *Filix femina*, cannot be warranted either by the shape of the involucre or any similarity of appearance.

Though a very common plant throughout Germany,

Germany in woody and mountainous countries. We are still without a very good figure of it: Bolton's Polyp. *cristatum*, tab. 23, does not well express the habit of the plant; it is rather better represented in Flora Danica, t. 707, and in Müller's Flora Fridrichsdaliana, t. 2. f. 2. [Engl. Bot. 1460.]

8. ASPIDIUM *Filix mas*—With bipinnate frond; primary leaflets alternate, lanceolate, with elongated point, and pinnated; secondary leaflets oblong, blunt, crenated, and serrated at the point. The stalk and chief ribs of the fronds thickly beset with chaffy scales.

This Fern, one of the most common throughout Europe, attains the height of two feet and upwards. It cannot be confounded with Aspid. *spinulosum*, its leaflets being without the spinous teeth, the leaflets of the first order not being so long petioled, and the stem not dilating at the places where the petioles issue. Among the exotic species it approaches nearest to A. *elongatum*; from which, indeed, it cannot be distinguished, unless you see the lowermost leaves, which, in the latter, are bipinnatifid; but not so in A. *Filix mas*.

After Lobel, who has given a very good figure of it (Icon. pag. 812), nobody has thought it worth while to publish a drawing of this common Fern. [Engl. Bot. 1458, Schkuhr, pl. 44.]

To the exotic species enumerated by Swartz I add the following two:

Aspidium *martinicense*—With pinnate frond, leaflets in four or five pairs, lanceolate, with undulate-repand margin, the lowermost pairs having two auriculated unequal appendages. The whole plant, about three feet in height, has a smooth stalk branching at the top into four or five pairs of large thin leaves, a foot and a half long, and three inches broad; the lowermost furnished at their bases with two auriculated appendages, the upper one very short, but the lower one half the length of the leaf itself. The spots of capsules are thinly scattered.

Father Plumier found this Fern in Martinico.

nico, and figured it, pl. 145, under the name *Hemionitis maxima linguæ cervinæ affinis.* It has not been since described by any botanist that I know of, though I have also received it by way of Paris from Martinico.

ASPIDIUM *lancastriense*—With pinnate frond and leaflets almost opposite, lanceolate, pinnatifid, with nearly triangular obtuse lobes, rather oblique, and sharply-serrated all around. The stalk and leaves are quite smooth. The lower surface of the lobes is furnished with a double row of fruit spots.

I know no Fern like this; perhaps it approaches nearest to Aspidium *Oreopteris.* I have received it from my friend the Rev. H. E. Mühlenberg, of Lancaster in Pennsylvania.

XIX. ATHYRIUM.

I refer you to what I have above said of the character of this genus, and proceed to enumerate its European species.

1. ATHYRIUM *Thelypteris*—With nearly bipinnate frond; primary leaflets narrow-

lanceolate, and divided nearly down to the base; secondary leaflets oblong, and becoming pointed by the reflection of their margins on both sides, entire, and for the most part confluent at their bases. The stalk is slender and almost smooth, and the spots of capsules, after arriving at complete maturity, become confluent, and cover the whole lower surface of the leaf. Hence Linnæus first mistook this plant for a species of Acrostichum.

I shall not repeat in this place what I have said above of the difference between this Fern and Aspidium *Oreopteris*, with which alone it can be confounded. It is not so frequently met with as the latter, nor have I been able to find it about Halle; for what Leyser considers as this species is Asp. *Oreopteris*; but in Pomerania and Mecklenburg, near Berlin, in Denmark and Sweden, it occurs in moist forests.

Figures of it are found in Flora Danica, tab. 760, in Schmidel's Icones et Descriptiones Plantar. tab. 11. 13, and in Hedwig's

Theoria

Theoria Generationis, tab. 6. [Engl. Bot. 1018.]

2. ATHYRIUM *fontanum*.—With bipinnate frond; primary leaflets alternate, triangular, oblique at the base, obtuse, and subdivided into blunt, nearly wedge-shaped, sharply-toothed secondary leaflets. The stalk is smooth, angular, and of a green colour. The spots of fructification, though at first separate, afterwards cover almost the whole lower surface of the leaflets, which now become reflected.

The whole little plant is scarcely a short span in length, and grows in a lanceolate form. It comes nearest in appearance to the following; the differences between them will be given with that species. I cannot state with certainty whether or not it is a native of Germany; Leers's plant (Flor. Herborn. n. 790.) is probably Athyrium *fragile*, this botanist not having found it near springs, but on rocks. But in Switzerland and France it is frequent near springs and limpid streams: my own specimens are from Dauphiné.

phiné. Whether it is a native of Britain appears not yet to be ascertained; and Bolton's indistinct figure, pl. 21, is not calculated to settle the matter. Nor can Barrelier's figure be quoted as certain.

3. ATHYRIUM *fragile*—With bipinnate frond; primary leaflets bipinnatifid, opposite, or alternate; secondary leaflets ovate, deeply divided or pinnatifid, with serrated lobes, rounded above, and wedge-shaped downwards.

The whole habit of this plant has something light, and flowing; all the divisions are remote from each other, especially those of the fertile frond, for in the steril fronds they are rather more crowded, and the leaflets broader. The stalk is smooth, and clothed with chaffy scales towards the base only.

The height of this Fern is from a few inches to a foot and a half. It adopts different forms according to the different stages of its growth, its fertility or barrenness; hence Hoffmann's Polypodium *anthriscifolium*

lium and *cynapifolium*. Also Dickson's Polypod. *denticulatum* (Fasc. 3. tab. 7. fig. 1.) appears to be only a variety of Athyrium *fragile*, approaching in some measure to A. *fontanum*.

From Athyrium *fontanum* this species differs particularly in its more lax growth, as also in the want of sharp teeth, and in the shape of the lobes, which are rounded in A. *fontanum*, but obovate in A. *fragile*.

This species is not unfrequent in our rocky forests. Whether Liljeblad's Polypodium *fragile* (Swensk Flora, p. 388.) be the same with ours, is dubious, since it is said there to grow in dry places, and compared to Aspidium *Filix mas*. Nor is Bolton's figure, tab. 27, correct; and the same may be said of that in Flora Danica, tab 401.

4. Athyrium *trifidum*—(Polypod. *trifidum* of Withering) With bipinnate frond; primary leaflets alternate, remote from each other, triangular, and pinnatifid; secondary leaflets ovate, lobed, and the lowermost constantly

stantly trifid, with obovate, obtusely-toothed lobes.

The principal character of this very distinct species is in the lowermost leaflets of the second order being constantly three-cleft.

It is dubious whether it be a native of Germany; at least Hoffmann's Polypod. *trifidum* is not this, but only a variety of Athyrium *Filix femina*. It has been found in England and Wales, and is figured in English Botany, pl. 163*.

5. ATHYRIUM *regium*—With bipinnate frond; primary leaflets remote, but generally opposite, lanceolate, and mostly again pinnate; secondary leaflets ovate, acuminate, deeply divided into blunt lobes, each bearing one spot of capsules. The stem is smooth, and, within the frond, furnished on both sides with a decurrent leafy substance. By the latter character, and the close pointed secondary leaflets, this species is sufficiently

* Dr. Smith has since found that it is by no means different from Polypodium *regium* Linn. (Fl. Brit. vol. iii. p. 1140.)—TR.

distinct

distinct from Athyr. *fragile*, to which it bears some resemblance.

It is met with about Jena and Oldenburgh, as also in moist places and the margin of brooks near Paris, where it was found by Vaillant, who has figured it in Botanicon Parisiense, tab. 9, fig. 1.

6. ATHYRIUM *rhæticum*—With bipinnate fronds; leaflets both of the first and second order remote from each other, in which it resembles Athyrium *fragile*; but the primary leaflets are lanceolate, very acuminate, and sharply serrated at the top: the secondary leaflets of the same shape, but rather more oblong, and dividing in bluntish sharply-toothed lobes. The stalk is thinly beset with chaffy scales, and, as in the preceding species, winged, or lined within the frond with a decurrent leafy substance, which gives it rather a quadrangular appearance. The whole fertile frond has a dingey green and curled aspect.

This Fern approaches nearest to Athyrium *fragile*, from which it is, however, distinct,

distinct, by its long-acuminate leaflets and angular winged stalk.

It is a native of some parts of Germany, as also of Switzerland, Dauphiné, and England. Bolton's figure, tab. 2. fig. 6, cannot be considered as representing this species, but rather Athyrium *regium*. There is a tolerably good figure of it in J. Bauhin's Historia, vol. iii. p. 477.

7. ATHYRIUM *Filix femina*—With bipinnate frond; primary leaflets pinnatifid, and, like the secondary, lanceolate, with lobes pointed, and sharply toothed or gashed.

This plant is so polymorphous, that it will be necessary to describe some of its varieties. There is one in which the stalk is almost entirely smooth; secondary leaves oblong, rounded at the top, and crenate all around; lobes short, rather blunt, and not very remote from each other. The secondary leaflets are likewise so coherent at the base, that the whole frond can only be considered as bipinnatifid. Schreber, who first discovered this variety near Leipzig, called it Polypo-

dium

dium *molle*; and it has since been adopted by most botanical writers as a distinct species; but it cannot be denied that it is frequently seen to pass into other varieties, and that within a very small space. This Athyrium (Polypodium *molle*) of Schreber, Roth and Hoffmann, should not be confounded with the P. *molle*, figured in Jacquin's Icones Rariorum Plantarum, which approaches nearest to Aspidium *patens*.

Another variety of Athyr. *Filix femina* has very broad fronds, a stalk beset with chaffy scales as far up as the leaves, secondary leaflets more deeply gashed, lobes long, linear, and sawed at the top with two or three teeth. This variety has been called Athyrium (Polypodium) *trifidum* by Roth and Hoffmann, but should not be confounded with that so called by Withering.

I have also observed specimens with leaflets almost regularly linear and remote from each other; with the lobes of the secondary leaflets very narrow and deeply gashed. This is Polypod. *incisum* of Hoffmann.

Lastly, Roth's Athyrium *ovatum* is nothing else but A. *Filix femina*, only that the secondary leaflets are more ovate, and rather wider at the base. At least the figure in Müller's Flora Fridrichsdahliana, tab. 2. fig. 3, quoted by him, is the real A. *Filix femina*, and, indeed, the very best figure we possess of it; for that given by Bolton, without being bad, is not very accurate.

This species, in its various forms, is found in woody places throughout Germany.

8. ATHYRIUM *alpinum*—With doubly-compound tripinnate frond; primary leaflets remote, delicately pinnate, as are the secondary ones with narrow, linear lobes, gashed at the top.

The whole plant scarcely attains the length of six inches, and is characterized by the particularly fine division of its frond. It has been hitherto found only in Crain, Carinthia, Salzburg, and Upper Italy.

The figure in Jacquin's Icones Rarior. Plantarum, vol. ii. fasc. 6 and 23, does not sufficiently well express the delicacy of the division

division of the leaves, but is much superior to that of Seguier. (Plantæ Veronens. tom. iii. tab. 1. fig. 3.)

9. Athyrium *montanum*—With more than twice-compound, ternate, and tripinnate frond; leaflets standing pretty remote from each other, and the last lobes very narrow, blunt at the tip, and sharply serrated.

In regard to the treble division of its frond, this fern approaches to Polypodium *Dryopteris*, but the uncommonly fine and multiplied divisions of the leaves constitute an essential difference.

This species is a native of Switzerland, Carinthia, Piedmont, Wales, and the Apennines. Long ago J. Bauhin (Hist. iii. p. 740.) found it on the Rhætian alps; afterwards Plukenet (Phytogr. tab. 89, fig. 4.) in Wales, and Allioni (Flora Piedmont. no. 2410.) on Mount Cenis.

LETTER XI.

ON THE GENERA WITH AN INVOLUCRE: DICKSONIA, CYATHEA, DAVALLIA, TRICHOMANES AND HYMENOPHYLLUM.

XX. DICKSONIA.

THE fructification of this genus being disposed in round spots, Linnæus added it to his Polypodium; but, not to mention that these spots are almost constantly situated at the margin, it has an essential distinguishing character in the involucres being cup-shaped, and formed by the thin margin turned over and opening inward; to this joins the inner side of the small cup, which, originating from the substance of the leaf, opens outwards. By this marginal situation Dicksonia is distinct from Cyathea, in which the cups of fructification are situated on the substance of the leaf itself. Besides this, Dicksonia is destitute of the projecting columnar receptacle

tacle to which the capsules are fixed; though, in some species, a small knob is seen in the middle answering the purpose of the column in Cyathea.

With Davallia this genus cannot easily be confounded, though in that also the spots of fructification are situated at the margin, and mostly at the point of the little lobes of the leaf; but the spots of capsules are merely covered by a scale opening outward.

Of the four species of Dicksonia which I possess, none exhibits the generic character so distinct as Dicksonia *flaccida*, found by Forster on the islands of the South Sea. You have here (fig. 31.) a faithful representation of the form of the spots of capsules in general (*a*), and also of the cups in particular as viewed through the microscope (*b*).

The species of this genus are partly natives of Japan, partly of Ceylon and the Moluccas, as also of the West Indies and the South Sea islands.

XXI. CYATHEA.

This name indicates that the fructification must

must be looked for in a cup, in which, by means of partial minute stalks, they are fixed to a central column projecting above the cup in the shape of a little fungus. The cup is closed in the beginning, but afterwards opens at the top. By this, and the situation of the clusters of capsules on the surface of the frond, Cyathea is distinguished from all the other genera of Ferns. Linnæus referred it to Polypodium, in doing which he attended merely to the scattered nature and orbicular shape of the spots of fructification.

Of the six species in my possession, none expresses the generic character more beautifully than a new one to which I have given the name of

CYATHEA *commutata.*—I received it by way of Paris from St. Domingo; and, on examination, found that Plumier had already figured it, tab. 14, under the name of *Filix alia caudata et spinosa*, but in such a manner that it must necessarily be taken for a Pteris. This error, however, is pardonable, since the spots of fructification, as you see it

in

in fig. 32, are often disposed near the margin, and so close together, that Plumier's representation appears to be the less defective.

It has a spinous stem of three feet in height, a pinnate frond with alternate leaflets above a foot long, lanceolate, entire, and only a little serrated at the tip. Each of the lowermost pair of leaflets gives out at the base another dependent leaflet of the same shape. The midrib of the fertile frond is smooth, but that of the barren ones is beset with straight short prickles.

This species is found in St. Domingo. I have caused a leaf to be drawn, fig. 32, *a*, and the cups of fructification, fig. 32, *b**.

The greater part of the species of Cyathea are arborescent, all natives of the West Indies and the islands of the South Sea. As for Cyathea *medullaris*, of which Bernhardi has made a new genus, (Sphæropteris,) I am entirely of Swartz's opinion: my specimen has,

* Swartz l. c. gives this as a synonym to his Cyathea *horrida* (Polypod. *horridum* L.)—Tr.

indeed, for the most part, closed cups, but some of them have already opened, and show the central column with sufficient distinctness. By comparing this species with my specimens of Cyathea *arborea*, which I received from Kew gardens, you may satisfy yourself that Forster's Polypodium *medullare* is a very good species of Cyathea.

XXII. DAVALLIA.

Linnæus united this genus with his Trichomanes, and partly also with Adiantum; and it must be owned that, with regard to habit, its species all agree either with the one or the other of those genera: but the clusters of seed-vessels are neither contained in projecting small cups, nor beneath the reflexed margins of the leaf. They are disposed in spots, each covered by a truncated scale opening outwards, but without an additional scale at the opposite side; they are constantly situated on the nerves of the frond, and projecting over its margin. I take my drawing of of the generic character from a new species, which I call

DAVALLIA *domingensis*—Its frond is bipinnate, with primary leaflets lanceolate, pinnate below and pinnatifid above; secondary leaflets also lanceolate, with obtuse crenated large teeth. The single spots of capsules, covered by their scales, are situated at the notches of these teeth. Sometimes the margin of the leaf is turned in; but this only takes place when the spots are very crowded; and, under such circumstances, the plant may be mistaken at first view for an Adiantum (fig. 33).

This species was discovered by Plumier in the forests of St. Domingo, and figured by him, pl. 7, under the name *Filix arborescens adiantoides minor*.

The only European species of this genus is

DAVALLIA *canariensis*—With tripartite alternately twice-compound frond, whose last divisions are lanceolate, but, when beginning to bear fruit, adopt an obovate form. It is

 a native

a native of Portugal and the Canary Islands, and is cultivated in our green-houses. A figure of it, though an indifferent one, was first given in Magnol's Hortus Monspeliensis, p. 82; but it is excellently represented in Jacquin's Icones Plantar. rariorum, vol. i. fasc. 7. tab. 200.

It may not be improper to observe in this place, that Swartz's Davallia *aculeata* appears to be a perfect Adiantum. The spots of seed-vessels are confluent, and covered by the margin of the frond turned in (fig. 37). I have never been able to see the fructification in a different state from that now described; whence I must, however reluctantly, contradict what the excellent Swartz has said of it. That I possess the right plant I am persuaded from comparing it with Plumier's figure, pl. 94.

XXIII. TRICHOMANES.

This and the following differ from the other genera of Ferns in the membranous transparent nature of their foliage, which is uncom-

uncommonly delicate in Trichomanes *trichoideum*, and beautifully cellular in almost all the rest (see Trich. *crinitum* and Hymenophyllum *bivalve*, fig. 35 and 36). But the chief character of Trichomanes consists in the elegant fructifications or their involucres, which, like a funnel-shaped cup, are narrower towards the base, and furnished with a projecting pistil or thread-like central column. In Hymenophyllum the involucre or reservoir of the capsules is not narrower at the base, but as broad, cup-shaped, and distinctly composed of two valves, as you see it, fig. 36, in H. *bivalve*. In both these genera the substance of the cups or involucres is not at all transparent, and is at the same time of a deeper colour than the delicate leaves; in both they are imbedded in the margin of the leaf itself, and in most species of Trichomanes project over it. Some, such as Trichomanes *muscoides*, *trichoideum*, *rigidum*, *radicans*, *pyxidiferum*, bear their cups on proper footstalks, mostly in the

axils

axils of the leaflets, and therefore entirely distinct from the frond.

Not one of these Ferns is arborescent; the stalk of most of them is so short and filiform that it scarcely merits the name. Trichomanes *scandens* and Hymenophyllum *multifidum* are among the largest, but even these seldom attain the height of one foot; and others, such as Trichomanes *muscoides*, *pusillum*, *membranaceum*, *reptans*, *pyxidiferum*, Hymenophyllum *tunbridgense*, &c. are so minute, that they might be mistaken for mosses.

Almost all of them have a much divided compound frond; in Trichomanes *scandens*, *radicans* and *rigidum*, in Hymenophyllum *hirtellum*, *clavatum*, *polyanthes* and *multifidum*, the frond is three and four times pinnate. Only Tr. *reniforme*, *membranaceum*, and Hymenoph. *asplenioides* have a simple frond.

As in enumerating the species of the more extensive genera, I have hitherto confined myself

myself to those of European growth, so here I have only to mention

TRICHOMANES *pyxidiferum*—It has a compound tripinnate frond, with a leafy substance running down the ribs and slender stalk; lobes of the leaves narrow, linear, not tapering to a point, but rather snipt at the top. The cups are both terminal and axillary on very short minute pedicles.

This little plant, scarcely attaining the height of four or five inches, has been found in England at one particular place only, viz. in the moist cavern of a rock near Bingley. In St. Domingo, where it was discovered by Plumier, it grows under mosses on the stems of decayed trees, and bears a great quantity of cups.

It is figured by Plumier, tab. 50, E; by Bolton, tab. 30, (but without capsules), and by Hedwig (Filic. Gener, et Spec. Fasc. 1.)

XXIV. HYMENOPHYLLUM.

It has already been mentioned that the cup-shaped involucres, consisting of two

valves,

valves, afford the chief distinctive character between this and the preceding genus. It might be united with Cyathea, if in this genus the cups were imbedded in the margin of the leaf itself, and if the whole habit and delicate transparent structure of the frond of Hymenophyllum would admit of such an union. Hence, too, it must be kept distinct from Dicksonia, which, properly speaking, has no bivalved cups, nor a distinct central column within the involucre. Lastly, it cannot be referred to Davallia, in which the clusters of capsules are merely situated under a single scale upon the surface of the leaf; not to mention the difference in habit and structure.

Of the twenty species known of this genus, the only European one is

HYMENOPHYLLUM *tunbridgense*—This has a nearly bipinnate frond, with principal leaves decurrent, secondary leaves or leaflets linear, not pointed, and sharply dentate all around. The cups of seed-vessels stand solitary, above the axils of the fronds, on short, delicate

delicate pedicles. The whole plant scarcely exceeds two inches in height, and cannot be confounded with Trichomanes *pyxidiferum* on account of its serrate leaves, not to mention the different form of the involucre of the capsules. Bolton is mistaken in supposing that the two mutually change into each other; Linnæus had already noticed the great difference in their fructification, and expressly pronounces this species to have two valved cups.

The native country of this species is Great Britain; it is particularly frequent in Wales and Yorkshire. It has also been found in Stift-Bergen in Norway, and in Italy. Bolton's figure of it, pl. 31, is not remarkably good; those of Flora Danica, tab. 914, and English Botany, pl. 162, are much superior.

LETTER

LETTER XII.

ON THE GENERA WITH CAPSULES NOT ANNULATED: SCHIZÆA, OSMUNDA, LYGODIUM, GLEICHENIA, ANGIOPTERIS, DANÆA AND MARATTIA.

XXV. SCHIZÆA.

The capsules of the genera which we are now about to examine are not, like the preceding, furnished with an elastic ring, but for the most part are only striated. The striæ, which are usually radiately arranged, may, however, be regarded as a mechanism adapted to assist in the dehiscence of the capsules.

In the genus Schizæa we find two rows of such top-shaped, longitudinally and radiately striated capsules, on the back of narrow, usually digitate appendages of the frond, occupying its summit as so many spikelets. They are furnished with no other involucre than bundles of hair interspersed among the fructi-

fructifications. Hence Linnæus placed the species of the genus with his Acrostichum; but the distichous spikelets formed by the fructiferous appendages (independently of the absence of the jointed ring) induced Smith to form them into a separate genus, which he called Schizæa, not merely on account of the appendages being divided, but from the general gashed appearance of the whole fronds. The framer of this genus appears, however, to have erred in describing a ring to its capsules, which does not exist in five of the known species, and is present only in Schizæa *spicata*, which, on this account, is to be referred to the genus Onoclea, as was first pointed out by Swartz in his Observationes Botanicæ, &c.*

1. Schizæa *pectinata*—A native of the Cape, and the only species with a simple linear frond and secund converging appendages, cannot easily be confounded with the four others, all of which have dichotomous leaves,

* Annals of Botany, vol. ii. p. 304.

but

but on that account are more difficultly distinguished from each other. The following characters, however, will be sufficient to keep them perfectly distinct:

2. SCHIZÆA *elegans* (Acrostichum *elegans*, Vahl.)—With four times dichotomously divided frond, the divisions of which are nearly wedge-shaped, wide at the top, and ribbed; appendages pinnate and revolute. Vahl, who received this species from Trinidad, has figured it in his Symbolæ Botanicæ, tab. 50.

3. SCHIZÆA *Forsteri*—With five or six times divided dichotomous frond, the ultimate divisions linear, ribbed, with abruptly attenuated extremity, where it is furnished with digitate, erect, steril appendages. This species is new, was found by Forster in Nova Caledonia, and called by him Acrostichum *dichotomum*, from which, however, it is entirely distinct. Bernhardi has given a good figure of it in Schrader's Botanical Journal (vol. ii. 1800, pl. 2. f. 3, 4).

4. SCHIZÆA *dichotoma*—Without leaves, with thrice dichotomously divided stalk, whose

whose ultimate divisions are linear, attenuated at the extremity, with appendages secund, horizontal, pinnate and converging, situated on the gradually attenuated tip of the branches. Linnæus received this species from China. We find figures of it in Petiver's Gazophylacium, t. 70, fig. 12, and in a memoir of Willdenow, (Uber einige seltene Farrenkräuter), pl. 3. fig. 2.

5. SCHIZÆA *bifida*—Without leaves, with twice dichotomous stalk, whose ultimate divisions are bent, filiform, and furnished at the top with almost erect, distinctly pinnate appendages. Willdenow, who received this species from New Holland, has figured it in the just mentioned memoir, pl. 3, fig. 2.

From all this it appears, that Schizæa *Forsteri* approaches nearest to Sch. *elegans*, from which, however, it differs in the lobes or divisions of the frond not being wider but narrower at the top, not wedge-shaped but linear; as also in the appendages not being pinnate and revolute, but digitate and straight. Schizæa *dichotoma* is distinct from Sch.

Sch. *Forsteri* in having no leaves, but a stalk only dividing into branches; as also in the appendages being horizontal, converging, and pinnate.

XXVI. OSMUNDA.

This genus at first sight resembles Onoclea or Botrychium; but is distinguishable from the former by the absence of the involucre and jointed ring; from the latter, by the striated or wrinkled surface of the capsules. In most species of Onoclea known to me we find at the place where both valves of the capsules join, a distinct hinge, representing part of a jointed ring; by which mechanism the seeds are probably scattered with elasticity. This construction may be seen at fig. 38, taken from Osmunda *regalis* and my O. *basilaris*; of which two species I shall here give some account.

OSMUNDA *regalis*—With a bipinnate frond, and leaflets alternate below, opposite above, obtusely-lanceolate, coarsely crenate, and almost lobed or auriculated at the base, and

and finely serrate towards the top. The racemes of capsules mostly issue from near the upper part of the frond; though not unfrequently the leaflets of the frond themselves run out into racemes of seed-vessels. The branches of the raceme are very numerous, and entirely destitute of hairs.

This Fern attains the height of five feet, and makes a beautiful appearance. It is found throughout Europe in moist forests. The figure of it in Flora Danica, t. 217, is not particularly good.

OSMUNDA *basilaris*, as I call a new species which I have received from Kew Gardens, is nearest related to O. *Claytoniana*, but distinguishable from it by its racemes occupying more the lower part of the frond, which is nearly bipinnate; the primary leaves running out into alternate, ovate-lanceolate, entire, beautifully veined leaflets. Towards the base of the frond appear the racemes of fructification; and the capsules are enveloped by reddish bundles of hair, wanting in O. *regalis*, but present in all the American species

of

of the genus. Its native country is probably the West Indies. There is no figure of it extant.

XXVII. LYGODIUM.

This genus, a native only of the tropical countries and Japan, was united by Linnæus with his Ophioglossum, on account of its capsules being disposed, in a similar manner, in a distichous spike. But in Ophioglossum this spike is jointed, and is not situated in the margin of the leaves, but on a proper naked scape, and the round capsules open transversally. In Lygodium, on the other hand, the spikelets occupy the margin of the leaf, each capsule being hid under a scale, which in old specimens is sometimes dropped off; all the capsules are wrinkled and striated, and open either transversely or laterally lengthwise. Another chief distinctive character is, that the species of Lygodium come up from their seeds with a curled frond; a circumstance not observed in Ophioglossum, which, in this respect, is similar to Psilotum, Botrychium and Lycopodium.

This

This genus has received several names; by Cavanilles it was called *Ugena*, *Ramondia* by Jussieu, *Hydroglossum* by Willdenow, *Odontopteris* by Bernhardi: all which authors have not so correctly given the generic character as Swartz has done, of whose observations I have here availed myself.

I have received from the Brasils a species of Lygodium, which might be considered as new, but that it agrees with a plant described by Breynius (Plantar. Exoticarum Centuria, t. 96), which by Linnæus and Willdenow has been regarded as a mere variety of Lygodium *scandens*; but is in fact a distinct species, called by Swartz Lygodium *venustum*. This has a round sarmentose woolly stem; frond tripinnate; leaflets either pinnate, or palmate, or three-lobed; the last leaflets are deeply serrate, and the extreme lobe is lanceolate, much lengthened out, blunt, and deeply crenate. The whole plant is covered with fine hairs. Part of the leaflet is represented fig. 39.

XXVIII. GLEICHENIA.

In the genus Gleichenia we see on the reverse of the frond, whose lobes are rolled back in the manner of Onoclea or Acrostichum, three or four capsules crowded together in a hollow, formed in the leaf, and divided into three or four cells. The capsules are slightly striate, pear-shaped, and open laterally and lengthwise.

Gleichenia *polypodioides* was placed by Linnæus under Onoclea; not, however, without expressing a doubt of its belonging to it; but, indeed, he had not a very distinct and correct idea of the generic character of Onoclea itself.—This Fern is found at the Cape, and the best figure of it is given by Swartz, Annals of Botany, vol. ii, pl. 10, f. 3.

XXIX. ANGIOPTERIS.

Of this genus we are only acquainted with a single species, brought by Forster from the South Sea, under the name of Polypodium *evectum*. At first sight it is more likely to be mistaken for a Pteris, the lines being so close

close to the margin of the frond; but on a more accurate examination there are seen on both sides of the secondary ribs of the leaf, not far from the margin, five, six, or seven pear- or egg-shaped striated capsules, closely opposite, in two rows, and opening longitudinally. Swartz has very well represented its generic character in the same plate of the above-quoted memoir, fig. 4.

XXX. DANÆA.

As the capsules of Danæa appear in the form of lines on the secondary veins of the frond, this genus might at first sight be supposed to belong to Asplenium, to which, indeed, Linnæus has referred the only species known to him. A more minute examination, however, shows that what seemed lines of fructification are really oblong capsules, immersed in the substance of the frond, and opening at the upper part in several pores. Each of these pores leads to a small loculament, of which there are more than twenty in each capsule. I refer you to the very good representation of the generic character given by Swartz*.

Plumier's *Lingua cervina nodosa maj. et min.*, tab. 108 and 109, represent two species of Danæa; in that of tab. 108, D. *nodosa*, the fertile has a different form from the steril frond; the leaflets of this latter being nearly entire and much broader than those of the fertile one, in which they are rather serrate. Both species are natives of the West India islands.

XXXI. MARATTIA.

This genus is nearly related to Danæa; its capsules, however, are not in parallel lines at the secondary veins of the frond, but in oval spots at the margin of the leaf, or dispersed on the whole under surface, opening at the upper part in two halves, and thus exposing a number of loculaments for the seeds. Swartz, in the above-mentioned paper, has given a very faithful representation of it (pl. 10. fig. 6).

* Annals of Botany, vol. ii. p. 288, pl. 10, fig. 5.

LETTER

LETTER XIII.

ON THE PTEROIDES OR PLANTS RELATED TO THE FERNS; AND FIRST OF THE GENERA BOTRYCHIUM, OPHIOGLOSSUM, PSILOTUM, LYCOPODIUM.

THE general observations I have to advance on the *Pteroides* are few, as all these plants have but little affinity one with another, and not much more with the proper Ferns. The genera Botrychium and Ophioglossum, indeed, agree with Lygodium and Osmunda in their external structure, but their germination is totally different. Rumphius (Herbarium Amboinense, vol. vi. tab. 68, fig. 3.) has given a faithful drawing of the evolution of the frond of Botrychium *zeylanicum*, from which it appears that the young leaves are at no period of their growth spirally coiled, but always completely straight. On the other hand, we observe the spiral growth of the frond in Pilularia and Marsilea.

One

One circumstance which the Pteroides have in common with the true Ferns is, the importance of the roots in the propagation of the species; they all easily multiply by radical tubers, particularly the Botrychia, which are indeed nearest related to the Ferns. Linnæus had long ago stated, in his Flora Suecica, that in the hollow stalk of Botrychium *Lunaria*, near to the root, the germ of the future plant is almost constantly to be found. Several Pteroides, that do not approach very near the Ferns, have no real stem, but their sarmentose roots put forth, at every part, fronds that perish annually; as is the case in Pilularia, Marsilea, and a few others. In Psilotum *triquetrum* we find nearly naked stems, clothed with small scales; and Equisetum is furnished with fine leaflike sheaths, covering its naked stalks and branches.

The propensity of the stem to strike root, which characterizes several Ferns, and almost all the Mosses and Jungermanniæ, is particularly observable in the species of Lycopodium,

copodium, especially in L. *rupestre*, *helveticum*, *alpinum*, *inundatum*, *complanatum*.

The internal structure of the Pteroides is not less various than the external; the Botrychia and Ophioglossa, which approach nearest to the Ferns, are, like these, furnished with distinct bundles of spiral vessels; the Lycopodia are destitute of pith, the centre of their stem being occupied by a woody substance consisting of a dense congeries of spurious tracheæ. The stalk of Equisetum is empty, and the circumference made up of bundles of spiral vessels intermixed with cellular substance.

We shall treat on the differences that take place in the sexual organs and fruit under the separate genera.

PTEROIDES.

1. Botrychium.—Fruit: globose, one-celled, smooth, coriaceous capsules, disposed in spikes or racemes, and opening either irregularly or lengthwise.

2. Ophioglossum.—Fruit: round, one-celled

celled capsules, disposed on a two-ranked, jointed spike, and opening transversely.

3. Psilotum.—Fruit: globose, three-celled, three-seeded capsules, sessile on the branches, and opening upwards.

4. Lycopodium.—Fruit: generally kidney-shaped or roundish, two- or four-valved capsules, in the axils of the leaves, or under separate scales in a spike, opening elasticly.

5. Pilularia.—Fruit, at the same time the reservoirs of the sexual organs: four-celled, round capsules, containing partly globular ovula surrounded by a loose membrane; partly, in other membranous envelopes, a quantity of grains, supposed to supply the place of anthers.

6. Marsilea.—Fruit, at the same time the receptacles of the sexual organs: two-valved, many-celled capsules, always standing double, containing partly egg-shaped ovula, surrounded by a loose membrane; and partly, at the base, small, transparent, pear-shaped cells, replete with yellow grains, apparently performing the function of anthers.

7. Sal-

7. SALVINIA.—The capsules containing the seeds are surrounded by many others, having withinside, upon a common stalk, anther-like bodies affixed, as in the plants of the sixteenth class, to partial filaments connate at the base.

8. ISOETES.—Both seeds and fecundating matter contained at the base of the leaf in proper reservoirs, and fixed to a number of transverse bars. The reservoirs of the seeds are separate from those of the anthers, but on the same plant.

9. EQUISETUM.—Fruits disposed in a raceme beneath peltate bodies, furnished with conical reservoirs, generally displaying four filaments, club-shaped at the end, and considered by some as anthers.

These genera are here classed according to the natural affinity they respectively bear to the proper Ferns; their relationship to each other is very distant.

I. BOTRYCHIUM.

The smooth, coriaceous nature of its seed-vessels,

vessels, without rings, distinguishes this Pteroid from the Osmundæ and Onocleæ, to which genera it is, however, nearly allied. But even in a natural system it must be separated from these Ferns on account of its young fronds being entirely void of spiral evolution. From Ophioglossum this genus differs in the dehiscence of the capsules, which is irregular, while in Ophioglossum it is constantly transverse.

Two of its species are indigenous to Europe:

1. Botrychium *Lunaria*—With simply-pinnate frond, and nearly crescent-shaped leaflets. The height of the whole plant scarcely exceeds a finger length; the separate peduncled raceme is commonly an inch and a half long. It is a native of the greatest part of Europe, growing in dry places and on eminences in the neighbourhood of woods. A figure of it is given in Flora Danica, tab. 18, on the left hand side.

2. Botrychium *rutaceum*—Frequently with a doubly-bipinnate frond, and ovate gashed

gashed leaflets. This more rare species is certainly distinct from the former, and found in moist meadows. Breynius first figured it, tab. 94 and 95, considering the latter as a different species, to which it has no claim, the only difference being in the size of the parts. Another good figure is given in Flora Danica, tab. 18. Also S. G. Gmelin, who gathered it on dry meadows, has described it as a distinct species (Nova Comment. Petropol. tom. xii. p. 516, 517, tab. 11, fig. 2.)

I have received a new species from Virginia, which I call Botrychium *dissectum*. The frond is tripartite, and nearly tripinnate; the secondary leaflets are lanceolate, obtuse, and divided into wedge-shaped, bluntly-crenate or gashed lobes. The spike is nearly tripinnate. This species agrees in some respects with Botrychium *virginicum*, in which, however, the secondary leaflets are acuminated, and divided into finely gashed lobes. Michaux (Flora Boreali-Americ. vol. ii. p. 274.) has a Botrypus *lunarioides* agreeing with my new species in the triple division

sion of the frond and spike, but differing by its roundish kidney-shaped leaflets: I consider this as the same with Osmunda *multifida* of Gmelin (Nov. Comment. Petrop. tom. xii. p. 517, tab. 11, f. 1).

II. OPHIOGLOSSUM.

In the disposition of its fruit and external form this genus agrees pretty well with Botrychium; but its spike is rather jointed, while the fruit is placed on it in two rows, closely grown together, and always opens transversely.

There are two species of this Pteroid natives of Europe.

1. OPHIOGLOSSUM *vulgatum*---With ovate, simple frond; stipes smooth, three or four inches long, terminated by an oblong or ovate, entire, rather succulent obtuse leaf, embracing the stem, and bearing from its middle a spike of one inch in length, and thickly clothed on both sides with seed-vessels. The dehiscence of the latter gives a jointed appearance to the spike.

The

The shape both of the frond and spike frequently varies, the former in being sometimes nearly round, sometimes sinuate, the latter in being double or treble.

This species is found throughout Europe in meadows, and is figured in Flora Danica, tab. 147, and less correctly by Bolton, tab. 2. fig. 1, and tab. 3.

2. OPHIOGLOSSUM *lusitanicum*—With lanceolate frond. This species is scarcely half the length of the former. The peduncled spike issues from the root, together with the lanceolate, entire leaves, narrowed at the base. The spike is, proportionally, much thicker than that of the preceding species, and has no frond below it. Gabriel Grisley first discovered this species in Portugal, and Barrelier afterwards gave a tolerably good figure of it (Plantæ per Galliam, &c. observatæ, tab. 252. ii).

III. PSILOTUM.

This genus was referred by Linnæus to the Lycopodia, from which, however, it is totally

totally distinct, both in its structure and the nature of its fruit. The latter consists of three-celled, three-seeded capsules, dispersed in the axils of the leaves, and opening upwards with three pores. The only genus to which this bears any resemblance is Gleichenia; which, however, is a true Fern, bearing capsules disposed by threes on the back part of the fronds. Hence Willdenow (in Römer's and Usteri's Magazin für die Botanik. No. 6, p. 15.) first distinguished a species of Psilotum (the Lycopodium *nudum* of Linnæus) by the name of *Hoffmannia*; which, afterwards, in a separate dissertation On rare Ferns, he exchanged for that of *Bernhardia*. Swartz, however, adding another species to this genus, and determining it more accurately, gave it the name of Psilotum, now generally adopted.

The first species (Psilotum *triquetrum*) is a native of the West Indies, and figured in Plumier's work, pl. 170, A. The second (P. *complanatum*) was brought over by Forster from one of the South Sea Islands:

it

it has the same number of divisions as the former, but is furnished with leaflike, linear branches, clothed all over with small delicate scales.

IV. LYCOPODIUM.

Though the fruit of this genus is, on the whole, kidney-shaped, yet some of its species furnish exceptions to this rule: for instance, it is angular in Lycopodium *myrtifolium*; oblong and angular in Lycopodium *scariosum*; nearly cup-shaped and divided in the middle in L. *tannense*. The form of the capsules is of two kinds even in the same plant; as in Lycopodium *Selaginoides*, *denticulatum*, *apodum* and *helveticum*: some being kidney-shaped and growing in spikelets under separate scales; others, composed of three or four valves, are angular and sessile in the axils of the leaves. The excellent Dillenius already observed this difference of the capsules in Lycop. *helveticum* (Histor. Muscor. p. 466, tab. 64, D.) and in Lycop. *Selaginoides* (*ibid.* tab. 68). The four valves of the capsules of the latter species are also

expressed

expressed in Flora Danica, tab. 70, and pointed out by Haller (Hist. Stirp. Helvet. n. 1717).

Besides this, we see in several species buds growing from the axils of the leaves, consisting at first of four leaflets, from which afterwards proceed several others. This peculiarity was first observed in Lycop. *Selago*, by Scheuchzer, (Itin. Helvet. tom. 1. p. 44.) and afterwards, in the same species, by Dillenius, (loc. c. p. 437, tab. 56. h—p.), and by Oeder (Flora Danica, t. 104). It was this observation upon which Linnæus founded a theory that prevailed for a considerable time; the kidney-shaped capsules were taken for anthers, the minute seeds for pollen, and the Dillenian bodies for a four-leaved calyx, from the bottom of which leaflike pistils arise, dropping off when the ovaries are arrived at maturity. The objection that these bodies might be buds, Linnæus endeavoured to remove by stating, that a bud never grows from the centre of a calyx, and the considering them as the rudiments of future branches,

branches, was inadmissible, from not being analogous to the dichotomous division of all the other branches. He did not, however, prove that the leaflets described by Dillenius really deserve the appellation of calyx; and the dichotomy of the branches is of course not to be seen in the bud. That these buds drop off and produce new plants, as observed by Linnæus, is not sufficient to make them calyxes enclosing seeds, since we know that the buds of mosses and of some other plants, such as Dentaria *bulbifera*, &c. do also fall off and propagate their species. (See Linnæus, de Semine Muscorum, in Amœnit. Acad. vol. ii. p. 293.)

How much the ideas of other naturalists respecting this subject were influenced by the hypothesis of Linnæus, appears from this, that even Haller himself (Hist. Stirp. Helv. tom. iii. p. 22.) considered the kidney-shaped capsules as anthers, and the well known *Pulvis Lycopodii* as pollen; in which he was confirmed by the authority of Neumann and other chemists, whose experiments, próving the abundance of wax contained in this powder, appeared to indicate an analogy between it and the pollen of other plants. Bergius's accurate chemical analysis of both these substances (Mater. Med. Veget. p. 852, 853.) presents the same results as to their similarity. The outward appearance of the powder of Lycopodium, similar to that of the globules of pollen, has been considered as an additional proof, each grain being covered with fine bristles, such as are observed in the pollen of the plants of the sixteenth and seventeenth classes of the Linnæan system.

Specious as this reasoning may be, it is impossible not to adhere to the original opinion respecting these parts, when we know that the kidney-shaped capsules, upon dropping off and scattering their contents, produce a number of seedling plants. That from the *Pulvis Lycopodii* of the shops, plants will grow up as from other seeds, I have been lately assured by a very credible witness, professor Willdenow; and the excellent observations of Brotero in the Trans-

actions

actions of the Linnean Society, vol. v. p. 162, relative to the germination not of the kidney-shaped, but the triangular four-valved capsules of Lycopodium *denticulatum*, which came up with obovate seed-lobes, only prove that the capsules of several species of this genus are of two different shapes.

It must, however, be confessed, that we are still in want of careful and unprejudiced observations, relative to the œconomy of the Lycopodia, from the first periods of their growth; for even Hedwig's investigations cannot be said to have thrown any light upon this subject. This naturalist, observing in the buds of Lycopodium *Selago* gray parallelopiped bodies, rather too precipitately concluded they were the male organs, without suspecting that they might be mere precipitations of the concentrated vegetable juices, such as we find in other plants. (Hedwig, Theoria Generationis, p. 112—116, t. 9.)

All the species of this genus are uncommonly leafy, their stems being generally covered, their whole length, with at least two rows of leaves. These are constantly simple, sessile, very narrow, and entire, or at most only ciliated. The broadest are seen in Lycopodium *Phlegmaria* and *myrtifolium*, which are, however, only ovate-lanceolate. The internal structure of the principal stem has the peculiarity of harbouring, in the centre of a soft cortical substance, an uninterrupted nucleus, composed of close bundles of spiral vessels, which, however, are not disposed in concentric circles.

The following are the European species of this genus :

1. Lycopodium *Selago*—With erect, dichotomous stem, increasing upwards, and furnished with eight rows of small, lanceolate-awl-shaped, somewhat concave leaves, closely imbricated. That these leaves are really eight-ranked, can be distinctly perceived by viewing a branch perpendicularly from its extremity. The kidney-shaped capsules are not disposed in distinct spikelets, but beneath the leaves themselves at the upper part of the branches. The buds, or what Linnæus

considered as flowers, are not unfrequently seen in old specimens.

This plant is found in bogs and moist woods, especially in alpine situations, in Rügen, Mecklenburg, Switzerland, Crain, &c. A figure of it is given by Dillenius (Hist. Musc. tab. 56, f. 1.), and in Flora Danica, tab. 104.

2. Lycopodium *alpinum*—With creeping stem, branches ascending, dichotomous, and leaves four-ranked, scaly, adpressed and acute. The spikes of fructification are round, without proper peduncles, being clothed towards their base with leaves. The scales that conceal the kidney-shaped capsules are distinct from the other leaves by their membranous texture, and by being pressed rather less closely to the stalk.

This species, the erect branches of which scarcely attain the height of one inch and a half, is only found in alpine situations, as on mount Brocken, in Salzburg, Crain, the Tyrol, Switzerland, and the alps between Swe-

den

den and Norway. A good figure of it is given in Flora Danica, t. 79.

3. LYCOPODIUM *annotinum*—With creeping stem, and shoots of the preceding year jointed, all erect, furnished with numerous linear, pungent, spreading, slightly serrated leaves. Fructification in round spikes. It attains the height of two feet, and is particularly distinguishable from others by its divaricate, pungent leaves. The scales also, under which the capsules are situated, have long attenuated points, and are of a more membranaceous structure than the leaves.

This species grows throughout Europe on woody mountains. It is figured in Flora Danica, t. 127, but better by Dillenius, t. 63, f. 9.

4. LYCOPODIUM *clavatum*—With creeping, variously curved stem, striking root here and there, and shoots soon becoming prostrate. Leaves numerous, linear, terminating in a silky hair. Spikes generally double, more rarely

rarely simple, or in threes and fours, on proper, nearly leafless peduncles. The scales of fructification spreading and membranaceous.

It is pretty common in woods, and even found on the heaths of Germany. The figure in Flora Danica is far less beautiful and accurate than that given by Dillenius, tab. 58, fig. 1.

5. Lycopodium *inundatum*—With creeping, strong rooted stems, and barren shoots also decumbent, while the fertile ones are ascendent. Neither exceed the length of a few inches; they are thickly clothed with fine, linear, curved leaves disposed without order. The fructiferous spike is rather thicker than the other shoots, and, like them, closely covered with leaves.

This species, which is not very common, inhabits inundated bogs, and is figured in Flora Danica, tab. 336, but better by Dillenius, t. 62, fig. 7.

6. Lycopodium *Selaginoides*—With numerous lanceolate ,finely ciliated, spreading leaves,

leaves, covering the shoots without order, and leafy spikes with scales longer than the leaves, membranaceous, and very spreading. The whole plant is scarcely an inch and half long, and upon first sight bears some distant resemblance to Lycopodium *Selago*, from which, however, it is sufficiently distinct, by the delicacy of all its parts, by the leaves not being disposed in rows, and having ciliated margins, as also by the proper spikes being clothed with very spreading scales. The two-fold form of its capsules has been already noticed.

This ranks among the more rare species of the genus, having been hitherto met with only in Bremen, Oldenburg, Silesia, Bavaria, Switzerland and Crain. Figures of it are found in Haller's Stirpes Helveticæ, tom. iii. tab. 46, fig. 1, (bad); in Flora Danica, tab. 70, (better), in Dillenius's Muscor. Hist. tab. 68, fig. 1, (incomparable).

7. LYCOPODIUM *complanatum*—With creeping stem and erect, dichotomous, leafy branches, a foot long; with short-lanceolate, acumi-

acuminate leaves, disposed in two ranks, connate below, and closely imbricated. Between the two ranks of the connate leaves, there are on the back, or outer surface, single, very fine and small scale-like leaves. The spikes of fructification are single, and grow two, three, or four together, on stalks about three inches long, beset with scale-like leaves. The scales that cover the capsules are membranaceous and spreading.

This species grows abundantly on woody mountains and heaths. There is a very bad figure of it in Flora Danica, tab. 78; that of Dillenius, tab. 59, is much superior.

8. LYCOPODIUM *helveticum*—With small sarmentose stems, and rather erect shoots, clothed with leaves alternately varying in form; for on two sides of the branches are oval, rather oblique, stem-embracing very spreading leaves, between which there are other narrow lanceolate ones, in two ranks, closely adpressed to the shoot. The small shoots and stems strike numerous, simple, filiform roots. The spikes of fructification are pedicled,

dicled, and clothed all over with leaf-like, moderately spreading scales. Besides the capsules lodged among these scales, there are other globose ones in the axils of the leaves; which two-fold form has been described above.

This elegant little plant, a native of the southern Alps, of the Tyrol, Crain and Switzerland, has been figured, though not particularly well, by Dillenius (tab. 64, f. 2.).

9. LYCOPODIUM *denticulatum*—With small creeping rooting stems and shoots, two-shaped leaves, the lateral ones of which are spreading, those of the middle adpressed and imbricated. The spikes are immediately sessile on the stems; which is in fact the only character that distinguishes this species from the former, the shape and disposition of the leaves being the same in both.

This was first discovered by Clusius in the olive-groves near Coimbra in Portugal, and figured in his Historia Stirpium, lib. vi. p. 249; another figure is given by Buxbaum (Centur. iii. tab. 69, fig. 1), who found

found it in Georgia; but the best representation is that of Dillenius (tab. 66, fig. 1, A). Brotero has presented us with an excellent description of its whole œconomy in the Transactions of the Linnean Society, vol. v. p. 162. Haller supposes he has found this also in Switzerland, and considers it as a mere variety of the preceding.

As for the exotic species of this genus, I shall make no further remark upon them than just to observe that Bernhardi was wrong in constituting a new genus (Tmesipteris) of Lycopodium *tannense*. A single specimen is insufficient to establish a genus upon; not to mention that (as before noticed) the occurrence of capsules of a different shape, together with the reniform capsules, is not uncommon in other species of Lycopodium.

LETTER

LETTER XIV.

ON THE PTEROIDS: PILULARIA, MARSILEA, SALVINIA, ISOETES, AND EQUISETUM.

These four genera mutually agree in bearing their sexual organs and seeds, at the base of the stalks or leaves, near the roots, in separate receptacles. Thus it appears that it is in the first tuberosity only, from which the young shoots and roots issue, that the juices are sufficiently concentrated to be applicable to the office of the propagation of the species. Another remarkable circumstance is, that in these plants the sexual parts are, as in the fig, shut up within their proper receptacles, the access of air being seemingly unnecessary to them. We clearly distinguish in the capsules of these genera both male and female organs; but it is in Salvinia only that their form corresponds with that of phænogamous plants.

V. PILU-

V. PILULARIA.

The whole plant has a rush- or grass-like appearance; it is creeping by means of little runners about a span long. These are often so matted together that it is difficult to disentangle them. The leaves are of a green colour, completely filiform, rounded, erect, and, in their first stage, capillary and spirally rolled up, as in the true Ferns. In the axils of the leaves are situated, on very short pedicles, hairy globules of a dark brown colour, surrounded by a double membrane, the outer one so compact, as not to be easily cut with a knife. A transversal section of this capsule shows that it is divided into four cells (fig. 40, *a*). Under the microscope we perceive the inside to be replete with bodies of two shapes, viz. globose seeds (*c*) surrounded by a loose very delicate membrane (*arillus*), and pear-shaped, tender, transparent bags, filled with yellow grains (*d*), which may be considered as pollen.

Bernard Jussieu was the first who subjected

jected this plant to a more accurate examination* ; but the figure he has given of the interior of the capsule is not quite correct. That the seeds in germination come up with one cotyledon has been well observed by this naturalist. Dillenius has likewise given a good description of the œconomy of this plant ; but his figure (tab. 79.) is not microscopical. The figure in Flora Danica, tab. 223, is by no means without merit, except that the surrounding membrane is represented as constituting a part of the seed, which is, moreover, incorrectly drawn as pear-shaped. The same error may be observed in Hedwig's figure of the sexual organs of Pilularia (Theoria Generat. tab. 8.); and I hope that the drawing here subjoined will appear to approach nearer to reality.

This plant is a native of most parts of Europe ; and is found in swampy meadows, but seldom in great abundance.

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* Mémoires de l'Acad. des Sc. an. 1739, p. 323—346.

VI. MAR-

VI. MARSILEA.

This plant occurs in the southern parts of Europe, in ponds and stagnant waters that dry up in summer, but not very abundantly. Its stalks are sarmentose. From the young shoots, which, as in the true Ferns, are at first spirally rolled up, issue four small obovate, entire, delicately nerved leaves. From the axils of the shoots issue elliptical, brown, hairy capsules, on short peduncles, either solitary or by twos and threes; these open below near the peduncle, separating into two oblong principal compartments or halves, each of which is divided into seven or nine loculaments (fig. 42, *a*). Each loculament contains an oblong ovary, surrounded by a loose transparent membrane, having at its base two or three pellucid, pear-shaped bags, replete with grains of a yellow colour floating in a clammy fluid, and probably fulfilling the office of pollen (fig. 42, *b*).

From this it appears, that the structure of these capsules is very analogous to the globules of Pilularia; whence it is proper to

leave

leave these plants in the immediate neighbourhood of each other, as they have been placed since the time of Linnæus.

This plant is not a native of the more northern countries, but has been observed in Franconia, Bavaria, Alsatia, France, Italy and Spain. For the best description and figure of it we are indebted to Bernard de Jussieu. Mémoires de l'Acad. des Sciences de Paris, 1740, p. 375.)

VII. SALVINIA.

The only species we know of this genus, Salvinia *natans*, occurs in several parts of Europe, in stagnant waters. It floats on the water in tufts half a foot long and a few inches wide, consisting of several principal and secondary branches, clothed with oblong, blunt, entire, opposite leaves. The lower surface of these leaves is rather convex, the upper concave, and furnished with little warts terminated each with three small stiff hairs. At the base of all its small branches, at the place where the first lateral

roots

roots issue, arises a minute pedicle bearing from six to nine round capsules about a line in diameter, and clothed with soft hairs. These capsules are all surrounded by double membranes, but the interior structure is not exactly the same in all: most of them contain, on a common receptacle, a number of oblong, pedicled bodies, of a yellow colour, readily dropping off upon the opening of the capsule. The uppermost capsule only contains, on a common receptacle, a smaller number (about twelve or fifteen) of white globular bodies. These are probably the seeds, and are of a larger size than the abovementioned oblong bodies, which may be considered as grains of pollen.

In what manner the impregnation of this plant is effected, is, indeed, not quite clear: it appears, however, that the globules of pollen float in a gelatinous fluid, which enables them to resist the diluting or destructive influence of the water; and that, when the capsules burst, these grains of pollen find their way to the ovula, and effect the impregnation in the same manner as is done in Pilularia and Marsilea, in which the pollen likewise floats in a clammy fluid. Indeed, according to Roth's excellent observations, most aquatic cryptogamous plants are so organized, that the fructifying matter cannot operate without the assistance of such a mucilaginous fluid.

This plant has been found rather more frequently than Marsilea, near Charlottenburg, in the Palatinate, and in Bavaria, as also in France. It was first described and accurately figured by Micheli (Nova Plantar. Genera, p. 107, tab. 58); he mistook, however, in considering the hairs of the warts of the leaves as fructifying organs. The best description and figure of it are given by Guettard (Mémoires de l'Académie des Sciences de Paris, 1762, p. 1120). Hedwig's observations (Theoria Generat. p. 106, t. 8, fig. 1—5.) agree with regard to the structure of the female organs, and he has pointed out with greater accuracy than Guettard, the original form of what proba-

bly

bly are anthers (fig. 3.); but he errs in considering the flowers (or, properly speaking, the capsules) as hermaphrodite. He at first opened several capsules in which he found the anthers; and afterwards he discovered female ones, the sexual apparatus of which he has figured with considerable exactness. This plant might, indeed, in some respects not improperly, be referred to the twenty-first class of the Linnean system.

VIII. ISOETES.

We now proceed to a vegetable which, wonderfully simple as it is in its structure, has not yet sufficiently attracted the attention of botanists to be thought worthy of an accurate examination. This plant is not so very uncommon, when we know how to look for and to recognise it. It grows at the bottom of carp-ponds, where, indeed, it would not be of easy access, did not the fish assist the botanist: these, in summer, during their spawning season, go in search of the Isoetes, and disengage it from the mud, when it is found floating at the edges of the pond. It appears in the shape of a grass, having a tuberosity at the lower part rather above the root: the leaves are thin, long, linear, and completely gramineous, except that they are somewhat articulated. At the place where they issue from the tuberosity they are swollen on the outside, by the formation of a cavity, the interior of which is closed with a broad scale.

On examining the interior of the bases of the leaves we soon discover a diversity in their œconomy; some (fig. 41. *a.*), having a cavity along which proceeds the midrib of the leaf, are very minutely dotted on the surface; while others (fig. 41, *c.*) have a gibbose surface, which does not cohere with the midrib. On opening the former of these, a quantity of gray powder will fall out, and the microscope discovers in the vacuity thus produced the remains of a gray powder adhering to transverse bars, which proceed from one part of the inner surface to the opposite one, and, by their insertion, occasion the above minute dots observable on the outside. (fig. 41, *b.*) On opening the other scales characterized by their gibbose surface, we discover larger globules of a white colour, also adhering to transverse bars, and surrounded by the above gray-coloured powder. (fig. 41, *d.*) These globules may on one side be divested of their white integument, when their surface will appear of a brownish colour, and surrounded by a cross-shaped hoop (fig. 41. *f.*); on the other side the white colour remains, and a small depression (*e*) is seen in the middle, which is probably the *hilus*, by means of which they were affixed to the transversal bars. The dissection of these delicate globules distinctly shows the embryo without seed-lobes. (*g.*)

This is the result of my repeated examination of the structure of this plant, and I am persuaded that the impregnation is performed in it in a similar manner as in Salvinia. If the gray powder be the fructifying substance (which I have no reason to doubt), this

this can without difficulty be conveyed to the ovaries; for the male reservoirs within the tuberosity lie close to the female, and the scale closing the cavity opens without difficulty upwards and sideways. In this plant also a clammy gelatinous fluid surrounds the pollen, and renders it fit for effecting impregnation. Portions of this pollen can be seen in the female reservoir.

You see from this that the generic character of this genus, as given by Linnæus, is incorrect, and that the same errors are continued. "The anther," says the Swedish naturalist, "is concealed in the basis of the leaf, as is the two-celled seed-capsule." This is repeated in Schreber's *Genera Plantarum*, with the addition that the male scales are outside, the female ones inside; a circumstance which I could never find: for both are aggregated, and cover each other without particular order. The figures of Dillenius (tab. 80. fig. 2.) and of Flora Danica (tab. 191.) only represent the exterior of the plant, the interior structure of the

the sexual organs being left unnoticed. Nearly the same may be said of the figure in English Botany, pl. 1084; and in the text Linnæus is followed.

This plant has perhaps hitherto been found more copiously in Sweden and Denmark than elsewhere; I have received a few specimens from France, and Dillenius discovered it in Wales.

IX. EQUISETUM.

The character of this genus and the œconomy of its several species stand in need of much further investigation. If we consider its habit, general internal structure, and even inflorescence, we find it bears some resemblance to Ephedra and Casuarina: all three are leafless plants, with branches jointed to their most remote ramifications, and the joints furnished with toothed sheaths at each articulation: all three have pithy or hollow channelled branches, divided by septa at the joints; and their sexual organs, destitute of of proper calyxes or flowers, are disposed in spikes, racemes or aments.

What principally distinguishes Equisetum from Ephedra and Casuarina is, that in the two last we clearly distinguish the sexual parts, which are not unlike the anthers and pistils of other plants; whereas, in Equisetum, it is by conjecture only that we assign to the parts we discover their appropriate office in the business of fructification. We find also, that those plants which are furnished with the supposed sexual organs, appear in the spring and soon die away, being followed by others of a more lasting nature. In what manner this phænomenon is to be explained, remains still a subject of future investigation.

All the species of this genus agree in bearing, on a proper scape, a raceme of fructification, whose short branches are disposed in whorls, and furnished at their extremities with small fleshy disks, each having at its lower surface six or seven wedge-shaped

shaped reservoirs opening inwards. These reservoirs, when arrived at maturity, discharge green-coloured globules, each of which is furnished with a little knob, and, laterally, with four twisted elastic filaments with club-shaped tips. These filaments are hygrometrical; contracting one after the other upon the application of the breath or any other moisture, and thus giving a continual saltatory motion to the globules. The surface of the filaments, in the younger state of the plant, is sprinkled over with minute grains, which, with Hedwig, we may properly consider as pollen. According to this theory the filaments would have the function of anthers, the greenish globules be the ovary or fruit, and the little knob upon each globule might be regarded as the stigma. Though Hedwig (Theoria Generationis, p. 82—86, tab. 1.) has succeeded in rendering this theory very plausible, yet there remain some doubts that cannot be removed, till the germination of these plants, and the gradual evolution of the supposed

posed sexual parts, shall have been accurately observed.

The species of this genus are divided according as they are simple or branched, and as the surface of the stems is smooth, rough or angular.

1. Equisetum *limosum*—With simple, smooth, striated stem, is frequently met with in inundated places.

2. Equisetum *palustre*—With somewhat branched, smooth, angular stems, and branches disposed by eights in whorls, having generally four prominent acute angles. The joints, at the places where they run out into the sheaths, are usually somewhat thickened. When the stem is quite simple, as is frequently the case with the young shoots, we have Equisetum *tenue* of Hoppe.

This species is distinct enough from the preceding by its more slender acute angled stem, with smooth surface.

3. Equisetum *fluviatile*—With smooth, striated, branched stems, divided, beneath almost every sheath, into a great number of branches.

branches. It might be joined with E. *limosum*, but that this species has an entirely simple stem, while E. *fluviatile* will often produce as many as twenty branches in each whorl. It differs from E. *palustre* in the want of projecting angles.—Equisetum *Heleocharis* of Ehrhart I consider as the same with E. *fluviatile*.

4. Equisetum *reptans*—With procumbent, creeping, much divided, smooth stems, and wide spreading quadrangular branches. This species, discovered in Sweden by Swartz, approaches nearest to E. *palustre*, but differs in its habit; its stem not being erect, but divided and procumbent at the very root. The branches too are slenderer than in the other species. It is described by Liljeblad (Svensk Flora, p. 384.) under the name of E. *tenellum*, and conjectured to be a variety of E. *hiemale*, from which, however, it is certainly very distinct. Its proper place of growth is the Alps of Jämtland and Torneo-Lapponark.

5. Equisetum *hiemale*—With simple, striated,

striated, rough stem, and sheaths truncated above. This species, which is not unfrequently met with in swampy places, has derived its name from continuing during winter.

6. EQUISETUM *arvense*—With smooth, angularly-striated stems; the fertile ones simple, the steril ones verticillately branched. The teeth of the sheaths are lanceolate. This is the most common species, covering many acres of land, and proving a real curse to the soil.

7. EQUISETUM *pratense*—With very acute-angled, rough, branched stem; branches uniformly bearing spikes, very spreading, and acute-angled; sheaths subulate-pointed. Differs from the preceding species chiefly in the sharpness of the angles of the stem and branches, in the fertile nature of the branches, and the subulate shape of the teeth of the sheaths.

8. EQUISETUM *sylvaticum*—With pretty smooth, angulate-striated stem, simple below, verticillately branched above: branches

twice

twice divided. The sheaths of the stem are nearly an inch long, scariose-membranous (as well as those of the branches), variously gashed, and elongated into bristles, which are particularly observable in the branches.

9. EQUISETUM *Telmateia*—With smooth, angular stems: the deeply and variously gashed sheaths of the fertile ones are so very long that they come into contact with each other, and thus cover the whole stem. The steril ones give out at each joint, from thirty to forty simple, octangular branches of a span in length.

This is the largest and handsomest of all the species.

LETTER

LETTER XV.

CHARACTER, PLACES OF GROWTH, AND GEOGRAPHICAL EXTENT OF THE MOSSES.

THE extensive natural order of the Mosses (Musci *frondosi*) exhibits such strong characters in structure and œconomy, that it is by no means difficult to distinguish the plants belonging to it from those of all the other orders of the Cryptogamous Class. This circumstance, added to their peculiarly pleasing external appearance and curious internal organization, cannot fail to excite a most lively interest even in those who have as yet made but little progress in the study of these plants.

The Mosses have nothing in common with the Ferns; or, at most, it is only some species of Trichomanes and Hymenophyllum that approach the former in external appearance. But a nearer relationship exists between them and the Hepaticæ, as it is the form of the capsules alone that separates these orders.

The Mosses are such cryptogamous plants as bear, on small leafy stems and branches, simple capsules, dehiscent at the top, where they are covered by a peculiar veil or calyptra. Their sexual organs, which may be distinctly seen with the help of a simple lens, consist partly in oblong bud-like gemmæ, supposed formerly to be anthers; and partly in an aggregation of pistils, intermixed with succulent filaments. If we take the above characters in a strict sense, the Mosses will appear to be distinguished from the Hepaticæ merely by their one-celled capsule opening at the top, while in the Hepaticæ the capsule has four cells opening with as many valves. In other respects, most Hepaticæ not only approach very near to the Mosses in their internal structure, but also in regard to their sexual organs, which are nearly similar, and not unfrequently their capsules are even furnished with a veil.

In

In the empire of Flora the Mosses rank with the most humble subjects; no arborescent one has hitherto been discovered; even the largest of them, such as Polytrichum *commune*, Timmia *longiseta*, seldom much exceed a span in length, though Mappi informs us that, in Alsace, the former of these will sometimes attain the length of half a yard. For the most part they scarcely exceed a few inches in height, and the genera Phascum and Grimmia contain several species which can only be discerned by the aid of a lens.

In their places of growth, and for geographical extent, the Mosses are very remarkable; for although, like the Ferns, most partial to shady and moist places, they are found to thrive also in very different kinds of soil, and even exposed to the intense heat of the sun in arid situations. On the southern sides of most barren rocks we find Dicranum *pulvinatum*, Barbula *ruralis*, Grimmia *apocarpa*; —on other sunny places, Gymnostomum *fasciculare*, Dicranum *varium*, Barbula *ruralis*

ralis and *unguiculata*, Hypnum *purum*, *cupressiforme*, *squarrosum*, *triquetrum*, *lutescens*, and Bryum *argenteum* ;—in pure dry sand, Schistostega or Gymnostomum *pennatum*, Grimmia *curvirostra*, Didymodon *pusillum*, Polytrichum *piliferum* and *nanum*, Dicranum *spurium*, Hypnum *rugosum* ;—on bare quartz, Grimmia *recurvata*, Splachnum *Frœlichianum*, Hypnum *murale*, Bryum *argenteum*, and *capillare* ;—on rocks of porphyry and granite, Gymnostomum *Hedwigia*, Grimmia *cribrosa*, *cirrhata*, Trichostomum *lanuginosum*, and *canescens* ;—on calcareous rocks, Grimmia *calcarea* and Didymodon *capillaceus* ;—on slate, Grimmia *Schisti* and Barbula *muralis* ;—on gypseous soil, Gymnostomum *curvirostrum*, Didymodon *capillaceus* ;—on the sides of pit-coals, Funaria *hygrometrica*, called on that account, by Lamarck, Charbonnière. Partial to an argillaceous soil, (but never occurring on the higher mountains, much less on alps,) are the different species of Phascum, Gymnostomum *ova-*

tum, and now and then Funaria *hygrometrica*.

The Mosses grow most luxuriantly in morasses, especially in such as are surrounded by trees: in the northern countries these are quite replete with different species of Moss, which grow still more luxuriantly if the soil contain iron-ochre or marcasite. These morasses seldom dry up entirely in summer, and are rarely frozen in winter, owing to their being covered with deep snow, and to the higher temperature caused by the sulphur and asphaltum. Such soil furnishes turf and peat, a material for fuel which occurs only in northern climates and in alpine tracts. In Sweden, and also in Canada, Germany, and Siberia, such peat- or turf-bogs are replete with Sphagnum *obtusifolium* and *acutifolium*; indeed they are almost entirely formed by these two Mosses, but harbour also the most beautiful Splachna: in Germany, Splachnum *ampullaceum*; on the Alps, Splachnum *mnioides*, *tenue*, *vasculosum*; in Lapland and

and Russia, Splachnum *luteum* and *rubrum*. Intermixed with the peat-moss (Sphagnum) are also found our Mnium *palustre*, *pseudo-triquetrum*, Meesia *uliginosa*, Hypnum *aduncum*, *cuspidatum*, *nitens*, *commutatum*, *cordifolium*; in Sweden, the new Cinclidium *stygium*; and in Scotland, Grimmia *nigrita*.

Even the rivers, brooks and springs are favourite residences of several Mosses. All the species of Fontinalis occur in the clear waters of rivers and wells; Fontinalis *anti-pyretica* is particularly partial to the proximity of waterfalls; it strikes its roots on the stones washed by the fall, and the vigour of its vegetation appears to be proportionate to the violence with which the waters break around it. Other species, growing exclusively in watery situations, or where they are exposed to be inundated, are Hypnum *fluitans*, Trichostomum *aquaticum*, Barbula *fontinalioides*, Gymnostomum *aquaticum*, Dicranum *aciculare*, *pellucidum*, Hypnum *riparium*, Bartramia *fontana*.

It is a circumstance sufficiently well known, that innumerable Mosses inhabit the stems and branches of old trees, and that the species of Orthotrichum, Neckera, Leskea, Hypnum, and some others, particularly delight in these situations, and may therefore be termed parasitical. Here, too, the Lichens prepare the mould necessary for the vegetation of Mosses.

Mosses are contented with a much lower temperature and rougher climates than most other vegetables. The periods of their most vigorous growth and propagation are the autumn and spring; in low countries they are seldom or never seen in the middle of summer, heat rather impeding their vegetation: we, therefore, find them in far greater abundance and vigour in alpine regions, which favour their growth too by the humidity continually precipitated from the air, and by the thin layer of light mould they afford them. In Germany and Switzerland the steep rocks of the alps are clothed by Mosses from the height of 3000 to 5500 feet: but at this last elevation

tion they cease, either from the eternal snow, or that the rocks are too naked to afford them nourishment. Lichens only, especially the Girophoræ, Verrucariæ, Urceolariæ, and Isidia, are still met with where no Mosses are any longer to be seen. The Mosses which continue at the highest elevation and disappear last are, Dicranum *strumiferum*, Encalypta *ciliata*, Polytrichum *alpinum*, Grimmia *cirrhata*, Trichostomum *fasciculare*, with a few others.

In the polar countries, where the soil never thaws more than for the depth of four inches, Mosses and Lichens are the only vegetable inhabitants; an observation, the truth of which has been confirmed by the accounts of Sujef, who went, under the directions of Pallas, in 1771, to the coast of the Icy Sea. The northern border of Siberia towards the coast of that Sea is, for the width of some hundred versts, an immensely extended morass, destitute of trees, where, in the middle of summer, the thaw never penetrates more than a span deep: here the whole soil is covered

by

by Mosses, which thrive although their roots are only just above the eternal crust of ice, on which, even in summer, you can travel in sledges drawn by rein-deer, as far as the coast of the Icy Sea. In Spitzbergen, according to Martens, the rocks of schistus, rising out of the everlasting masses of ice, are thickly clothed with Mosses. In Greenland they constitute the most numerous class of vegetables: Crantz states, that, when seated on a rock there, he had counted about twenty species without rising from his seat.

The northernmost Lapmarks of Sweden and Norway are the true native country of the Mosses: and not long since, a young Swedish botanist, Wahlenberg, on his extremely laborious but interesting journey up to the coast of the Icy Sea, has reaped a very rich harvest of Mosses, among which are many species entirely new. The circumstances are similar in North America; the higher up to the north, the greater number of Mosses is to be found. According to Michaux, in Florida and Carolina there are few,

few, in Pensylvania more, and most of all in the swamps and forests from Canada to Hudson's Bay.

In the southern hemisphere also the Mosses particularly extend towards the pole. There are only fourteen species enumerated in Thunberg's Flora Japonica, and all of these, with the exception of two, are common in Europe. But in Patagonia and Terra del Fuego almost the whole of the swampy soil is covered by Mosses. Dillenius received his most rare species from the former of those countries; and we know full well what great treasures, in this natural order, were brought from thence by Commerson: it is therefore a matter of regret that Forster, who speaks in high terms of the abundance of Mosses in Terra del Fuego, interested himself too little about them, and collected so few.

Though the colder climates are particularly favourable to the Mosses, yet they are known to thrive even between the tropics, provided they find a proper place of growth on alps or in shady swamps. What a rich booty

booty in Mosses fell under the observation of the excellent Swartz during his stay in Jamaica and other West India islands! What a number of new species were brought by Commerson from the Mascarenhas, and by Sonnerat from Madagascar! We have therefore ground to conjecture that even in Africa, which has hitherto furnished us with the smallest number of Mosses, an incalculable host of new species may perhaps be concealed from the eye of the botanist, on those alps which are supposed to exist beneath the equator, and are laid down in our present maps under the appellation of the Mountains of the Moon.

LETTER

LETTER XVI.

STRUCTURE OF THE MOSSES.

In describing the structure of these vegetables, and deriving conclusions from it with regard to their œconomy, I must first remark, that, as far as I have yet been able to observe, all their parts are composed of one original form only, viz. the cellular. Of spiral vessels I could never discover even the slightest trace, either in the stalk or any other part, though I have frequently and carefully subjected them to different, even to the highest, powers of the microscope. In the stems of Polytrichum *commune* (the thickest we know of) we observe, in the middle of a coat of cortical substance, a woody heart, which one might be inclined to think consisted of bundles of spiral vessels; but the microscope discovers in it nothing but straight tubes, like those of the liber.

Neither

Neither could I ever observe any thing but compact bundles of elongated cells in the strongest ribs of the leaves.

The want of spiral vessels is compensated by the softness, delicacy and ductility of the cellular texture; and, indeed, in no other plants are the elegant, beautiful forms of that texture so distinctly displayed as in the leaves of the Mosses and Hepaticæ. Nor do I know if in any other plant the first origin and formation of the cellular substance can be so distinctly observed, as in the natural order of Mosses. For this reason I have given a drawing of part of the youngest leaf of Funaria *hygrometrica* (fig. 43.), which shows how the scarcely existing simple and extremely delicate lamella is bordered on one side by minute pyramidal vesicles, and how the granulated precipitations from the vegetable juices closely arrange themselves at the lower part in squares, where some interstices are still visible: below it the empty spaces between the squares are already filled up by those precipitations, and thus

thus the green parenchyma is formed; while the septa already cohere in continued lines, because the precipitated particles, more closely crowded together, are in contact with each other in an uninterrupted series. The preparation from which this drawing is made, is indeed very useful in demonstrating the commencement of the organization of the leaves. How much the examination of every other part of the Mosses will ultimately lead the observer to the existence of a simple cellular composition, we shall have an opportunity of seeing hereafter.

Let us now examine the separate parts of the Mosses, beginning with the roots. These are of nearly the same nature in all; they are, without exception, fibrous, never produce tubers or adopt a tap-shape, so common in other vegetables. The power of elongation, which is striking in many of the perennial Mosses, does not so much belong to their roots as to the stalk and its creeping branches. The original roots decay in a short time, but new ones are put forth in

their

their stead. The extremities of the fibres of the root are thickened, and furnished in most cases with a calyptra of a spongy texture, like the fibrous roots of the Palms, Ferns, and several aquatic plants.

It is still uncertain whether any of the Mosses are annual and propagated by means of seeds only, as has been supposed to be the case in several species of Phascum and Gymnostomum. But in these the gemmæ, which have been mistaken for anthers, drop off and strike root, although their stems do not possess the faculty of propagating by means of prolongation, which is possessed by the generality of Mosses in a remarkable degree, their stems and delicate branches producing roots from every part that comes in contact with the ground, more especially from the axils. This is particularly observable in most species of Hypnum, Leskea and Neckera. In some Mosses, even the extremities of the shoots and the points of the leaves put forth roots; as in Hypnum *lucens*, *longirostrum*, and Mnium *cuspidatum*. In the

the two last it is the rib of the leaf which gives origin to the new root; but in Hypnum *lucens*, whose leaves are destitute of ribs, the cellular texture itself is prolongated into fibrils of roots*.

In many of the creeping Mosses, the tendency of the stalks to strike root is so great, that not unfrequently nearly the whole of it is clothed with fibrils issuing from all the axils of the leaves; insomuch that the stalk appears from thence woolly or tomentose, as in Hypnum *rutabulum*, *plumosum*, *velutinum*, *murale*, *commutatum*, and particularly in H. *tomentosum*, a native of St. Domingo, in *Leskea subtilis*, and many others.

The stalk is never wanting in Mosses, except, perhaps, in a few species of Phascum, and in some measure in Buxbaumia *aphylla* and Diphyscium *foliosum*. It is either simple or branched; in which latter case it divides into runners of creeping

* Hedwig Fundamenta Histor. Natural. Muscor. frondos. vol. i. p. 13. tab. 1. fig. 4.

branches,

branches, which are very numerous in the species of Hypnum, Leskea and Maschalocarpus. In several species these are often thickened at their extremities, from whence they put forth new shoots; examples of which are found in Polytrychum *commune*, Mnium *cuspidatum*, *palustre*, Bartramia *fontana* and several others.

The stem, branches and runners of Mosses are generally rounded, and become angular only when furnished with foliaceous substance, as is the case in Mnium *undulatum*. The surface of these parts is never observed to be hairy; in cases where they do not appear smooth, the roughness is caused by fibrils of the roots, or by remnants of decayed leaves, the midribs of which often remain adhering to the stalk. It is by these chaffy remains that the stalks, especially towards the lower part, acquire a reddish hue, which is most frequently observed in the Mosses that inhabit swamps, such as in Mnium *palustre*, Splachnum *ampullaceum*, Sphagnum *obtusifolium*, and also in Bartramia *Halleriana*.

All

All Mosses are furnished with leaves: Buxbaumia *aphylla* seems, indeed, destitute of them, when bearing fruit, but at a more early period a number of awl-shaped leaves shoot up from the root, as has already been well observed and figured by Schmiedel (de Buxbaumia, tab. 1, fig. 2—4). The difference in the form of the primary and succeeding leaves of the Mosses is less considerable than in other plants. Young Mosses are sometimes found entangled with Confervæ, particularly with C. *frigida* and *arenaria*, which latter has been erroneously taken by Hedwig for the cotyledons; of which deception I shall speak more fully hereafter.

It is rather a remarkable circumstance that we know of no Moss that is provided with petiolated leaves; these parts are in all sessile, and often stem-embracing: sometimes, too, the foliaceous substance is decurrent, as in Mnium *undulatum*. The leaves never drop off at certain periods, but generally persist till the stalks or branches themselves decay. They usually stand very close

close together, and without order, round the stalk: in some, however, they are distichous, as in Neckera *pinnata*, *crispa*, Leskea *complanata*, *trichomanoides*, Hypnum *denticulatum*; or three-ranked, as in Hypnum *trifarium* of Weber, Fontinalis *antipyretica*; four-ranked, as in Hypnum *tetragonum*; or five-ranked, as in Bryum *squarrosum*, Conostomon *arcticum*; or six-ranked, as in Hypnum *triquetrum*.

The leaves of the Mosses are also constantly found simple; at least we do not know of any that are lobed or pinnated, unless the delicate incisions at the extremities of the leaves of Buxbaumia *foliosa*, and the distichous position of those of Gymnostomum *pennatum*, of Dicranum *bryoides*, *adiantoides*, and *asplenioides* are to be considered as so many exceptions. As no succulent or rounded leaves occur among the Ferns, so in the Mosses they are never seen to be otherwise than quite flat and thin, and are composed of the most regular cellular texture. For although those of Dicranum

cygneum

cygneum and Hypnum *trichophyllum*, and of most species of Grimmia appear to the naked eye to be bristly, yet the microscope will prove them to be more of a lanceolate or linear shape. They are scarcely ever hairy: the only exceptions are those of Maschalocarpus *hirtellus* and Leskea *cristata*. We find their lower surface rough to the touch in Bartramia *sphærocarpa*. When, as in Trichostomum *canescens*, they appear of a whitish gray colour, this is caused by dry, scariose shreds, the remains of the leaves deprived of their cellular texture. At the base of the leaves of some (such as Hypnum *abietinum* and *delicatulum*) are found articulated hairs or succulent filaments, which are nothing but the rudiments of the fibres of roots. The leaves of Mosses are as often with ribs as without; their margin is as commonly entire as serrate, or dentated, and is seldom ciliated. In Neckera *hypnoïdes* the midrib of the leaf divides in the particular form of a fork, continued quite up to the point. Where there are teeth or serratures, these are generally observed towards the point, and are often only visible when highly magnified.

The interior structure of these leaves is very simple : a loose cellular texture between two lamellæ, the pores of which are almost invisible, is all that we can discover even by the assistance of the most powerful microscopes. The epidermis displays none of those beautifully organized absorbing pores, which are observed on the fronds of the Ferns: these even disappear in the species of Trichomanes and Hymenophyllum, which likewise show a natural affinity to the Mosses in some other respects. This epidermis, both in the Ferns just mentioned and in Mosses, is so very delicate, that it is scarcely possible to detach it from the parenchymatous substance below: but on placing a fresh segment of a leaf under water, it is easily seen that the fluid enters it at all points, though the pores elude the sight of the observer. Fig. 43 exhibits to you the delicate nature of the precipitates in the very commencement

of

of being organized into four-sided cells; and the same phænomenon you may observe in almost all the young leaves of Mosses. This, as it were, sieve-like texture of the leaves of the Mosses is the cause of their being soaked with so much facility when dry; and, indeed, Trichostomum *lanuginosum*, Barbula *ruralis*, and many others, on their upper part being merely immersed in water, will become in appearance as fresh as though they were in full vegetation. In other plants, the epidermis of which is furnished with regularly organized apertures, this cannot be effected.

The form of the leaves of Mosses frequently differs according to the different parts to which they are affixed. Those that surround the gemmæ and buds are broader, or longer, or are extenuated into hairs, as is particularly striking in the species of Hypnum, of which more shall be said in its proper place.

LETTER XVII.

ORGANS OF PROPAGATION OF THE MOSSES.

THE credit of having first illustrated the obscure physiology of the fructification of the Mosses, is due to Peter Antony Micheli. He observed in more than thirty species the club-shaped bodies, intermixed with succulent filaments (fig. 44, 45, *c.*), noticing at the same time that those Mosses, which are furnished only with such bodies in buds or little stars, generally bear no fruit, and hence appear to be male plants, (Micheli, Genera Plantar. tab. 59, A. B. F.) He likewise observed other knobbed bodies (fig. 46.) either on the points of the leaves, or on particular stalks (tab. 59, D. T.); they also did not appear to bear fruits; but he found these to make their appearance in such places as were occupied by pistils (fig. 47.), which he represented very correctly at fig. E. of the same plate. Micheli's work was published at Florence in 1729.

Neither Dillenius, nor Linnæus, who in general was no great advocate for microscopical investigation, made any further progress in this interesting pursuit; and the latter even deviated so wide from the truth, as to take the capsules for anthers, and the stellated expansions of the leaves for the female organs. In this he followed Dillenius, who had, however, expressed himself with more caution (Hist. Musc. p. 229.).

From the time of Micheli to that of Hedwig, Schmiedel alone observed the above club-shaped bodies and knob-shaped sexual organs, in Buxbaumia and Tetraphis, and he mistook them for buds. In this he was also followed by Kœlreuter. Other botanists, as Hill, Schreber, &c., though sensible of Linnæus's error respecting the capsules of Mosses, fell into another, by looking for the male organs either in the calyptra, or in the succulent filaments that surround the pistils (fig. 47.).

My

My late friend, John Hedwig, was the first who, following the footsteps of Micheli, explored the secrets of nature in the fructification of Mosses, with the most laudable zeal and a penetration peculiar to himself. It is indeed wonderful to see the success that attended the researches of this naturalist in the discovery of these organs in the most delicate Mosses, even in a dried state.

These minute parts are often not to be found without great difficulty; much depending on the season of the year: the young buds and fruit will for the most part be sought for in vain both in the parching heat of summer, and in the intense frost of winter; but are readily found in spring, after the earth is unbound by the thaw, and in autumn, during the frequent rains and fogs of the season. But in swamps, and on the northern side of mountains, as on Mount Brocken, an attentive observer may often find them even in the midst of summer. There is some difference also in this respect in different genera and species: the young

fruit

fruit is more difficultly discovered when concealed within buds, as in the species of Hypnum, Leskea and Neckera, than when seen in disk- or star-shaped expansions, and sometimes even surrounded by differently coloured leaves, as is the case in Polytrichum, Funaria, Mnium, Gymnostomum, Splachnum; or when appearing in pedicled heads, as in Tetraphis, Sphagnum, Mnium *androgynum*, and some others.

With regard to the gemmæ (*Knospen-Keime*), organs calculated for the propagation of the Mosses, we have to observe, that though they are usually distinct from the young fruits, either on the same or on two different plants, yet there are several genera and species, such as Bartramia, Didymodon, Mnium *crudum* and *cuspidatum*, in which they are disposed close to each other, so that the gemmæ are surrounded by the pistils (fig. 47), or *vice versa*. In others, especially in most species of Mnium, we find in one instance merely gemmæ, in another young fruits only, and again both parts

united.

united. It appears, indeed, that Nature does not in this respect strictly follow any particular law. Nor is it altogether an unusual occurrence among the phænogamous plants, that bulbs and tubers are intermixed with the young fruit, as is the case in Allium *Scorodoprasum* and others.

In cases where the gemmæ and pistils or young fruits are separate in the same plant, they are either placed horizontally near each other on proper pedicles, as in some species of Splachnum, and in Funaria; or the gemmæ are situate in the axils of the leaves, while the pistils are inserted on the extremities of the branches, as in Barbula and Phascum; or they both appear at the tip of the branches, as in Polytrichum; or both close to each other in the axils of the leaves, as in Orthotrichum *striatum*.

The nature of those parts in which the gemmæ are formed, and which envelop them, is various; they have often the shape of buds, and in this case are usually situate in the axils of the leaves. In order to distinguish

guish these from the common leaf-buds, it is necessary to have recourse to the magnifying glass, which will show the former to be thicker and more opaque, as may be observed in Barbula *ruralis* with the naked eye. The best mode of examining them is carefully to detach the exterior leaves of the bud by means of a lancet, when the gemma itself may be conveniently viewed with a common lens. These gemmæ, usually situated in the axils of the leaves, are for the greatest part sessile; though there are a few examples of their being supported by very short pedicles, as in Orthotrichum *striatum* and Timmia *megapolitana*.

Those gemmæ that he found entirely enveloped in the closed leaflets of these buds, Hedwig called capitated, or head-shaped; he applies, however, the same appellation to others supported by proper pedicles, and which to him appeared to consist of mere grains of pollen (fig. 46). For my own part, I consider the distinction between half opened and quite closed buds as very unimportant,

portant, and am of opinion that the head-shaped bodies (fig. 46.) found in Tetraphis *pellucida*, Mnium *androgynum*, Sphagnum *obtusifolium* and some other Mosses, are organs the use of which remains still to be ascertained. In most species of Jungermannia such pedicled heads or clubs are so extraordinarily frequent, that some, (as Jungerm. *byssacea**, *reptans*, &c.) when examined in the month of November, are seen to be almost covered by them. But exactly the same kind of grains are likewise found in the pedicled heads of the Mosses. In the Jungermanniæ they are often situated on the points of the leaves, and turn to a brown colour, as I shall show you at another opportunity; but with regard to the Mosses, nothing similar has been observed, except by Micheli, who (Nov. Gen. Plantar. tab. 59, fig. 3.) has a "*Muscus alpinus, viticulis longis, foliis acutis, hamosis et unam partem spectantibus*," whose upper leaves are fur-

* Fig. 46, exhibiting such a pedicled head or club, is taken from this species.

nished with these heads or club-shaped bodies. No botanist appears to have determined this Moss since Micheli.

With respect to the question, whether those granular heads or knobs are to be considered as real anthers, my observations have not enabled me to answer it in the affirmative. Hedwig thought them to be such; and, indeed, if they were to be regarded as gemmæ, it would seem contrary to all analogy to find these on the points of the leaves and stalks, and even supported by pedicles, by which they are entirely separated from the branches of the plant.

Against Hedwig's opinion are the observations of Vaillant, Dillenius, and Haller, relative to the pedicled bodies on those disks of Mnium *palustre* which are described as male flowers by Hedwig. According to the accounts given separately by these three naturalists, each of the disks which, according to Micheli, contain the florets, produce pedicled bodies, the tips of which dissolve into a powdery substance. Dillenius confesses

that

that he had not made these observations with all the care they required. Haller describes them in Mnium *palustre*, as spongy pulverulent clubs, and adds, that, examined more closely, they are seen to consist of small leafy rosules. If we take those bodies for anthers, it is difficult to conceive why they constantly drop off a long time before the appearance of the pistils. This subject is, however, still in want of accurate investigation, as is the observation of Haller, (Stirp. Helvet. n. 1853.) that the same bodies in Tetraphis *pellucida* are transformed into small leafy rosules, which he found to be the case in a specimen gathered in the neighbourhood of Bex.

I think that I have myself made a similar observation in Dicranum *sciuroides*. This moss, as is well known, bears gemmæ in axillary buds, and seldom produces fruit; but in very old and close forests, especially in the Hartz mountains, I have discovered on its leaves, and on their margins, dust-like grains, which gave them a curled appearance, and seemed to contain a subtile powder similar to that observed at the points of the leaves of the Jungermanniæ. In the axils of the leaves of Mnium *annotinum* small buds occur, which, without being sexual organs, contain minute grains exactly similar. (Hedwig. Spec. Musc. Frond. tab. 43, f. 7, *a a*.)

Lastly, we find on Mosses discoid or stellated expansions, more striking to the eye than other parts, especially when the enveloping leaflets are of a different colour. A drawing of such a small star, taken from Funaria *hygrometrica*, in which they are to be observed throughout the autumn till the middle of winter, you may see at fig. 45. Nor are these forms unusual in the genera Polytrichum, Mnium, Gymnostomum, Meesia.

In dissecting these expansions of the Mosses, you are first of all to remove the enveloping leaflets, which, in most of them, are perfectly distinct from the other leaves: in Gymnostomum *Hedwigia* they are very long, with points gray and ciliated; in

Gymnost.

Gymnost. *aquaticum* they are cordate, while those of the stem are lanceolate; in Polytrichum *hercynicum* they are ventricose, broader and smaller than those of the stem; and in Dicranum *crispum* we even find two differently formed enveloping leaflets, the outer ones being long, narrow and subulate, while the inner are blunt and elliptical.

Having taken away the enveloping leaflets, you discover follicles or clubshaped bodies, generally intermixed with succulent filaments. The former are either sessile, such as we see them in Barbula *ruralis*, (fig. 44.), and in Funaria *hygrometrica* (fig. 45.); or furnished with short pedicles, which are rather longer in Orthotrichum *striatum* than in other Mosses. The follicles are observed of different shapes at different periods; they are at first quite dense and nearly opaque, as they appear in fig. 44: some time after a granulated substance shows itself within them, the upper part becomes more or less empty, and they discharge their granulated contents,

espe-

especially if at this time of their perfect maturity they are immersed in water: they now put on a darker colour, and the delicate membrane surrounding them becomes reticulated. (Fig. 45, *c*. and Fig. 47.*)

The club-shaped bodies themselves are surrounded by, or intermixed with, succulent filaments. These are the same organs that are seen in the axils of the leaves, and constitute the first rudiments of the roots; and also the same with those which, on the surface of the calyptra, appear in the shape of articulated hairs. The succulent filaments are generally jointed, as they appear in fig. 44, 45, 47, and they seem to be without joints only in Hypnum *luridum*, Maschalocarpus *fulgens*, and Dicranum *asplenioides*, *spurium* and *strumiferum*. The above figures also exhibit the usual shapes of these filaments; they are either quite narrow and filiform (fig. 47.), or somewhat thickened at the extremity, short-jointed, and filled with a fine granulated substance (fig. 44.), or club-shaped, being furnished

with

with a round protuberance the top. The succulent filaments are found in vast numbers, not only among and around the club-shaped bodies, but also about the pistils; in some, however, they seem to be wanting, as in Gymnostomum *curvirostrum*, Encalypta *vulgaris*, Grimmia *apocarpa*, Dicranum *pulvinatum*, Orthotrichum *crispum* and *striatum*. In cases where they are present, they remain as long as the club-shaped bodies and pistils, and are often still observable long after these have fulfilled their functions.

Of what use in the œconomy of Mosses the club-shaped bodies are, is a difficult question, that we will next consider. They differ from the anthers in other vegetables both in having a more delicate structure, and in that they do not contain any distinct globules of pollen, but merely an unorganized pulverulent matter, seen by Hedwig to explode under water with elasticity. However, as they make their appearance a short time before the evolution of the fruit, and are in many genera situated promiscuously with the pistils;

as

as they become flaccid and empty as soon as the ovaries begin to enlarge; and as there is no other organ known to which we can with equal degree of probability ascribe the function of impregnation,—botanists could hardly avoid adopting, or at least acknowledging the probability of Hedwig's opinion, that these bodies were real anthers.

In later times, however, several objections have been raised against this hypothesis, which has met with a powerful antagonist in the celebrated Gærtner. This botanist, when treating on this subject in the introduction to his classical work on fruits and seeds, maintains the improbability, that the fructifying principle of these supposed anthers should operate on the pistils at so considerable a distance; it being well known that, in most Mosses, the club-shaped bodies are found on different plants from those that bear fruit. But this objection has been attempted to be removed by stating, that in many genera both these organs are intermixed; that when they are separate on the same plant, as in Timmia and Splachnum, they are not at any great distance from each other; and that, when produced on distinct plants, as in Neckera, Leskea, and Hypnum, these grow crowded together in such numbers, that female plants can scarcely be found without male ones in their immediate neighbourhood. This is very evident in Hypnum *cuspidatum*, *prælongum*, *cupressiforme*, *lutescens*, and in other common Mosses. On the other hand, it may be seen that Mosses often remain steril, because the plants are all either male or female, without an admixture of the other sex in their neighbourhood, as frequently occurs in Hypnum *rugosum*, *abietinum*, Dicranum *sciuroides*.

The objections to the theory of impregnation by means of the club-shaped bodies, when these are found on distinct stems, may be weakened also by the observation that it is common to all the plants of the class Cryptogamia to be impregnated from a distance, and that often the gentlest breeze is sufficient

sufficient to assist in the accomplishment of that operation. Thus these bodies, if they be real anthers, need not the aid of insects; nor, indeed, is it to be supposed that the succulent filaments are nectaries, as has been thought by some, since no trace of honey, or of insect in pursuit of it, has ever been discovered in the flowers of Mosses. I must not, however, omit mentioning an observation that I have had several opportunities of making in Barbula *unguiculata*: in the autumn, within the young shoots containing the male flower-buds, a number of animals, perfectly resembling the Vibriones of paste and vinegar, are frequently found. Though I do not consider these animalcules as instruments of fructification, I have a great desire to know whether, and in what manner, they are connected with the œconomy of the vegetable: for it would be remarkable, even if they are to be reckoned as the enemies of this little plant, since no Moss has been hitherto observed to be liable to be attacked by insects or worms.

One of the strongest objections against Hedwig's theory is, that the buds, in which many of the Mosses bear the club-shaped bodies, are entirely closed, whence it is inexplicable how the fructifying matter can find its way from them to the distant pistils. Hedwig, indeed, states that the buds expand at certain times; but certainly this cannot be said of several genera, such as Hypnum, Leskea, Neckera, Maschalocarpus, in which they remain perfectly closed, whether they contain Hedwig's supposed anthers, or pistils.

Though I have formerly been a zealous advocate for Hedwig's theory of the fructification of Mosses, it has nevertheless appeared to me an insurmountable objection, that the supposed anthers can again produce buds and strike roots; which is certainly the case with regard to the disks of Polytrichum *commune*, Bartramia *fontana*, Mnium *palustre*, *undulatum*, *cuspidatum*, *punctatum*, and with those of Barbula *ruralis*. In Bryum *argenteum* we see the buds containing

taining the supposed anthers, constantly drop off, strike root, and produce new plants: this I have observed myself times out of number. Still more in point is the experiment first made by David Meese, of sowing the stellulæ of Polytrichum *commune*, containing merely club-shaped bodies; when he found that plants came up, which in their turn produced fruit*. Another excellent naturalist, Dr. Roth, has made similar observations with regard to Hypnum *squarrosum* and Bryum *argenteum*.

Hedwig proceeded upon the preconceived opinion, that in all cryptogamous, as in phænogamous plants, there must necessarily be found two distinct organs of fructification. This prejudice (for as such we must view it) imposes upon nature a law, which human reason has established upon analogy only, without the proof of a satisfactory induction. We have already seen that in the Ferns fruit is formed without anthers, of

* Verhandlingen der Maatsh. to Haarlen. D. X. St. 2. p. 171.

which

which we shall hereafter have a more striking example in the Lichens. It is therefore not improbable but that the Mosses are likewise without anthers, the structure of their leaves being alone sufficient to free their juices of all oxygen, and thus suffer the carbon and hydrogen, the chemical agents in the first formation of the fruit, to enter into combination for this purpose.

It is more probable, therefore, that these supposed anthers are mere gemmæ, produced by the superabundance of the juices, and hence surrounded by succulent filaments. This opinion was defended by Schmiedel and Gærtner, and has been particularly confirmed by Roth. It explains a circumstance often observed, viz. that Mosses which produce a plentiful crop of gemmæ (such as Hypnum *abietinum* and Dicranum *sciuroides*) seldom bear fruit; their nutritious juices being all expended in the formation of gemmæ. It is only in situations where the soil is particularly good, and the air very moist, that they can produce both buds and

fruit

fruit together. The case is exactly the same with other bulbiferous plants; the more the crop of bulbs multiplies, the fewer seeds arrive at maturity. Having Mnium *undulatum* growing in great quantity, on the northern slope of a hill, close to my house, I had frequent opportunities of seeing the Hedwigian anthers continually mixed with the rudiments of the fruit of that Moss; but I have never seen the latter increase. If the above bodies really deserved the appellation of anthers, why are they never seen to impregnate the surrounding germens? There is no difficulty in accounting for this circumstance, if we consider these parts as gemmæ; the Moss in question, continually putting forth new shoots, and the soil in which it stands being too deficient in moisture, is unequal to the performance of both these functions. Immediately behind my dwelling-house grows Brium *turbinatum*, in which I have never been able to discover the Hedwigian anthers; yet it bears perfect fruit and seeds. And what is more, in Splach-

num

num *ampullaceum* I have often observed, that the disks with rudiments of young fruit prove abortive, whenever, according to Hedwig's expression, they are hermaphroditical, that is to say, as soon as gemmæ (the club-shaped bodies) stand intermixed with the rudiments of the young fruit; these being deprived by the former of their nourishment. Near these, however, we see buds that are without club-shaped bodies, and whose ovaries arrive at maturity. How can this be reconciled with Hedwig's theory?—But it is time to proceed to the young fruits themselves.

The young fruits are at first enclosed in leaflets often different from the leaves of the stem: they are in the shape of stars or roses in Mnium; in that of a tunicated bulb in Funaria. In general they are longer and run out into a finer point than the others, as is the case in Gymnostomum *Hedwigia*, Leskea *paludosa*, Neckera *undulata, pennata*, Hypnum *recognitum* and *Velutinum*. Sometimes, however, these flower-enveloping leaves

leaves are much broader than those of the stem, as in Dicranum *ambiguum*, Leskea *sericea* and Hypnum *serpens*. They are serrated in Hypnum *delicatulum*, and in Neckera *filiformis*, in which the cauline leaves are entire; and in Barbula *convoluta* and Fontinalis *falcata* they embrace the peduncle like so many sheaths. If the cauline leaves are reflected or bent towards one side, the enveloping leaves stand erect, as in Hypnum *uncinatum*, *aduncum*, *filicinum*, *Halleri*; but, on the other hand, in Hypnum *longirostrum* and *Rutabulum* the fruit-leaves are reflected and the cauline erect. Lastly, they are sometimes entire, when the cauline leaves are toothed; as in Hypnum *riparioides*.

The young fruits are enveloped in these leaflets, mostly several together, and particularly numerous in the genus Mnium. It is in Schistostega or Gymnostomum *pinnatum* alone that we find a solitary ovary. For the most part, however, only one of all these rudiments becomes fertile, in which

case

case it swells and is protruded; the others remaining in their imperfect state till they drop off, when the capsule has arrived at maturity. We have only a few instances of several ovaries in the same flower becoming fertile, as in Dicranum *multisetum*, Polytrichum *undulatum* and Mnium *cuspidatum*.

If we attend to the gradual development of the fruit, we first find an oblong body, the ovary (fig. 47, *a.*), terminating in a style. This latter part is of a very delicate structure: its interior is perforated by a longitudinal canal, which gives out on both sides minute transversal branches, by means of which it communicates with the external surface. The extremity of the style is either furnished with a simple aperture, or with two distinct horns, which might be considered as stigmas, but more probably serve for the excretion of the superfluous humours. (fig. 47 *b.*) These pistils are entirely surrounded by succulent filaments, which, however, are for the greatest part only filiform, and do not exhibit such a variety

of

of form as the same parts when surrounding the gemmæ.

In progress of time the ovary swells, and its external membrane becomes ventricose, loosing by degrees its cohesion with that organ, till at last it is only connected with it at the upper part; the central channel of the style is obliterated, and the ovary or young fruit is gradually raised within this integument. Thus you see (fig. 48.) in Encalypta *vulgaris* the bell-shaped exterior integument of the ovary still fixed at the base of the proper peduncle of the latter, terminated by the style; and the reddish peduncle is faintly to be seen through it. Now when this latter comes to be elongated, the delicate integument must necessarily separate at its lower margin, and be elevated along with the capsule, to which it becomes the *calyptra*.

The *calyptra* of the Mosses, therefore, was originally the external, loose, organized integument of the ovary, though at the time when the capsule rises and arrives at maturity,

rity, it becomes a thin scariose membrane. Until the seeds are completely ripe, this calyptra coheres with the upper part of the capsule; at which period, or, in some cases, a little sooner, it drops off. The obvious use of it is the protection of the capsule, particularly of its upper more delicately constructed part; whence, when prematurely torn off, the seeds are prevented from arriving at perfect maturity.

This calyptra is found in all the Mosses without exception; for though Dillenius (Hist. Muscor. p. 241. 251.) has denied its existence in Sphagnum and Phascum, careful examination proves that, however deciduous, it is not wanting in these genera, as was first pointed out by Schreber with regard to Phascum. Yet it can by no means be used as a character to distinguish the Mosses from the Hepaticæ, since the latter, except Targionia, are likewise furnished with it.

The calyptra is generally smooth, but is hairy in the genera Orthotrichum, Polytri-

chum,

chum, Maschalocarpus; these hairs, however, are nothing else but succulent filaments, which, at first surrounding the ovaries in great numbers, rise together with the exterior integument of the latter; whence we find them more or less articulated. In Polytrichum the hairs serve the same purpose as the calyptra itself, which part in this genus is very small, and almost concealed by them.

From what has been said, it appears that Schmiedel was wrong in comparing the calyptra of the Mosses to the corolla of other plants. It is developed at the time when the ovary begins to enlarge, and remains until perfect maturity of the fruit: hence it may much better be compared to the loose integuments of the fruit in phænogamous plants.

LETTER XVIII.

ON THE FRUIT OF THE MOSSES.

In the definition of the Mosses, it has been already observed, that their fruit is, without exception, a capsule opening at the top, by which character especially they are distinguished from the Hepaticæ. In order to subject the fruit to a more accurate examination, we begin with its peduncle.

The capsules are scarcely ever sessile: in Diphyscium *foliosum*, the genus Phascum, Neckera *disticha* and *filiformis* the peduncle is indeed very short, but cannot be said to be entirely wanting: in others, such as Timmia *longiseta*, Splachnum *luteum* and *rubrum*, it is very long.

This part takes its origin, according to the different situation of the fruit, either from the axils of the leaves, or from the extremity or base of the branches. The first

first situation is common to almost all the species of Hypnum, Leskea and Neckera; the second to those of Mnium, Schistostega and Splachnum; and the third to Hypnum *spiniforme* and Dicranum *taxifolium*. It does not, however, follow that the peduncle should always be in the same relative situation as the young fruit; the growth of the plant often effecting some changes in this respect: thus if, in the genus Gymnostomum and Dicranum, the young fruit appears at the extremity of the branches, the peduncles are often found in the axils; the prolongation of the branches, by the further growth of the Moss, making that point lateral which was before terminal.

The peduncle is constantly round, and quite naked: Leskea *cristata*, a native of the South Sea islands, furnishing perhaps the only instance of a hairy one; it is rather rough, or at least beset with small prominent points in Hypnum *prælongum*, *rutabulum* and *lutescens*, in Leskea *sericea* and *involvens*.

This

This part in most Mosses has a vertical direction, though it generally bends when the capsule arrives at maturity. In several species this curvature is made use of as a distinguishing character, as in Phascum *curvicollum*, Grimmia *plagiopus*, Dicranum *pulvinatum*, Hypnum *arcuatum*, Bryum *Zierii*, Dicranum *cygneum*, Leskea *cristata*. In some others the peduncles are bent in various directions, as in Dicranum *flexuosum* and *fragile*. In the genera Barbula and Funaria they are observed to be sometimes hygrometrical, twisting up on the application of moisture, and untwisting again on becoming dry. In some of our Leskeæ (as L. *polyanthos*, *subtilis* and *paludosa*) they are persistent after the capsules are long perished and dropped off.

With regard to the capsule itself, it is either attached immediately to its peduncle, or, by means of an intervening *apophysis*, which is either short and truncate, as in the genus Polytrichum and some species of Dicranum, (and, indeed, in Dicranum *virens*, fig.

fig. 49, *a*, it forms a kind of protuberance not observed by Hedwig); or it is extended into a long neck, as in Pohlia *elongata*, (fig. 50.), and in Bryum *longicollum* of Swartz (fig. 65.); nay, in some species of Splachnum, this part exhibits a receptacle larger than the capsule itself, or an uncommonly beautiful umbrella, as in Splachnum *rubrum* (fig. 51.).

The capsule is usually rounded, but in some species of Polytrichum becomes angular. At the more advanced periods of maturity it is often striated, as in Grimmia *striata*, Orthotrichum *striatum*, and Hypnum *arcuatum*. Its form may be said to be either globular, cylindrical, pear- or egg-shaped.

The sides of the capsule consist of two membranes, a solid exterior, and a delicate transparent interior one. In some Mosses, the exterior of these membranes only is prolongated into the teeth of the peristome, as in Tetraphis (fig. 52.) and Conostomum (fig. 53.); in others only the interior one, as in Diphyscium (fig. 69.) and Barbula (fig. 54.); and in others, again, both these membranes appear in a double row of teeth at the mouth, as is the case in Orthotrichum (fig. 55.) and Hypnum (fig. 56.). Not unfrequently the mouth of the capsule is entirely destitute of teeth, as in Gymnostomum and Sphagnum. In Phascum there is a total want of a mouth, properly so called, the whole capsule bursting irregularly towards the top.

The form of the mouth of the capsule is of the greatest consequence in affording characteristic marks, being not only constantly similar in the same species, but also scarcely varying in any assemblage of related species: hence it was a happy idea of the late Hedwig, to pay particular attention to the formation of this part in his classification of the Mosses; though it cannot be denied that the other parts of the capsules are also of essential service in the better determination of the genera.

What is called the *lid*, is the uppermost part

part of the capsule, which, in general, arrives quicker at maturity than the part immediately surrounding it, and, by separating at a certain period, exposes the mouth of the capsule to view. We know but of one genus, that of Phascum, in which this lid is wanting. In Schistostega the lid does not altogether separate at its base, but divides radiately into slits, which come off by degrees. In most Mosses that part runs out into a delicate point, or kind of beak, which is needle-shaped in Dicranum *aciculare*, crooked or bent in Grimmia *calcarea* and *microdon*, Dicranum *falcatum*, &c.

Beneath this lid is a *ring*, consisting of a delicate disk with thin succulent processes (fig. 57.) The nearer this part arrives at maturity, the more these succulent processes must give way; till, upon some change in the atmosphere, the ring bursts, and the lid adhering to it is lifted up and thrown off: an effect which is particularly promoted by the moisture of the air; for, on removing the lid from a completely ripe and dry capsule, and placing it in a drop of water under the microscope, the small jointed ring is distinctly seen to twist off in the manner exhibited by fig. 57. As this ring assists so much in the disengagement of the lid, it would seem to be indispensable to the capsules of Mosses; but that this is not the case, is proved by the capsules of several genera being entirely destitute of it: at least no ring has been as yet discovered in Polytrichum, Trichostomum, Gymnostomum and Splachnum.

The unilocular capsule of the Mosses is traversed by a vertical *column*, which may clearly be distinguished even in ripe and open capsules, as in those of Splachnum *rubrum* (fig. 51, *a*.) and Climacium *dendroides* (fig. 70.) This part was originally the continuation of the fruit-stalk, and connected with the sides of the capsule by means of transverse fibres. The seeds are not so much attached to it as they are to the inte-

rior

rior surface of the capsule; whence its chief function appears to be the attraction and concentration of the juices.

The *seeds* themselves are always extremely minute, constantly globular, and, in some few cases (as in Gymnostomum *ovatum*), beset all around with fine bristles, just like those of Lycopodium, and the globules of pollen of the plants belonging to the sixteenth class of the Linnean system. One cannot behold without admiration the means employed by nature to promote the discharge of the seeds from the opened capsules. We find that the teeth, especially those originating from the inner membrane of the capsule, are so very sensible to the moisture of the surrounding atmosphere, that the most imperceptible degree of it occasions their contraction, which ceases as soon as the stimulus is removed. In some cases, however, as in Mnium *crudum*, I have observed that they will now and then return to their original state even when still under the influence of moisture. This alternate

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contraction and dilatation must necessarily be of very great assistance in the dispersion of the seeds, which may therefore be easily accounted for even without recurring to the particular nature of the pedicle of the fruit, which, being long, slender and curved, is indeed put into a vibratory motion by the slightest breeze.

That the globules, here called seeds, are in reality such, or that they produce young plants by actual germination, has been proved by Hedwig; though it must be confessed that the form of the seedling plants appears to be rather different from what he thought it. The first experiment he made in 1774, with the seeds of Funaria *hygrometrica*, and afterwards with those of Gymnostomum *pyriforme*, Mnium *cæspitosum* and others, when he constantly observed the young plants to emerge from the ground, furnished with succulent, round, jointed filaments, which appeared to take their origin in the seed itself*. These he considered as the

* Fundamenta Hist. Nat. Muscor. Frondos. vol. ii. p. 56. tab. v. fig. 25, 26. tab. vi. fig. 27—30.——Theoria Generat. p. 152. tab. xvi. fig. 9—11.

seed-

seed-lobes or cotyledons; but observed, at the same time, that they remain adhering to the young plant even in its more adult state, and has so figured them, with all their branches, in Histor. Nat. Muscor. tab. vi. fig. 29.

I have myself had an opportunity of paying a continued attention to the germination of Mosses; and Hedwig's observation appears upon the whole very correct; but, when he considers the above-mentioned filaments as cotyledons, I must beg leave to dissent from him, and to give the results of my inquiries, and the conclusion to which they have led me.

I had constantly observed, that before the flower-pots in our hot-houses were covered by the Moss which is so apt to spring up on them, a great number of small green spots appeared: these, when subjected to the microscope, so exactly resembled Confervæ that they could be taken for nothing else. In the midst of this congeries of delicate silk-like threads, I soon after observed the

the seedling plants of several Mosses, such as Gymnostomum *pyriforme*, *truncatum*, Barbula *unguiculata*, Funaria *hygrometrica*. The Confervæ are so closely applied to the tender Mosses, and so entangle them, that it is easy to imagine that both constitute one body. This intimate connexion subsists after the young plants are considerably advanced. Conferva *arenaria* and *frigida* are what I have observed the more frequently in our flower-pots. The Moss exhibited in fig. 58 is a young Barbula *unguiculata*: it is already pretty far advanced, having no less than nine leaves; and at the lower part of its stem is seen a quantity of jointed, branched, succulent filaments, which I take to be Conferva *arenaria*. In the beginning, when the Moss has scarcely two leaves, the Conferva is likewise simple; but, in proportion as the one grows up, the other becomes more branched, till, ultimately, when the Moss commences to flower and bear fruit, the Conferva entirely disappears.

I am certain that Hedwig's cotyledons of

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the Mosses are the same with what, from my observations, I take to be Confervæ. But we shall soon see that, independently of these observations, they cannot be supposed to be seed-lobes. In the first place, it appears to me entirely contrary to every notion we have of cotyledons, that they should be persistent after the plant is already considerably advanced in growth. In all other vegetables, even in the Ferns, those parts fall off as soon as the growth of the plant indicates that it stands no longer in need of them for its nutrition. But what militates still more against all analogy with regard to cotyledons is, that here they continue to grow, and even to branch out, in proportion as the plant increases in size; whereas, in all other plants they soon shrivel up and drop off. These filaments being jointed, branched, filled with a granular substance, and rather incrassated at the extremities, have a structure exactly similar to Confervæ, and there seems no reason why we should not consider them as such. No-

body

body will object that a Conferva could not attach itself to the delicate Moss, and rob it of part of its nourishment; since we know that this happens in several other instances, of which Conferva *muscicola* of Schrader affords an example. Nay, also lichens are known to be parasitical on Mosses; for instance Parmelia *muscicola*, Urceolaria *scruposa* ; *bryophila*, and Lecidea *muscorum*.

I am sensible that a strong objection may be urged against my opinion, in that Hedwig professes to have seen these filaments issue from the seeds of the Mosses; and, indeed, he has figured them in this state. To this I can only answer, that what Hedwig has figured, plate 5, fig. 25, of his Historia Muscorum, is different from what is represented in pl. 6 of the same work: if the former might be considered as cotyledons, the latter can be nothing but Confervæ. Or may we take refuge in the metamorphosis of one imperfect organization into another, hinted at in one of the first letters? I confess my ignorance, and wish that my scepticism

ticism with regard to the nature of these parts may be only ascribed to my zeal in the search after truth, and a desire to receive instruction from those who may be able to give it.

I avail myself of this opportunity to observe, that Phascum *serratum* of Dickson (fasc. 1. t. 1. f. 1.), called Ph. *velutinum* by Hoffman, and Ph. *confervoides* by Bridel, does not appear to me to be a different species from Ph. *serratum* of Schreber. It is characterized by the jointed, branchy filaments that proceed from the stem; and Dickson is correct in stating this plant to be a link in the natural chain connecting the Mosses with the Algæ, as being partly a Moss, partly a Conferva. Schreber (de Phasco, p. 9.) affirms expressly that he found his Ph. *serratum* near Leipzig, growing, for the most part, together with Byssus *velutina*; and we know, that what were formerly called by this name, are really Confervæ. A great part of those plants, formerly called Byssus *velutina*, is called Conferva *crispabilis* by

Mohr;

Mohr*; but this is not jointed in the manner of the Confervæ that grow on Phascum *serratum*. That excellent observer, Schmiedel†, had before discovered the jointed filaments in several Mosses, especially in Tetraphis *pellucida* and in Phascum *pellucidum*; and Schreber‡ very properly observes, that these minute threads are generally destroyed in the examination of the more minute Mosses. We likewise observe these Confervæ adhering to Phascum *cohærens*§, a native of Pennsylvania, and perhaps not different from our Phascum *muticum*.

To conclude this letter, I add, that on Sphagnum *alpinum* Linn. (Dicranum *Wahlenbergii*), of which I possess specimens from Greenland and Lapland, I have observed two distinct Confervæ, one of which has the greatest resemblance to Conf. *bipunctata* of

* Schrader's Bot. Journ. vol. ii. p. 473.

† Icones Plantar. et Analyses Partium, tom. i. tab. 3, fig. 22, 23.

‡ De Phasco, p. 14.

§ Hedwig. Species Muscorum, tab. 1. f. 1.

Dillwyn.

Dillwyn. Thus, too, Weber and Mohr* found, near Vadstena, a species of Linckia parasitical on Gymnostomum *lapponicum*.

LETTER XIX.

CLASSIFICATION OF THE MOSSES.

THE difficult task of dividing the Mosses into classes, according to the principles of botanical philosophy, was first ventured upon by Hedwig, and executed with a degree of acuteness and skill, that, independent of his other merits, would have secured to him the wreath of immortality. A rational scepticism, the fruit of an impartial investigation of the doctrines of others, is, however, the first qualification of a genuine naturalist; and I respect the memory of that excellent man too much to suppose that, were he still

* Naturhistorische Reise durch Schweden, p. 101, t. 1. f. 5.

living,

living, he could be displeased with my diffident examination of his arrangement.

In order to judge properly of the principles laid down by Hedwig, we must distinguish the classification proposed in his Historia naturalis Muscorum frondosorum, vol. ii. p. 83, seq., from the one he inclined to since the year 1792, which he never executed, but only hinted at in Usteri's Annals, No. 3, p. 43, seq.

The fundamental principle of this classification was the form of the mouth of the capsule; an idea previously pointed out by Haller, who (Opusc. Botan. p. 40—59.) observes, that the shape of the teeth and ciliæ round the mouth of the capsules of Mosses appeared to offer an important ground of division. After Saussure had given the results of his observations on those parts, Haller extended this idea further in his Historia Stirpium Helveticarum, tom. iii. p. 18, 19. Schmiedel likewise paid great attention to the peristome, subjecting several Mosses to microscopical examination, especially Buxbaumia.

baumia. Linnæus himself inclined to the same idea, when, in a letter to Schreber (de Phasco, p. v.) he expresses his wish that some botanist might introduce that method into Muscology. That great man was too much advanced in years at that time to betake himself to microscopical investigations, which in fact had never occupied much of his attention. Such an idea of classification was, however, quite consonant with the principles laid down in his Philosophia Botanica; the examination of the essential differences of the sexual organs and fruits being ever the first rule of classification (Philos. Botan. § 167.). The characters must all be derived from the number, form, proportion and situation of the whole of the organs of fructification (Ibid. § 170). The external habit is only to be consulted as it were by stealth, that no spurious genera may be framed from characters of insufficient value (Ibid. § 171). The more constant we find any one of the sexual organs, the more secure must be the generic character

character derived from it (Ibid. § 177). The form of the fruit was not, indeed, so much attended to by Linnæus, as that of the flower (Ibid. § 180. 186); but this law could apply only to the phænogamous plants, since even in the Ferns, and much more in the Lichens, the observer, finding no trace of flower, must be contented with the form and situation of the fruit.

Hedwig, improving on Micheli's discovery of the sexual parts of the Mosses, and following up Haller's idea, gave to the botanical world a classification of these plants taken from the number, form, and division of the teeth which surround the mouth of the capsules. At the same time, for the subdivisions of his classes, he availed himself of the male flowers as they are called; whether these put on the form of a disk, a knob, or a bud. Thus the three genera Mnium, Bryum, and Hypnum for the most part agree in the shape of the two peristomes; but Mnium has disk-shaped, Bryum knob-shaped, and Hypnum bud-shaped male

flowers.

flowers. Fissidens and Dicranum have both a simple peristome, consisting of cleft teeth: but the former has bud-shaped, the other knob-shaped, male flowers. Tortula and Barbula have a simple peristome, with twisted ciliæ: but to the former Hedwig ascribes bud-shaped, to the latter knob-shaped male flowers. In like manner Grimmia has bud-shaped, and Weissia knob-shaped male flowers; and both agree in the form of the peristome and the number of its teeth.

These principles were also followed by Hedwig in arranging the Mosses, in his large splendid work; and among several other botanists Leysser, in the second edition of the *Flora Halensis*, adopted his new genera without hesitation. Schreber, in his edition of Linnæus's *Genera Plantarum*, successfully attempted some alterations, particularly by uniting most of those genera which were separated by Hedwig, on account of the diversity of their male flowers. Thirty-two genera that had been established by Hedwig, were reduced by Schreber to twenty-five; and he would no doubt have assigned a different place also to Hedwig's Pohlia, Meesia, and Webera, if he had examined the peristomes of these Mosses with his accustomed care and accuracy.

About the same time Willdenow* also began to examine the Hedwigian system according to principles, which at the same time that they are undeniably correct, are for the most part applicable only to the classification of phænogamous plants. Hedwig, in his answer to these botanists, so far coincided with Willdenow's ideas, as to allow, that the external form of the flowers could not remain a ground of division; he also agreed that the disk form originated from that of the knob, and that even the axillary or terminal situation might not be of very great importance; he maintained, however, that, for want of sufficient characters to distinguish the genera by in the natural system, the situation of the male flowers must be considered as very useful in a systematic arrangement.

* Usteri's Magazin für die Botanik, N° 9. p. 28.

rangement. Thus Hypnum and Bryum could not be properly united; yet the only essential difference of these genera, so very distinct in habit, consisted in the flowers of the former being axillary, while those of the latter are terminal. Other objections of Willdenow he parries in a very satisfactory manner*.

While Bridel was arranging the Mosses under Hedwig's genera according to the "Historia nat. Muscorum frondosorum," and "Adumbrationes Muscorum," almost without alteration, Willdenow again proposed a method, derived merely from the form of the peristome†, in which many changes are happily suggested. He appears, however, not to have paid sufficient attention to the different forms which those parts adopt; at least this may be said of his genus Pohlia: to which he attributes a simple peristome with ciliæ between the teeth, and re-

* Usteri's Annalen der Botanik. Shiek 3. p. 43. sey.

† Schrader's Journal der Botanik 1799. vol. ii. p. 1. sey.

fers to it several of Hedwig's Neckeræ; an error he was probably led into by misconceiving the drawings in Hedwig's splendid work, and considering the teeth of the inner peristome, visible between those of the outer, as belonging to these latter. Willdenow further allows no other difference to exist between Fontinalis and Meesia (*uliginosa* Hedw.) than that the capsule of the former is included in the enveloping leaflets. This, however, is contrary to his own principles, according to which the characters afforded by these leaflets are unimportant; not to mention that the pedicled capsules of Fontinalis *falcata* and *capillacea* of Jacquin and Dickson have no such leafy covering. To the genus Leskea, Willdenow refers such Mosses as have an inner peristome consisting of a membrane whose margin is divided into sixteen simple teeth. This is indeed correct, but then we are prevented from classing with them either Mnium *marchicum* or *sphærocarpum* Hedw., both of which belong to Bartramia, and Timmia, the teeth of

whose

whose inner peristome are not simple, but clearly cohering at the points. Hence what Mosses, according to this, should be referred to Bartramia, is difficult to say, since the irregular teeth of the inner peristome occur less in this genus than in many others. In short, in his more minute examination and determination of the Mosses, we do not recognize that rare acumen and spirit of deep research, which mark the other investigations of Willdenow.

I am of opinion that, in establishing a classification of Mosses, we ought certainly to proceed upon the principles of botanical philosophy, but that in their application a somewhat greater latitude must necessarily be allowed in this family than in the phænogamous plants. The artificial system should swerve as little as possible from the natural. In cases where the whole habit of two genera is altogether different, as in Hypnum and Bryum, such a difference cannot, indeed, be taken into the artificial generic character, but in such cases we must look among the

the essential parts for characters; by means of which an artificial diagnosis of the genera may be formed. Thus, in a natural arrangement the genus Salvia has the nearest affinity with Rosmarinus, but their structure being different, we find an artificial distinctive character in the transversal processes of the stamens of Salvia, which is wanting both in Rosmarinus and Monarda.

With how much latitude the rules of the Linnæan Philosophia Botanica should be applied to the cryptogamous plants, appears also from this, that even a system built upon the form of the peristome alone, is condemned by §§ 180 and 186, according to which the form of the flowers is to be consulted. Now, as the parts considered by Hedwig to be male flowers, are most probably not really such, but propagating gemmæ, it would follow that these parts could not be resorted to as a principle of classification. But the arrangement of the ferns, and even of the grasses, proves that the botanist should avail himself of the situation of the fruit in cases where characters more essential are wanting. Thus nature has separated Hypnum from Bryum by their whole habit; a character which the systematic botanist consults only by stealth: but on examining the more essential characters, and finding that no species of Bryum ever bears its fruits in the axils of the leaves, which is peculiar to the genus Hypnum (with the exception of H. *spiniforme*), for want of a better he takes hold of this artificial distinctive character. In the same manner, I think, we should proceed with regard to the genera Grimmia and Maschalocarpus: both are distinct in nature; but we perceive no other artificial character applicable as generic, than that the fruits in the latter are situated in the axils of the leaves. These are the only two cases in which we have occasion to avail ourselves of the inflorescence in the formation of the generic character.

As for the question Whether the calyptra ought to be used as a distinctive character of the genus, it must be answered in the affirmative,

affirmative, even by the most strenuous follower of the Linnæan rules. The lid (operculum) and calyptra are essential parts of the fruit, as well as the teeth of the peristome; though it must be allowed that their rank as distinctive characters is subordinate to the latter. It is not the finer or thicker point, not the straight or curved direction of the beak (rostellum), but the dehiscence of the lid into several pieces, that can justify us in making a distinct genus of Gymnostomum *pennatum*. The size of the calyptra and its hairy integument may, indeed, be noticed (the former in Encalypta, the latter in Polytrichum and Orthotrichum), but without considering them as principal characters; for several Maschalocarpi and one species of Neckera (N. *composita*) are also furnished with a hairy calyptra.

Such are the principles of a classification of the Mosses, which, after reiterated examination, I offer to your notice. Let us now proceed to arrange under it the genera of this natural order.

LETTER

LETTER XX.

GENERA OF THE MOSSES.

If, according to what has been advanced in the preceding letter, the number, form, proportion and situation of the parts essential to fructification, afford the best generic characters*, the following genera must be considered as genuine.

I. PHASCUM.

The capsule of this genus is furnished with a calyptra, but it wants the lid: the former of these parts was discovered by Schmiedel in 1750, and afterwards, in 1758, by Leysser; it was next figured by Oeder, (Flora Danica, t. 249), and Schreber threw further light upon it by his excellent observations on the whole genus. The capsule, being destitute of a lid, cannot open in the

* Linnæi Philosophia Botanica, § 170.

same

same manner as that of the other mosses, but drops off entire and closed. Thus the seeds are not scattered till the capsule rots or decays. In one instance only (in Phascum *curvicollum*), Hedwig observed the capsule to open by the falling of a kind of lid. The columnar receptacle does not appear to be wanting, at least Schmiedel has observed this part in Phascum *subulatum*. Several species, such as Ph. *curvicollum*, *nitidum*, *patens*, being annuals, have no gemmæ, or what Hedwig considered as anthers; but in others, they are produced in the axils of the leaves.

This genus comprehends the smallest species of Mosses: Ph. *muticum* and *serratum* are almost always microscopical objects, since they seldom exceed half a line in length. Ph. *piliferum* and *subulatum* will attain the height of eight lines, and Dickson has referred to this genus several Mosses of still larger dimensions; but as it appears that this botanist seldom uses the microscope,

microscope, it is doubtful whether his Ph. *alternifolium*, *strictum*, *bryoides*, are really congeners of the other Phascums.

The places of growth of most of its species are in an argillaceous soil, or in good garden mould; Phascum *crispum* occurs frequently with us in church-yards, Phascum *muticum* and *cuspidatum* in orchards, Phascum *subulatum* in woods under the shade of Bæomyces *pyxidatus*. Most frequently they are mixed with Confervæ, as above mentioned. In alpine regions they are seldom met with. Dickson's Ph. *strictum* is perhaps the only one that inhabits alpine swamps; and it is dubious whether this really belong to the genus.

II. SCHISTOSTEGA.

The lid in this genus does not completely separate, but splits from the centre into fine segments, by the rolling back of which the mouth of the capsule is opened. The best figure of this split lid is given in Hedwig's Descript.

Descript. et Adumbrat. Musc. Frond. vol. i. tab. 29. fig. 11. Weber first separated this genus from Gymnostomum, with which it was united by Hedwig, while Dickson, its discoverer, referred it to Mnium. Following the principles above laid down, we must approve of this alteration: for if Phascum is a distinct genus on account of its wanting the lid, it is equally proper to establish the genus Schistostega from the character of the fissures of this part.

One species only, Schistostega *pennata*, is known, which has so many peculiarities in its external habit, that even on this account we could not hesitate to keep it distinct from other genera. It is furnished with a kind of frond, like that of Blechnum *boreale*, beset on both sides with a row of leaves; the steril fronds being pinnatifid, the fertile ones pinnate. The steril plants only produce gemmæ at their extremity: the fruit-stalks too are constantly terminal: their small capsules are cylindrical, and their lids

lids separate in the manner above described, leaving the mouth completely naked.

Dickson first received this Moss from Devonshire: it has since been found likewise in Germany, especially in Lusatia and near Pyrmont. It appears to be biennial.

III. SPHAGNUM.

Mouth of the capsule naked; calyptra bursts in the middle, the lower half remaining below the capsule. The club-shaped gemmæ are situated on the same plant with the fruits, at the extremities of the branches.

This genus, so distinct from other kindred genera, is, as far as we know, found only in swamps and peat-moors, whence it has obtained the name of Peat Moss. It seldom bears fruit except in alpine countries, where most of the springs take their origin in large swampy plains covered all over by Sphagnum, which at an advanced period of growth adopts a reddish colour. In North America too Sphagna are very common, and

and harbour and nourish many swamp-plants, such as Empetrum *nigrum*, Vaccinium *oxycoccos* and *uliginosum*, Eriophorum *alpinum*, Anemone *alpina*, and several species of Pedicularis. It is in such situations only that we find growing among this and other Mosses, Heritiera *Gmelini*, Leptanthus *ovalis*, Frasera *Walteri*, Centaurea *verna*, Sarracenia *purpurea*, Helleborus *trifolius*, Dionæa *muscipula*. And this is the reason why these plants are so difficult to be cultivated.

With regard to Sphagnum *alpinum* L., it was Dillenius who first discovered this Moss in swamps upon Snowdon; he suspected it to be a Sphagnum, and Linnæus did not hesitate to take it up as such, Schreber has insinuated that it might be a Bryum, and Dickson actually gave it as Bryum *immersum* in his Cryptogamic Plants, so that it must remain dubious to which genus we ought to refer it, till we shall have received it from the very place where Dillenius found it. Wahlenberg, in his late

interesting

interesting tour in Lapland, has found a Dicranum, which, upon comparison, bears great resemblance to Sphagnum *alpinum*, specimens of which, without capsules, I have received from England: there is, however, this difference, that in Sphagnum *alpinum* and Bryum *immersum* Dicks. the capsules are said to be sessile in the axils of the leaves, while in Wahlenberg's plant they are furnished with long stalks.

IV. GYMNOSTOMUM.

The capsule in this genus has a naked mouth. The gemmæ are found either in the axils of the leaves as buds, or at the extremity of the plant in the form of disks; from which circumstance Hedwig has divided the genus into two; the one, first called Hedwigia, afterwards Anictangium, (more correctly Anœctangium) having axillary and bud-shaped, the other, Gymnostomum, terminal and disciform flowers: but when we examine the species separately and without prejudice, this distinction does not appear to hold

hold good, even if we adopt Hedwig's idea of anthers. Gymnostomum *prorepens* and *curvirostrum* have evidently bud-shaped axillary flowers, and in the latter even the fruit-stalks are inserted in the axils of the leaves. In Hedwigia or Anœctangium *lapponicum* we clearly perceive the flowers to be terminal. And if Hedwig's Gymnostomum *æstivum* really have a capsule with a naked mouth (which does not however appear altogether certain), its twofold flowers are still found to be axillary. Hence I believe that we are in the right to unite Hedwig's Anœctangium with Gymnostomum, as has already been done by Swartz. And should it be proved that Hedwig's male flowers ought to be considered as receptacles of gemmæ, the distinction of these two genera will be entirely done away.

I have still to observe, that of the four exotic Anœctangia, enumerated by Hedwig in his "Species Muscorum Frondosorum," one, namely An. *cirrhosum*, is certainly a

Neckera,

Neckera, and the remaining three, natives of the South-Sea Islands, are very questionable. I had an opportunity of seeing specimens of all the three in the herbarium of the botanist from whom Hedwig received them; and though I could not discover any peristome in them, yet this affords no proof that the same would be the case if the specimens were perfect.

V. TETRAPHIS.

The mouth of the capsule is furnished with four pointed, detached teeth, taking their origin from both membranes. The club-shaped gemmæ, either alone or with the rudiments of the fruit, are situated at the extremities of the branches. Besides these, however, the steril branches produce other pedicled knobs, out of which, according to the observation of Haller above alluded to, new leaves are developed. I have expressed the character of the genus, in fig. 52, representing a new species, Tetraphis *ovata*, found by Funk on the mountains called Fichtelgebirge.

VI. ADREÆA.

The mouth of the capsule is furnished with four teeth, conniving towards the top, and cohering with the lid (fig. 58).

Linnæus, mistaking the curved teeth of the peristome for the valves of the capsule, considered this plant as a species of Jungermannia. Ehrhart was the first who proved it to be essentially distinct from Jungermannia, and gave the new genus the name it now bears, but persevered in the error of calling the teeth valves of the capsule; leaving it to Hedwig to correct the mistake, and to develop the genuine character of this Moss.

VII. OCTOBLEPHARUM.

The mouth of the capsule is furnished with eight distinct teeth. No apophysis to the capsule. The club-shaped gemmæ, near the rudiments of the young fruits, in the axils of the leaves.

There is but one species of this genus known,

known, and that is a native of the Tropical Islands.

VIII. SPLACHNUM.

Mouth of the capsule surrounded by eight distinct teeth, simple or in pairs. Capsule furnished with a cone- or egg-shaped, globular or umbrella-shaped apophysis. The club-shaped gemmæ situated with the rudiments of the young fruits near the extremity of the branches; or there appear disks with pistils that remain steril, but have near them buds which afterwards produce real fruit.

The character of this genus, the most beautiful of any, is given in fig. 51, from Splachnum *rubrum*. All the species are inhabitants of peat-bogs, especially in alpine regions.

IX. GRIMMIA.

Mouth of the capsule furnished with sixteen distinct teeth. Capsules without exception at the extremities of the shoots.

The teeth, in this genus, are subject to several variations: in some species they are very broad; in others, as in Grimmia *Schleicheri*, *calycina*, *radians*, they are strong and of a red colour (fig. 59); in others again, as in Grimmia *fugax*, *pusilla*, *virens*, *crispa*, &c., they are filiform and deciduous. On account of this difference in the teeth, and also in the inflorescence, Hedwig divided this genus into two, viz. Weissia and Grimmia; but not to mention that the supposed male flowers are not what he thought them to be, whence no generic character can be derived from them, we know that his Weissia *calcarea*, *radians*, and *calycina* have broader teeth than Grimmia *recurvata*. The perforation observed in the teeth of Grimmia *plagiopus* and *cribrosa* is of greater moment, and these species ought therefore to constitute a separate genus. I also refer to the genus Grimmia, Leersia or Encalypta *lanceolata*, which cannot belong to the latter genus, being destitute of its principal character, the large

ventricose,

ventricose, bell-shaped calyptra. Its club-shaped gemmæ are situated in the axils of the leaves, but the peduncles of the fruit at the extremities of the branches. The teeth of the peristome are thicker than in Grimmia *fugax* and *cirrhata*, but thinner than those of Gr. *apocarpa*. So likewise Orthotrichum *anomalum* and *cupulatum* might be referred to this genus; their peristome being only simple.

X. ENCALYPTA.

The mouth of the capsule is furnished with sixteen distinct teeth, and the capsule itself covered by a large ventricose, bell-shaped calyptra, generally hanging down as far as the basis. In Encalypta *vulgaris* the calyptra is, in most cases, so intimately connected with the lid, that they fall off together with it; often too the peristome remains adhering to it, in which case this Moss may be mistaken for Gymnostomum *truncatum*, which, indeed, it much resembles; and it inhabits the same places. In Encalypta

ciliata

ciliata the calyptra is toothed and ciliated at the base, and in E. *streptocarpa* lacerated, and the capsule turned towards the right.

If the calyptra be considered as an essential part of the fructification, it must necessarily be resorted to for distinguishing genera. It is also to be observed that the club-shaped gemmæ are situated, like buds, in the axils of the leaves; as are the peduncles also, though the rudiments of the young fruits were originally terminal.

XI. MASCHALOCARPUS.

Mouth of the capsule furnished with sixteen distinct teeth: calyptra very delicate, small, and, in several species, beset with fine hairs. Not only the club-shaped gemmæ, but also the peduncles of the fruit, constantly issue from the axils of the leaves of the sarmentose plant.

From Grimmia this genus differs particularly in that its fruit is never situated at the extremities of the shoots, but regularly in the axils of the leaves. While its sarmentose

nature

nature distinguishes this genus sufficiently in the natural system from Grimmia, and approximates it to Hypnum, the artificial system, privately consulting the natural habit, must endeavour to express this by an essential character; such is the axillary situation of the fruit. Weber and Mohr propose to divide this genus according as its calyptra is naked or hairy, distinguishing the latter species by the name of Leptodon. I cannot however agree with this, as the want of a single and less important character in some of the species is not sufficient to separate them from the rest of the genus (Linn. Philos. Bot. § 175); for, if it were, the genus Orthotrichum should also be divided, some of its species having a naked calyptra.

I have changed the name Pterigynandrum, given to this genus by Hedwig, into Maschalocarpus, the Greek term for the axils of the leaves being μασχαλη, not πτερον. Hence, too, I could not admit the name Pterogonium, applied to it by Swartz.

XII. COS-

XII. COSCINODON.

Mouth of the capsule furnished with sixteen simple, solid, distinct teeth, perforated like a sieve (fig. 75).

This genus, to which belong Grimmia *cribrosa* and *plagiopus* of Hedwig, I offer to the consideration of botanists; the perforation of the teeth appearing in this case to be of the same importance as in the genus Mnium. The name is derived from κοσκινον, a sieve.

Though Michaux's Trematodon, according to his description, agrees with this genus, yet the only species he gives of it, as far as can be judged from specimens in the possession of Bridel, is Dicranum *ambiguum*, in which there is no real perforation of the teeth, but only a slight connexion of them by means of transverse fibres, such as we find also in European specimens of this Moss.

XIII. CONOSTOMUM.

The mouth of the capsule furnished with sixteen

sixteen simple teeth, conniving upwards in the shape of a cone (fig. 53). The gemmæ are disposed in disks at the summits of the shoots, from whence, likewise, the peduncles issue. This genus was first established by Swartz, who received the only species of it, Conostomum *arcticum*, from Lapland; and it is from this excellent botanist that we expect a fuller description of this remarkable polar Moss.

XIV. POLYTRICHUM.

The mouth of the capsule furnished with 24, 32, or more, simple, short teeth, and closed by a particular membrane, uniting the tips of the teeth (fig. 60). The calyptra, in several species, is clothed with hairs. The capsules of some species are furnished with an apophysis. The gemmæ and rudiments of the young fruit are constantly situated at the extremities of the shoots, and generally surrounded by disciform involucres.

This genus, also in the natural system, is distinct

distinct from all others by its peculiar habit; but if, as Ehrhart, Hoffmann, and Weber have proposed, we should separate from it those species that have a smooth calyptra, and form them into distinct genera, this would be contrary to the rule in § 175 of Philosophia Botanica; and, for the sake of consistency, we should be likewise obliged to separate Orthotrichum *pumilum* from its genus. In this manner the number of genera would be multiplied without reason.

XV. DICRANUM.

Mouth of the capsule beset with sixteen solid, split, incurved teeth, and the capsules, in some species, furnished with an apophysis. I have taken, for an example, the capsule of Dicranum *virens* (fig. 49), as the small swelled apophysis, essential to this species, has been neither figured nor mentioned by Hedwig. (See his Descript. et Adumbrat. Musc. frond. vol. iii. tab. 32.)

The peduncles of the fruit issue either out of the axils of the leaves, or at the extremities

extremities of the shoots. I am of opinion that Hedwig's division of this genus into Fissidens and Dicranum, from the situation of the male flowers, cannot be admitted; in which Swartz, Schrader, and Weber agree with me.

XVI. TRICHOSTOMUM.

The mouth of the capsule is beset with sixteen simple, filiform, erect teeth, split down to their base (fig. 61). The fruit appears either in the axils of the leaves, or is terminal.

This genus differs from the foregoing in the deep division of the teeth of the peristome, their filiform nature and erect situation. To Trichostomum should be referred Barbula *curta* of Hedwig, or Tortula of Swartz, the teeth of whose peristome are by no means twisted.

XVII. BARBULA.

Mouth of the capsule beset with twisted ciliæ that are to be regarded as continuations

of

of the inner membrane (fig. 54). I cannot but refer to this genus Hedwig's Trichostomum *fontinaloides*; in which the ciliæ of the peristome are neither as solid, nor as perforated, nor disposed so exactly in pairs, as Hedwig (Descript. et Adumbr. vol. iii. tab. 14.) represents them: being a continuation of the inner membrane, they are extremely delicate, and constantly twisted; we cannot, therefore, hesitate to rank it with the Barbulæ. The peduncles of the fruit are sometimes axillary, at other times terminal.

The difference between Barbula and Tortula, derived by Hedwig from the situation of the male flowers, cannot now be attended to. Nor can I as yet subscribe to Bridel's proposal of establishing a new genus, Syntrichia, from Barbula *ruralis* and *agraria*, on account of their ciliæ cohering at the base; a circumstance which I have observed also in other species.

XVIII. DIPHYSCIUM.

The mouth of the capsule furnished

with

with a simple plicate membrane, traversed longitudinally by veins anastomosing with each other (fig. 69). This membrane takes its origin from the interior surface of the capsule; and there is no exterior apparatus to the mouth. The capsule itself is of a ventricose oval shape, and issues immediately from the root, without a perceptible peduncle.

The only species known of this genus has been, hitherto, referred to Buxbaumia, from which it differs in the want of an exterior, and the particular structure of the interior, peristome. Ehrhart first established it as a new genus under the name of Webera *Diphyscium*; but there being already a plant of the fifth class known by that generic appellation, I follow Dr. Weber, who has converted Ehrhart's specific name into that of the genus.

XIX. DIDYMODON.

The mouth of the capsule beset with sixteen or thirty-two teeth disposed in pairs, and the capsule is without an apophysis (fig. 62). Hedwig's Swartzia, afterwards called Cinontodium, cannot be separated from this genus, the distinction being founded solely on the situation of the supposed anthers.

Splachnum agrees with Didymodon in having its teeth sometimes in pairs, but its capsule is constantly furnished with an apophysis, which is wanting in the latter genus. In Didym. *inclinatus* the teeth are broader than in the other species, and also open.

XX. ORTHOTRICHUM.

The mouth of the capsule is furnished with a double peristome; the exterior one consisting of eight or sixteen solid teeth; and the interior one of eight or sixteen fine hair-like ciliæ (fig. 55). The calyptra, in most species, is beset with erect hairs. This latter circumstance is on the whole not unessential in such cases, and serves here as an artificial character to distinguish this from the following genus. But even Orthotrichum

trichum *striatum* has sometimes a naked calyptra, and in O. *pumilum* and *obtusifolium* it is never otherwise.

XXI. NECKERA.

The mouth of the capsule has a double peristome; the exterior one consisting of sixteen teeth, the interior of as many detached erect ciliæ, not united at their bases. The fruit is constantly found in the axils of the leaves.

The difference between this and the preceding genus is very slight. In habit the species of Neckera are sarmentose, like the Hypna; but something similar is also observed in the growth of several Orthotricha. The dioicous inflorescence cannot be adopted as a discriminating character: the number of the teeth and ciliæ is subject to variation in Orthotrichum, and the hairy covering of the calyptra is entirely wanting in some of its species. Thus nothing remains both for essential and artificial distinction, but the detached erect situation of the inner ciliæ,

ciliæ, which in Orthotrichum are always bent inward and vaulted. In several species these ciliæ are placed in such a manner among the teeth of the outer peristome, that they appear to issue from the same base with them, and thus give the idea of a simple peristome: but in most cases it can be distinctly seen that the ciliæ issue behind the teeth, from the inner membrane of the capsule (fig. 76).

Most species of this genus have a very short pedicled capsule, concealed in the enveloping leaflets; whence Neckera *pennata* (which, with Leskea *complanata*, and Neckera *curtipendula*, beautifully adorn the stems of old trees,) was referred by Linnæus to the genus Fontinalis, the character of which he states to be a capsule surrounded by its proper leaflets; which corresponds with what he observed in that species of Neckera.

XXII. CLIMACIUM.

The mouth of the capsule has a double peristome: the outer one consisting of sixteen teeth, and the inner of as many

ciliæ,

ciliæ, disposed in pairs, conniving above, detached at the base, but united by means of transversal fibres. Peduncles axillary.

Weber and Mohr were the first who formed Neckera *dendroides* into a proper genus, under the above name: following them in this, I here give the first delineation of the generic character in fig. 70.

XXIII. TIMMIA.

The mouth of the capsules furnished with a double peristome; the outer one consisting of sixteen short, almost truncated teeth, and the inner of as many membranaceous long teeth, disposed in pairs, and disengaged the whole of their length. Fig. 63, representing the generic character, is also applicable to Meesia *longiseta* and *dealbata* of Hedwig. The peduncles issue from the extremities of the shoots, by which circumstance, as well as by the short, and, as it were, truncated teeth of the outer peristome, and the unconnected inner ciliæ, this genus is pretty distinct from the preceding.

XXIV. MEESIA.

The mouth of the capsule has a double peristome; the outer one consisting of sixteen shorter or longer teeth, the inner of the same number, reticulated, flat, between two linear processes. The peduncles are constantly at the extremities of the shoots.

Hedwig considered this as belonging to the preceding genus, from which, however, it is distinct, in the form of the inner peristome, whence Willdenow proposed the separation, giving to Meesia *longiseta* the name of Timmia, and retaining that of Meesia for Meesia *uliginosa*. This is, indeed, a very proper change; we shall, however, see hereafter, that Hedwig's Timmia cannot be referred to Leskea, though Willdenow thought it might. I have still to observe, in this place, that Bryum *macrocarpon* of Hedwig belongs to this genus, and, with respect to the generic character, differs from it only in having the teeth of the outer peristome longer. The best representation of the generic

generic character is given in Hedwig's Historia Nat. Muscor. frondosor. vol. ii. tab. 9, fig. 57.

XXV. LESKEA.

Mouth of the capsule with a double peristome; the outer consists in sixteen long-acuminated teeth; the inner in a delicate membrane, running out into uniform acuminated teeth (fig. 71).

The situation of the pedicles of the fruit is constantly axillary, a character which, together with the form of the inner peristome, distinguishes this genus from the preceding. In the natural system it clashes with the genus Hypnum, of which it has the sarmentose, branchy habit. Nor is it an easy matter, in several of the species of these genera, to distinguish the form of the inner peristome, since (in Hypnum) the ciliæ between the teeth of the inner peristome are sometimes so delicate that they become visible only by means of a very high magnifier: in such cases the student runs the risk of mistaking a true Hypnum for a Leskea; from whence it appears, that it often requires much more careful attention to distinguish the form of the peristome, than the situation of the flowers.

XXVI. FUNARIA.

The mouth of the capsule has a double peristome; the outer one of sixteen pointed teeth, rather obliquely turned, and cohering at the top; the inner of as many ciliæ, lying flat (fig. 72).

Peduncles of the fruit constantly terminal.

These characters are sufficient to distinguish this genus from all the rest.

XXVII. BARTRAMIA.

Mouth of the capsule with a double peristome; the outer one consisting of sixteen pointed, detached teeth; the inner of a delicate membrane, terminating in as many acuminately divided teeth.

Peduncles of the fruit terminal, except

in

in one species, Bartramia *Halleriana*, in which the peduncles issue from the axils of the leaves.

The generic character of Bartramia has been framed with great accuracy by Swartz, in Schrader's Botanical Journal, vol. ii. p. 180. 1800. According to the above character, explained by fig. 64, taken from B. *Halleriana*, it would appear that Mnium *fontanum*, *marchicum*, and *sphærocarpon*, are all three congeners of Bartramia; and my own observations convince me of the propriety of referring them to this genus. I am also inclined to do the same with Pohlia *elongata*, and Bridel's P. *intermedia*; but I confess that this requires more attentive and frequent examinations than I have as yet had an opportunity of making.

XXVIII. BRYUM.

Mouth of the capsule with double peristome; the outer one consisting of sixteen detached teeth; the inner of a membrane, terminating in pointed, imperforate teeth,

teeth, with intermediate delicate ciliæ. The peduncles are constantly terminal.

I have illustrated the generic character of Bryum by a drawing of Hedwig's Webera *longicollis* (fig. 65), which with regard to the form of its inner peristome, indeed, agrees with Hedwig's Webera *pyriformis*, but in no respect with Webera *nutans*. The peristome has neither been figured by Swartz, who calls the plant very correctly Bryum *longicollum*, nor by Schwägrichen, who refers it to Webera. Every way agreeing with this in form, we find the inner peristome of Webera *pyriformis*, Arrhenopteron *heterostichum*, Bryum *delicatulum*, *argenteum*, *julaceum*, *alpinum*, *Zierii*, *capillare*, *cæspiticium*, *annotinum*, and *squarrosum*. Now as these agree likewise in the situation of the peduncles of the fruit, they might, according to my own opinion, properly be added to the genus Bryum. Probably, too, the Pohliæ of Hedwig should be referred to the same: the account of the membrane of the inner peristome being furnished with

sixteen

sixteen teeth, does not even apply to Pohlia *elongata*, the peristome of which, such as it occurs most frequently, is represented in fig. 50. Viewed in this light, we might take this moss for a Bartramia, its teeth being split; but I believe that ciliæ will also be found between the pairs of teeth, such as really exist in Pohlia *inclinata* and Bryum *pallens* of Swartz; and that all these are species of Bryum is not a matter of doubt. If the form of the inner peristome of Pohlia *elongata* be such as Hedwig (Descript. et Adumbr. vol. i. tab. 36.) has figured it, and such as Briedel (Muscolog. Recent. vol. ii. p. 3. f. 12.) describes it in his Pohlia *intermedia*, it would follow that these two must be separated from P. *inclinata*, and Bryum *pallens* of Swartz, and referred to Leskea.

XXIX. MNIUM.

Mouth of the capsule with double peristome: the outer consisting of sixteen detached teeth; the inner of a membrane terminating in pointed, much perforated teeth, with

with intermediate fine ciliæ. The peduncle of the fruit is constantly terminal.

The form of the inner peristome is subject to variation : the openings in the teeth being often so large, that there remains but little of the membrane on both sides, as in Timmia *austriaca* (fig. 66), and *megapolitana* of Hedwig ; in other cases something more remains of it, as in Webera *nutans* of Hedwig ; in others again the openings are round, and a considerable portion of the membrane remains on both sides, as in Mnium *cuspidatum* and *punctatum*. This *more* or *less* cannot possibly afford a reason for dividing the genus ; no more can the circumstance that in the species of Timmia some disks contain merely club-shaped gemmæ without rudiments of young fruit, this being likewise the case in Mnium *crudum* and *hornum*. Hence I consider the following species as belonging to this genus : Timmia *austriaca* and *megapolitana*, Bryum *pulchellum*, Mnium *palustre*, *hornum*, *crudum*, *pseudotriquetrum*, *turbinatum*, *cuspidatum*,

datum, *stellare*, *punctatum*, *undulatum*, *roseum*, *serratum*, and *rostratum*.

XXX. CINCLIDIUM.

The mouth of the capsule has a double peristome; the outer one consisting of sixteen detached teeth; the inner of a cuneiform arched membrane, elongated upwards into sixteen, uniform, connected rays, below which it is perforated with large round openings. The capsule itself is furnished with an apophysis. The peduncles of the fruit terminal.

This genus was discovered by Olof Swartz, and described and figured in Schrader's Botanical Journal, vol. i. n. 27. 1801. The only species known is Cinclidium *stygium*, an inhabitant of the peatbogs of the north of Sweden.

XXXI. HYPNUM.

Mouth of the capsule with double peristome: the outer one of sixteen detached teeth; the inner of a membrane running out

into

into pointed teeth, with intermediate fine ciliæ. The peduncles of the fruit are constantly axillary, which is the only artificial character that distinguishes this genus from Bryum. In natural affinity it is distinct from the latter in its habit, being decumbent, sarmentose, and variously branched. In the latter respect it agrees with Leskea, from which however it differs in the form of the inner peristome. That this character is, however, often very difficult to be observed, I have stated in speaking of Leskea.

The delineation of the generic character (fig. 56) I have taken from a new species, which I call Hypnum *Ludwigianum*, it being discovered by Mr. Ludwig on the Sudetic mountains. Its small stems are simply branched, leaves ovate, veinless, slightly serrated, imbricated, and capsule erect. It stands next to Hypnum *serpens* and *molle*, from both of which, however, it is distinct by the serratures of the leaves.

The very difficult arrangement of the species

cies of this extensive genus might be best effected by separating, according to Weber's proposal, the species with veinless, from those with veined or nerved leaves, and by attending to the direction of the leaves whether they are secund or not.

XXXII. FONTINALIS.

Mouth of the capsule with a double peristome: the outer one consisting of sixteen diverging, subulate teeth; the inner of a cuneiform, netted membrane, with irregular square meshes composed of bundles of vessels. The fruit is situated in the axils of the leaves (fig. 77).

XXXIII. BUXBAUMIA.

Mouth of the capsule furnished with a double peristome; the outer one consisting of sixteen very short truncated teeth; the inner of several rows of filaments, cuneiformly joined together, and only slightly connected at the base; of these the inner ones are the longest. The capsule is oblique (fig.

(fig. 68). The peduncles issue immediately from the root.

Thus I have given you a prospectus of the Genera of Mosses, such as I think they ought to be framed according to the rules of Botanical Philosophy. Far, however, from intruding my classification on others, it is still my first wish, that botanists would agree in framing a stable nomenclature, without which, the confusion arising from the increasing number of names of the same Moss must be endless. Of this inconvenience I need mention one example only:—Grimmia *cirrhata* is called by Dillenius Bryum, Mnium by Linnæus, Afzelia by Ehrhart, Weissia by Hedwig, Dicranum by Roth, Barbula by Bridel, Leersia by Willdenow, Gymnostomum by Schrank, and Hypnum by Weiss.

LETTER

LETTER XXI.

SYNOPTICAL VIEW OF THE GENERA OF MOSSES.

To enable you to see the whole natural family of the Mosses at one view, I give you the following table:

I. Capsule without lid and without regularly shaped mouth *Phascum.*

II. Capsule with a lid divided into rays *Schistostega.*

III. Capsule with naked mouth

A. calyptra bursting transversally *Sphagnum.*

B. calyptra deciduous, and of the usual form *Gymnostomum.*

IV. Mouth of the capsule furnished

A. with a simple peristome

1. with teeth proceeding from the outer, or from both the inner and outer surface of the capsule

a. with four distinct teeth *Tetraphis.*

b. with

b. with four teeth bent outwards, and united at top *Andreæa.*

c. with eight distinct teeth

a a. capsule without apophysis *Octoblepharum.*

b b. with apophysis *Splachnum.*

d. with sixteen teeth

a a. teeth distinct

a a a. fruitstalks terminal

* with large bell-shaped calyptra *Encalypta.*

** with a common small calyptra *Grimmia.*

b b b. fruitstalks axillary *Maschalocarpus.*

b b. teeth united at top in the form of a cone *Conostomum.*

c c. teeth split

a a a. bent and solid *Dicranum.*

b b b. filiform and erect *Trichostomum.*

d d. perforated like a sieve *Coscinodon.*

e. with 16, 32, or more teeth, connected upwards by a transversal membrane *Polytrichum.*

f. with 16 or 32 teeth disposed in pairs *Didymodon.*

2. with processes of the inner membrane

a. with twisted ciliæ *Barbula.*

b. in

b. in a wedge-shaped process *Diphyscium.*

B. with a double peristome

1. The outer, 8 or 16 teeth distinct

a. inner ciliæ not connected at the base by a membrane, and

aa. vaulted inwards *Orthotrichum.*

bb. erect *Neckera.*

b. inner teeth, long, in distinct pairs, outer ones very short *Timmia.*

c. inner ciliæ, long, in pairs, connected by transversal fibres, outer teeth of usual length *Climacium.*

d. inner teeth connected toward the base by a membrane and

aa. uniform

aaa. with terminal fruitstalks *Meesia.*

bbb. with axillary fruitstalks *Leskea.*

bb. disposed in pairs *Bartramia.*

cc. unequal, with intermediate ciliæ

aaa. with terminal fruitstalks

* teeth strongly perforated *Mnium.*

** teeth imperforate *Bryum.*

bbb. with axillary fruitstalks *Hypnum.*

e. membrane perforated below the teeth *Cinclidium.*

f. membrane without teeth, reticulated *Fontinalis.*

g. a double

g. a double row of filaments instead of inner peristome, the outer teeth truncated *Buxbaumia.*

2. outer teeth connected at top, inner ciliæ flat *Funaria.*

LETTER XXII.

ON THE MUSCI HEPATICI.

THAT the Musci Hepatici are very nearly related to the real Mosses is evident, both agreeing in their natural, and in several of their artificial characters. Most species of Jungermannia are leafy and branched like the real Mosses, and like them strike roots with the greatest facility. Like Tetraphis *pellucida* and Bryum *androgynum*, they produce either on the tips of the leaves, or on particular peduncles, little heads that appear to be of a pulverulent nature, and are probably analogous to buds. The interior

structure

structure of their stems and leaves, is, without exception, loosely cellular; and there is no appearance of spiral vessels even in the fruit-stalks, that grow so very rapidly. But this cellular texture, in most Jungermanniæ, is of a very delicate nature, and transparent, such as we are used to see it in the species of Splachnum, and in the very young and tender leaves of other Musci frondosi. (Fig. 46, 73.)

The straight canals in the leaves of most species of Jungermannia form no midrib; except in Jungerm. *furcata*, *palmata*, and *pinguis*, where we find a nerve supplying the place of a little stem, and traversing the substance of the leaf; but in this, also, we look in vain for spiral vessels.

As the Jungermanniæ approach the Mosses in J. *ciliaris*, *Leersii*, *complanata*, and *platyphylla*, so they recede from them in J. *pinguis*, *palmata*, *furcata*, and *epiphylla*, gradually putting on the form of the other Hepaticæ. Indeed, the difference of external habit in the former species and

 the

the latter is so great, that we can scarcely blame Micheli for making several genera of our present Jungermannia. But, when we examine the more essential parts, we find that, with regard to these, all the species agree.

The principal characters of the genus Jungermannia are the four-valved capsules (fig. 74) and the chain-shaped seed-dispersers, which are remarkably sensible to moisture and dryness.

The apophyses of the capsules have a form like to the ovaria of the Mosses (fig. 47); and are covered by a similar calyptra (fig. 48), which, however, is not persistent, but, as soon as the fruit begins to rise up, splits from top to bottom, and drops off. These parts were first represented by Schmiedel (de Jungermannia, fig. 3. 8. 9.); and afterwards by Hedwig (Theoria Generat. tab. 17. fig. 8—11, tab. 19. fig. 4—7, tab. 24. fig. 3, tab. 25. fig. 1.) Some of the latter figures are copied in vol. ii. of Hoffmann's Botanical Pocket-book.

The

The capsules of the Jungermanniæ are pedicled without exception; the pedicle is very delicate, shining like a thread of silver, composed of a very loose cellular texture, and of such wonderfully rapid growth, that, in J. *epiphylla*, it will often increase, in one night, the length of several inches. It constantly rises from a particular bell-shaped calyx, which is divided, at the upper part, into two, three, four, and more segments, is somewhat plicated, and more persistent than the fruit. Hence, in Jungermannia *reptans*, *complanata*, and *byssoides*, we often find the whole plant covered by a number of empty calyxes.

In this calyx, the fruit at first lies concealed; but, as it opens, we observe in it a small, shining, black globule, which gradually rises: as soon as the peduncle is sufficiently elongated, this globule bursts into four valves, covered all over with a subtile brown dust, consisting of grains of seeds, each suspended to a chain-like seed-disperser, (fig. 74. a. b.) which, by means of their

 hygro-

hygrometrical nature, twist and jerk upon the application of the slightest moisture, and thus disperse the seeds. That these are real seeds, was first ascertained in 1780, by Hedwig: those of J. *epiphylla*, having been committed to the earth, germinated in the course of a few days, struck root, and grew up into young plants.

With regard to the supposed fructifying organs of these plants, it must be confessed that their nature is as yet rather involved in obscurity. Micheli, but particularly Schmiedel, had already observed on the tips of the branches, and even of the leaves, small heaps of minute grains (fig. 46. 73.) that made their appearance at a certain period of the growth of these plants, but did not constantly keep pace in their evolution with that of the female organs. If these small heaps, or heads, are situate at the points of the leaves, as is the case in J. *excisa* (fig. 73), they generally are of a reddish-brown colour, but they soon after put on a darker hue, and mostly drop off after four-

four-and-twenty hours. If situate at the extremities of the branches, as in J. *byssacea* (fig. 46), these little heaps or heads are of a light-yellow colour, but equally deciduous with the others. The growth of the plant is uncommonly accelerated during the presence of these small heads, and soon afterwards the calyxes are produced with their black capsules. These heads bearing the greatest resemblance to those of several Mosses, it is probable that, like them, they merely contain the naked gemmæ.

Besides this, Schmiedel and Hedwig have observed, in J. *epiphylla*, small vesicles, replete with a pulverulent substance; and the latter of these botanists even noticed, in one instance, this powder to issue from these vesicules immersed in the substance of the leaf itself, in the same manner as we see the pollen discharged from the anthers (Schmiedel, de Jungermannia, fig. 7.—Hedwig, Theoria Generationis, tab. 14. fig. 1, 2.—Hoffman, Flora Germ., tab. 4. fig. d). Similar bodies were found by Hedwig, in Jungerm.

Jungerm. *furcata* (tab. 22. fig. 1, 2, 3), and even pedicled vesicles in J. *pusilla* and *palmata* (tab. 20. fig. 2. a. a. a., fig. 6. g. g.); all which he considered as anthers. I myself have often observed similar bodies; but it appears to me that they are rather made too much of in Hedwig's drawings, and that they may with greater probability be considered as gemmæ than anthers.

II. MARCHANTIA.

This genus agrees so much, in its external appearance, with some species of Jungermannia, that, on a superficial view, Marchantia *cruciata*, for instance, might be mistaken for Jungermannia *epiphylla*; the species of Marchantia, too, as well as J. *epiphylla*, *palmata*, and *pinguis*, inhabit very moist places, shady woods, and the borders of rivulets, where the soil is thickly traversed by the roots of trees. But the species of Marchantia are, on the whole, of a much firmer structure than those of Jungermannia; their growth is always lobated, like

like that of some lichens (Peltidea *hymenina, canina*): these lobes, too, are generally furnished with a strong midrib, more prominent at the under than the upper surface, and it is in M. *hemisphærica* and *cruciata* alone that this midrib is wanting.

The surface of the leafy expansions is rough, like shagreen, and consists of a beautiful net-work, in each of the meshes of which the microscope discovers a little protuberance. The lower surface, all over beset with villous roots, is dark, or of a reddish colour, furnished with a proper, wrinkled epidermis, adhering to the midrib. By means of the root-like villi, the plant lays hold of the soil, from which it cannot be detached but by moisture rather long applied.

The species of Marchantia are found green throughout the year; but it is at certain periods, only, that we discover their organs of propagation. Towards autumn, some plants begin to display a number of scattered papillæ, which soon open, and are found

found to contain numerous oblong bodies, acuminated at both extremities, and out of which the young plant emerges, as from seed. These bodies, as has been justly observed by Micheli, Dillenius, and Schmiedel, are to be considered as gemmæ.

There is another kind of gemmæ, which have been regarded as anthers, and are generally found on different plants from those that bear fruit: they are egg-shaped, and contained in disks furnished with peduncles, as in Marchantia *polymorpha*; or without peduncles, as in M. *conica*. It is only in M. *androgyna* that we find the receptacles of gemmæ, and of the seeds, borne on the same plant. This presence of gemmæ of two different kinds is not peculiar to Marchantia; for they exist also in bulbous plants, in Tetraphis *pellucida*, &c.

The above-mentioned disks dry up, and towards the middle of summer, other specimens of Marchantia, which always grow together in groups, produce small pedicled stars, which, in M. *polymorpha*, have from eight

eight to ten rays, or only four in M. *cruciata*, and appear halved in M. *chenopoda* of Martinico, having four or five acuminated segments pointing towards one side only. In M. *hemisphærica*, they form hemispherical umbrellas, with from three to eight obtuse segments; in M. *conica*, they appear like small cones, furnished below with from five to seven notches; in M. *tenella*, this cone is surrounded, towards the base, with many fringes; in M. *androgyna*, it is very little, or not at all, divided below. The little peduncles of these organs issue out of the midst of the substance of the leaf, in M. *hemisphærica* and *chenopoda*; out of the sinuses, in M. *polymorpha* and *androgyna*; and out of proper calyxes, in M. *conica* and *cruciata*.

Beneath these umbrellas, stars, or cones, the rudiments of the fruit are generated. Under each ray of the star, and under each segment of the umbrella, or cone, several capsules (in M. *conica* one only) are contained in proper calyxes, which, in M. *chenopoda*, *cruciata*, and *polymorpha*, are

regularly

regularly divided into four, and in M. *hemisphærica*, *conica*, *androgyna*, and *tenella*, into more segments. The capsules, before they arrive at maturity, bear each a pistil, and are furnished with a delicate calyptra, which afterwards bursts, and the capsule opens in such a manner that it displays several segments rolled back. The seeds which they contain are provided with similar elastic flings as those of Jungermannia.

That these are real seeds, capable of germinating into young plants, was proved, by the experiments made by Necker, (Physiologia Muscor. p. 118, 119) as early as the year 1772, and by Hedwig (Theoria Generat. p. 179.) with M. *polymorpha*. The best figures of the receptacles of the gemmæ and fruit, are given by Schmiedel (Icon. et Analys. tab. 9, 29, 31, 34), and by Hedwig (Theor. Gener. tab. 26—28). But before these botanists, much had been already done towards the illustration of those parts by Dillenius (Hist. Musc. tab. 75—77).

III. ANTHO-

III. ANTHOCEROS.

The interior structure of this Hepatica agrees with that of the fronds of the Marchantiæ and of some species of Jungermannia. The whole substance is made up of beautiful hexagonal cells, each of which, on the surface, is marked with a small protuberance; and these, when seen through a microscope, give to the whole a shagreen-like appearance.

In this genus we distinguish two kinds of organs on the same plant. In the substance of the leaf itself, within a proper involucre, are enclosed several small heaps of minute, egg-shaped bodies, of a reddish-yellow colour, surrounded each by a jointed ring: these parts were taken by Schmiedel and Hedwig for the male organs, but may with greater propriety be considered as naked gemmæ. From the middle of these small heaps, out of a proper calyx, with toothed and reflexed margin, there issues a horn-like body, covered, at first, by a brown villous calyptra, which latter soon falls off, when the horn splits into two valves, showing a fine filiform column in the centre: the seeds are now discharged, beset all over with delicate bristles, and each furnished with a jointed pedicle, by means of which they are probably ejected with a jerk.

Micheli has already represented these parts (tab. 7), but mistook the horn for the male flower, and the reddish-yellow grains for the seeds. Schmiedel examined these sexual organs more accurately, and has figured them with greater correctness (Icon. tab. 19 and 47); and Hedwig has since thrown additional light upon the subject (Theoria Generat. tab. 29, 30, 31).

IV. BLASIA.

In this genus, also, the organs of propagation agree, in the more essential points, with those of the other plants of this natural order. Nor is the totally cellular organization which we find in the species of Marchantia and Anthoceros, here wanting; only with this difference, that, in the fertile plants, the

the lobes are traversed by a distinct nerve, directed straight towards, and terminating in, the capsules. In the spring, at the extremity of this midrib, is seen an egg-shaped capsule, which appears, at first, immersed in the substance of the leaf itself, but is afterwards prolonged into a cuneiform, truncated tube, of the form of an elephant's proboscis, and which, as long as it remains closed, is furnished with a reddish-coloured point, seemingly the remains of the calyptra. In due time the seeds are protruded from the ovary into this tube, at the mouth of which they arrange themselves, in such a manner that the whole appears in the form of the pulverulent capitula of Tetraphis. Schmiedel saw these seeds germinate.

Besides the midrib, we see almost in all specimens of Blasia, within the substance of the leaves, scattered, dark-green dots, which, if more closely examined, are found to consist of aggregate vesicles, clothed all over with delicate hairs; these, from their appearance, may be considered as naked

gemmæ,

gemmæ. There is, however, another kind of gemmæ, by which this plant propagates itself; these shoot out on the lower surface of the leaf, and are soon surrounded by a crenulated leafy substance.

Schmiedel and Hedwig have given most excellent details of this genus; the former in a monograph (" de Blasia," in his Dissertationes Botanicæ), the latter in his " Theoria Generationis," &c.

V. TARGIONIA.

The only species as yet known of this genus has, likewise, so much in common with the species of Marchantia, Blasia, and Anthoceros, that Linnæus was very right in referring it to the same family. Targionia *hypophylla* grows on the declivities of rocks, where these are covered by good mould, kept moist by the water trickling down on them. It forms narrow lobes, of a green colour, rounded at the extremity, furnished, on their lower surface, with reddish plicated membranes, and, in the centre, with fibres per-

forming

forming the office of roots. Early in spring it produces lateral shoots, and in March, a brownish-red fruit begins to form itself beneath the rounded extremity of the lobes, which afterwards opens with two valves, and contains a single seed.

On examining this fruit more closely, before it has opened, it is found to consist of two membranes, the exterior of which is of a purple red colour, and separable from the interior, which is transparent, and formed of a net-work with hexagonal meshes. Within these meshes are lodged glandular bodies, similar to those in Blasia, Anthoceros, and the species of Jungermannia. They may be considered either as fecundating organs, or as mere precipitations of the surplus of the proper juices of the plant. That they abound with proper juices, containing carbonated hydrogen, may be also inferred from the turpentine-like smell these plants diffuse on being dissected.

In the cavity formed by the above-mentioned

tioned membranes, on an elevation of the bottom, is seen the ovary, furnished, at the upper part, with its pistil, exactly like the pistils of the Jungermanniæ, and of some of the frondose Mosses. By the sides of this ovary are always found other pistils, but which, as in several species of Jungermannia, are abortive. The pistil of the fertile ovaries, as soon as these begin to swell, disappears, and the capsule now takes the appearance of a beautiful net, containing numerous minute seeds, connected together by extremely delicate threads.

Such I have constantly found the sexual organs of this Moss, during the space of four years that I have examined it; and I have given figures and descriptions of it, in the Transactions of the Swedish Academy, 1802, p. 85—91. pl. 4, and in the Bulletin de la Societé Philomatique, an 9, no. 52, p. 27. The same had been before examined and described from dried specimens, by Schreber. (See "Naturforscher," no. 15, p. 236.)

This

This plant is found near Halle and Dresden, and in Italy.

VI. SPHÆROCARPUS.

This genus approaches very near to the foregoing; the fruit, when arrived at maturity, divides, in the same manner, into two valves, and contains a solitary seed; but the capsule is bottle-shaped, begins to open at the top, and afterwards splits its whole length: it is not situated on the lower, but on the upper surface of the frond. Within the cells of the frond are also seen the greenish, glandular, minute bodies, with which the species of Blasia and Jungermannia are furnished. You find the whole form of the plant faithfully represented in fig. 78, but having examined only dried specimens, I was unable to add the dissections. According to Micheli, who has first discovered the only species of this genus, Sphærocarpus *terrestris* grows in the gardens about Florence, in pure sand. I received my specimens from England.—See also Schmiedel's Icones, tab. 28. f. ii. 1—8.

VII. RICCIA.

The gradual transition to the forms less and less complicated in the vegetable world, is particularly illustrated by the species of this genus, which, if their internal structure were not absolutely reticulated and cellular, must have been classed with the Lichens, and especially with Endocarpon, with which Riccia agrees in more than one respect. Its principal character consists in the receptacle of the fruit, or seed-vessel, being lodged in the substance of the leaf, or of the plant itself, so that it can only be discovered by the darker colour of the place where it is situated. But this receptacle of the fruit is, in all the species, furnished with a duct, which may be compared to the pistil of other imperfect plants. In two of its species, R. *coriandrina* (Micheli, tab. 57. fig. 1.) and R. *pyramidata*, when

when the seeds are arrived at perfect maturity, the fruit escapes from, and projects over the substance of the leaf, and is all around pubescent and short pedicled in the former, sessile and cone-shaped in the latter of these species. In the other species it either projects very little (as in R. *minima* and *crystallina*, Schmied. Icon. tab. 45.), or it remains within the substance till the frond decays. In all the species it contains a great number of minute white seeds, which are connected together by means of threads.

Besides these receptacles of the fruit, there are likewise, within the substance of several species, extremely minute receptacles of gemmæ, distinguishable by their lighter colour, and which, in R. *coriandrina* and *pyramidata*, give out threads at the surface of the leaf; it is, however, remarkable, that they are never found in the same leaf, nay often not even on the same plant which contains the receptacles of the fruit.

Micheli was the first who examined and figured (tab. 57) the sexual organs of this

 genus;

genus; and after him Schmiedel (Icones et Analys. tab. 44, 45); and Hedwig (Theoria Generat. tab. 31). Its known species occur partly in company with the Lemnæ, in our ponds, partly with the Marchantiæ, in a moist soil. About Kröllwitz, large parts of the rocks are covered with Riccia *ciliata* and *glauca*; and R. *pyramidata* is also found in the same neighbourhood.

LETTER XXIII.

ON THE CHARACTER, ŒCONOMY, AND PROPAGATION OF THE LICHENS.

HITHERTO, my dear friend, you have accompanied me through those parts of the vegetable kingdom, of which, being able to define the limits, we could give a satisfactory definition: but of the family which we are next to examine, it is more difficult to obtain a precise idea, on account of the great latitude

tude allowed to it by the general consent of botanists.

Even the new and excellent system of Acharius is not exempt from this imperfection; at least, the difference between the Phycenæ (or cryptogamous water-plants, the proper Algæ), and the Byssi and Lichens, is not given with sufficient precision, and the principles adopted are not always adhered to. Thus, for instance, the rudiments of the Confervæ, in Lichen *viridis* of Schreber, are considered as a species of the genus of Lichens called Lepraria: though the microscopical drawing, fig. 79. b. shows them to be a real Conferva. In the same manner Acharius establishes as Lichens, Parmelia *pannosa* and *velutina* (Method. Lichen. p. 245), which, more closely examined, prove to be new species of Conferva*. Thus too, the genera Pulveraria, Lepraria, Spiloma, Variolaria, can scarcely be considered as any thing else but the young

* Weber und Mohr, Naturhistor. Reise durch Schweden, p. 104.

offspring

offspring of other Lichens, or of Byssi, to which several species of Lepraria at least ought certainly to be referred. At fig. 103 is the leaf of a Moss, stained with the germinating powder of Parmelia *pollinaria*, such as we frequently see it on the declivities of rocks. Acharius would have declared it to be a Pulveraria. On the other hand, I am of opinion, that Lichen *hippotrichoides*, *verticillatus*, *radiciformis*, and *aïdelus* of Humboldt (Flora Fribergens.) are, without reason, excluded from the Lichens; since they have distinct organs of propagation, shooting out from the sides of the plant.

Vegetables whose organs of propagation are so simple, cannot possibly be distinguished by a few essential characters; but we are under the necessity of having recourse to the whole of the characters, both natural and artificial, to arrive at a proper and exclusive definition. I should define Lichens to be cryptogamous plants, not of a distinctly cellular, but of a fibrous, compact, or gelatinous structure, whose sexual

organs

organs are contained in obvious scutellæ, patellulæ, peltæ, thalamia, disks, or pilidia, and which multiply also by means of a germinating powder or of peculiar germinating warts.

Indeed, in giving the general character of Lichens, regard should always be had to their internal structure. Endocarpon has, like Riccia, the receptacles of seeds lodged within the substance of the leaves, but their respective structure is entirely different; the latter having a completely cellular structure, while that of Endocarpon (fig. 80. b.) is compact, and formed of nothing but pure precipitations from the vegetable juices, except here and there some very slight rudiments of a cellular organisation. In the peltæ of Peltidea *horizontalis* (fig. 81. b.) are observed oblong cells gradually elongated into canals, such as occur also in Peltidea *saccata* (fig. 104): but in this Lichen I observe, beneath the layer of seeds, another layer composed of distinct cells, as is seen in the figure just quoted. The woody stem of

Usnea

Usnea *florida* consists of a loose bark, formed by precipitation, of a hair- and dust-like intermediate substance, and of a woody pith composed of closely aggregated canals (fig. 105): but never is there the least appearance in any Lichen of spiral vessels, or spurious tracheæ, and seldom of a completely distinct cellular structure. Rudiments of cells are, sometimes, though seldom, met with on the lower surface of the lobated Lichens, where their destination seems to be to absorb the moisture of the soil. Such imperfect cells may be distinctly seen in Peltidea *saccata* (fig. 104).

The difference between the woody pith and the granular bark is particularly exemplified in the formation of the seminal tubercles and disks of several Lichens. In Usnea, for instance (fig. 83), the orbillæ consist almost entirely of an elongation of the woody pith, and, in this genus as well as in Parmelia and Peltidea, contain tubular ducts, among which the seeds are lodged: the outer part of such orbillæ, scutellæ or

peltæ,

peltæ is a continuation of the granular cortical substance of the plant. In several species of Usnea, as also in Parmelia *divaricata* and *sarmentosa*, we see the cortical substance peel off in horizontal rings, leaving the woody pith in form of threads.

The connection which the cortical substance has with the propagation by means of lateral prolongation, as it is called, is likewise very obvious in the Lichens. The germinating powder issues from the whole surface of the cortical substance in Parmelia *pulveracea*, *conspersa*, *pollinaria*, (fig. 103); from certain parts only, in Parm. *farinacea*, *glomulifera*, *scrobiculata*, and Peltidea *aphthosa*. In the Usneæ (in U. *plicata* γ *dasopogon*, fig. 84. a. a. a. a), as likewise in Parmelia *conspersa*, fig. 85, and Cetraria *juniperina*, the germs appear in the form of papillæ, and in Lecidea *pustulata* in minute arborescent elongations.

This propagation by lateral prolongation, or by gemmæ, in the more imperfect plants, prevails more as the degree of organisation

is

is lower. It begins to occur in the Ferns, is more general in the Mosses, still more so in the Hepaticæ, and most prevalent of all in the Lichens and Confervæ. The cortical substance contains the precipitates of the vegetable juices in that concentrated and perfect form, in which we observe them in the rudiments of the young Lichens and the Pulverariæ (fig. 86).

The juices being so concentrated, no oxygen is extricated in the Lichens by the influence of light, and a green colour is but seldom observed in these plants.

On subjecting Pulveraria *chlorina* to the microscope (fig. 86. b). you find a subtile germinating powder mixed with delicate hair-like threads, the same as in the cortical substance of Parmelia *citrina*, *parietina*, and of Cetraria *juniperina* and *pinastri*. Is this Pulveraria (which is produced in shady places in the fissures of rocks and trees) to be considered as the first rudiments of the fronds of those yellow Lichens? I can scarcely doubt it.

Lepraria

Lepraria *lutescens* (fig. 87. a.) viewed through the microscope (fig. 87. b.) exhibits the same appearance as the gemmæ of Parmelia *candelaria* and *parietina*. I am also induced to think that Lepraria *incana* becomes Lecidea *muscorum*. I see this plant spring up on all flower-pots when kept moist and warm: the crust which it at first forms on the mould becomes gradually more solid, till at last the patellulæ of Lecidea appear. In the same manner I have often observed the gradual transition of the germinating powder (fig. 103) in Parmelia *pollinaria*.

The crust on many of the Lichens, such as Calycium *hyperellum*, (fig. 88. a. b.) consists almost entirely of this powder, which, wherever it flies, reproduces the same plant.

Indeed a superficial observation only could give rise to the idea that this powder is the fecundating substance analogous to the pollen of other plants; an opinion principally defended by Hedwig, but without producing any proofs in its support, except

what

what are founded on a misconceived analogy. A great number of Lichens seldom or never produce receptacles of fruit, and are propagated merely by this powder. Lecidea *pustulata* is very common with us: it is only in Sweden, however, and there very rarely, that it bears patellulæ; but its whole surface is covered with the same powder of germination standing on particular branchy pedicles, which wherever it is carried by the winds produces new plants. Fructifications very seldom occur, too, in Parmelia *jubata*, in Cetraria *nivalis*, *fallax* and *glauca*, which, nevertheless, propagate with great facility. Nor has fruit been scarcely ever observed in Gyrophora *anthracina*, Parmelia *scortea*, *chalybiformis*, *melaloma*, nor in Lecidea *cechumena β difracta*, in Lichen *bicolor* and *pubescens*. But this is no obstacle to their propagation, the powder of germination supplying the place of seeds.

As a still stronger proof that this powder is by no means analogous to pollen, we need only refer to the experiments of those naturalists who, since the time of Micheli, have seen young Lichens germinate from it. The botanist just mentioned having first observed this in Bæomyces *pyxidatus* δ *tuberculosus* (tab. 41. L. Q.), founded on it his theory; according to which the powder is considered as seed, while the fruit itself is supposed to perform the function of the flowers,—an opinion which has but very little to recommend it. But on the other hand, if we consider the dust that covers the surface of Lichens as cortical substance, endowed with the faculty of germinating, this theory appears to coincide with all the observations made by Schreber, Schmidel, Flörken, and others, and which every attentive observer will find to be perfectly correct. From these it appears that in the neighbourhood of the more advanced Lichens, a number of young plants spring up exactly in that quarter to which the rain or current of air has washed or blown the germinating powder from the mother plant.

Nor do we see the necessity of anthers to

Lichens,

Lichens, since the fruit of other cryptogamical plants is developed without distinct fecundating organs. Lichens contain in all their parts very concentrated proper juices, as has been already mentioned; and from these is formed, by precipitation, a mealy powder, endowed with the faculty of germinating, and also germinating papillæ and proper seeds. And thus, although, as in the naked Worms and Zoophytes, no difference of sex is observable, yet propagation is most vigorously carried on by means of gemmæ and seeds. It is presumptuous in man to prescribe to infinite wisdom general laws, which, though followed in the formation and propagation of some creatures, can be dispensed with in the more simple formation of others.

The Lichens, besides the powder just described, are furnished with other organs of propagation, namely the tubercles, which likewise originate in the cortical substance, and appear in some Lichens on such specimens as have no receptacles of seeds. Thus you

you see in Usnea *plicata* γ *dasopogon* (fig. 84) these tubercles at first of a reddish, afterwards of a blackish colour, only on those plants that are without orbillæ; and where these appear, the former are never observed. On the other hand, in Parmelia *conspersa* (fig. 85) they are seen together with the scutellæ on the same specimen. In Stereocaulon *paschale* (fig. 89. a. b.) the whole surface of the plant appears to be covered by these tubercles; nevertheless there is a great number of seminal capitula observed on them at the same time. In Cetraria *juniperina* brown tubercles make their appearance all around the circumference of the frond, and often at the same time with them a light yellow germinating powder borders the whole margin. From this circumstance some were induced to constitute two distinct species; but Acharius (Method. Lichen. p. 298, 299) has proved them to be only varieties.

In one genus, Sticta (fig. 90. b.), these tubercles or papillæ only occur on the back

part

part of the frond: they are lodged in particular cups (cyphellæ), which appear empty as soon as the gemmæ have fallen out.

The proper reservoirs of the seeds of Lichens differ in form, in the following manner:

1. *Scutellæ*—open, orbicular reservoirs, coated below and on the margin by the cortical substance of the frond, and above by a coloured seminal layer. (Parmelia, fig. 82, a; Urceolaria, fig. 91; Sticta, fig. 90, a.)

2. *Patellulæ*—open, flat or convex, roundish, sessile reservoirs, formed of a proper substance, not surrounded by a margin of cortical substance (Lecidea, fig. 92).

3. *Peltæ*—open, oblong or lenticular, quite flat, sessile reservoirs, adpressed close to the frond, and furnished with a distinct border, which is not closely attached to the flat reservoir (Peltidea, fig. 81). Rather thicker, approaching nearer the form of scutellæ, with distinct inflexed border, are the peltæ of Ceteraria (fig. 101).

4. *Orbillæ*—open, quite flat, little coloured,

loured, unmarginated expansions of the interior substance of the frond, which are furnished below only with cortical substance, and above with a thin layer of seeds (Usnea, fig. 83.).

5. *Pilidia*, or *cephalodia*—open, roundish reservoirs, which are either pedicled or sessile, but always strongly coloured, and lined with a layer of seeds, frequently falling off in the form of powder. (Calicium, fig. 83. b.; Bæomyces, fig. 93; Stereocaulon, fig. 89. a. b.; Isidium, fig. 97. b. The two former have generally pedicled, the two latter sessile, pilidia).

6. *Tricæ*—closed, elongated, twisted reservoirs, formed of a proper substance, of a black colour, bearing their seeds on the interior side, beneath a proper membrane (Gyrophora, fig. 94. b.).

7. *Lirellæ*—closed, elongated, straight, or somewhat curved reservoirs, formed of a proper, black, spongy mass (Opegrapha, fig. 102. a. b.).

8. *Thalamia*—closed, round reservoirs within the substance of the frond itself, sur-

rounded by a proper membrane, which contains the seeds enclosed in a proper bag (Endocarpon, fig. 80. a. b.).

9. *Tubercula*—closed, roundish, or conical reservoirs, projecting out of the substance of the frond, and containing a pulverulent heap of naked seeds within a proper involucre (Verrucaria, fig. 98; Trypethelium, fig. 95.).

Within the layers of these reservoirs are lodged the seeds, either entirely exposed and connected among each other, as in Verrucaria (fig. 99. a.), or contained in proper transparent purses, as in Thelotrema and Endocarpon (fig. 80. b.), or contained in the tubular processes of the seminal layer, as in Peltidea (fig. 81. b. fig. 104.), and in Parmelia.

Though the seeds themselves are sometimes round, yet their more common form is oval, as in Verrucaria (fig. 98. a.); or they are pointed at both ends, as in Peltidea (fig. 81. b.); or divided in the middle by a transverse line, and as it were didymous, as in Parmelia and Peltidea *saccata* (fig. 104.).

That

That the bodies of which I have been speaking are real seeds, can scarcely be doubted, though there are no observations on record of young Lichens having been raised from them.

LETTER XXIV.

GENERAL OBSERVATIONS ON THE EXTENT OF THE LICHENS OVER THE WORLD.

The Lichens abound in every part of the world: the most barren rocks in the northernmost regions, and the vicinity of glaciers where eternal ice prevails, are inhabited by these wonderful vegetables; and the barest and hardest masses of granite and porphyry receive from them the first rudiments of vegetation. Braving the inclemencies of every climate and season, Lichens are the never-failing companions of the travelling botanist;

in the most elevated, cold, and inhospitable alpine and polar regions, these desert him last; even on the loftiest mountains of the temperate regions, on the verge of eternal snow, the eye of the botanist is still soothed by the brilliant Peltidea *crocea*, and in the North, by the beautiful Peltidea *polaris*, Parmelia *chlorophana*, Lecidea *Wahlenbergii*. There are even a considerable number of Lichens that seem to thrive the most vigorously on the loftiest alps; their more simple, half-organized, structure resisting the intense cold, occasioned by the adjoining perpetual ice, which is sufficient to destroy all vitality in the more perfectly organized beings. The species of Gyrophora and Sphærophora, Parmelia *stygia*, *fahlunensis*, Bæomyces *vermicularis*, Peltidea *crocea*, Cetraria *islandica*, *nivalis*, *cucullata*, Cornicularia *tristis* and *aculeata*, are seen 2000 feet above the level of the sea.

The primitive mountains, the fundamental pillars as it were of our globe, have proper Lichens that cover the barren surface

of

of their masses of porphyry and granite. Lecidea *atrovirens*, *sulfurea*, *silacea*, *ochroidea*, Urceolaria *tessulata*, Parmelia *ventosa*, *erythrella*, *intricata*, *gelida*, *plicatilis*; Gyrophora *hyperborea*, *proboscidea*, *pellita*, prefer granite rocks; while those of porphyry are covered by Lecidea *pustulata*, *fumosa*, *athroocarpa*, *cechumena*, *confluens*, *hæmatomma*, with Endocarpon *complicatum*, Parmelia *ciliaris*, *furfuracea*, *caperata*, and Gyrophora *spadochroa*. On the hardest rock-crystal are found Lecidea *dendritica*; on mica, the species of Opegrapha called after Persoon, with Verrucaria *trachona*; on sandstone, Lecidea *privigna* and Parmelia *craspedia*; on basaltes, Parm. *fuscata*; on gneiss, Parmelia *fahlunensis* and Lecidea *silacea*; on marble, Urceolaria *purpurascens*; on schistus, Lecidea *Dicksonii* and *polytropa*.

Calcareous rocks, and old walls coated with lime, are inhabited by Parmelia *saxicola*, *crassa*, *fulgens*, *elegans*, *circinnata*, *miniata*, *murorum*, by Lecidea *immersa*, *epipolia*, *cupularis*, *nigra*, *testacea*, by Verrucaria

Schraderi,

Schraderi, *grysea*, *muralis*, and by Urceolaria *calcarea*, *exanthematica*, *hypoleuca*. Parmelia *cretacea* prefers pure white chalk.

Our breccias and rocks of quartz are covered with Lecidea *athroocarpa*, *lapicida*, *atrovirens*, *fusco-atra*, *cechumena*, with Urceolaria *scruposa*, *cinerea*, with Parmelia *parella*, *tartarea*, *saxatilis*, *caperata*, *erythrella*, *multipuncta*.

On argillaceous soil are seen Lecidea *sanguineo-atra*, *argillacea*, *decipiens*, Peltidea *spuria*, Bæomyces *roseus* and *rupestris*.

Lichens particularly abound on such soils as are unfavourable to other vegetation. Most species of Bæomyces grow on arid heaths; Peltidea *venosa*, Parmelia *limosa* and *subtilis*, on mud; Lecidea *miscella*, *icmadophila*, *granulosa*, *vernalis*, *microphylla*, *lurida*, *vesicularis*, Calicium *capitellatum*, Verrucaria *spongiosa*, *picina*, Parmelia *lacera*, *scotina*, Endocarpon *pusillum*, *lachnæum*, Peltidea *canina*, *hymenina*, *horizontalis*, on moist coarse clay.

Mosses beginning to decay afford a habi-

 tation

tation particularly suited to Lichens, where they form incrustations in such a manner, as to exhibit a sort of firm stony rind surrounding their stalks. In such situations we find, among others, the gelatinous Parmeliæ, such as *tenax*, *crispa*, *cristata*, *myriococca*, *muscicola*, and likewise P. *fusco-lutea*, *hypnorum*, *parella* β. *upsaliensis*, *tartarea* β. *frigida*, *epibryon*, *lepidora*, *brunea*, *epigea*, *lentigera*, *lanuginosa*, *scrobiculata*, Lecidea *muscorum*, *uliginosa*, *candida*, Urceolaria *scruposa* ε. *bryophila*, *panyrga*, and also Isidium *gonatodes*, which is at present considered as a variety of Parmelia *tartarea*. One Lichen grows even on a species of Jungermannia, viz. Lecidea *Jungermanniæ*.

That they are also parasitical on other Lichens, is proved by the examples of Lecidea *scabrosa*, found on Bæomyces *rupestris*; of Calicium *stigonellum*, on Thelotrema *pertusum*; of Calicium *paroicum* inhabiting Lecidea, or Parmelia *hæmatomma*.

But the habitation the most congenial to Lichens is the bark of trees, and they are not unfre-

unfrequently seen to partake of the qualities of that part. Thus Parmelia *pulmonacea* partakes of the constituent parts of the oak-bark on which it grows, just as Parm. *prunastri*, *fraxinea*, *pollinaria*, and *farinacea* commonly admit into their composition an admixture of the constituent parts of the bark of the different trees which they inhabit. The youngest and smoothest barks are occupied by Opegrapha; while the larger Parmeliæ are usually found only on the rugged and cracked bark of old trees, and on decayed wood. On old spars and planks are seen Lecidea *viridescens*, *Erysibe*, Parmelia *subfusca*, *parietina*, *elegans*, *angulosa*, *ambigua*, Bæomyces *botrytis*, Calicium *peronellum*, *glaucellum*, Verrucaria *stigmatella*.

Many Lichens take up their abode under water, on the surface of stones, such as Endocarpon *Weberi*, Parmelia *hydrochara*, *fluviatilis*, *flaccida* β. *rivularis*. Even in mines under ground, Humboldt discovered several species, comprehended

hended by Roth under the name of Rhizomorpha.

In this manner are the Lichens dispersed all over the face of the globe. Placed almost on the lowest degree of organisation, they often require nothing for their conservation but the moisture of the atmosphere, precipitated on the naked masses of rock. But on these rocks, by their decay, they form a stratum of mould, favourable to the growth of the more highly organised Mosses and Jungermannias. Scarcely is there a tree found in the torrid as well as the frigid zone, that is not, at some period of its existence, covered by Lichens: for, unconfined to any particular climate or degree of latitude, wherever there occur mould, stones, rocks, or trees, Lichens are sure to be found.

These plants merit the attention which has of late been bestowed upon them, if in no other respect, yet certainly on account of the various œconomical uses to which they are applied, such as in dyeing, and even as affording food both for man and beasts.

LETTER

LETTER XXV.

DISTRIBUTION OF THE LICHENS INTO GENERA.

Micheli and Dillenius, the two earliest Lichenologists, in their time saw the necessity of subdividing this extensive family into several genera. But this necessity became still more urgent, from the great accumulation of newly discovered species, which, exclusive of those of Pulveraria, Lepraria, Variolaria, and Spiloma, amount already to six hundred. Even if the difference in their forms had not been very striking, the subdivision of so numerous an assemblage would still have been convenient to assist the memory: but how very different in external appearance are Usnea and Verrucaria, Opegrapha, Parmelia *fraxinea*, *pulmonacea*, and Sticta *filicina*, &c.! How was it possible to unite plants so different in form into a single genus?

Micheli,

Micheli, who has made many invaluable disquisitions on the structure of the receptacles of the seeds and the seeds themselves, has, nevertheless, in his principal division of the Lichens, distinguished them, according to the nature of their fronds, under the denomination of *Lichenes gelatinosi*, *crustacei*, *cauliferi*, *pulmonacei*, &c. Dillenius, who with less propensity to microscopical investigation united the greatest accuracy and excellence in representing the external forms, and describing the species, also divided the Lichens according to the form of the fronds only, purposely neglecting the difference in the fruit. His three genera, Usnea (the present one, together with some Parmeliæ), Coralloides (our Bæomyces, with several Parmeliæ), and Lichenoides (all the rest), are not correctly defined, although the single species are characterized with great accuracy.

Linnæus, who distinguished scarcely an hundred species of Lichens (though Dillenius had already established upwards of an hundred

hundred and ninety) threw them all into one genus, to which he applied the incorrect character of Micheli, of the male flowers being situated in a round receptacle, and the female flowers consisting of the mealy powder scattered over the fronds; and divided them, according to the difference of the fronds, into several families, to many of which, as Lichen *scriptus*, *geographicus*, *fragilis*, &c., the above character is not at all applicable.

Hoffmann has, more lately, attempted a division of Lichens resting chiefly on the diversity of the fronds, which has met with considerable applause in Germany. We must allow to this botanist the merit of having discovered a great number of new species, and distinguished the known ones with accuracy; but he paid too little regard to the receptacles of the seeds, the most essential part of these vegetables, and therefore, of all others, affording the most useful principle of classification, as has been urged by Willdenow, Persoon, Schräder, Humboldt,

boldt, and others, who have proposed different arrangements. These authors distinguished the lirellæ, pilidia, tricæ, scutellæ, and peltæ; but there was still wanting a more exact microscopical examination of these reservoirs of the seeds, as well as a general view of the whole family. The accomplishment of this was reserved for that excellent Swedish naturalist, Erich Acharius, to whom we owe not only the knowledge of a great number of new species, but likewise a most complete synonymy, and lastly, the framing of a system as perfect as could possibly be expected, constructed according to the rules of Botanical Philosophy, and founded chiefly on the form of the fruit.

It cannot, however, be denied, that Acharius has enumerated, as distinct genera of Lichens, bodies that appear to be only the first rudiments of other Lichens, or some of them species of Byssus. I shall not here repeat what I have before observed respecting the identity of Lepraria *byssoides*

and

and a Conferva, the transition of Lepraria *incana* into Lecidea *muscorum*, and the identity of the Pulverariæ and Leprariæ with the powder and papillæ of germination of other Lichens. Nor can I adopt the genus Spiloma, which differs from the Pulverariæ merely in its colour being black: as to Spiloma *melanops*, I suppose I may confidently maintain that it is a true species of Byssus. Nor can the genus Variolaria be deemed a genuine one, as it consists of nothing but accumulated powder of germination, or heaps of germs (soredia). Thus the three first genera, in which no seed-receptacles have ever been observed, may be properly omitted.

I now proceed to explain to you the genera that I think proper to adopt.

I. OPEGRAPHA (Fig. 102).

Naked, pulverulent seeds lodged in lirellæ, which are oblong, covered at first by the bark, afterwards open, and immersed in the thinner barks. The margin of the lirella is double, one proper, the other adventitious,

adventitious, furnished by the bark of the Lichen.

With regard to some species of this genus, O. *Persoonii*, *vulvella* and *rubella*, a doubt may arise whether they should not rather be referred to the genus Hysterium: but this mushroom has no bark, its seeds nestling within a spongy or pulpy mass.

II. LECIDEA (Fig. 92).

Roundish or angular patellulæ, surrounded by a proper margin, adpressed to the frond or the bark, but of a quite different substance and colour. Sometimes the patellulæ, when the plant becomes old, run into each other and appear like small tricæ, and might in this state be mistaken for Gyrophoræ. (Lecidea *silacea*, *Oederi*, *privigna.*)

The patellulæ are mostly furnished with a proper margin, which is generally of a fainter colour than the disk; when the plant appears like a species of Parmelia. But still the colour of the margin of the patellula is very

very different from that of the bark. In Lecidea *Dilleniana* the patellulæ are of a blueish-black, the margin is quite black, and the cortical substance of a reddish colour. In Lec. *rosella* the margin is much paler coloured than the rose-red disk of the patellulæ. In Lec. *petræa* the last-mentioned part is black with blueish margin, while the bark is white. In a similar manner the paler margin is distinct from the darker coloured patellulæ, even in Lec. *aurantiaca* and *cyrtella*.

Sometimes the bark itself approaches so near to the margin of the patellula, that it covers its outside, though it cannot properly be said to contribute to the formation of that part. The nature of this spurious margin of the patellula is best seen in Lecidea *corticola*, in which the whole patellula often falls out, and leaves the cortical margin in the shape of a cup. This difference is, however, not always very obvious, and in such dubious cases it is necessary to examine the seminal layer itself. If the seeds are still

still lodged in proper transparent bag-shaped membranes or tubes, as in fig. 82. b. the plant is a Parmelia. Hence Lichen *hæmatomma* of Ehrhart and Retzius (not of Sowerby), first referred by Acharius to Lecidea, is actually a species of Parmelia (see Achar. Suppl. ad Meth. 35). Lichen *cupularis* Ehrh. (Hedwig Stirp. 2. t. 20. B.), taken by Acharius for a Lecidea, I can consider only as a species of Parmelia, the margin of the tile-red patellulæ being white like the crust, and the seeds being lodged in particular tubes. Hence too, Lec. *orosthea* is evidently a Parmelia; for the margin belongs to the patellula itself, and is of the same colour with the cortical substance.

In Lecidea the seeds cover the seminal layer in the form of powder, without being enclosed in particular tubes.

The cortical substance is either pulverulent and cracked, or lobated and foliose; but never branched or stipitate.

III. CALICIUM (Fig. 88, a. b).

Round, top- or disk-shaped, peduncled or sessile pilidia, almost always of a different colour from that of the pulverulent bark. The surface of these pilidia is at first surrounded by a delicate membrane, which afterwards bursts, when the whole surface dissolves into a subtile dust which soon falls off.

The peculiar appearance of its fructification distinguishes this Lichen from all the rest. But specimens without fruit may be easily mistaken, on account of their pulverulent bark, for a Lepraria of Acharius, or for young plants of Parmelia *candelaria* and *parietina*.

IV. GYROPHORA (Fig. 94. a. b).

Tricæ closely attached to the frond, at first closed, afterwards irregularly bursting, and exhibiting, on their interior surface, naked seeds in the form of powder. They

are

are constantly of a black colour, and distinct from the patellulæ crowded together in the windings of the Lecidea, in this, that they are originally single and disk-shaped, but afterwards, by running into each other, put on the appearance of tricæ.

The cortical part is always leafy, and generally attached to its place of growth by its centre; from which circumstance Hoffman called the genus Umbilicaria. As long as the fruit of Lichen *pustulatus* was unknown, it was natural, on account of its frond being exactly similar, to refer this plant to the genus Gyrophora; but since distinct patellulæ have lately been discovered on it in Sweden, it evidently belongs to the genus Lecidea.

V. TRYPETHELIUM (*Bathelium Achar.*) Fig. 95. a. b. c.

Roundish or cuneiform tubercles, formed of a proper substance, projecting over the cortical part; they are closed and often covered with a papilla. Their interior consists

 of

of several cavities, lined with a proper membrane and filled with a blackish seminal powder.

The bark is pulverulent or cracked, and constantly of a different colour from the tubercula.

I have taken this character from a species which is found only on the Cascarilla bark, and which, therefore, I call Trypethelium *Eluteriæ*. The papilla, which in the other species, Bathelium *mastoideum*, according to Acharius, covers the tubercle, does not appear essential to me ; and I rather think that this genus is distinct from the following, merely in the pulverulent, not concatenated, seeds, and in the greater number of cavities found in each of the tubercles. From Thelotrema it is distinguishable both by the naked pulverulent seeds and by the tubercles being formed of a proper substance distinct from that of the cortical part.

VI. VERRUCARIA (Fig. 98. a. b. c.).

Roundish or wedge-shaped, closed tubercles,

cles, formed of a proper substance, somewhat projecting over the cortical part, and containing within a single cavity, a pulverulent nucleus composed of concatenated seeds (a).

The cortical substance is mostly pulverulent, or extremely thin and membranous, but constantly of a different colour from the seminal tubercles.

VII. ENDOCARPON (Fig. 80. a.—d.).

Closed, round thalamia, within the substance of the bark itself, not projecting above it, but only indicated on the surface by single, distinct dots (d). A perpendicular section (a) shows that these thalamia are of a different substance and colour from the bark. They contain the seeds (b) enclosed in proper pellucid, membranous pouches, extending radiately from the centre of the thalamium to its circumference. The last quoted figure clearly shows that these receptacles are separate from the cortical substance, which is generally foliaceous.

This genus cannot by any means be united

united with the foregoing, the thalamia being different from tubercles, and the seed not being naked and collected, as it were by concatenation, into a pulverulent nucleus, but enclosed in proper purses.

VIII. THELOTREMA (Fig. 99, a, b. c.).

Closed, multilocular thalamia, partly formed of cortical substance; loculaments lined by proper membranes (c), containing the seeds, surrounded by pellucid membranous pouches. The thalamia, by their raising the cortical substance, project above the surface of the plant. Another principal character that distinguishes the preceding genus from this, is, that in the former the thalamia are formed of a proper substance independent of that of the bark. The cortical part is mostly cartilaginous.

To this genus belongs the Lichen *pertusus* L.

IX. SPHÆROPHORON (Fig. 96).

Roundish closed cistellæ formed of corti-

cal

cal substance: they at last burst irregularly and throw out the naked seeds. The frond almost always forms little shrubs, with smooth surface and solid stems.

To this genus belong Lichen *globiferus* and *fragilis* L.

X. ISIDIUM (Fig. 97. a. b.).

Open globules or pilidia, entirely surrounded by a seminal layer; they are situated on the tops of particular germinating papillæ, and are internally furnished with a solid nucleus. The germinating papillæ cover almost the whole of the cortical substance, which is generally hard and of no defined shape.

It does not appear that the receptacles of the fructification are not formed of a proper substance. The pilidia are evidently so: they are so loosely fastened to the papillæ, that these cannot be considered to be a part of the receptacle of the fruit, any more than the spurious margin in Lecidea.

The above character of the papillæ being sur-

surrounded by a seminal layer, is indeed also met with in Calicium; but in this the globules have proper pedicles differently coloured from the rest of the frond: while in Isidium they are immediately situated on the papillæ, on which, when they drop off, they leave a little hollow. To this genus belongs Lichen *corallinus* L.

XI. URCEOLARIA (Fig. 91).

Depressed, concave scutellæ, with a double margin, the one proper, of the same colour with the scutella, and often also with the cortical substance; and a spurious one originating from the cortical substance. The surface of the scutellæ is covered by the open seminal layer in which are lodged naked pulverulent seeds.

This genus agrees with the Lecideæ, particularly with regard to the seeds, and in that the scutellæ are often furnished with a proper margin. But this margin is almost constantly surrounded by another, the continuation of the cortical substance; a character

racter that approximates Urceolaria to Parmelia. In the former, however, the margins are never free as in the Parmeliæ, nor are the seeds in particular tubes. Besides this, the Urceolariæ are distinguishable from the Lecideæ and Parmeliæ chiefly by the depressed concave surface of the scutellæ; and if the scutellæ of Parmelia and the orbillæ of Peltidea *saccata* are similar in appearance, still these are destitute of the proper margin. Little as I am inclined, for the above reasons, to unite Urceolariæ with Parmeliæ, nevertheless it appears to me that they might perhaps be referred to Lecidea, if the plane or convex discoid form in the latter were not so decided and general. I must, however, observe that Urceolaria *diamarta*, according to specimens I have received from the Riesen Gebirge, is evidently a Lecidea, and should be placed between Lec. *silacea* and *Oederi*.

XII. PARMELIA (Fig. 82).

Thickish, flat, concave or convex scutellæ,

tellæ, projecting over the cortical substance, and destitute of proper margin, but deriving this part from the bark. The surface of the scutellæ is covered with a seminal layer, which contains didymous seeds in proper tubes. These characters keep this genus distinct from Lecidea; it happens, however, not unfrequently, that the borrowed margin disappears in the older scutellæ, when the species of Parmelia perfectly resemble those of Lecidea. This is especially the case with Parmelia *rubra* and *effusa*.

The cortical substance in this extensive genus, of which two hundred species are already known, adopts various forms; it is ovate, lobate, shrub-like, filiform, pulverulent, gelatinous, and coriaceous.

XIII. STICTA (Fig. 90. a. b).

Flat, or somewhat convex scutellæ, projecting over the cortical substance from which they take their margin; they are always situated on the surface of the frond, while on the lower surface (b.) there are depressions

depressions or cups (cyphellæ) that have been, or are still, filled with small heaps of germinating powder. The seminal layer contains the seed in proper tubes.

The cyphellæ on the lower or reverse surface of the frond, constitute the generic character. The frond is generally firm, coriaceous, and lobate.

To this genus belongs, among others, the Lichen *sylvaticus* L.

XIV. PELTIDEA (Fig. 81. a. b.).

Oblong, kidney-shaped, mostly flat, seldom concave, thinly membranous peltæ, closely adpressed to the frond, on both sides of which they are generally situated not far from the edge. Their margin originates from the frond. The seminal layer contains the oblong seeds within tubes. Frond coriaceous, or membranaceous, and lobate.

To this genus belong Lichen *caninus*, *aphthosus*, *arcticus*, L.

XV. CETERARIA (Fig. 101.).

Disciform, thickish peltæ, flatly adpressed, with free margin originating from the frond. The seminal layer appears to contain the seeds within tubes. The frond is lobate, with lobes very irregularly slit, mostly curled at the margin.

This genus is intermediate between Peltidea and Parmelia: with the former of which it might, perhaps, be united, did not the peltæ, from their more rounded circumference, and greater thickness, approach to the nature of scutellæ.

To this genus belong L. *nivalis*, *islandicus*, *juniperinus*.

XVI. USNEA (Fig. 83.).

Round, flat, coriaceous, somewhat coloured orbillæ, furnished, on the lower surface only, with cortical substance, from which, however, they do not derive any margin; nor have they a proper one. The seminal layer contains round, naked seeds. The

The frond consists of branched threads, or is nearly shrub-like, and the cortical substance is very distinguishable from the woody centre. On such specimens as bear no orbillæ, we see papillæ of a different colour from that of the threads (fig. 84. a).

XVII. CORNICULARIA (Fig. 100).

Disciform, dark-coloured orbillæ, pedicled in the centre, surrounded by radiated threads, and generally without a margin. There is, at first, the rudiment of a margin, which, however, loses itself in the above-mentioned radiated threads. The seminal layer, as it appears to me, contains round naked seeds. The frond is mostly shrub-like, with stiff solid branches.

This genus, according to Acharius, is distinguishable from the preceding, to which it is nearest related, both by the darker colour, and form of the orbillæ, which are not flat, but either convex or concave, as well as by the shrub-like, stiff habit of the frond. These characters seem, however, insuf-

insufficient, and perhaps this genus might have been united to the preceding.

To Cornicularia belong Lichen *tristis* Web., *aculeatus* Ehrh., and perhaps also L. *lanatus* and *pubescens*, L.; but the fructification of these has not been yet discovered.

XVIII. STEREOCAULON (Fig. 89. a. b).

Open, roundish, strongly coloured pilidia, at first surrounded by a distinct, proper margin, which they afterwards lose. The pilidia are formed by the cortical substance itself: they have no proper pedicles, but are sessile all over the frond. Their surface is covered by a seminal layer, in which the naked seeds are lodged. The frond is shrub-like, rough, cracked, solid, and generally covered by germinating papillæ. To this genus belongs, among others, Lich. *paschalis*, L.

XIX. BÆOMYCES (Fig. 93).

Roundish or convex, strongly coloured pilidia,

pilidia, without proper margin, either on proper pedicles, or sessile on the margin of the frond, which is dilated into the form of a funnel. Their whole surface is covered by a seminal layer, in which the naked seeds are lodged. The body of the pilidium itself is formed by the substance of the pedicle. The frond is seldom foliaceous and lobated, but more commonly flat and pulverulent.

To this genus belong Lichen *rangiferinus*, *pyxidatus*, *cocciferus*, &c. It agrees with the genera Isidium, Stereocaulon, and Calicium, in the essential parts; but differs from Stereocaulon, in its pedicled pilidia without a margin, as also in the hollow form of the pedicle; from Isidium, in the absence of germinating papillæ on which the globules are situated; from Calicium, in the difference subsisting between the substance of the pedicles of the fruit and of that of the pilidium itself.

From the preceding observations the following Synoptical Table of the Genera of Lichens may be given :—

A. The reservoirs of the seeds formed of a proper substance

a. the seeds themselves represent a naked, black powder

1. in lirellæ; *Opegrapha.*

2. in patellulæ; *Lecidea.*

3. on pilidia;

a a. with pedicles of proper substance; *Calicium.*

b b. sessile on the tips of the papillæ and deciduous; *Isidium.*

4. in tricæ; *Gyrophora.*

5. in many-celled protuberances; *Trypethelium.*

b. seeds cohering as if concatenated

6. in one-celled protuberances, *Verrucaria.*

c. seeds contained in proper membranaceous purses

7. in common loculaments; *Endocarpon.*

B. The reservoirs of the seeds partly formed of the common substance of the whole mass

a. The

a. The seeds themselves representing a naked black powder

a a. the common cortical substance wholly surrounding the external surface of the reservoir of the seeds,

8. in round reservoirs on proper peduncles; *Sphærophoron.*

b b. the common cortical substance forming the nucleus of the reservoir, which is surrounded by the seminal layer,

9. in margin-less pilidia on proper pedicles; *Bæomyces.*

10. in heads, marginated at first, sessile on the frond; *Stereocaulon.*

c c. the common cortical substance forming the external margin of the concave scutellæ, which have also a proper margin; (11.) *Urceolaria.*

b. seeds round and cohering as if concatenated; the cortical substance surrounding only the lower surface of the reservoirs, and forming radiated processes around the latter,

12. in flat orbillæ, with filiform frond; *Usnea.*

13 in disciform orbillæ, with stiff, shrub-like frond; *Cornicularia.*

c. Seeds lodged in proper pellucid membranaceous purses. The cortical substance forming the whole many-celled thalamium; (14.) *Thelotrema.*

d. Seeds lodged in proper delicate tubes of the seminal layer.

a a. the common cortical substance forming the margin of the reservoir of which it constitutes a part:—scutellæ. (15.) *Parmelia.*

b b. the common cortical substance surrounding loosely and free the margin of the reservoir without constituting a part of it;

a a a. scutellæ on the upper, and cyphellæ on the lower surface; (16.) *Sticta.*

b b b. peltæ; (17.) *Peltidea.*

c c c. disciform peltæ; (18.) *Ceteraria.*

This table, which accords with the present state of our knowledge, will probably admit of many alterations when the structure and propagation of the related plants, especially the Confervæ and Fungi, shall have been submitted to a careful examination.

EXPLANATION OF THE PLATES.

PLATE I.

Fig. 1. Tuberous root of Aspidium *Filix mas*, natural size. *a a.* calyptra of the ends of the roots (p. 29). *b. b.* the tubers themselves *c. c.* the chaffy paleæ (p. 27).

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Fig. 4. Vertical section of the same, to show the brown membrane enclosing the bundles of vessels (p. 38); natural size.

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PLATE II.

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PLATE

PLATE III.

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involucres

involucres do not join so completely as to produce a cup.

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Fig.

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Fig.

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FINIS.

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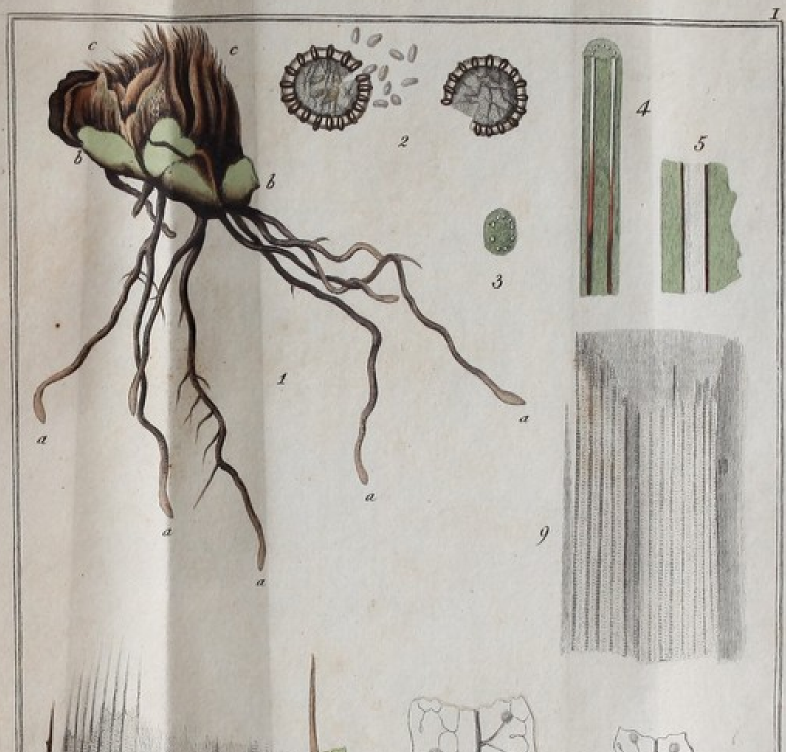

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